ZEEHAN SLAG DUMP RETREATMENT PROJECT

PRE-FEASIBILITY STUDY (VOLUME I)

PYROSMELT N.L. 368001 JULY 1991

EXECUTIVE SUMMARY

The Zeehan slag dump retreatment project proposes the construction of a relocatable 15t/hr Sirosmelt slag fuming plant to produce 20,651 tonnes per annum of saleable zinc oxide fume which will then be further processed to produce one or more zinc chemicals and an lead - silver residue.

This pre-feasibility study has concluded that a full feasibility study is now warranted.

The Zeehan slag dumps are located in Western Tasmania and comprise a proven reserve of lead blast furnace slag of 450,750 tonnes grading an average of 13.4% zinc, 1.7% lead and 54g/t silver.

Pyrosmelt N.L., holds a 100% interest in a licence to treat the resource subject to a 5% Net Smelter Return royalty payable to the owner, Pasminco Limited.

This study has considered four Sirosmelt slag fuming process options in order to determine the optimum plant configuration:

Option A : Twin furnace plant operating continuously with zinc recovery to fume of 94%

Option B : Single furnace plant operating continuously with zinc recovery to fume of 80%

Option C : Single furnace plant operating on a batch basis with zinc recovery to fume of 94%

Option D : Single furnace plant operating continuously with zinc recovery to fume of 94%

Option D is a variation on Option B where the single furnace is operated continuously at higher temperature to achieve higher zinc recoveries.

Financial modelling has shown Option D to be the optimum Sirosmelt plant configuration for producing raw zinc oxide fume. The higher zinc recovery achieved in Option D has yet to be demonstrated in pilot plant testwork, but project sensitivity analysis shows the project to be attractive at lower zinc recoveries.

The raw fume can be further processed to produce either an enriched fume by roasting, or a range of zinc sulphate chemicals or pure zinc oxide by leaching. Zinc oxide production offers the best return per tonne of raw fume processed, but the markets for all zinc chemicals are competitive and further market research may show that a number of products will need to be produced if all the fume is to be processed.

This study has succeeded in identifying the major cost driver for the slag fuming stage, which is largely operating costs. The principal component of operating costs is fuel, of which coal is the cheapest and preferred source. Oxygen enrichment was considered as a variation for Option C but found to be unattractive and this result is equally applicable to the other process options. Project revenues are highly dependent on zinc recovery to fume and to the added value obtained by processing the raw fume to one or more zinc chemicals.

Financial modelling has determined the optimum plant throughput to be 15 tonnes per hour.

Detailed modelling and sensitivity analysis has been undertaken on a Base Case where a 15 tonne per hour (112,500 tonnes per annum) Sirosmelt plant having the optimum configuration (Option D) produces a 20,651 tonnes per annum of raw fume of which 50% is converted to zinc oxide and 50% is sold as-is to the Risdon zinc refinery in Tasmania for use in zinc metal production. On this basis the project has a pre-tax net present value of $21.3 million and an internal rate of return of 56% for a total capital cost of $13.5 million.

The project has an initial life of 4 years based on the current resource. After treatment of the Zeehan slag reserve the plant will either stay on site and treat other locally sourced materials, or it will be dismantled and moved elsewhere to treat other zinc slag resources or metalliferous residues, a number of which have already been identified.

A preliminary Environmental Scoping Study has been prepared in relation to the Sirosmelt slag fuming stage and has been submitted to the Office of the Environment. No particular environmental hazards have been identified and indeed the project has a number of positive environmental features including the reduction to safe levels of zinc and cadmium in the slag and the return of slag to a form which can be more easily landscaped and revegetated.

This study concludes that a full feasibility study is definitely warranted. This will comprise slag bulk density tests, further mineralogical work, pilot plant testwork and demonstration runs, detailed engineering design and costing and further market research.

The Office of the Environment has issued guidelines for the preparation of an Environmental Management Plan which will be prepared in parallel to the full feasibility study.

The cost of the full feasibility study is estimated at $770,000.

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1 INTRODUCTION

1.1 Scope

1.2 Sirosmelt Technology

1.0 INTRODUCTION

This report presents the results of preliminary feasibility studies considering the retreatment of the Zeehan slag dumps in Western Tasmania.

The dumps comprise a proved reserve of 450,750 tonnes of slag containing significant recoverable zinc values together with minor recoverable values of lead and silver. The slag, the residue of silver-lead smelting operations, accumulated over three distinct operating phases during the period 1898 to 1946 but mostly during the period 1898 to 1914.

It is proposed that the SIROSMELT submerged lance smelting technology will be used to recover the majority of the zinc, lead and silver contained in the slag dumps in the form of an intermediate raw oxide "fume" which will be further processed to produce one or more of a range of added value zinc chemicals.

On completion of the retreatment of the Zeehan slag reserves it is proposed that the plant will either remain on site to treat other locally sourced ores, or will be demounted and moved to the site of another resource.

The aims of the preliminary feasibility studies were to confirm reserves, confirm the viability of the Sirosmelt slag fuming stage, demonstrate the overall viability of the project and identify the principal operating and capital cost drivers. The study also sought to assess the environmental impact of the Sirosmelt plant and to identify any issues that might cause environmental concern.

1.1 SCOPE

The preliminary feasibility studies have comprised:

- Drilling, sampling, assaying and reserve estimation carried out by Pyrosmelt and evaluated by consultants, Resource Services Group Pty Ltd.
- Preparation of a preliminary Environmental Scoping Study for the slag fuming stage by BHP Engineering Consultants Pty Ltd for submission to the Tasmania Office of the Environment.
- Slag fuming process and plant optimisation studies by Ausmelt Pty Ltd and Pyrosmelt.
- Slag fuming plant design, capital and operating cost estimation to +/- 30% by Ausmelt Pty Ltd and, independently, by BHP Engineering Pty Ltd.
- Slag fuming plant size optimisation studies by Ausmelt and Pyrosmelt.
- Preliminary estimation of raw fume process plant capital and operating costs carried out by Pyrosmelt.

- Preliminary fume and zinc chemical market evaluations undertaken by Pyrosmelt.
- Financial evaluation and cash flow modelling carried out by Pyrosmelt.

This report is based on slag fuming evaluations carried out by Ausmelt, but where parallel work has been carried out independently by BHP Engineering for confirmatory purposes, their results are also presented for comparison.

It is important to note that BHP worked without the benefit of significant practical experience of Sirosmelt technology and as a result did not adequately consider all processing and plant options, nor the optimum processing/plant option.

Detailed plant description and engineering design was outside the scope of the work carried out by Ausmelt but was included in the BHP Engineering work and is integrated into this report.

1.2 SIROSMELT TECHNOLOGY

'Sirosmelt' is a submerged combustion process, where process air and fuel are injected below the surface of a liquid slag bath via a lance. The lance is cooled by the process air, and a protective coating of solid slag forms on the lance, allowing it to be inserted deep into the molten slag without damage. Combustion of the fuel within the slag bath provides the heat for the reduction reactions. New feed and reductant are added in lump form through a port in the top of the furnace. These additions are rapidly consumed in the slag bath due to the intense stirring of the bath by the submerged injection of air.

'Sirosmelt' was originally developed by the CSIRO. The technology has been further developed by Ausmelt Pty Ltd for the treatment of tin, tantalum, lead, zinc and copper concentrates and various metalliferous residue materials. MIM Limited have also adopted the technology under the name ISASMELT for the smelting of lead and copper concentrates and more recently for copper-nickel concentrates and lead battery residues.

MIM and Ausmelt are the only parties authorised by the CSIRO to licence the technology to third parties.

Isasmelt/Sirosmelt plants are located at:

- Mt Isa, Queensland - Copper & lead
- Port Pirie, South Australia - Research facility
- Newcastle, New South Wales - Silver
- Arhnem, Netherlands - Tin

The scale of these plants range from a few tonnes per hour to 24 tonne per hour. A plant was also operated in Sydney processing tin ores in the late 70's until low tin prices forced its closure. Commercial plants have operated since 1978 and a number of plants are now planned or being constructed worldwide.

The zinc fuming process is an established industrial process. The suitability of SIROSMELT technology for the recovery of zinc, lead and silver from slag by fuming has been demonstrated by Ausmelt and CSIRO in various laboratory and pilot scale tests. Zinc fuming using Sirosmelt is characterised by low capital costs.

Ausmelt is currently building a 120,000t/annum Sirosmelt zinc fuming plant for Korea Zinc Co. Ltd.

A schematic representation of a Sirosmelt plant is shown in Figure 1.

2 RESOURCE EVALUATION

2.1 Location and Ownership

2.2 Volumetric Survey

2.3 Air-Core Drilling

2.4 Sample Analysis

2.5 Reserve Estimation

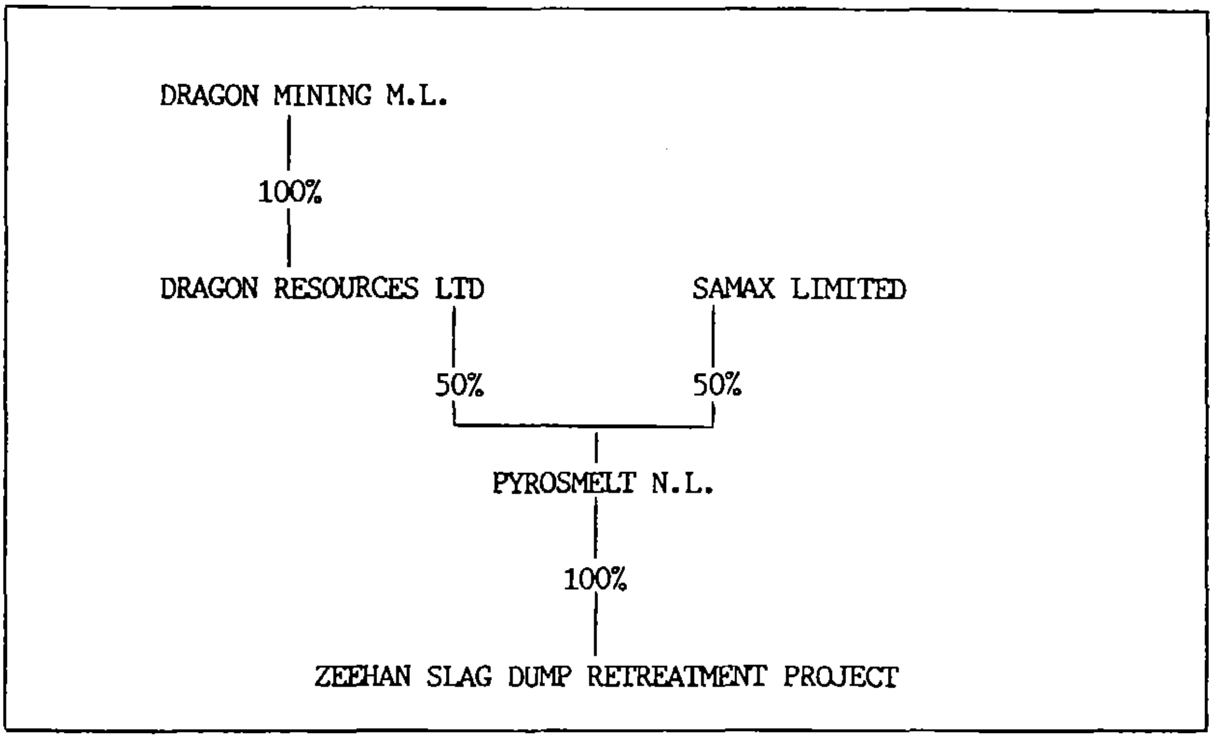
2.6 Mineralogy

2.1 LOCATION & OWNERSHIP

The Zeehan slag dumps are located on Mining Lease 60M/77, held by Pasminco Limited, 2.5km SSE of the small town of Zeehan in Western Tasmania (Figures 2 & 3).

On 7th March 1990 Pasminco granted to Pyrosmelt N.L. a licence to retreat the slag dumps whereby Pasminco retains a 5% Net Smelter Return royalty.

Pyrosmelt N.L. is jointly owned by Dragon Resources Ltd, a wholly owned subsidiary of public listed Australian company Dragon Mining N.L., and SAMAX Ltd, a private U.K. based company:



The slag is contained in two adjacent compact and discrete dumps referred to as the North and South dumps. The smaller North Dump comprises 'platey' slag which appears to have been poured molten onto the dumps. The South Dump also comprised a predominantly platey slag, but at its base contains a layer of finer grained 'granulated' slag.

2.2 VOLUMETRIC SURVEY

The slag dumps have been surveyed with a theodolite by Pasminco's Survey Department. All survey data is stored on SURPAC (by Pasminco) and has been copied to a MICROMINE database (by Resource Services Group).

2.3 AIR-CORE DRILLING

In September 1990 Pyrosmelt's drilling contractor, Wallis Drilling, completed 36 'air-core' holes through the dumps into the natural surface on a surveyed 20 x 20m grid. Nine holes were drilled on the North Dump, and 27 holes on the South Dump (Figures 4 and 5).

Sample recovery was excellent and penetration rates were satisfactory. Samples were collected at 1m intervals throughout the slag profile. These samples were spilt on site to provide samples for analysis and the remainder of the samples were bagged and stored in Zeehan to provide feed for feasibility pilot plant testing.

Approximately 10% of samples were collected in duplicate to check for grade variability within individual sample intervals.

Drill logs and sample logs were compiled by contract geologist Lyndsay Newnham (Appendix A). All drill hole data has been entered onto a MICROMINE database.

2.4 SAMPLE ANALYSIS

A total of 375 samples and duplicates were analysed for zinc, lead and silver by Analabs in Tasmania. These elements were determined using a peroxide fusion digest and an AAS finish. This digest was chosen on the basis of pilot analysis using a number of different digests on a number of samples.

Analytical results are shown on the drill logs in Appendix A.

In addition 16 of the 375 samples were selected for analysis for a wide range of elements to fully characterise the slag for metallurgical purposes and to quantify any potential penalty elements that might impact negatively on product purchase terms. This analysis was carried out by Analabs Perth laboratory. The results are given in Table 1 and show only low values of potential penalty element (see Section 3.4.2).

As a check on the accuracy and precision of Analabs analyses, 40 of the 375 sample pulps and 4 of the 16 sample pulps were submitted to Australian Assay Laboratories for check analysis using identical analytical methods.

The results are summarised in Table 1.

A quantitative comparison has yet to be carried out on the field duplicates and the inter-laboratory checks. This is planned as a component of the full feasibility study. However a preliminary examination of the data reveals that field duplicates show very good agreement, and, there is no significant bias in, or difference between, the results from the different laboratories.

No assays for fluorine, chlorine, and gallium were undertaken as there is no reason to believe these will be problematic.

2.4.1 Specific Gravity

Specific gravity determinations (water displacement tests) were carried out on three samples:

Sample Origin	Nature	Specific gravity
North/South Dump	Platey	3.54 g/cc
South Dump	Platey	3.66 g/cc
Base South Dump	Granular	3.75 g/cc
	Average	3.65 g/cc

Sand fill replacement tests will be carried out to determine bulk density as a part of the full feasibility study.

For the purposes of this study a conservative bulk density of 3.0 has been assumed.

2.5 RESERVE ESTIMATES

All drill hole, analytical and survey data has been entered onto MICROMINE by consultants Resource Services Group (RSG) who have examined the data geostatistically and carried out grade contouring and block modelling.

RSG have estimated slag tonnages and grades using the assumed bulk density of 3 tonnes/m^3 and volumes computed down to the slag/natural surface interface:

	Tonnes	Zn%	Pb%	Ag ppm
South Dump	369,600	13.92	1.69	52
North Dump	81,150	10.83	1.85	62
TOTAL	450,750	13.36	1.71	54

These reserves are sufficiently well defined to be classified as "proved reserves" under the AusIMM guidelines and no further drilling is considered necessary.

A Memorandum by RSG outlining data characteristics and ore-reserve estimates is included as Appendix B.

If a bulk density of 3.4 is assumed for the dumps, then the tonnage of slag available increases by 13% to 510,850 tonnes.

2.6 MINERALOGY

In 1974 AMDEL undertook a preliminary mineralogical evaluation of the Zeehan slag on behalf of Pasminco, with samples of platey and granulated slag being examined optically, by electron probe microscopy and by X-Ray Diffraction.

AMDEL concluded that the slag was largely amorphous or glassy with 70-80% of the sample showing no exsolution texture coarser than 1μm.

Zinc was found to be contained largely in the glass phase, with minor amounts in detectable sphalerite and spinel phases. Any zinc contained in sphalerite may not be recovered in the Sirosmelt plant envisaged. Further mineralogical work is required to fully quantify the proportion of zinc contained in sphalerite as this may affect plant recoveries.

AMDEL concluded that there was no potential for physical beneficiation of the slag to increased zinc levels.

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3 SIROSMELT SLAG FUMING - PRODUCTION OF RAW FUME

3.0 SIROSMELT SLAG FUMING - PRODUCTION OF RAW FUME

It is expected that the slags will be treated on the Zeehan slag dumps site.

3.1 PROCESS DESCRIPTION

Zinc fuming using Sirosmelt involves the feeding of slag from the existing dumps into a Sirosmelt furnace together with fuel. Zinc oxides in the slag along with silver and oxides of lead and other minor elements in the slag are reduced and volatilised. The intense stirring and flushing action of the process gas removes the reduced metals from the bath. Above the bath the metals are rapidly oxidized by supplementary air added through the top of the lance. The oxidized fume product passes out of the top of the furnace through a cooler and is then collected in a baghouse.

Four practical options were considered for operation of the Sirosmelt technology for slag fuming:

Option A: Two furnace continuous operation - 94% zinc recovery and a discard slag containing 1% zinc

Slag is smelted under oxidising conditions to ensure efficient combustion of the fuel. The slag is then tapped to a second furnace where it is reduced.

Fume is produced during both smelting and reducing operations and so in a two furnace operation it is possible to collect two fumes each of which will be of slightly different composition.

This configuration has the advantage that conditions for smelting and reduction can be optimised but the use of two furnaces involves higher capital and operating cost than for those options involving only one furnace.

Option B: One furnace continuous operation - 80% zinc recovery and a discard slag containing 3% zinc

Smelting and reduction are carried out continuously in the same furnace. A compromise must be reached between the need for good oxidising conditions to ensure efficient combustion of the fuel for smelting and the need for reducing conditions to reduce the metal oxides.

Capital and operating costs are lower at the expense of zinc recovery.

Option C: One furnace batch operation - - 94% zinc recovery and a discard slag containing 1% zinc.

The furnace is charged periodically under oxidising conditions to allow for smelting of the charge. Subsequently the conditions are changed to allow for reduction of the slag before being tapped.

The batch operating mode requires a larger furnace to achieve an equivalent throughput, with a consequent increase in capital costs. Batch operation also increases operating costs.

Option D: One furnace continuous operation - 94% zinc recovery and a discard slag containing 1% zinc

This is a variation on Option B where the furnace is operated at a higher temperature with higher fuel consumption such that a higher zinc recovery is achieved.

Higher temperature operation carries a higher operating cost.

With the exception of Option D, all cases have been demonstrated feasible by pilot plant testwork carried out on similar materials using Ausmelt's Dandenong pilot plant prior to this study.

A 1% zinc discard slag level is harder to achieve in a one furnace continuous operation (Option D) due to the compromise operating conditions. This discard slag level will need to be demonstrated in pilot plant testwork.

Ausmelt consider there to be a 95% probability of achieving a discard slag level of 1.5% Zn the temperature used in the model Option D (1400 centigrade). However achieving less than 1% in slag has a 50% probability. The sensitivity of Option D to a discard slag level is discussed in Section 6.5.4.

3.2 OPERATING COST ESTIMATE

Ausmelt have determined operating costs for Options A-D above, based on a plant having a 15 tonne per hour throughput. This throughput was chosen by Ausmelt on the basis of their experience and has been supported by plant size optimisation studies (see Section 6.3).

Operating Costs for each of Options A-D are summarised in Table 2 and detailed in Tables 3-6.

Option D was considered subsequent to Options A-C, as an add-on to the original scope of work. Consequently much of the intermediate data generated during the estimation of operating and capital costs for Options A-C, and presented in this report, was not output for Option D and therefore no such intermediate data is presented for Option D. This does not detract from the reliability of the Option D estimates which were made using the same methodology as for Options A-C.

3.2.1 Personnel

The manning requirements were estimated on the basis of a 3-shift, continuous operation, with a 4th shift to provide change-over and holiday/sick leave relief. Each shift would consist of a foreman and four or five plant operators, depending on the plant operating mode, and one maintenance engineer.

Staff functions are Manager, Metallurgist, Chemist and Office Clerk/Typist.

The man-hour costs are based on a 24 hours per day operation and the rates are based on those typical for operations in Australia and include an overhead allowance.

There are a number of mining communities close to the site, and it is assumed that the work force will be drawn from these. No provision has been made in the operating costs for accommodation, as it is considered that adequate housing will be available in the nearby towns. Due to substantial redundancies at nearby mines there is likely to be a good availability of skilled labour.

3.2.2 Consumables

An allowance has been made for tapping consumables, such as rods, oxygen, etc. This allowance is higher for batch operation where tapping is on a batch basis rather than continuous.

An allowance has been made for safety equipment, such as tapping coats, boots, face shields, helmets etc.

In order to provide a conservative estimate of operating costs, an allowance has been made to bag the product fume into 1t bulk bags for safe transport to market. The cost of bags has been allowed at $30 each, though savings will be possible with limited re-use.

3.2.3 Fuel Usage

The Sirosmelt furnace can operate on natural gas, coal or diesel. Given that natural gas is not readily available in Tasmania, coal was considered to be the cheapest fuel source.

Coal consumptions are based on the consideration of total energy requirements for smelting and reduction and the energy (calorific) value of the chosen coal.

Total energy requirements for each of the four slag fuming options were calculated by Ausmelt and the energy balances for each of options A-C are shown in Tables 7-9. An energy balance was not generated for Option D though it was automatically calculated during the calculation of operating costs. The terms used in the presentation of energy balances are described as:

Combustion - The heat produced by burning fuel coal at the rate specified. This was calculated by multiplying the heat capacity of the fuel by the relevant flow rate.

Combustion Preheat - Based upon experience and measurements on operating plants, it has been assumed that the combustion air is heated to 300^{o}C as it passes down the lance. The enthalpy of air (ie. O_2 and N_2) was calculated at 300^{o}C, using thermodynamic data.

Smelt Air Preheat - Smelt air is defined as the air involved in bath chemical reactions rather than combustion of lance fuel. This was calculated on the same basis as for Combustion Preheat. The reactions heat is derived from the reactions involved in each process stage. It was calculated by multiplying the relevant molar quantities by the relevant heat of reaction.

Liquid Slag - This heat is an allowance for the heat contained in the liquid slag flowing into the slag reduction furnace, or the heat contained in a liquid slag prior to commencement of each process stage.

Afterburn Recuperation - Based upon experience and measurements on operating plants, it is assumed that 30% of the available heat from afterburning reactions is recovered by the bath contents.

Combustion Products - The heat contained in the gaseous products of combustion calculated, using thermodynamic data, from the individual components (CO_2, H_2O, N_2) heat content at the furnace operating temperature.

Smelt Products (Gaseous) - The heat content of the gaseous products from the reactions at the furnace operating temperature.

Slag Heat - The heat content of the product slag in or flowing from the furnace at the operating temperature.

Furnace Losses - The heat loss from the furnace at the operating temperature. This was calculated from heat flow considerations on the insulated base and roof section, and watercooled walls.

Fume - The heat content of the fume calculated from the addition of the relevant heat contents of the individual fume components at the operating temperature, including relevant latent heats of vaporisation.

Coal is also required as a reductant to reduce the zinc oxide in the slag to zinc metal. Coal reductant requirements are given in Tables 3-6.

The basis of the Ausmelt operating cost estimate is a coal cost of $80/tonne delivered to Zeehan from the Cornwall Coal Company's Fingall Valley colliery. Since then quotes of $72.00 per tonne delivered have been received from the Merrywood Coal Company for coal from either their Fingall Valley mine (operational) and from Derwent Valley mine (not operational).

Because the Merrywood coal is virtually identical in character and calorific value (if anything, slightly superior) this lower quote has been included in Pyrosmelt's financial evaluation (Section 6) without amending heat and mass balances.

The Derwent Valley mine is not scheduled to open for 18 months to 2 years. However, for a contract of the size envisaged for this project, the opening could be brought forward.

Because the cost of coal is the single largest single contributor to plant operating costs quotations were also obtained from mainland coal companies. The lowest of these quotations was for Hunter Valley coal. Total operating costs using Hunter Valley coal were recalculated for Option C (Table 10).

In Tasmania, a road transport levy is payable where road transport is used in preference to rail where rail services are otherwise available for the proposed route. The coal company has advised that, in this case, the levy would not apply.

The use of diesel fuel instead of coal as the main fuel for the furnace was also considered but operating costs were substantially higher with only slightly lower capital costs (Table 10).

3.2.4 Power

Two tariff rates would apply to this operation, as detailed in Appendix D.2.3. Tariff No 83 was used for this study.

Power requirements for each process option are shown in Tables 3-6.

3.2.5 Water

Water for furnace cooling will be taken from Austral Creek which flows close to the foot of the slag dump, provided flow rates are sufficient. If not water will be taken from the larger Little Henty River which is close by. A Water Right from the Rivers and Water Supply Commission will be required. This has been costed at 10 cents per m^3 for 126,750 m^3 per annum consumption.

3.2.6 Diesel Fuel

Diesel fuel is required for the front-end loader operation. An allowance of 5kg/hour has been made at $910 per tonne diesel.

Diesel is also required for the launder burners at the rate of 20kg/hour.

3.2.7 Maintenance

The principal maintenance cost is for additional refractories to replace those that have failed or worn out, and their fitting. Up to 1.5 relines per annum have been costed at $402,000 per reline and $50,000 has been allowed for other maintenance items. A maintenance engineer has been costed under Personnel.

3.2.8 Laboratory

The furnace is controlled on the basis of the zinc content of the final discard slag. To achieve effective control, the Chemist will take regular samples of slag, fume and feed and analyse these on a portable x-ray fluorescence machine mounted in his cabin. The cost of the analyser is included in the capital cost estimate (Section 3.3).

3.2.9 Operational Environmental Monitoring

Routine environmental monitoring will be required as part of the licence conditions for the smelter. Based on licence conditions for other industrial operations the expected requirements will include:

1. 24 hour composite samples once per month of liquid discharge from site.
2. volume recorded for liquid effluent discharges whilst sampling.
3. 6 monthly checking of gaseous emissions from stack: dust, metals.
4. continuous SO_2 monitoring.
5. annual noise survey.

In addition the licence may require:

6. periodic (yearly or biennially) monitoring of vegetation.
7. water sampling in nearby streams.
8. water/seepage monitoring of water flows on site before entering the process water dam (say monthly x 3 sites).

It is assumed that this work will be carried out by external consultants at a cost of $60,000 per annum.

3.2.10 Exclusions

The following have been excluded from Ausmelt's operating costs estimate:

- Consultants fees (other than those described above)
- Head office overhead costs
- Product fume transport costs have been incorporated into the financial model (Section 6).

3.2.11 Oxygen Enrichment

As a variation, the effect of 40% oxygen enrichment was considered for Option C. Whilst the capital cost was reduced, operating costs were increased (Table 10), with a negative net result.

This result is equally applicable to Options A, B and D.

3.2.12 Operating Cost Comparison

Table 11 shows the comparison of total annual operating costs estimates carried out independently by Ausmelt and BHP Engineering for Options A and B as these were the only cases considered by BHP Engineering. The BHP Engineering estimate is factored from their estimate of operating costs of a 10t/hr plant using their scaling factor. Where BHP have treated certain items as operating rather than capital cost items the BHP estimate has been adjusted so a direct comparison can be made.

The estimates show close agreement and both estimates fall within the stated accuracy of each other. The Ausmelt estimate is considered the more representative in view of their more recent and more relevant experience, particularly with regard to the current construction of a zinc fuming plant for Korea Zinc.

3.2.13 Scale Factor

Operating costs for plants of different size can be scaled according to the following Ausmelt formula which is based on the Zeehan data and past operating experience and detailed feasibility studies on other slags:

$$\text{New Opex} = 230 \times \text{New Production Rate}^{-1.16296} + 58.1$$

3.3 CAPITAL COST ESTIMATES

Capital costs have been estimated by Ausmelt to +/-30% for each of Options A-D based on the basic design criteria listed in Appendix C. These estimates are summarised in Table 2.

Capital cost breakdowns for each of Options A-C are given in Tables 12-14.

3.3.1 Plant Design

Capital costs are based on existing detailed designs held by Ausmelt for which quotations have been obtained. The capital costs estimates are for a modular, demountable plant.

It was not a part of Ausmelt's scope of work to produce flowsheets and plant layout drawings or a detailed description of the plant. However these were prepared by BHP Engineering whose base case was a 10 t/hr single furnace plant operated continuously to a discard slag level of 3% zinc.

A detailed plant description based on the BHP design is given in Appendix D, and the accompanying major equipment list is presented in Appendix E.

3.3.2 Major Equipment Lists

Ausmelt has generated equipment lists based on in-house designs for each of Options A-C (Tables 15-17). These show the capacities of the various items and the installed power requirement.

3.3.3 Technology Licence

A licence will be needed to use Sirosmelt technology. This may be obtained from either MIM or Ausmelt. Ausmelt have included in the capital costs an amount of $540,000 as a licence fee.

3.3.4 Rehabilitation

A rehabilitation cost of $50,000 for the site has been allowed in the capital cost estimates.

3.3.5 Oxygen Enrichment

Oxygen enrichment generally increases the efficiency of the fuel combustion so that throughput can be increased. Thus, for a given throughput plant, furnace size will be reduced with a consequent reduction in capital cost

Oxygen enrichment was considered for Option C only (Table 10) but no net benefit was obtained. This result is equally applicable to the other process options.

3.3.6 Capital Cost Comparison

Table 11 shows a comparison of total capital cost estimates carried out independently by Ausmelt and BHP Engineering for Options A and B, the only cases considered by BHP Engineering. The BHP Engineering estimate is factored from its estimate of operating costs of a 10t/hr plant using its own scale factor. Where BHP has treated certain items as operating rather than capital costs the BHP estimate has been adjusted so a direct comparison can be made.

Furthermore the BHP estimate shown in Table 11 includes a 15% loading as the BHP design, unlike the Ausmelt design, is not demountable and BHP have estimated that the capital cost would increase by 15% if the plant were to be constructed in a modular demountable format.

The estimates show reasonable agreement. As for operating costs the Ausmelt estimate is considered the more representative.

3.3.7 Scale Factor

Capital costs for plants of different size can be scaled according to the following Ausmelt formula:

$$\text{New Capex} = (\text{New Production rate/Old Production Rate})^{0.6} \times \text{Old Capex}$$

3.4 MARKETING OF RAW FUME

It is proposed that the raw zinc oxide fume produced by the Sirosmelt plant will be further processed to produce zinc chemicals. However a significant market exists for the zinc oxide fume "as-is" with zinc refineries around the world who use it as a feed in the production of zinc metal. Payment is dependent on fume composition.

3.4.1 Fume Composition

The basis used for estimating the composition of the product fume for the purposes of this study was:

- The average assay values for Zn, Pb and Ag for the combined slag dumps as determined by block modelling by RSG (see Section 2).
- Minor element analyses based on the 'whole rock composition' assays (Table 1).

Fume compositions for lead, zinc and silver are shown for each of Options A-D in Table 2. For options A-C further compositional data is shown in Tables 18-20, being the mass balances calculated by Ausmelt. These tables also show the coal requirements for a given quantity and grade of slag feed and the output quantities and compositions of reduced discard slag. A detailed mass balance was not provided for Option D though it was automatically calculated to determine fume output and grade. The compositions of raw fumes for Options B and D are only slightly different.

For the minor elements, the raw fume composition is based on 100% recovery of volatile elements or compounds (Bi, Cd, Ge, As, Sb, SnS) and 1% recovery of all other elements due to entrainment of 1% of incoming feed in the exiting fume and off-gases.

3.4.2 Payments & Penalties

Pyrosmelt has made preliminary marketing investigations for the raw fume product both on its own account, and through consultants Colwell, Kennedy & Associates.

The raw fume product can be sold to electrolytic zinc refineries and to lead-zinc smelters employing Imperial Smelting Furnace (ISF) technology, both of which produce zinc metal.

Other applications for "zinc oxide", i.e pigments or fertiliser usually require a higher purity zinc oxide than will be directly produced using the Sirosmelt process.

For treatment in a Imperial Smelting Furnace (ISF), the raw fume would require agglomeration, probably as briquettes. Pasminco have a briquetting plant at their Cockle Creek ISF plant in Newcastle, New South Wales. If this was a likely destination for the fume then use may be made of this facility.

In both cases raw zinc fume is purchased on standard zinc concentrate purchase terms. However zinc-oxide fume is generally higher grade than zinc concentrate, and unlike concentrate, the fume does not contain environmentally unacceptable sulphur.

The fume is clearly a premium product and an attractive feed for these plants. However, because zinc oxide fume has, to date, only been produced in relative small quantities the producers have not yet been able to demand better terms. Production of raw zinc fume is increasing worldwide and is slowly becoming a more significant source of zinc metal. Potential purchases are therefore being forced to consider improving their terms.

Indicative terms have been offered for the Zeehan fume product by Pasminco subsidiary Electrolytic Zinc's Risdon zinc refinery near Hobart in Tasmania and via Colwell Kennedy by Korea Zinc's ISF plant. Terms were also obtained from Sumitomo in Japan.

The terms offered by Colwell Kennedy Associates were best on a direct comparison basis, as the treatment charges were considerably lower. However when transport costs are taken into consideration the Pasminco terms yield the better overall return. The Sumitomo terms were little different to those from Pasminco but transport costs to Sumitomo's plant in Japan would be considerably higher.

The Pasminco Risdon Refinery Terms are : :

Metal Payment:

Zinc	:	85% of SHG settlement subject to a minimum of either a deduction of 8 units
Silver	:	deduct 90g/t and pay 70% of balance.
Lead	:	deduct 3 units and pay 50% of balance at LME settlement.
Where	:	LME is London Metal Exchange, DMT is Dry Metric Tonne, SHG Zinc is Special High Grade Zinc

Treatment Charge:

Base	:	US$300.00/DMT f.i.s. Risdon.
Escalator	:	US$0.16/DMT for each US$1.00/t increase over US$1,500.00/t zinc price.

De-escalator:		US$0.10/DMT for each US$1.00/t decrease below US$1,500.00/t.

Penalties:

Iron	:	deduct 0.5 unit payable zinc for each 1.0% Fe over 10.0%
Arsenic	:	US$1.00/DMT for each 0.1% over 0.25%
Chlorine	:	US$0.50/DMT for each 0.1% over 0.5%
Fluorine	:	US$3.00/DMT for each 0.1% over 0.2%
Magnesium Oxide	:	US$2.50/DMT for each 0.1% over 1.0%
Silica	:	US$2.00/DMT for each 0.1% over 3.0%

It should be noted that the quotation provides for penalties based on the amounts of fluorine and chlorine contained in the fume. This is because these elements are undesirably high in zinc fumes derived from the steel dusts. However they are not expected to be significant in Zeehan slag and at this stage have not been determined.

Tables 18-20 show that none of the penalty elements in the fume are at or above penalty levels.

Ultimately, terms will depend on negotiations between the producer and the customer. Pasminco's Risdon refinery might reasonably be expected to lower the above treatment charge and for the purposes of this study a treatment charge of US$250 per tonne has been used, all other terms as above.

4 FUME PROCESSING - PRODUCTION OF ZINC CHEMICALS

4.0 FUME PROCESSING PRODUCTION OF ZINC CHEMICALS

Whilst the raw fume produced from the Sirosmelt furnace is saleable as-is, only 64% of the contained zinc value is realised. It is therefore desirable to further process this raw fume to produce a range of added value products.

4.1 PROCESS DESCRIPTIONS

A discussion of the potential process routes for treatment of raw zinc oxide fume is given in a report by J.Canterford & C.Moorrees of the CSIRO prepared for Ausmelt Pty Ltd in 1985 with reference to the fume produced from a small but comparable slag dump in Queensland (Appendix F).

The CSIRO identified four process routes, For two of these, Ausmelt commissioned engineering consultants Refractory and Metallurgical Services (RMS) to carry out a preliminary estimate of capital and operating costs.

The production of zinc metal was not considered as the capital costs for a zinc electrowinning plant were and still are considered to be prohibitive. The potential added value products are :

4.1.1. Zinc Enriched Fume (low lead)

Roasting of the raw zinc fume would result in an enriched zinc oxide fume containing most of the silver and a lead residue which could be sold.

Roasting of the fume would be carried out in a conventional roaster and the enriched zinc oxide fume would be collected in a baghouse.

Considering Option D, it is projected that the oxide fume grade will be increased from 68.4% zinc to 77% zinc (96% zinc oxide).

4.1.2 Basic Zinc Sulphate - $ZnSO_4.3Zn(OH)_2$

Leaching of the fume with sulphuric acid would result in the dissolution of greater than 95% of the contained zinc whilst the lead and silver would remain in the residue as sulphates. This residue could also be sold.

Zinc sulphate can be precipitated out from the leach liquor in a number of different phases having different degrees of hydration.

Basic zinc sulphate can be precipitated by the addition of sodium hydroxide to the leach liquor.

In a commercial plant the raw zinc fume would be fed to a mixing tank to produce a slurry for transport to the leaching tanks. here it would be mixed with sulphuric acid of 40-50% strength produced on site from concentrated acid. The leach slurry is then thickened and filtered to remove the lead/silver residue. The zinc-pregnant liquor is then neutralised with 50% sodium hydroxide solution resulting in the precipitation of basic zinc sulphate. The resulting slurry is then thickened and filtered. Sodium hydroxide would be re-generated from the filtered solution by the addition of limestone. This does however result in the generation of an alkaline gypsum slurry which may constitute a disposal problem.

The filtered sulphate would be dried in a small rotary kiln.

4.1.3 Zinc Sulphate Monohydrate - $ZnSO_4.H_2O$

The production of the monohydrate phase involves the same leaching steps as above but the monohydrate phase is precipitated from the leach liquor by pressure crystallisation in a steam heated stainless steel autoclave. The precipitate would be dried as above.

By using lower temperature-pressure conditions it is possible to precipitate zinc sulphate heptahydrate but this has not been considered further as at lower temperature/pressure the precipitation process is not as efficient and the product contains greater amounts of water of crystallisation which will have a detrimental transport cost.

4.1.4 High Purity Zinc Oxide - ZnO

Relatively high purity zinc oxide can be produced from the zinc-pregnant leach liquor by spray roasting in an Aman-type reactor at temperatures of 900-1000^{o}C.

Sulphur dioxide gas would be produced and further study will be required to see if sulphuric acid regeneration is warranted.

The assumed overall recoveries of zinc from the primary fume to the various products is given in Table 21 based on the work carried out by the CSIRO.

At this stage no decision has been made as to where the raw fume would be treated, as this will depend on the complex interplay between market location, the availability of cheap reagents, particularly sulphuric acid, and the benefits of using waste heat energy from the Sirosmelt plant all of which will be considered in the feasibility study.

It would however seems logical to transport the fume to be processed close to either the market or the acid source as the raw fume will contain a higher zinc content than the derivative chemicals, with the exception of zinc oxide, and subject to the effect of the bulk densities of the various materials the raw fume is likely to have the lowest zinc-unit transport costs.

One obvious location is Risdon in Tasmania where large quantities of sulphuric acid are produced. This has been selected for the Base Case financial evaluation.

4.2 OPERATING COST ESTIMATES

The annual operating costs for the four fume processing methods considered above are given in Table 21. These estimates are for a plant capable of treating 20,651 t.p.a of raw zinc fume, i.e all the fume produced from Sirosmelt Option D.

The estimates in Table 21 are based on estimates made by Ausmelt or for Ausmelt by RMS (Appendix G) for the 1985 Queensland slag project where it was projected that 14,068 t.p.a of primary fume would be produced.

In Table 21 Ausmelt's 1985 estimates have been inflated at 10% p.a and factored proportionally to account for the higher fume production rate. In the case of zinc sulphate monohydrate and basic zinc sulphate the RMS estimates of operating costs were first adjusted by subtracting product transport costs as this study uses ex-works prices for the zinc chemicals in its financial evaluation.

It is estimated that a small dedicated Sirosmelt plant capable of producing lead/lead silver bullion from the lead/lead silver residues from zinc chemical production would have an operating cost of $1.0 million per annum.

4.4 CAPITAL COST ESTIMATES

The capital costs for the four fume processing methods are also given in Table 21. As with operating costs the capital costs estimates in Table 21 are for a plant treating all the raw fume output from Sirosmelt Option D. As with operating costs, all capital costs were estimated in 1985 and have therefore been factored and inflated as above.

The capital and operating costs estimates in Table 21 are for comparison only. For the Base Case financial evaluation (Section 6.4), however, it is assumed that a smaller plant is constructed where only half of the fume is treated and the operating and capital costs used in the financial evaluation have been scaled from Table 21.

It is estimated that a small dedicated Sirosmelt plant capable of producing lead/lead silver bullion from the lead/lead silver residues from zinc chemical production would have a capital cost of $1.3 million.

4.5 MARKETING

4.5.1. Zinc Enriched Fume (low lead)

It is projected that the Option D raw zinc fume of 20,651 t.p.a grading 68.4% zinc could be converted to 17,427 tonnes of enriched fume grading 77.0% zinc. This secondary fume therefore contains 96% zinc oxide, but the level of other impurities such as cadmium may prevent its sale into conventional zinc oxide markets (see section 4.5.4 below) and so, for the purposes of this study it has been assumed that this fume is sold to Risdon, on the same terms as raw fume.

4.5.2 Zinc Sulphate

70% of zinc sulphate production is used principally in the manufacture of fertilisers, sprays and animal feeds in which it serves as a valuable trace element and disease control agent.

Generally speaking this market does not mind the form in which the sulphide is present, whether basic, monohydrate or heptahydrate, provided the price paid reflects the zinc content. From the producers point of view the decision on which phase is most appropriate will be a function of the cost of production relative to the cost of transport per unit of contained zinc. Nevertheless market intelligence suggests that most zinc sulphate is sold in the monohydrate form.

Zinc sulphate is also used in the manufacture of rayon as a crenulating agent in the precipitation bath. It is the starting point for a number of other zinc chemicals and is used in textile dying and printing, flotation reagents, electrogalvanising, paper bleaching and glue.

The price of agricultural grade zinc sulphate monohydrate (33% zinc) is currently US$470 per tonne. Pure zinc sulphate monohydrate, for industrial applications, commands a higher price at US$660/tonne.

On an equivalent basis, basic zinc sulphate (57% zinc sulphate) should sell for US$800/tonne (agricultural grade) and US$1140/tonne (industrial grade).

Table 21 shows the total possible annual production of zinc sulphate assuming 100% of the raw fume is processed.

The market for zinc sulphate in Australia is small, and markets generally are very competitive as the the generally low capital cost of production means that production is within the reach of many companies. However, the markets are expanding steadily and some producers market an impure product containing up to 6% lead. With increased regulation the use of these materials should decline.

Given the current competitive market which is said to be in oversupply it is unlikely that sufficient sales could be generated to allow for conversion of all of the zinc in the raw fume to zinc sulphate. However Pyrosmelt has already, through a third party, identified a possible market for some 30,000 t.p.a of heptahydrate, equivalent to 21,000 tonnes of monohydrate or 12,100 tonnes of basic zinc sulphate, i.e at least half the zinc contained in raw fume.

4.5.3 Zinc Oxide - ZnO

The principal use of zinc oxide, consuming 90-95% of production, is in the rubber industry as a vulcanization activator and accelerator to slow the aging of the rubber.

Zinc oxide is also used in paints as a mildewstat and acid buffer as well as a pigment. It is also used in agriculture for the same purpose as zinc sulphate.

Some zinc oxide is used in ceramics and in coated photocopy paper.

Approximately 4,000 tonnes of oxide are consumed in Australia each year and there are currently three Australian producers. In Australia at least the market is in oversupply.

Zinc oxide is currently produced pyrometallurgically from zinc by two processes, the 'French' and 'American' processes. That produced from the American process tends to be less pure and this, together with the shape of the zinc oxide particles produced generally precludes its use in rubber. The French process produces a purer zinc oxide product which finds the widest application.

Further work will be required to determine the level of impurities and particle shape that might result from spray roasting of raw fume leach liquor from Zeehan slags.

Challenge Metals are currently selling zinc oxide at a price equal to the current zinc price per tonne.

The market for zinc oxide is greater than that for zinc sulphate as the following table of US production and imports illustrates:

1980 US	Production (tonnes)	Imports (tonnes)
Zinc oxide	145,509	29,843
Zinc sulphate	35,159	3,871

4.5.4 Lead/Lead-Silver Residues

The lead residue from raw fume enrichment and the lead/silver residue from hydrometallurgical processing of the raw fume can be sold to lead smelters on typical lead concentrate terms, i.e.

Payment

Lead : deduct 3 units, pay balance
Silver : pay 95%

Treatment Charge - US$170/tonne concentrate

Table 21 shows the lead/lead-silver residue revenues where all of the raw fume is processed.

Table 21 also shows the financial benefits that result from processing the 100% of the raw zinc fume, expressed in terms of annual project benefit, and benefit per tonne of primary fume processed.

It shows that the production of zinc oxide is the most attractive of the four raw fume processing options showing a significant net benefit. Enrichment of the raw fume, however, is unattractive with a negative net benefit.

5 ENVIRONMENTAL MANAGEMENT

5.0 ENVIRONMENTAL MANAGEMENT

BHP Engineering Pty Ltd have completed a preliminary Environmental Scoping Study with respect to the Sirosmelt slag fuming plant only. This has been submitted to the Tasmania Office of the Environment who as a result has issued detailed guidelines for the preparation of an Environmental Management Plan.

The Scoping Study (Appendix H) is considered to be conservative in those areas where detailed data is unavailable. Pyrosmelt is committed to the responsible environmental management of the site and recognises the need to incorporate environmental factors in the design of the project.

The Scoping Study concluded that the slag fuming plant will have a minimal and readily managed environmental impact. Some aspects of the project are expected to lead to a long term improvement in the environmental status of the site such as the removal of residual metal values from the slag and the product granulated discard slag is expected to rehabilitate more successfully than the existing platey slag (as evidenced by field observation).

Of the anticipated impacts, sulphur dioxide emissions in particular, have been evaluated in a preliminary manner and have been shown to be well below the maximum acceptable levels.

The Office of the Environment guidelines do not identify any major issues or concerns that would impact negatively on the proposed development.

Pilot plant testwork is considered an important step in actually demonstrating the proposed process and generating reliable quantitative data for the EMP.

Since the Environmental Scoping Study was prepared an area adjacent to the smelter site has been nominated for listing in the National Estates Register to protect various geological features exposed in an a small abandoned quarry. This is not expected to affect the proposed operations.

6 FINANCIAL ANALYSIS

6.1 FINANCIAL MODEL

A financial model has been constructed by Pyrosmelt to:

1. Determine the optimum Sirosmelt plant configuration (Options A-D).

2. Determine the optimum throughput of the optimum Sirosmelt plant configuration in order to establish the Sirosmelt component of a base case.

3. Establish and to fully the base case.

The model is able to consider all major project variables and inputs. The variables used in the above determinations are presented in the Base Case model (Fig. 6). Specifically:

Working Capital

Working capital is provided by an overdraft which is set to maintain a minium balance of $200,000. Working capital is repaid as a first priority from 90% of cash flow surpluses.

Capital Costs

These are drawn down as specified and are met 100% by equity funding or by debt as specified. Capital debt is repaid as a second priority from cash flow surpluses after repayment of working capital overdraft.

All evaluations used 100% equity funding whereby Project and Pyrosmelt pre-tax NPV and IRR returns will be similar.

Inflation, Overdraft Rate, Capital Debt Rate, Discount Rate.

The model does not inflate revenues or costs so "real"(net of inflation) interest rates for the overdraft required to meet working capital and the debt component of capital costs (if relevant) are input. The discount rate has been adjusted accordingly.

Revenues

Base Case revenues for raw fume are based on Pasminco terms but using a lower treatment charge of US$250/t (refer Section 3.4)

Base Case revenues for zinc oxide and lead/lead-silver residues are those ex-works revenues obtained net of all directly attributable operating costs (Section 4.5 and Table 21)

Marketing Costs

A nominal marketing fee of 0.5% of net combined product revenues is used.

Product Transport Costs

A cost of $34 per tonne of product has been allowed for raw fume transported from Zeehan to Pasminco's Risdon refinery. This is a conservative costs as potential backloading options have been omitted ie if coal is sourced from the Derwent Colliery near Hobart.

No transport cost has been allowed for zinc chemicals as the prices used are ex-works.

Pasminco Royalty

Pasminco is paid a royalty of 5% of the Net Smelter Return being the revenues generated net of all directly attributable treatment charges, penalties, transport and insurance costs

State Government Royalty

A royalty is payable to the Tasmanian Government. It is based on a formula comprising "ad velorum" and a "profits" based payments as follows:

$$R = N/100 + (P \times C)$$

where :-

"R" is the amount of royalty to be determined annually; and
"N" is the annual net sales of the mining product; and
"P" is the annual profits (net of depreciation and gross of finance costs) in respect of the mining product; and
"C" is the product of 0.3 x P/N

The State Government royalty is determined annually on the basis of the audited project profit and loss account for the project. It is paid quarterly subject to no payment being made where a profit is below $50,000 per quarter. The model credits the project with a negative royalty payment where losses are incurred so that the accumulated royalty is close to the actual.

The capital costs and any capital interest (if appropriate) are capitalism and depreciated linearly at 10% per annum for the purpose of determining "P" (annual profits).

Capital Write Down and Residual Value

Base Case capital costs are written off linearly and totally over an assumed 10 year life for the Sirosmelt and chemicals plant.

The Model determines a residual value on completion of treatment of the specified resource based on the above capital write down. This residual is included in the project NPV and IRR.

Taxation

All results are on a pre-tax basis.

Commodity Prices

The model was set with the following commodity prices which reflect the expected average prices to be received over the life of the project:

Zinc Price = US$1200 per tonne
Lead Price = UK£ 300 per tonne
Silver Price = US$4.00 per ounce

Exchange Rates

The model was set with the following exchange rates which reflect the expected rates to be received over the life of the project:

US$/A$ = 0.76
GB£/A$ = 0.43

6.2 DETERMINATION OF OPTIMUM SIROSMELT PLANT CONFIGURATION

To determine the optimum Sirosmelt plant configuration NPV and IRR were generated using fixed and variable operating costs, capital costs, smelt fume and reduce fume outputs and specifications obtained from Ausmelt mass balances for each of the four plant configuration options. The model was adjusted to assume that all raw fume was sold as is to Risdon.

The results are shown in Table 22 and it is clear that Option D provides the better returns. This is essentially a function of lower capital and operating costs per tonne of slag compared to Options A and C and additionally the higher zinc recovery compared to Option B.

6.3 DETERMINATION OF OPTIMUM SIROSMELT PLANT THROUGHPUT

To determine the optimum Sirosmelt plant throughput for the optimum plant configuration NPV and IRR were generated using an adjusted model where capital was totally written off over the life of the resource, rather than the life of the plant, resulting from each throughput examined.

Throughputs were adjusted for Option D plant ratings of 5, 10, 15, 20 and 25 tonnes per hour. Capital and operating costs were adjusted according to Ausmelt formula presented in Sections 3.2.13 and 3.3.7 The model also assumed that all raw fume was sold to Risdon.

The spatial limitations of the model prevented data for the 5 tonne per hour case being generated.

The results (Table 23) show that the best returns are obtained between ratings of 10-15 tonnes per hour and that 15 tonnes per hour provides the highest NPV. The optimum throughput for Option D is therefore 15 tonnes per hour.

6.4 BASE CASE EVALUATION

Having established the optimum plant configuration and throughput a Base case was established where 50% of the raw fume is processed to produce 7,945 t.p.a. of added value zinc oxide and the balance of the raw fume is sold as-is to Risdon.

The additional capital costs of the fume processing plant were factored from Table 21 and incorporated into the model.

This conservative revenues position is based on preliminary market research which has shown that market factors could possibly restrict the amount of zinc oxide able to be sold. However, that is not to say that all of the raw fume could not be processed into a variety of zinc chemicals.

The Base Case also assumes that the lead/lead-silver residue from fume processing is sold to a lead refinery on the terms outlined in Section 4.5.4. Smelting of these residues in a dedicated Sirosmelt plant is not warranted as the associated capital and operating costs exceed the value of contained metals.

The Base Case as evaluated by the pre-feasibility model provides the following return (Figure 6):

NPV	**$21.3m**	**10% discount rate (real)**
IRR	**56%**	
NET PROJECT CASH FLOW	**$48.1m**	
COMBINED NET METAL REVENUES	**$78.3m**	
BREAK EVEN	**2.0yrs**	
INITIAL RESOURCE LIFE	**4.0yrs**	
RESIDUAL	**$7.4m**	
CAPITAL COSTS	**$13.5m**	**($12.2m + $1.3m)**
WORKING CAPITAL	**$1.5m**	
INTEREST ON WORKING CAPITAL	**$0.8m**	**13% real**
OPERATING COSTS	**$33.1m**	
PASMINCO ROYALTY	**$3.7m**	
STATE ROYALTY	**$4.4m**	

6.5 BASE CASE - SENSITIVITY ANALYSIS

The sensitivity of the Base Case to the following was assessed:

6.5.1 Zinc price and US$/A$ exchange rate

The project is very sensitive to zinc price and US$:A$ exchange rate as a majority of the revenues for the raw fume and the zinc oxide are zinc based, the price of which is fixed in $US.

A 25% increase in the zinc price from US$1200 to US$1500 results in a 18% increase in the NPV and the project breaks even at 1.75 years as opposed to 2.0 years. The project has a 49% IRR at a US$900 zinc price but the profit is obtained almost exclusively from the processing of the raw fume to zinc oxide.

A 5.2% increase in the US$:A$ exchange rate from 0.76 to 0.80 results in a 4% decrease in the NPV from $21.3m to $20.5m.

Table 24 presents a matrix of Base Case project NPV and IRR over a range of zinc prices and US$/A$ exchange rates. These are also compared to a project where only raw fume is produced to indicate the significant benefit obtained by processing the raw fume to zinc oxide or zinc chemicals generally.

6.5.2 Operating Costs

The project is very sensitive to operating costs and in particular variable operating costs.

A 10% increase in combined fixed and variable operating costs results in a 7.5% decrease in NPV from $21.3m to $19.7m (Table 25).

The project provide a considerable internal rate of return even when operating costs are increased by 30%.

The largest component of operating costs in slag fuming is the cost of the coal. As the model is based on theoretical determinations of coal usage it is essential that feasibility testwork using the actual coal to be bought as fuel and reductant is undertaken.

The largest component of operating costs for raw fume processing is sulphuric acid.

6.5.3 Capital Costs

The project is not particularly sensitive to changes in capital cost. A 30% increase in capital costs only reduces the NPV by $1.8m from $21.3m to 19.5m (Table 26).

6.5.4 Zinc Recovery

The project is not particularly sensitive to zinc recovery during the production of raw fume (expressed as the level of zinc in the discard slag).

Previous sections have discussed variations in the level of zinc in discard slag from a continuously operated single furnace. The Base Case assumes that a level of 1% zinc in discard slag is achieved and this assumption is made on the basis of theoretical determinations and testwork by Ausmelt on Zeehan and other materials respectively. However, the requirement for this to be demonstrated during feasibility testwork is emphasised.

Table 27 examines returns for variable levels of zinc in discard slag. It shows that even at high levels the project provides high returns but that project returns are very sensitive to a change. A 50% change in the level of zinc in slag from 1.0% to 1.5% zinc results in a reduction in NPV from $21.3m to $19.9m.

6.5.6 Reserves

The project is very sensitive to a change in the reserves available or an equal change in the bulk density of the in-situ slag.

A 30% decrease in the reserves or bulk density results in a 26% decrease in the NPV from $21.3m to $15.8M and similar increase if the reverse is the case (Table 28)

Although specific gravity measurements, which do not reflect the bulk nature of the slag, averaged 3.7 the bulk density of 3.0 used in the Base Case is still considered as conservative.

7 CONCLUSION AND RECOMMENDATIONS

7.0 CONCLUSIONS AND RECOMMENDATIONS

This pre-feasibility study has demonstrated that production of a zinc fume for processing into value-added zinc chemicals using the Zeehan slag dumps is an attractive commercial proposition.

Financial evaluation has determined that the the optimum plant throughput is 15 tonnes per hour and the optimum Sirosmelt plant configuration is one where the a single furnace plant is operated continuously to a discard slag level of maximum 1% zinc.

A base case has been considered in detail incorporating the optimum Sirosmelt plant configuration and throughput and where 50% of the raw fume is sold as-is and where 50% is converted to added-value zinc oxide by an acid leach process.

A full feasibility study is now warranted.

The major economic drivers for the project, in order of importance, were found to be:

- Market value of primary fume product and the market for the added value product, including the effects of exchange rate variations.
- Operating costs; in particular coal, but also labour, power and sulphuric acid.
- Capital cost
- Plant throughput
- Size of resource.

The preliminary Environmental Scoping Study and the Tasmania Office of Environment Environmental Management Plan guidelines indicate that the Sirosmelt slag fuming plant will not have any significant detrimental effect on the Zeehan environment.

8 FULL FEASIBILITY STUDY

8.1 Resource Studies

8.2 Pilot Plant Testwork

8.3 Chemical Processing Testwork

8.4 Market Research

8.5 Detailed Design and Engineering

8.6 Environmental Management Plan

8.7 Estimated Cost

8.8 Project Schedule

8.0 FULL FEASIBILITY STUDY

The full feasibility study should include:

8.1 RESOURCE STUDIES

Whilst no further drilling is required, further use can be made of the existing data for more detailed geostatistical evaluation (krigging etc) and reserve estimation.

Ore reserve block models can form the basis for production scheduling based on a consideration of the in-situ value of ore blocks and the practical considerations of mining such ore-blocks.

Sand-fill replacement tests will be required to determine slag bulk density for final ore reserve estimates. This can be undertaken at the same time as the extraction of bulk samples for pilot plant testing.

Some further mineralogical work will be required prior to undertaking pilot plant testwork to quantify the amount of zinc contained in sphalerite in the slag.

8.2 PILOT PLANT TESTWORK

Ausmelt have recommended that this be approached on a progressive basis as follows :

1. Two preliminary sighter tests to simulate continuous operation and determine discard slag levels.

2. Two further sighter tests to build on the results of the two preliminary tests

3. A continuous test to simulate continuous operation over a significant time period designed to :

   - establish final design criteria
   - establish emission levels etc for the Environmental Management Plan
   - provide fume samples for further testwork and marketing purposes.

8.3 CHEMICAL PROCESSING TESTWORK

Testwork will be required to further investigate the preferred process route for adding value to the primary fume. This testwork should be carried out on samples produced from the pilot plant.

8.4 MARKET RESEARCH

Further research and negotiations are required to maximise the terms obtained for raw fume, whilst a study is also required to determine the most suitable blend of added value products and to determine the other product parameters which might affect such a decision.

8.5 DETAILED DESIGN & ENGINEERING

This would utilise the data generated during pilot plant testwork to derive operating and capital costs to +/- 10%. A production site for processing of primary fume will also need to be chosen.

8.6 ENVIRONMENTAL MANAGEMENT PLAN

This will be prepared according to the guidelines issued by the Office of the Environment.

8.7 ESTIMATED COST

The cost of the full feasibility is estimated as follows :

	$	Cost Basis
Resource Evaluation		
- Bulk Sampling & Density determination	5,000	Estimate
- Geostatistical Reserve evaluation	5,000	Estimate
- Mineralogical work	2,000	Estimate
Pilot Plant Testwork		
- Two preliminary tests	50,000	Ausmelt Quote
- Two further test	50,000	Ausmelt Quote
- Demonstration Run	60,000	Ausmelt Quote
Chemical Processing Testwork	50,000	Estimate
Engineering & Design (Sirosmelt Plant)	207,000	Estimate
Engineering & Design (Fume Process Plant)	100,000	Estimate
Environmental Management Plan	77,000	BHP Eng. Quote
Market Research	25,000	Estimate
Project Management & Supervision	70,000	
Contingency	69,000	
TOTAL	$770,000	

8.8 PROJECT SCHEDULE

It is estimated that the full feasibility study will take approximately 6 months with a further 3 months required to progress the Environmental Management Plan through to approvals and permitting.

Procurement and construction is estimated to take 9 months.

TABLE 1. - ANALYTICAL DATA - ZEEHAN SLAG SAMPLES

Row	A	B	C	D/E	F	G	H	I	J	K	L	M	N	O
1	ZEEHAN CHECK SAMPLING DATA AND WHOLE ROCK ANALYSIS													
5	HOLE NO	INTERVAL		ASSAY	Pb	Pb		Zn	Zn	Zn		Ag	Ag	
6		FROM	TO		%	%		%	%	%		ppm	ppm	
8	Amalabs	Method			PF/AAS			PF/AAS	617			PF/AAS		
10	AAL	Method			D530/A	D530/I		D530/A		D530/I		D530/A	D530/I	
12	ZAC 2	4	5	AMALABS - Split 1	2.11			6.25				52		
13				AMALABS - Split 2/WHOLE	2.05			6.20	7.40			40		
14				AAL - Split 2 pulp	2.02			5.95				40		
16	ZAC 6	4	5	AMALABS - Split 1	2.25			17.20				60		
17				AMALABS - Split 2/WHOLE	2.35			16.03	14.50			71		
19	ZAC 7	1	2	AMALABS - Split 1	1.05			9.35				66		
20				AMALABS - Split 2/WHOLE	1.00			10.10	12.30			63		
22	ZAC 12	1	2	AMALABS - Spl	3.00			16.54				55		
23				AMALABS - Split 2/WHOLE	2.04			15.96	15.40			54		
24				AAL - Split 1 -pulp	2.81			14.40				40		
25				AAL Split 2 pulp WHOLE		3.00				15.10			60	
27	ZAC 14	6	7	AMALABS - Split 1	2.10			10.92				60		
28				AMALABS - Split 2/WHOLE	2.00			10.46	11.50			55		
30	ZAC 17	4	5	AMALABS - Split 1	1.40			11.15				52		
31				AMALABS - Split 2/WHOLE	1.43			10.94	12.20			50		
33	ZAC 19	4	5	AMALABS - Split 1	2.31			12.07				75		
34				AMALABS - Split 2/WHOLE	2.20			12.22	12.10			70		
36	ZAC 21	4	5	AMALABS - Split 1	1.35			15.50				43		
37				AMALABS - Split 2/WHOLE	1.24			15.32	16.70			40		
38				AAL Split 2 pulp WHOLE		1.15				15.00			40	
40	ZAC 23	4	5	AMALABS - Split 1	1.00			15.70				56		
41				AMALABS - Split 2/WHOLE	1.75			15.92	15.60			52		
43	ZAC 25	9	10	AMALABS - Split 1	2.40			11.00				70		
44				AMALABS - Split 2/WHOLE	2.34			11.00	12.60			75		
46	ZAC 27	2	3	AMALABS - Split 1	1.67			14.00				45		
47				AMALABS - Split 2/WHOLE	1.61			14.60	15.60			47		
48				AAL Split 2 pulp WHOLE		1.52				14.90			50	
50	ZAC 28	9	10	AMALABS - Split 1	1.29			16.00				50		
51				AMALABS - Split 2/WHOLE	1.18			17.10	16.00			56		
53	ZAC 29	8	9	AMALABS - Split 1	1.42			16.30				41		
54				AMALABS - Split 2/WHOLE	1.27			16.57	17.00			41		
56	ZAC 31	1	2	AMALABS - Split 1	1.82			26.60				43		
57				AMALABS - Split 2/WHOLE	1.72			20.00	15.10			41		
59	ZAC 32	4	5	AMALABS - Split 1	1.54			16.15				47		
60				AMALABS - Split 2/WHOLE	1.50			16.60	16.90			49		
61				AAL Split 2 pulp WHOLE		1.45				16.10			60	
63	ZAC 34	4	5	AMALABS - Split 1	1.25			15.55				64		
64				AMALABS - Split 2/WHOLE	1.24			15.50	16.30			60		
66		AVERAGE AMALABS SPLIT 1			1.86			14.46				55		
67		AVERAGE AMALABS SPLIT 2 WHOLE ROCK			1.70			14.60	14.25			54		
68		AVERAGE AAL SPLIT 2 WHOLE								15.48			53	
70		AVERAGE AMALABS SPLIT 2 WHOLE ROCK				>	Hole Nos ZAC 12,21,27, 32 only							
71		AVERAGE AAL SPLIT 2 WHOLE				>	Hole Nos ZAC 12,21,27, 32 only							
73	AMALABS METHOD				AAL METHOD									
75	199/PB/AAS			Sodium Peroxide fusion AAS finish	D530/A	Peroxide Fusion - AAS								
76		400		XRF Whole Rock glass fusion	D530/I	Peroxide Fusion - ICP								
77		613		LECO furnace	FA50	Fire Assay								
78		300		Fire Assay	D800	LECO furnace								
79		617		wet chem titration	D400	XRF Whole rock								
80		224		ICP Acid Digestion	D410	Pressed Powder XRF								
81		615		Furnace - Weigh										
82		101		Acid Digestion										
83		401		XRF										

Row	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
5	Cu	Bi	Ni	Co	Au	AuChk	Cd	S	Ge	CaO	SiO2	Fe2O3	Al2O3	MgO	<GOI	As	Sb	Se	Na2O	K2O	MnO	P2O5	TiO2
6	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	%	%	%	%	%	%	ppm	ppm	ppm	%	%	%	%	%
8	PF/AAS	PF/A[illegible]	PF/AAS	[illegible]AAS	300	300	PF/AAS	LECO	224	400	400	400	400	400	615	101	401	401	101	400	400	400	400
10	D530/I	D530/[illegible]	D530/I	[illegible]/I	FA50	FA50	D530	LECO	D530	D400	D400	D400	D400	D400	WEIGH	D410	D410	D410					
12															NB All +ve								
13	2100	<1[illegible]	175	100	<0.000	0.009	2	2.90	5.71	11.30	23.30	38.60	4.30	1.55	4.73	195	350	1000	0.07	0.61	0.2	0.109	0.23
17	2100	<100	75	75	0.065		3	3.05	8.52	5.02	17.70	39.20	3.35	1.00	3.43	310	410	370	0.06	0.49	9.55	0.077	0.16
20	2100	<[illegible]	100	75	0.065		1	3.70	8.40	7.57	17.00	39.00	3.30	1.35	5.10	235	360	430	0.08	0.44	9.55	0.074	0.15
23	3700	<100	50	25	0.04		4	3.10	6.15	14.70	22.50	24.60	4.00	1.75	5.66	400	330	410	0.07	0.82	4.61	0.17	0.19
25	4000	<1[illegible]	<100	<100	0.06		<10	3.24	<200	14.28	15.00	22.60	4.27	5.27	6.22	442	449	455					
28	2500	<[illegible]	75	50	0.065		30	3.00	6.50	10.40	20.90	34.10	3.00	1.55	3.40	360	480	390	0.05	0.60	0	0.147	0.17
31	1500	<1[illegible]	100	75	0.13		10	3.05	6.88	13.30	20.30	30.40	3.30	1.55	4.40	450	300	260	0.09	0.57	0.77	0.12	0.15
34	2450	<[illegible]	100	75	0.1		4	3.70	9.12	9.16	19.40	35.90	3.45	1.50	3.56	290	410	660	0.03	0.46	7.9	0.084	0.14
37	2700	<1[illegible]	75	50	0.18		5	3.55	9.42	11.00	20.70	29.20	3.90	1.25	4.54	230	220	170	0.05	0.63	5.0	0.096	0.19
38	2700	<[illegible]	<100	<100	0.12	0.12	<10	3.85	<200	9.16	15.00	21.50	2.65	3.14	7.30	252	317	218	0.12				
41	2200	<100	150	100	0.15		3	4.05	9.79	11.90	15.90	30.70	3.50	1.25	4.26	800	500	340	0.09	0.50	8.95	0.073	0.14
44	1700	<[illegible]	100	75	0.08		1	3.75	9.74	6.90	10.60	37.70	3.40	1.15	2.76	310	360	320	0.11	0.40	10.6	0.079	0.14
47	1900	<100	50	50	0.155		8	2.90	11.50	13.20	20.10	29.60	4.10	1.25	5.77	370	330	220	0.00	0.65	6.66	0.193	0.10
48	1900	<100	<100	<100	0.16		<10	3.06	<200	10.10	15.10	21.60	2.64	3.43	5.65	428	473	270					
51	1000	<[illegible]	50	50	0.135		1	2.75	13.10	13.60	19.90	20.10	3.00	1.40	4.09	330	390	210	0.08	0.64	5.61	0.146	0.17
54	2550	<100	50	50	0.215		<1	3.05	12.30	12.50	21.40	28.50	3.90	1.45	4.32	210	340	70	0.05	0.57	6.05	0.143	0.15
57	1550	<[illegible]	50	50	0.125		2	2.65	12.80	18.30	20.40	29.00	4.05	1.35	5.51	400	470	310	0.08	0.66	6.15	0.10	0.2
60	2500	<100	50	50	0.29		2	2.70	12.00	12.70	19.00	29.20	3.45	1.50	5.90	320	410	75	0.07	0.59	6.5	0.15	0.22
61	2500	<[illegible]	<100	<100	0.26		<10	2.84	<200	9.69	14.90	21.30	2.27	3.39	5.84	239	574	66					
64	2450	<[illegible]	50	50	0.455	0.46	2	3.05	10.00	13.40	20.60	27.90	4.15	1.35	5.33	250	410	110	0.07	0.7	5.65	0.12	0.19
67	2220	<[illegible]	81	63	0.13		4.90	3.30	9.51	11.35	19.90	32.00	3.70	1.3	4.74	350	380	304	0.07	0.56	7.46	0.12	0.17
70	2700	<[illegible]	56	44	0.16		4.80	3.06	9.77	13.10	20.70	20.15	4.06	1.44	4.74	330	323	219					
71	2775	<100	<100	<100	0.15		<10	3.25	<200	10.70	15.20	21.75	2.96	3.01	7.14	365	453	252					
73															N.B. GOI = Gain on Ignition								

TABLE 2.

OPERATING & CAPITAL COST AND FUME COMPOSITION DATA

OPTIONS A-D

	Case A	Case B	Case C	Case D
Capital Cost (AUD$million)	14.6	12.0	13.1	12.2
Operating Cost (AUD$/tonne)	68	59	68	61
Products:				
Smelt Fume (tonnes per annum)	11640	17783	11639	20651
Zn (%)	64.6	67.6	64.6	68.4
Pb (%)	10.0	9.3	10.0	9.1
Ag (g/t)	365	239	365	235
Reduce Fume (tonnes per annum)	9390	-	9390	-
Zn (%)	70.4		70.4	
Pb (%)	7.4		7.4	
Ag (g/t)	136		136	
Furnace Size (m)				
Smelt ID	3.5	4.0	4.7	4.0
Height	7.0	7.0	7.8	7.0
Reduce ID	2.9	-	-	-
Height	4.8	-	-	-

TABLE 3.

OPERATING COST - OPTION A

Item	Rate	Units	Unit Cost	Units	Useage		Cost AUS$	
Labour:								
Manager			1 75000	$/a			75000	
Metallurgist			1 60000	$/a			60000	
Chemist			1 50000	$/a			50000	
Clerk			1 35000	$/a			35000	
Foreman			4 48000	$/a			192000	
Furnace Operators			20 40000	$/a			800000	
Maintenance			3 44000	$/a			132000	
							Sub Total	1,344,000
Fuel:								
Smelting	3318	kg/h	0.08	$/kg	7500	h/a	1990800	
Fuming	534	kg/h	0.08	$/kg	7500	h/a	320400	
Standby F1	600	kg/h	0.08	$/kg	1260	h/a	60480	
Standby F2	350	kg/h	0.08	$/kg	1260	h/a	35280	
Launder Burners	20	kg/h	0.91	$/kg	7500	h/a	136125	
Vehicles	5	kg/h	0.91	$/kg	8760	h/a	39749	
							Sub Total	2,582,834
Power:								
Compressors			0.07	$/kWh	17700	MWh/a	1203600	
Motors			0.07	$/kWh	3750	MWh/a	255000	
Lighting			0.07	$/kWh	131	MWh/a	8935	
							Sub Total	1,467,535
Consumables:								
Tapping Rods	0.5	m/t	1	$/m	112500	t/a	56250	
Tapping Oxygen	0.2	m3/t	1	$/m3	112500	t/a	29363	
General			1	$/t	112500	t/a	112500	
Safety			500	$/man	31	men/a	15500	
Reductant Coal			80	$/t	8303	t/a	664200	
Bulker Bags			30	$/bag	10515	bags/a	315450	
Process Water			0.1	$/t	126750	t/a	12675	
							Sub Total	1,205,938
Maintenance:								
Refractories	1.5	relines/annum					603000	
General							50000	
							Sub Total	653,000
Administration:								
Analytical							10000	
Office							40000	
Insurance							40000	
Environmental							60000	
Product Transport							210300	
External Assays							40000	
							Sub Total	400,300
TOTAL OPERATING COST (YEARLY) AUS								$7,653,606

TABLE 4.

OPERATING COSTS - OPTION B

Item	Rate	Units	Unit Cost	Units	Useage		Cost AUS$	
Labour:								
Manager		1	75000	$/a			75000	
Metallurgist		1	60000	$/a			60000	
Chemist		1	50000	$/a			50000	
Clerk		1	35000	$/a			35000	
Foreman		4	48000	$/a			192000	
Furnace Operators		16	40000	$/a			640000	
Maintenance		3	44000	$/a			132000	
							Sub Total	1,184,000
Fuel:								
Smelting	3318	kg/h	0.08	$/kg	7500	h/a	1990800	
Standby F1	600	kg/h	0.08	$/kg	1260	h/a	60480	
Launder Burners	10	kg/h	0.91	$/kg	7500	h/a	68063	
Vehicles	5	kg/h	0.91	$/kg	8760	h/a	39749	
							Sub Total	2,159,091
Power:								
Compressors			0.07	$/kWh	16238	MWh/a	1104150	
Motors			0.07	$/kWh	3375	MWh/a	229500	
Lighting			0.07	$/kWh	131	MWh/a	8935	
							Sub Total	1,342,585
Consumables:								
Tapping Rods	0.5	m/t	1	$/m	112500	t/a	56250	
Tapping Oxygen	0.2	m3/t	1	$/m3	112500	t/a	29363	
General			1	$/t	112500	t/a	112500	
Safety			500	$/man	27	men/a	13500	
Reductant Coal			80	$/t	7275	t/a	582000	
Bulker Bags			30	$/bag	8891	bags/a	266738	
Process Water			0.1	$/t	117750	t/a	11775	
							Sub Total	1,072,125
Maintenance:								
Refractories	1.5	relines/annum					432000	
General							50000	
							Sub Total	482,000
Administration:								
Analytical							10000	
Office							40000	
Insurance							40000	
Environmental							60000	
Product Transport							177825	
External Assays							40000	
							Sub Total	367,825
							TOTAL OPERATING COST (YEARLY) AUS	$6,607,626

TABLE 5.

OPERATING COSTS - OPTION C

Item	*Rate*	*Units*	*Unit Cost*	*Units*	*Useage*		*Cost AUS$*	
Labour:								
Manager		1	75000	$/a			75000	
Metallurgist		1	60000	$/a			60000	
Chemist		1	50000	$/a			50000	
Clerk		1	35000	$/a			35000	
Foreman		4	48000	$/a			192000	
Furnace Operators		20	40000	$/a			800000	
Maintenance		3	44000	$/a			132000	
							Sub Total	1,344,000
Fuel:								
Smelting	5232	kg/h	0.08	$/kg	4688	h/a	1962000	
Slag Fuming	1740	kg/h	0.08	$/kg	1875	h/a	261000	
Standby F1	600	kg/h	0.08	$/kg	2198	h/a	105480	
Vehicles	5	kg/h	0.91	$/kg	8760	h/a	39749	
							Sub Total	2,368,229
Power:								
Compressors			0.07	$/kWh	19350	MWh/a	1315800	
Motors			0.07	$/kWh	3375	MWh/a	229500	
Lighting			0.07	$/kWh	131	MWh/a	8935	
							Sub Total	1,554,235
Consumables:								
Tapping Rods	1	m/t	1	$/m	112500	t/a	112500	
Tapping Oxygen	0.5	m3/t	1	$/m3	112500	t/a	73406	
General			1	$/t	112500	t/a	112500	
Safety			500	$/man	31	men/a	15500	
Reductant Coal			80	$/t	9125	t/a	729997	
Bulker Bags			30	$/bag	10515	bags/a	315436	
Process Water			0.1	$/t	127500	t/a	12750	
							Sub Total	1,372,089
Maintenance:								
Refractories	1.5	relines/annum					555000	
General							50000	
							Sub Total	605,000
Administration:								
Analytical							10000	
Office							40000	
Insurance							40000	
Environmental							60000	
Product Transport							210291	
External Assays							40000	
							Sub Total	400,291
							TOTAL OPERATING COST (YEARLY) AUS	$7,643,844

TABLE 6.

OPERATING COSTS - OPTION D

Item	Rate	Units	Unit Cost	Units	Useage		Cost AUS$	
Labour:								
Manager		1	75000	$/a			75000	
Metallurgist		1	60000	$/a			60000	
Chemist		1	50000	$/a			50000	
Clerk		1	35000	$/a			35000	
Foreman		4	48000	$/a			192000	
Furnace Operators		16	40000	$/a			640000	
Maintenance		3	44000	$/a			132000	
							Sub Total	1,184,000
Fuel:								
Smelting	3520	kg/h	0.08	$/kg	7500	h/a	2112000	
Standby F1	688	kg/h	0.08	$/kg	1260	h/a	69350	
Launder Burners	10	kg/h	0.91	$/kg	7500	h/a	68063	
Vehicles	5	kg/h	0.91	$/kg	8760	h/a	39749	
							Sub Total	2,289,161
Power:								
Compressors			0.07	$/kWh	16988	MWh/a	1155150	
Motors			0.07	$/kWh	3450	MWh/a	234600	
Lighting			0.07	$/kWh	131	MWh/a	8935	
							Sub Total	1,398,685
Consumables:								
Tapping Rods	0.5	m/t	1	$/m	112500	t/a	56250	
Tapping Oxygen	0.2	m3/t	1	$/m3	112500	t/a	29363	
General			1	$/t	112500	t/a	112500	
Safety			500	$/man	27	men/a	13500	
Reductant Coal			80	$/t	7275	t/a	582000	
Bulker Bags			30	$/bag	10326	bags/a	309765	
Process Water			0.1	$/t	117750	t/a	11775	
							Sub Total	1,115,153
Maintenance:								
Refractories	1.5	relines/annum					453600	
General							50000	
							Sub Total	503,600
Administration:								
Analytical							10000	
Office							40000	
Insurance							40000	
Environmental							60000	
Product Transport							206510	
External Assays							40000	
							Sub Total	396,510
							TOTAL OPERATING COST (YEARLY) AUS	$6,887,109

TABLE 7.

ENERGY BALANCE - OPTION A

Case A : Energy Balance - Smelt Stage

Heat In	GJ/h	Heat Out	GJ/h
Combustion	-85.61	Combustion Products	47.39
Combustion Preheat	-7.72	Smelt Products	7.41
Smelt Preheat	0.00	Slag Heat	27.03
Reactions	3.29	Furnace Losses	8.33
Liquid Slag	0.00	Fume	3.08
A'burn Recup.	-3.20		
Total	-93.25	Total	93.25

Case A : Energy Balance - Reduce Stage

Heat In	GJ/h	Heat Out	GJ/h
Combustion	-13.77	Combustion Products	7.93
Combustion Preheat	-1.24	Smelt Products	1.33
Smelt Preheat	0.00	Slag Heat	25.62
Reactions	2.49	Furnace Losses	4.57
Liquid Slag	-27.03	Fume	2.65
A'burn Recup.	-2.55		
Total	-42.10	Total	42.10

TABLE 8.

ENERGY BALANCE - OPTION B

Heat In	GJ/h	Heat Out	GJ/h
Combustion	-89.85	Combustion Products	49.74
Combustion Preheat	-8.11	Smelt Products	8.25
Smelt Preheat	0.00	Slag Heat	25.58
Reactions	5.04	Furnace Losses	9.50
Liquid Slag	0.00	Fume	4.82
A'burn Recup.	-4.79		
Total	-97.89	Total	97.89

TABLE 9.

ENERGY BALANCE - OPTION C

Case C : Energy Balance - Smelt Stage

Heat In	GJ/h	Heat Out	GJ/h
Combustion	-134.98	Combustion Products	74.71
Combustion Preheat	-12.18	Smelt Products	11.84
Smelt Preheat	0.00	Slag Heat	43.22
Reactions	5.27	Furnace Losses	12.30
Liquid Slag	0.00	Fume	4.93
A'burn Recup.	-5.13		
Total	-147.02	Total	147.02

Case C : Energy Balance - Reduce Stage

Heat In	GJ/h	Heat Out	GJ/h
Combustion	-44.88	Combustion Products	25.86
Combustion Preheat	-4.05	Smelt Products	5.22
Smelt Preheat	0.00	Slag Heat	102.27
Reactions	9.94	Furnace Losses	13.29
Liquid Slag	-108.06	Fume	10.61
A'burn Recup.	-10.20		
Total	-157.25	Total	157.25

TABLE 10.

OPTION C : OPERATING COST VARIATIONS

OPTION	C	C	C	C
VARIATION	Base Case	40% O_2 Enrichment	Hunter Valley Coal	Diesel Oil
Capital Cost (AUD$ million)	13.1	11.0	13.1	12.9
Operating Cost (AUD$/tonne)	68	75	73	158

TABLE 11

OPERATING & CAPITAL COST COMPARISION - 15 T.P.H. SIROSMELT PLANT

	OPERATING COST		CAPITAL COST	
	OPTION A	OPTION B	OPTION A	OPTION B
AUSMELT ESTIMATE ($m)	7.65	6.61	14.60	12.00
BHP ENG. ESTIMATE ($m)	7.87	5.91	16.68	13.12

TABLE 12.

CAPITAL COST - OPTION A

	Cost $AUS
CIVIL/SITE WORKS	220000
FEED HANDLING	253000
SIROSMELT FURNACE/S	1712000
GAS HANDLING	2288958
BUILDINGS	945000
SERVICES	2833250
TOTAL CAPITAL EQUIPMENT	$8,252,208
Installation	1204831
Spares	412610
Shipping/Handling	206305
Insurance	165044
Pre-commissioning	35000
Commissioning & Training	207900
EPCM	1891408
Royalties	580000
Contingency	1418556
Site Rehabilitation	200000
TOTAL INSTALLED COST	$14,573,862

TABLE 13.

CAPITAL COST - OPTION B

	Cost $AUS
CIVIL/SITE WORKS	183333
FEED HANDLING	195000
SIROSMELT FURNACE/S	1155000
GAS HANDLING	1638138
BUILDINGS	945000
SERVICES	2544300
TOTAL CAPITAL EQUIPMENT	$6,660,771
Installation	971616
Spares	333039
Shipping/Handling	166519
Insurance	133215
Pre-commissioning	35000
Commissioning & Training	207900
EPCM	1526477
Royalties	580000
Contingency	1144858
Site Rehabilitation	200000
TOTAL INSTALLED COST	$11,959,396

TABLE 14.

CAPITAL COST - OPTION C

	Cost $AUS
CIVIL/SITE WORKS.	183333
FEED HANDLING	205000
SIROSMELT FURNACE/S	1341000
GAS HANDLING	1983043
BUILDINGS	945000
SERVICES	2698550
TOTAL CAPITAL EQUIPMENT	$7,355,926
Installation	1075889
Spares	367796
Shipping/Handling	183898
Insurance	147119
Pre-commissioning	35000
Commissioning & Training	207900
EPCM	1686363
Royalties	580000
Contingency	1264772
Site Rehabilitation	200000
TOTAL INSTALLED COST	$13,104,663

TABLE 15.

MAJOR EQUIPMENT LIST - OPTION A

			Qty	Capacity	Power (kW)
1		CIVIL/SITE WORKS			
1.01		Earthworks			
1.02		Drainage			
1.03		Concreting			
2		FEED HANDLING			
2.01	F1	Slag Crushing Plant		50 t/h	50.0
2.02	F1	Slag Transfer Conveyor	10 m	20 t/h	5.0
2.03	F1	Slag Feed Bin/Feeder	30 t	15 t/h	10.0
2.04	F1	Reductant Coal Feed Bin/Feeder	10 t	1 t/h	7.5
2.05	F1	Elevator Conveyor	20 m	20 t/h	10.0
2.06	F1	Rotary Valve		20 t/h	1.0
2.07	F1	Feed Chute		20 t/h	
2.08	F2	Reductant Coal Feed Bin/Feeder	10 t	1 t/h	7.5
2.09	F2	Elevator Conveyor	20 m	20 t/h	10.0
2.10	F2	Rotary Valve		20 t/h	1.0
2.07	F2	Feed Chute		20 t/h	
3		SIROSMELT FURNACE/S			
3.01	F1	Furnace Shell & Gas Offtake			
3.02	F1	Furnace & Gas Offtake Refractories	2 sets		
3.03	F1	Water Cooled Copper Blocks			
3.04	F1	Sirosmelt Lances	1+3		
3.05	F1	Lance Flexibles	3+3		
3.06	F1	Lance Hoist		2 t	5.0
3.07	F1	Lance Maintenance Hoist		1 t	2.0
3.08	F1	Standby Burner		8 GJ/h	
3.09	F1	Over Flow Weir			
3.10	F1	Transfer Launder			
3.11	F1	Launder/Weir Burners	4	2 GJ/h	
3.12	F2	Under Flow Weir			
3.13	F2	Furnace Shell & Gas Offtake			
3.14	F2	Furnace & Gas Offtake Refractories	2 sets		
3.15	F2	Water Cooled Copper Blocks	2		
3.16	F2	Sirosmelt Lances	1+3		
3.17	F2	Lance Flexibles	3+3		
3.18	F2	Lance Hoist		2 t	5.0
3.19	F2	Lance Maintenance Hoist		1 t	2.0
3.20	F2	Standby Burner		5 GJ/h	
3.21	F2	Over Flow Weir			
3.22	F2	Drain Launder			
3.23		Operating Decks			
3.24		Support Structure			
3.25		Slag Granulation Launder	10 m		
3.26		Slag Granulation Pit	36 m3		
3.27		Tapping Equipment			
4		GAS HANDLING			
4.01	F1	Gas Cooler		30000 Nm3/h	5.0
4.02	F1	Baghouse		55000 Nm3/h	
4.03	F1	ID Fan		55000 Nm3/h	150.0
4.04	F2	Gas Cooler		8000 Nm3/h	5.0
4.05	F2	Baghouse		16000 Nm3/h	
4.06	F2	ID Fan		16000 Nm3/h	60.0
4.07	F1/F2	Stack	25 m	71000 Nm3/h	

TABLE 15.(Cont.)

			Qty	Capacity	Power (kW)
5		BUILDINGS			
5.01		Control Room	6x3 m		1.0
5.02		MCC	6x3 m		
5.03		Laboratory	12x6 m		3.0
5.04		Offices	12x6 m		3.0
5.05		Furnace	40x20 m		
5.06		Ablutions	6x3 m		1.5
5.07		Lunch Room	6x3 m		1.0
5.08		Workshop	12x12 m		5.0
5.09		Compressor House	6x3 m		
6		SERVICES			
6.01		Compressed Air Supply 100 kPa		6000 Nm3/h	60.0
6.02		Compressed Air Supply 230 kPa		32000 Nm3/h	2200.0
6.03		Compressed Air Supply 700 kPa		1000 Nm3/h	100.0
6.04		Air Piping 100 kPa	10 m		
6.05		Air Piping 230 kPa	100 m		
6.06		Air Piping 700 kPa	100 m		
6.07	F1	Fuel Coal Feed Bin/Feeder	20 t	5 t/h	10.0
6.08	F1/F2	Fuel Coal Hammer Mill		5 t/h	35.0
6.09	F1	Fuel Coal Fuller Kinyon Pump		5 t/h	30.0
6.10	F1	Fuel Coal Piping	20 m		
6.11	F2	Fuel Coal Feed Bin/Feeder	5 t	1 t/h	7.5
6.12	F2	Fuel Coal Fuller Kinyon Pump		1 t/h	10.0
6.13	F2	Fuel Coal Piping	20 m		
6.14		Water Storage - Slag Granulation	100 t		
6.15		Water Pump - Slag Granulation		100 t/h	30.0
6.16		Water Piping - Slag Granulation	50 m		
6.17		Water Sump Pump - Slag Granulation		100 t/h	11.0
6.18		Water Cooling Tower - Slag Granulation		20 GJ/h	
6.19		Water Storage - Furnace/Gas Cooling	100 t		
6.20		Water Pump - Furnace Cooling	1+1	110 t/h	18.0
6.21		Water Piping - Furnace Cooling	50 m		
6.22		Water Sump - Furnace Cooling			
6.23		Water Sump Pump - Furnace Cooling	1+1	110 t/h	15.0
6.24		Water Cooling Tower - Furnace Cooling		12 GJ/h	
6.25		Water Pump - Gas Cooling	1+1	30 t/h	10.0
6.26		Water Piping - Gas Cooling	100 m		
6.27		Workshop Equipment			
6.28		Safety Equipment			
6.29		Laboratory Equipment			
6.30		Front End Loader		5 t	
6.31		4WD Plant Vehicle		1 t	
6.32		Electricals	3.0 MW		
6.33		Instrumentation	36 loops		

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TABLE 16.

MAJOR EQUIPMENT LIST - OPTION B

			Qty	Capacity	Power (kW)
1		CIVIL/SITE WORKS			
1.01		Earthworks			
1.02		Drainage			
1.03		Concreting			
2		FEED HANDLING			
2.01	F1	Slag Crushing Plant		50 t/h	50.0
2.02	F1	Slag Transfer Conveyor	10 m	25 t/h	7.5
2.03	F1	Slag Feed Bin/Feeder	50 t	25 t/h	12.0
2.04	F1	Reductant Coal Feed Bin/Feeder	10 t	2 t/h	7.5
2.05	F1	Elevator Conveyor	20 m	25 t/h	10.0
2.06	F1	Rotary Valve		25 t/h	1.0
2.07	F1	Feed Chute		25 t/h	
3		SIROSMELT FURNACE/S			
3.01	F1	Furnace Shell & Gas Offtake			
3.02	F1	Furnace & Gas Offtake Refractories	2 sets		
3.03	F1	Water Cooled Copper Blocks			
3.04	F1	Sirosmelt Lances	1+3		
3.05	F1	Lance Flexibles	3+3		
3.06	F1	Lance Hoist		2 t	5.0
3.07	F1	Lance Maintenance Hoist		1 t	2.0
3.08	F1	Standby Burner		8 GJ/h	
3.09	F1	Over Flow Weir			
3.10	F1	Launder/Weir Burners	4	2 GJ/h	
3.11		Operating Decks			
3.12		Support Structure			
3.13		Slag Granulation Launder	10 m		
3.14		Slag Granulation Pit	36 m3		
3.15		Tapping Equipment			
4		GAS HANDLING			
4.01	F1	Gas Cooler		44000 Nm3/h	7.5
4.02	F1	Baghouse		85000 Nm3/h	
4.03	F1	ID Fan		85000 Nm3/h	180.0
4.04	F1	Stack	25 m	85000 Nm3/h	

TABLE 16.(Cont.)

			Qty	Capacity	Power (kW)
5		BUILDINGS			
5.01		Control Room	6x3 m		1.0
5.02		MCC	6x3 m		
5.03		Laboratory	12x6 m		3.0
5.04		Offices	12x6 m		3.0
5.05		Furnace	20x20 m		
5.06		Ablutions	6x3 m		1.5
5.07		Lunch Room	6x3 m		1.0
5.08		Workshop	12x12 m		5.0
5.09		Compressor House	6x3 m		
6		SERVICES			
6.01		Compressed Air Supply 100 kPa		15000 Nm3/h	70.0
6.02		Compressed Air Supply 230 kPa		43000 Nm3/h	2400.0
6.03		Compressed Air Supply 700 kPa		1000 Nm3/h	100.0
6.04		Air Piping 100 kPa	10 m		
6.05		Air Piping 230 kPa	50 m		
6.06		Air Piping 700 kPa	50 m		
6.07	F1	Fuel Coal Feed Bin/Feeder	20 t	6 t/h	12.0
6.08	F1	Fuel Coal Hammer Mill		6 t/h	40.0
6.09	F1	Fuel Coal Fuller Kinyon Pump		6 t/h	30.0
6.10	F1	Fuel Coal Piping	20 m		
6.11		Water Storage - Slag Granulation	100 t		
6.12		Water Pump - Slag Granulation		500 t/h	40.0
6.13		Water Piping - Slag Granulation	50 m		
6.14		Water Sump Pump - Slag Granulation		100 t/h	11.0
6.15		Water Cooling Tower - Slag Granulation		20 GJ/h	
6.16		Water Storage - Furnace/Gas Cooling	100 t		
6.17		Water Pump - Furnace Cooling	1+1	120 t/h	20.0
6.18		Water Piping - Furnace Cooling	50 m		
6.19		Water Sump - Furnace Cooling			
6.20		Water Sump Pump - Furnace Cooling	1+1	120 t/h	15.0
6.21		Water Cooling Tower - Furnace Cooling		12 GJ/h	
6.22		Water Pump - Gas Cooling	1+1	32 t/h	10.0
6.23		Water Piping - Gas Cooling	100 m		
6.24		Workshop Equipment			
6.25		Safety Equipment			
6.26		Laboratory Equipment			
6.27		Front End Loader		5 t	
6.28		4WD Plant Vehicle		1 t	
6.29		Electricals	3.1 MW		
6.30		Instrumentation	18 loops		

TABLE 17

MAJOR EQUIPMENT LIST - OPTION C

			Qty	Capacity	Power (kW)
1		CIVIL/SITE WORKS			
1.01		Earthworks			
1.02		Drainage			
1.03		Concreting			
2		FEED HANDLING			
2.01	F1	Slag Crushing Plant		50 t/h	50.0
2.02	F1	Slag Transfer Conveyor	10 m	20 t/h	5.0
2.03	F1	Slag Feed Bin/Feeder	30 t	15 t/h	10.0
2.04	F1	Reductant Coal Feed Bin/Feeder	10 t	1 t/h	7.5
2.05	F1	Elevator Conveyor	20 m	20 t/h	10.0
2.06	F1	Rotary Valve		20 t/h	1.0
2.07	F1	Feed Chute		20 t/h	
3		SIROSMELT FURNACE/S			
3.01	F1	Furnace Shell & Gas Offtake			
3.02	F1	Furnace & Gas Offtake Refractories	2 sets		
3.03	F1	Water Cooled Copper Blocks			
3.04	F1	Sirosmelt Lances	1+3		
3.05	F1	Lance Flexibles	3+3		
3.06	F1	Lance Hoist		2 t	5.0
3.07	F1	Lance Maintenance Hoist		1 t	2.0
3.08	F1	Standby Burner		12 GJ/h	
3.09	F1	Over Flow Weir			
3.10	F1	Launder/Weir Burners	4	2 GJ/h	
3.11		Operating Decks			
3.12		Support Structure			
3.13		Slag Granulation Launder	10 m		
3.14		Slag Granulation Pit	36 m3		
3.15		Tapping Equipment			
4		GAS HANDLING			
4.01	F1	Gas Cooler		33000 Nm3/h	5.0
4.02	F1	Baghouse		60000 Nm3/h	
4.03	F1	ID Fan		60000 Nm3/h	160.0
4.04	F1	Stack	25 m	60000 Nm3/h	

TABLE 17.(Cont.)

			Qty	Capacity	Power (kW)
5		BUILDINGS			
5.01		Control Room	6x3 m		1.0
5.02		MCC	6x3 m		
5.03		Laboratory	12x6 m		3.0
5.04		Offices	12x6 m		3.0
5.05		Furnace	20x20 m		
5.06		Ablutions	6x3 m		1.5
5.07		Lunch Room	6x3 m		1.0
5.08		Workshop	12x12 m		5.0
5.09		Compressor House	6x3 m		
6		SERVICES			
6.01		Compressed Air Supply 100 kPa		6500 Nm3/h	65.0
6.02		Compressed Air Supply 230 kPa		29000 Nm3/h	2000.0
6.03		Compressed Air Supply 700 kPa		1000 Nm3/h	100.0
6.04		Air Piping 100 kPa	10 m		
6.05		Air Piping 230 kPa	50 m		
6.06		Air Piping 700 kPa	50 m		
6.07	F1	Fuel Coal Feed Bin/Feeder	20 t	5 t/h	10.0
6.08	F1	Fuel Coal Hammer Mill		5 t/h	35.0
6.09	F1	Fuel Coal Fuller Kinyon Pump		5 t/h	30.0
6.10	F1	Fuel Coal Piping	20 m		
6.11		Water Storage - Slag Granulation	100 t		
6.12		Water Pump - Slag Granulation		100 t/h	30.0
6.13		Water Piping - Slag Granulation	50 m		
6.14		Water Sump Pump - Slag Granulation		100 t/h	11.0
6.15		Water Cooling Tower - Slag Granulation		20 GJ/h	
6.16		Water Storage - Furnace/Gas Cooling	100 t		
6.17		Water Pump - Furnace Cooling	1+1	80 t/h	15.0
6.18		Water Piping - Furnace Cooling	50 m		
6.19		Water Sump - Furnace Cooling			
6.20		Water Sump Pump - Furnace Cooling	1+1	80 t/h	12.0
6.21		Water Cooling Tower - Furnace Cooling		12 GJ/h	
6.22		Water Pump - Gas Cooling	1+1	25 t/h	10.0
6.23		Water Piping - Gas Cooling	100 m		
6.24		Workshop Equipment			
6.25		Safety Equipment			
6.26		Laboratory Equipment			
6.27		Front End Loader		5 t	
6.28		4WD Plant Vehicle		1 t	
6.29		Electricals	2.7 MW		
6.30		Instrumentation	18 loops		

TABLE 18.

MASS BALANCE - OPTION A

Case A : Mass Balance - Smelting

INPUT:		Wgt	Zn	Pb	Fe	SiO2	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Zeehan Slag	%		13.4	1.7	22.4	20.0	11.4	3.3	0.2	0.0	3.7	1.3	12.4	5.0	g/t	54
	kg/h	15000	2004.0	258.0	3357.1	2994.0	1702.5	499.5	33.6	5.3	555.0	195.0	1857.0	750.0	g/h	810
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		11.5		
(Reductant)	kg/h	646			5.2	74.8	3.4	2.6			25.2	2.3		74.3		
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		5.1		
(Fuel)	kg/h	3318			26.8	384.4	17.7	13.6			129.3	12.0		169.2		
Total Feed	kg/h	18964	2004.0	258.0	3389.1	3453.2	1723.6	515.8	33.6	5.3	709.5	209.3	1857.0	893.5	g/h	810
OUTPUT:		Wgt	Zn	Pb	Fe	SiO2.	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Slag	%		7.4	0.8	24.6	25.1	12.5	0.2	0.2	0.0	5.2	1.5	13.6		g/t	18
	kg/h	13630	1002.0	103.2	3355.2	3418.7	1706.4	25.8	33.2	0.3	702.4	207.2	1857.0		g/h	243
	Rec		50.0	40.0	99.0	99.0	99.0	5.0	99.0	6.0	99.0	99.0	100.0			30
Fume	%		64.6	10.0	2.2	2.2	1.1	1.7	0.0	0.3	0.5	0.1	0.0		g/t	365
	kg/h	1552	1002.0	154.8	33.9	34.5	17.2	25.8	0.3	5.0	7.1	2.1	0.0		g/h	567
	Rec		50.0	60.0	1.0	1.0	1.0	5.0	1.0	95.0	1.0	1.0	0.0			70
Total Output	kg/h	15182	2004.0	258.0	3389.1	3453.2	1723.6	51.6	33.6	5.3	709.5	209.3	1857.0		g/h	810

Case A : Mass Balance - Slag Fuming

INPUT:		Wgt	Zn	Pb	Fe	SiO2	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Slag	%		7.4	0.8	24.6	25.1	12.5	0.2	0.2	0.0	5.2	1.5	13.6		g/t	18
	kg/h	13630	1002.0	103.2	3355.2	3418.7	1706.4	25.8	33.2	0.3	702.4	207.2	1857.0		g/h	243
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		11.5		
(Reductant)	kg/h	461			3.7	53.4	2.5	1.9			18.0	1.7		53.0		
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		5.1		
(Fuel)	kg/h	534			4.3	61.8	2.8	2.2			20.8	1.9		27.2		
Total Feed	kg/h	14625	1002.0	103.2	3363.2	3533.8	1711.7	29.9	33.2	0.3	741.2	210.8	1857.0	80.2	g/h	243
OUTPUT:		Wgt	Zn	Pb	Fe	SiO2	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Reduced slag	%		1.0	0.1	26.7	28.0	13.6	0.2	0.3	0.0	5.9	1.7	14.8		g/t	6
	kg/h	12548	120.2	10.3	3346.4	3516.2	1703.1	20.9	33.1	0.1	737.5	209.7	1857.0		g/h	73
	Rec		12.0	10.0	99.5	99.5	99.5	70.0	99.5	50.0	99.5	99.5	100.0			30
Fume	%		70.4	7.4	1.3	1.4	0.7	0.1	0.0	0.0	0.3	0.1	0.0		g/t	136
	kg/h	1252	881.8	92.9	16.8	17.7	8.6	1.5	0.2	0.1	3.7	1.1	0.0		g/h	170
	Rec		88.0	90.0	0.5	0.5	0.5	5.0	0.5	50.0	0.5	0.5	0.0			70
Total Output	kg/h	13800	1002.0	103.2	3363.2	3533.8	1711.7	22.4	33.2	0.3	741.2	210.8	1857.0		g/h	243

INPUT:		Wgt	Zn	Pb	Fe	SiO2	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Zeehan Slag	%		13.4	1.7	22.4	20.0	11.4	3.3	0.2	0.0	3.7	1.3	12.4	5.0	g/t	54
	kg/h	15000	2004.0	258.0	3357.1	2994.0	1702.5	499.5	33.6	5.3	555.0	195.0	1857.0	750.0	g/h	810
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		11.5		
(Reductant)	kg/h	969			7.8	112.2	5.2	4.0			37.8	3.5		111.4		
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		5.1		
(Fuel)	kg/h	3483			28.1	403.4	18.5	14.3			135.8	12.6		177.6		
Total Feed	kg/h	19452	2004.0	258.0	3393.0	3509.7	1726.2	517.8	33.6	5.3	728.5	211.0	1857.0	1039.0	g/h	810
OUTPUT:		Wgt	Zn	Pb	Fe	SiO2	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Slag	%		3.1	0.3	26.0	26.9	13.3	0.2	0.3	0.0	5.6	1.6	14.4		g/t	19
	kg/h	12897	400.8	38.7	3359.1	3474.6	1708.9	25.9	33.2	0.3	721.2	208.9	1857.0		g/h	243
	Rec		20.0	15.0	99.0	99.0	99.0	5.0	99.0	5.0	99.0	99.0	100.0			30
Fume	%		67.6	9.3	1.4	1.5	0.7	1.1	0.0	0.2	0.3	0.1	0.0		g/t	239
	kg/h	2371	1603.2	219.3	33.9	35.1	17.3	25.9	0.3	5.0	7.3	2.1	0.0		g/h	567
	Rec		80.0	85.0	1.0	1.0	1.0	5.0	1.0	95.0	1.0	1.0	0.0			70
Total Output	kg/h	15267	2004.0	258.0	3393.0	3509.7	1726.2	51.8	33.6	5.3	728.5	211.0	1857.0		g/h	810

TABLE 19.

MASS BALANCE - OPTION B

TABLE 20.

MASS BALANCE - OPTION C

Case C : Mass Balance - Smelting

INPUT:		Wgt	Zn	Pb	Fe	SiO2	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Zeehan Slag	%		13.4	1.7	22.4	20.0	11.4	3.3	0.2	0.0	3.7	1.3	12.4	5.0	g/t	54
	kg/h	24000	3206.4	412.8	5371.4	4790.4	2724.0	799.2	53.7	8.4	888.0	312.0	2971.2	1200.0	g/h	1298
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		11.5		
(Reductant)	kg/h	1033			8.3	119.7	5.5	4.2			40.3	3.7		118.8		
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		5.1		
(Fuel)	kg/h	5232			42.2	608.1	27.9	21.5			203.9	18.9		266.8		
Total Feed	kg/h	30265	3206.4	412.8	5421.9	5518.1	2757.4	824.9	53.7	8.4	1132.2	334.6	2971.2	1585.6	g/h	1298
OUTPUT:		Wgt	Zn	Pb	Fe	SiO2	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Slag	%		7.4	0.8	24.6	25.1	12.5	0.2	0.2	0.0	5.1	1.5	13.6		g/t	18
	kg/h	21795	1603.2	165.1	5367.7	5461.9	2729.8	41.2	53.2	0.4	1120.9	331.2	2971.2		g/h	389
	Rec		50.0	40.0	99.0	99.0	99.0	5.0	99.0	5.0	99.0	99.0	100.0			30
Fume	%		64.6	10.0	2.2	2.2	1.1	1.7	0.0	0.3	0.5	0.1	0.0		g/t	365
	kg/h	2483	1603.2	247.7	54.2	55.2	27.6	41.2	0.5	8.0	11.3	3.3	0.0		g/h	907
	Rec		50.0	60.0	1.0	1.0	1.0	5.0	1.0	95.0	1.0	1.0	0.0			70
Total Output	kg/h	24278	3206.4	412.8	5421.9	5518.1	2757.4	82.5	53.7	8.4	1132.2	334.6	2971.2		g/h	1298

Case C : Mass Balance - Slag Fuming

INPUT:		Wgt	Zn	Pb	Fe	SiO2	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Slag	%		7.4	0.8	24.8	25.1	12.5	0.2	0.2	0.0	5.1	1.5	13.6		g/t	18
	kg/cycle	54488	4008.0	412.8	13419.2	13652.4	6824.5	103.1	132.9	1.1	2802.2	828.1	7428.0		g/cycle	972
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		11.5		
(Reductant)	kg/cycle	1843			14.9	213.5	9.8	7.8			71.8	6.8		211.9		
Coal	%				0.8	11.6	0.5	0.4			3.9	0.4		5.1		
(Fuel)	kg/cycle	1132			9.1	131.1	6.0	4.6			44.1	4.1		57.7		
Total Feed	kg/cycle	57462	4008.0	412.8	13443.2	13997.0	6840.3	115.3	132.9	1.1	2918.1	838.8	7428.0	269.6	g/cycle	972
OUTPUT:		Wgt	Zn	Pb	Fe	SiO2	CaO	S	Cu	As	Al2O3	MgO	Resid.	H2O		Ag
Reduced slag	%		1.0	0.1	26.8	27.9	13.6	0.2	0.3	0.0	5.8	1.7	14.9		g/t	6
	kg/cycle	49981	481.0	41.3	13376.0	13927.0	6806.1	80.7	132.3	0.5	2903.6	834.6	7428.0		g/cycle	292
	Rec		12.0	10.0	99.5	99.5	99.5	70.0	99.5	50.0	99.5	99.5	100.0			30
Fume	%		70.4	7.4	1.3	1.4	0.7	0.1	0.0	0.0	0.3	0.1	0.0		g/t	136
	kg/cycle	5008	3527.0	371.5	67.2	70.0	34.2	5.8	0.7	0.5	14.6	4.2	0.0		g/cycle	680
	Rec		88.0	90.0	0.5	0.5	0.5	5.0	0.5	50.0	0.5	0.5	0.0			70
Total Output	kg/cycle	54989	4008.0	412.8	13443.2	13997.0	6840.3	86.5	132.9	1.1	2918.1	838.8	7428.0		g/cycle	972

TABLE 21

EVALUATION OF RAW FUME PROCESSING OPTIONS

BASIS : PROCESS 20,651 tpa RAW FUME	ZINC ENRICHED FUME (77%Zn)	BASIC ZINC SULPHATE (57%Zn)	ZINC SULPHATE MONOHYDRATE (33%Zn)	ZINC OXIDE (80%Zn)
CAPITAL COST	$ 1,300,274	$ 7,525,985	$ 5,913,645	$ 2,600,548
ANNUAL OPERATING COST	$ 914,613	$ 5,911,045	$ 4,636,776	$ 1,300,274
PRODUCT (ANNUAL TONNES)	17,427	22,303	34,243	15,891
ANNUAL REVENUE - PRODUCT	$13,554,269	$23,476,840	$21,176,592	$25,091.052
- LEAD RESIDUE	$ 545,801	$ 1,037,988	$ 1,037,988	$ 1,037,988
ANNUAL REVENUE - PRIMARY FUME	$14,262,903	$14,262,903	$14,262,903	$14,262,903
ANNUAL BENEFIT	-$1,077,446	$ 4,340,880	$ 3,314,901	$10,565,863
BENEFIT/TONNE PRIMARY FUME	-$52/t	$210/t	$161/t	$512/t
BENEFIT/TONNE SLAG	-$9.6/t	$39/t	$29/t	$94/t
ZINC RECOVERY FROM FUME	95%	90%	80%	90%

368073

TABLE 22

COMPARISON OF RETURNS FOR SIROSMELT PLANT CONFIGURATION OPTIONS A-D

(SLAG FUMING ONLY)

	OPTION A (Twin Continuous)	OPTION B (Single Continuous) (High Zn in Slag)	OPTION C (Batch)	OPTION D (Single Continuous) (Low Zn in Slag)
NPV ($m)	5.6	4.7	6.4	8.9
IRR (%)	21	21	23	30
CAPEX	14,573,862	11,959,396	13,104,663	12,200,000
FIXED OP COSTS ($/qtr)	561905	616217	552092	494344
VARIABLE OP COSTS ($/t)	45.32	34.48	45.60	41.21
BREAK EVEN (Yrs)	4.00	4.00	3.75	3.25

N.B. Zn @ $US 1200/t, Pb @ £300/t, Ag @ US$4.00/oz
$US:$A @ 0.76, £:$A @ 0.43
Includes plant residual - write down over 10 years

TABLE 23

OPTION D - IRR v THROUGHPUT, FOR PLANT SIZE OPTIMISATION

(SLAG FUMING ONLY)

THROUGHPUT (tph)	5	10	15	20	25
CAPEX ($)	6,272,898	9,507,935	12,200,000	14,476,741	15,535,780
CAPEX ($/t slag)	169	128	108	97	89
ANNUAL SLAG THROUGHPUT (tpa)	37125	74250	112500	149625	186750
TOTAL OPER COST ($/t) (FACTORED & ADJUSTED FOR MERRYWOOD COAL)	81.7	64.2	58.8	59.0	54.9
NPV ($m)	No Data	6.8	7.2	5.8	5.6
IRR (%)	No Data	88	88	66	60
PROJECT LIFE (yrs)	12	6.25	4.00	3.25	2.50

N.B. - No residual value - capital costs written off over life of resource.
- Optimum throughput is 15tph.
- Zn @ US $1200/t, Pb @ £300/t, Ag @ US $4.00/oz, US$:A$ @ 0.76, £:AS @ 0.43

368075

TABLE 24

SENSITIVITY ANALYSIS-EXCHANGE RATE AND ZINC PRICE VARIATIONS

		ZINC PRICE (US$/t)													
		900		1000		1100		1200		1300		1400		1500	
US$:A$		NPV ($m)	IRR (%)	NPV ($m)	IRR (%)	NPV ($m)	IRR (%)	NPV ($m)	IRR (%)	NPV ($m)	IRR (%)	NPV ($m)	IRR (%)	NPV ($m)	IRR (%)
0.80	A	-1.0	8	1.7	14	4.5	20	7.2	26	9.9	32	12.4	37	15.0	42
	B	8.2	28	11.8	36	15.4	44	19.1	52	22.6	59	26.2	66	29.7	74
0.78	A	-0.4	9	2.5	16	5.3	22	8.0	28	10.7	34	13.3	39	15.9	44
	B	8.9	30	12.7	38	16.5	46	20.2	54	23.8	62	27.4	69	31.0	76
0.76	A	0.3	11	3.2	17	6.1	24	8.9	30	11.6	35	14.3	41	17.0	47
	B	9.8	32	13.7	40	17.6	48	21.3	56	25.1	64	28.7	71	32.4	79
0.74	A	1.0	12	4.0	19	6.9	25	9.8	32	12.6	37	15.3	43	18.0	49
	B	10.8	34	14.8	42	18.7	51	22.6	59	26.4	67	30.1	75	33.9	82
0.72	A	1.8	14	4.9	21	7.8	27	10.7	34	13.6	40	16.4	45	19.1	51
	B	11.8	36	15.9	45	19.9	53	23.8	62	27.7	70	31.6	78	35.4	85

A = SLAG FUMING ONLY
B = BASE CASE

N.B. Zn @ US $1200/t, Pb @ £300/t, Ag @ US $4.00/oz; £:A$ @ 0.43
Includes plant residual - write down over 10 years

TABLE 25

SENSITIVITY ANALYSIS - OPERATING COST VARIATIONS

FIXED COST ($/qtr)	VARIABLE COST ($/t)	VARIATION %	SLAG FUMING NPV ($m)	SLAG FUMING IRR (%)	BASE CASE NPV ($m)	BASE CASE IRR (%)
642647	53.57	+30	3.5	18	16.4	45
593213	49.45	+20	5.3	22	18.1	49
543778	45.33	+10	7.1	26	19.7	53
494344	41.21	0	8.9	30	21.3	56
444910	37.09	-10	10.6	34	22.9	60
395475	32.97	-20	12.3	38	24.5	64
346041	28.85	-30	14.0	42	26.0	68

N.B Zn @ US$1200/t, Pb @ £300/t, Ag @ US$4.00/oz
$US:$A @ 0.76, £:A$ @ 0.43
Includes plant residual - write down over 10 yrs

TABLE 26

SENSITIVITY ANALYSIS - CAPITAL COST VARIATIONS

CAPEX SLAG FUMING ($m)	VARIATION %	NPV ($m)	IRR (%)	CAPEX BASE CASE ($m)	VARIATION %	NPV ($m)	IRR (%)
15,860,000	+30	7.0	23	17,550,356	+301	19.5	44
14,640,000	+20	7.6	25	16,200,329	+20	20.1	47
13,420,000	+10	8.3	27	14,850,301	+10	20.7	52
12,200,000	0	8.9	30	13,500,274	0	21.3	56
10,980,000	-10	9.5	33	12,150,247	-10	22.0	62
9,760,000	-20	10.1	37	10,800,219	-20	22.6	69
8,540,000	-30	10.7	41	9,450,192	-30	23.2	78

N.B. Zn @ US$1200/t, Pb @ £300/t, Ag @ US$4.00/oz
$US:$A @ 0.76, £:A$ @ 0.43
Includes plant residual - write down over 10 yrs

TABLE 27

SENSITIVITY ANALYSIS - ZINC RECOVERY VARIATIONS

ZN IN SLAG (%)	FUME PROD (tpa)	ZN IN FUME (Zn%)	FIXED OP COSTS ($/tr)	VAR OP COSTS ($/t)	SLAG FUMING NPV ($m)	SLAG FUMING IRR (%)	BASE NPV ($m)	BASE CASE IRR (%)
1.0	20651	68.4	494344	41.21	8.9	30	21.3	56
1.5	19934	68.2	524812	39.53	7.8	27	19.9	54
2.0	19217	68.0	555281	37.85	6.7	25	18.5	51
2.5	18500	67.8	585749	36.16	5.7	23	17.1	48
3.0	17783	67.6	616217	34.48	4.6	20	15.7	45

N.B. Zn @ $US 1200/t, Pb @ £300/t, Ag @ US $4.00/oz
US$:A$ @ 0.76, £:A$ @ 0.43
Includes plant residual - write down our 10 years

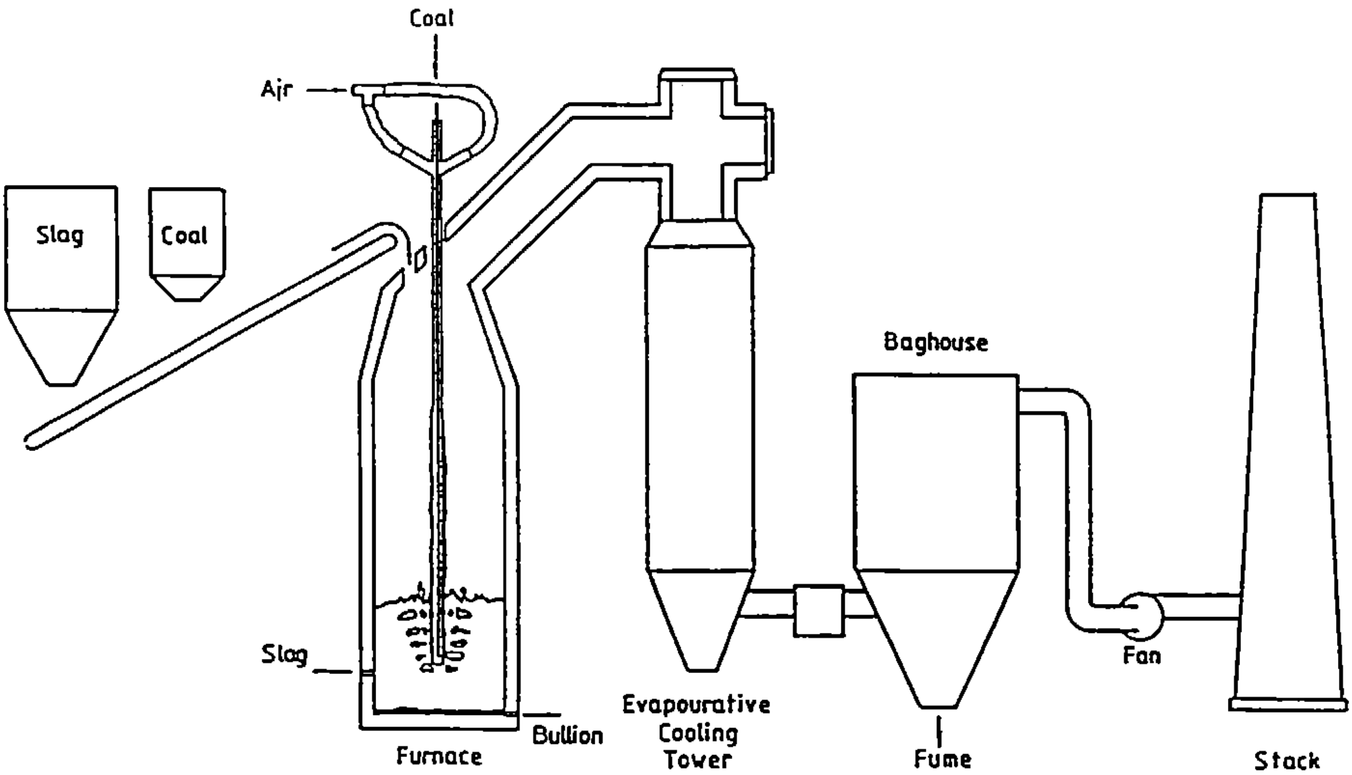
TABLE 28

SENSITIVITY ANALYSIS - RESERVE VARIATIONS

RESOURCE (tonnes)	or BULK DENSITY EQUIVALENT	VARIATION %	SLAG FUMING NPV ($m)	SLAG FUMING IRR (%)	BASE CASE NPV ($m)	BASE CASE IRR (%)	PROJECT LIFE (yrs)
585975	3.90	+30	11.3	31	26.5	58	5.25
540900	3.60	+20	10.5	31	24.8	58	5.00
495825	3.30	+10	9.8	31	23.2	57	4.50
450750	3.00	0	8.9	30	21.3	56	4.00
405675	2.70	-10	8.2	30	19.7	56	3.75
360600	2.40	-20	7.4	30	17.9	56	3.25
315525	2.10	-30	6.5	28	15.8	54	3.00

N.B. Zn @ $US 1200/t, Pb @ £300/t, Ag @ US $4.00/oz
US$:A$ @ 0.76, £:A$ @ 0.43
Includes plant residual - write down our 10 years

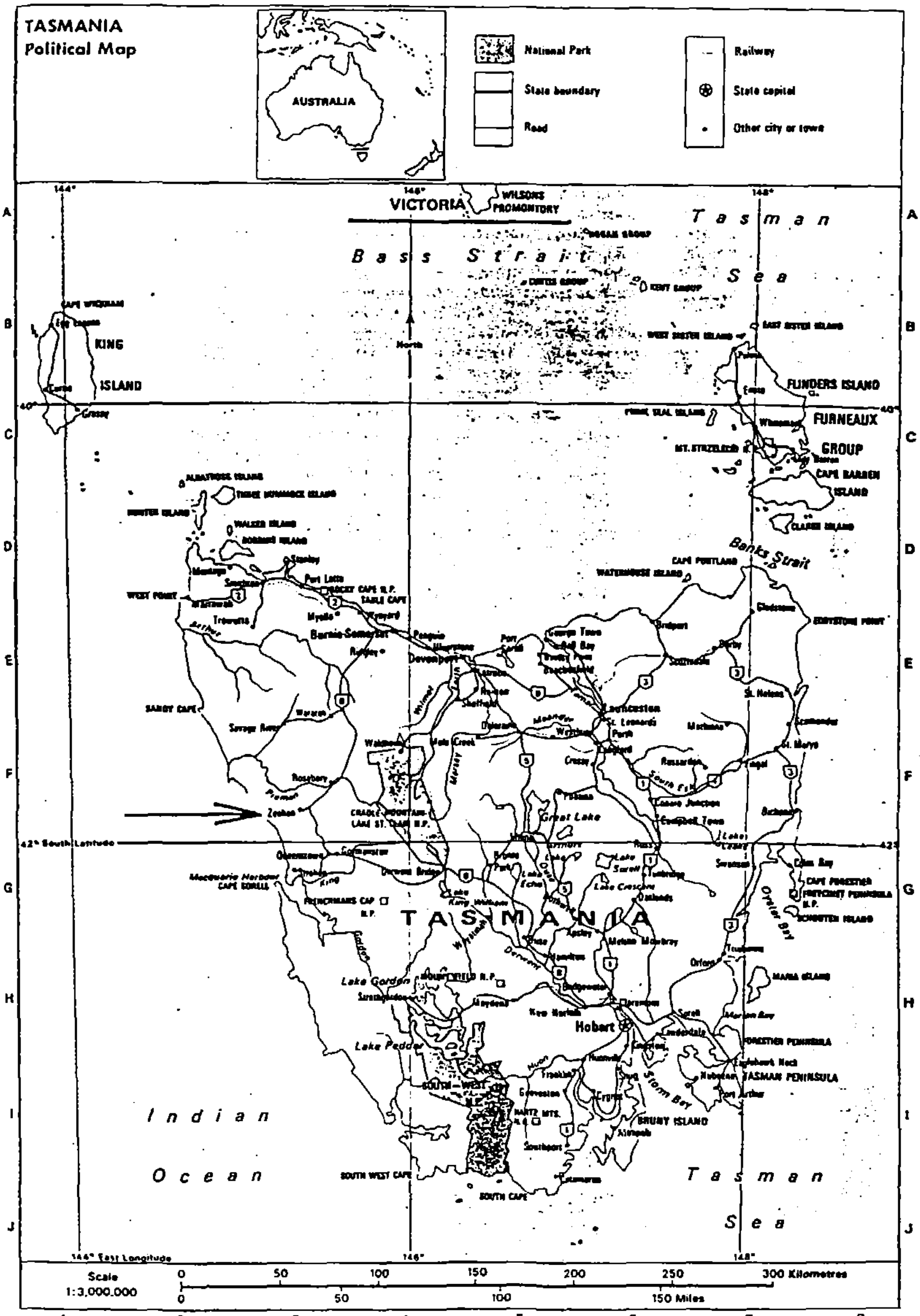
FIGURE 1.



SIROSMELT PLANT - SCHEMATIC REPRESENTATION

FIGURE 2.

ZEEHAN - LOCATION PLAN

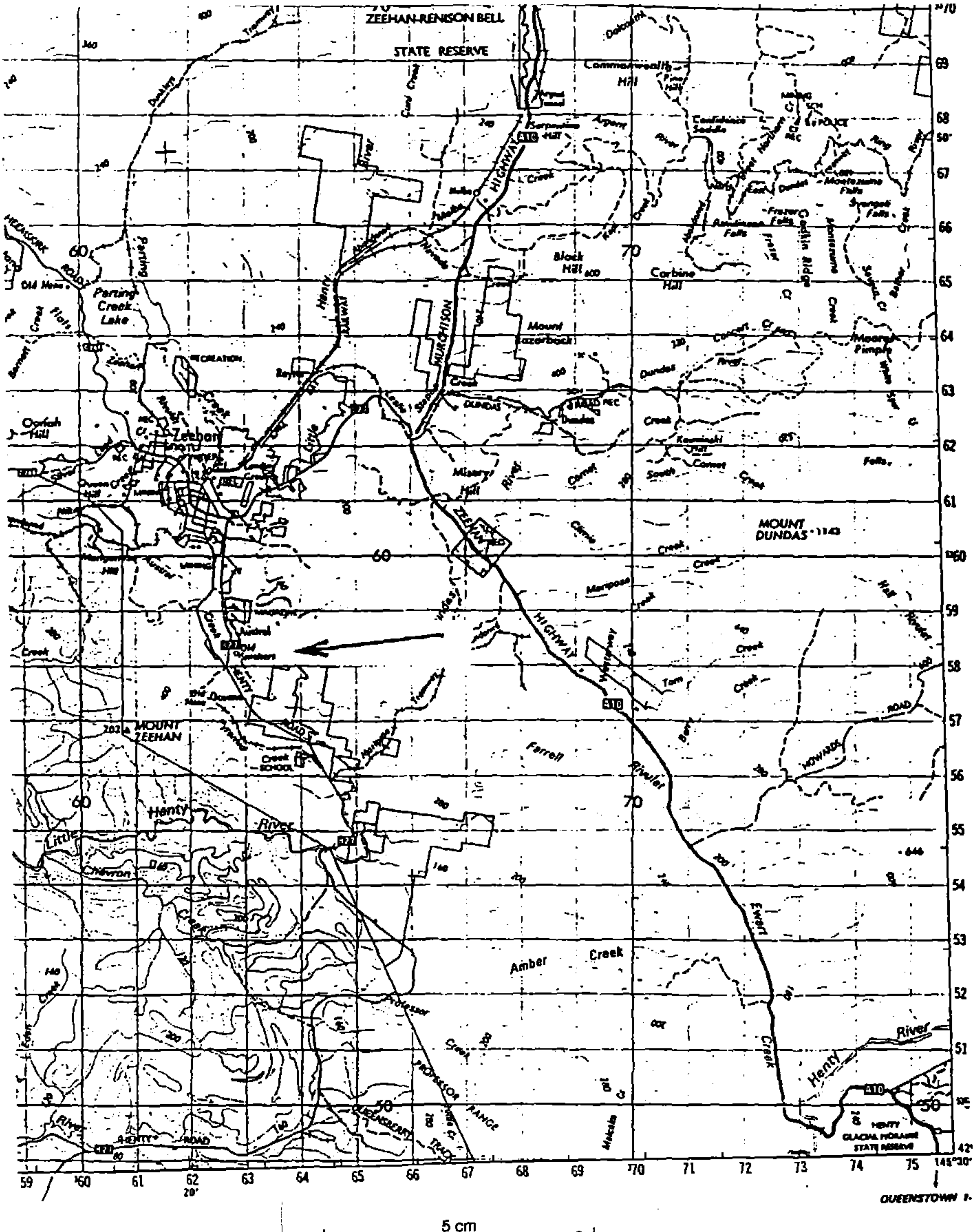


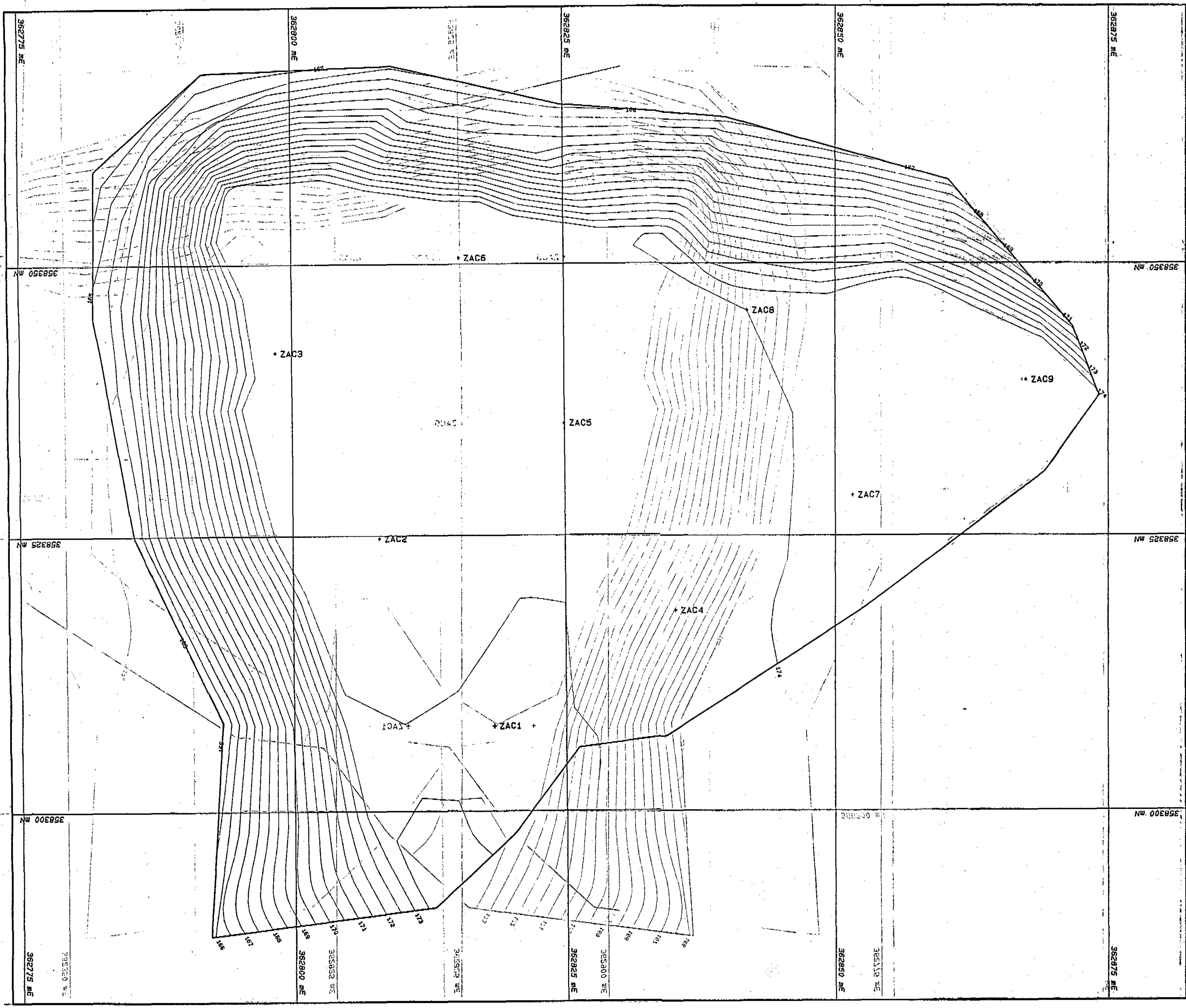
5 cm

368083

FIGURE 3.

SMELTER SITE - LOCATION PLAN





NOTES :
CONTOURING BY DIGITAL TERRAIN MODELLING
CONTOUR INTERVAL : 0.5m
LABEL INTERVAL : 1.0m

NOTE: BOUNDARY LINE IS DERIVED FROM EDITING OF SURPAC FILE

5 cm

368084

97-3965

ZEEHAN SLAG DUMP RETREATMENT
PROJ.-PRE-FEASIBILITY STUDY
RL 9603 - PYROSMELT VOL 1

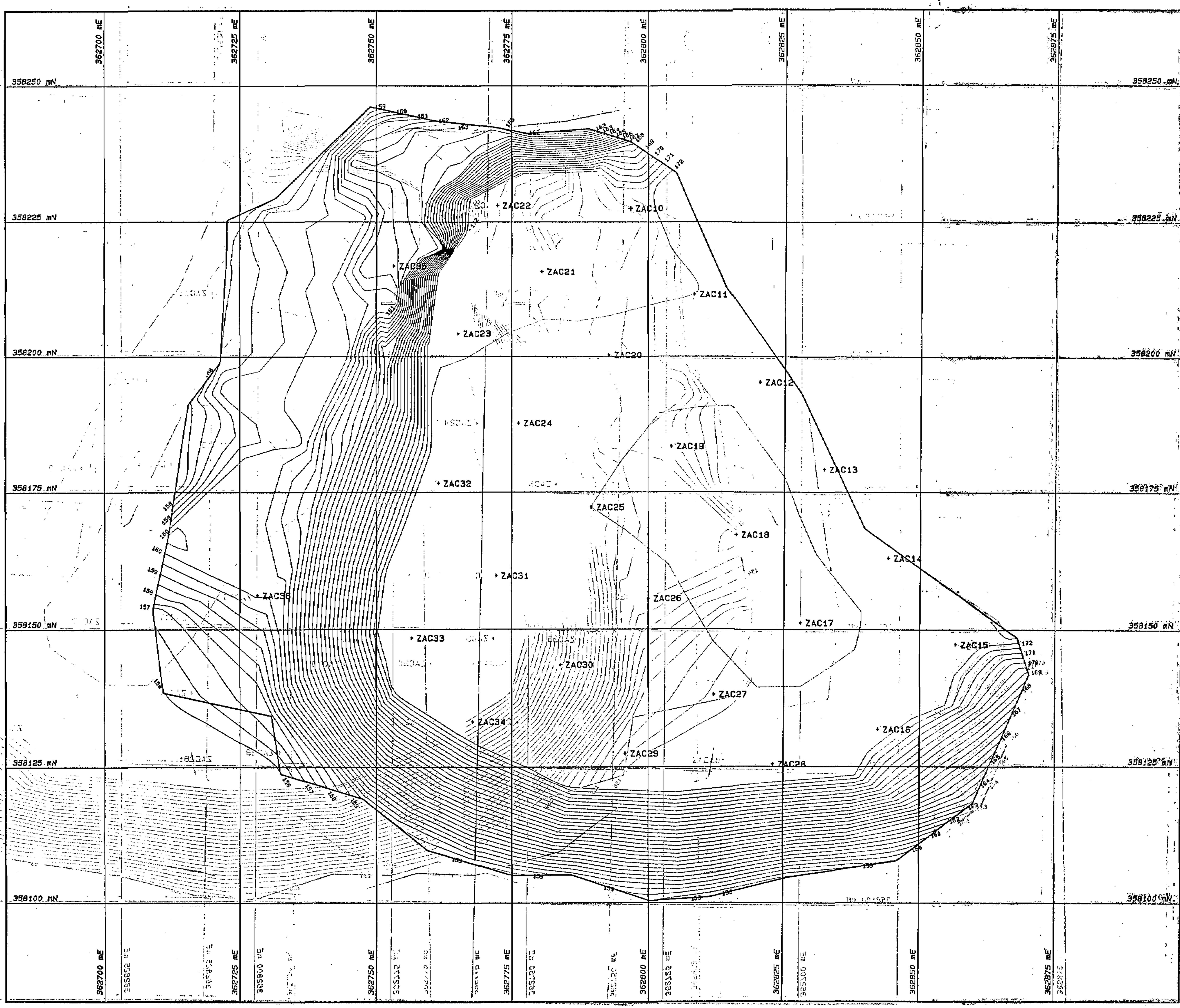
FIGURE 4.

SCALE	DATE	SHEET
1: 250	28/10/90	1 of 1
	REF No.	

0 12.50m

R. S. G.
ZEEHAN DUMPS
NORTH DUMP
SURFACE CONTOURS
AND DRILL HOLE
LOCATIONS

DRAGON MINING LIMITED



NOTES :
CONTOURING BY DIGITAL TERRAIN MODELLING
CONTOUR INTERVAL : 0.5m
LABEL INTERVAL : 1.0m

NOTE: BOUNDARY LINE IS DERIVED FROM EDITING OF SURPAC FILE

5 cm

368085

97-3965

ZEEHAN SLAG DUMP RETREATMENT
PROJ. PRE-FEASIBILITY STUDY
RL 9603 - PYROSMELT VOL 1

FIGURE 5.

SCALE	DATE	SHEET
1:500	28/10/90	1 of 1
	REF No.	

0 25m

R. S. G.
ZEEHAN DUMPS
SOUTH DUMP
SURFACE CONTOURS
AND DRILL HOLE
LOCATIONS

DRAGON MINING LIMITED

97-3965

ZEEHAN SLAG DUMP RETREATMENT
PROJ.-PRE-FEASIBILITY STUDY
RL 9603 - PYROSMELT - **VOL 2**

ZEEHAN SLAG DUMP RETREATMENT PROJECT

PRE-FEASIBILITY STUDY (VOLUME II)

PYROSMELT N.L.

JULY 1991

368086

RL 9603

see Folio 1

VOLUME II

APPENDICES

APPENDIX A

DRILL HOLE LOG SHEETS - ASSAY RESULTS

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368089

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE		DESCRIPTION		Pb%	Zn%	Ag (g/t)
ZAC 01	00.0	TO 01.0	Slag; dk.gy, platey:		1.37	11.54	53
	01.0	02.0	"		1.96	12.15	50
	02.0	03.0	"		1.67	13.40	53
	03.0	04.0	"		1.65	13.62	45
	04.0	05.0	"		1.78	14.71	53
	05.0	06.0	"		1.62	15.93	49
	06.0	07.0	"		1.70	14.18	57
	07.0	07.5	Platey slag + brn. soil. Base of Slag 7.3m. Approx.		1.85	12.01	52
	07.5	09.0	Soil; brn, damp.				
			E/H. 09.0m.				
				7.5m	1.68	13.54	51

ANALYTICAL DATA (ppm)

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 09 SEP 90

Co-ordinates

8307.7 m N/S

2818.4 m E/W

173.4 R.L.

HOLE No. ZAC 01

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368090

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm)		
						Pb %	Zn %	Ag (g/t)
ZAC 02	00.0	TO	01.0	Slag: dk. gy, platey.		1.65	7.90	60
	01.0		02.0	"		1.42	8.06	62
	02.0		03.0	"		2.45	9.54	64
	03.0		04.0	"		1.82	8.56	56
	04.0		05.0	"		2.11	6.25	52
	05.0		06.0	"		2.05	7.63	50
	06.0		07.0	"		1.92	8.15	47
	07.0		08.0	"		2.22	7.93	52
	08.0		08.5	Slag, platey + Dk. brn. soil. Base of slag 8.3 Approx.		2.01	7.57	62
	08.5		09.0	Dk. brn soil and water (brn mud.)				
				E/H: 9:0m.				
	04.0		05.0	Duplicate sample.	Method 104	2.05	6.20	48
					617		7.40	
					8.5m	1.95	7.97	55

DRILLING RECORD

Drill Type: Mantis 200 Air Core	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8324.7 m N/S	ZAC
Date: 09 SEP 90	2807.9 m E/W	02
	173.8 R.L.	

SAMPLING RECORD

Material: .... Sampled By: ....

Lab. Req. No. .... Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD — SAMPLE DATA SHEET — 368091

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 03	00.0	TO	01.0	Slag: dk.gy, platey:		1.60	13.55	63
	01.0		02.0	"		1.20	11.78	58
	02.0		03.0	"		1.00	9.62	54
	03.0		04.0	"		1.40	11.50	62
	04.0		05.0	"		1.35	10.95	51
	05.0		06.0	"		1.53	10.50	55
	06.0		07.0	"		2.40	12.60	83
	07.0		08.0	"		2.36	10.95	73
	08.0		09.0	"		2.17	12.49	90
	09.0		09.4	Platey Slag + Soil ; Base of slag 9.3m. approx.		2.30	9.41	83
	09.4		11.0	Brn soil.				
				E/H: 11m.				
					9.4m.	1.69	11.45	66

DRILLING RECORD		
Drill Type: Mantis 200 Air Core	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8341.8 m N/S	ZAC
Date: 09 SEP 90	2798.5 m E/W	03
	173.8 R.L.	

SAMPLING RECORD	
Material:	Sampled By:
Lab. Req. No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

306092

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb%	Zn%	Ag (g/t)
ZAC 04	00.0	TO	01.0	Slag; dk. gy., platey.		1.71	14.96	56
	01.0		02.0	"		1.65	13.62	44
	02.0		03.0	"		1.70	13.80	46
	03.0		04.0	"		1.77	13.28	48
	04.0		05.0	"		1.63	14.51	45
	05.0		06.0	"		1.87	13.97	50
	06.0		06.8	Platey slag + minor soil; Base of Slag 6.6m approx.		1.60	14.67	51
	06.8		08.0	Soil; dk. brn, damp.				
				E/H: 8.0m.				
					6.8m.	1.70	14.09	48

DRILLING RECORD			SAMPLING RECORD		PROJECT
Drill Type: Mantis 200 Air Core	Co-ordinates	HOLE No.	Material:	Sampled By:	Project:
Dip: -90 Azm: —	8318.2 m N/S	ZAC	Lab. Req. No.	Date:	Cost Code:
Date: 09 SEP 90	2835.4 m E/W	04			
	173.7 R.L.				

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368093

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		Pb%	Zn%	Ag (g/t)
						ANALYTICAL DATA (ppm)		
ZAC 05	00.0	TO	01.0	Slag; dk.gy, platey		1.95	8.26	59
	01.0		02.0	"		1.62	7.80	40
	02.0		03.0	"		2.02	8.00	35
	03.0		04.0	"		2.35	7.75	65
	04.0		05.0	"		1.58	8.89	60
	05.0		06.0	"		1.49	8.11	52
	06.0		07.0	"		1.93	9.14	68
	07.0		08.0	Platey slag + minor brn.soil. Base of Slag 7.9m.approx.		1.60	10.11	50
	08.0		09.0	Soil; brn, moist.				
				E/H: 09.0m.				
					8.0m	1.81	8.50	53

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 09 SEP 90

Co-ordinates: 8335.2 m N/S; 2825.0 m E/W

173.7 R.L

HOLE No. ZAC 05

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368094

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE	DESCRIPTION		ANALYTICAL DATA (ppm) Pb%	Zn%	Ag (g/t)
ZAC 06	00.0 TO 01.0	Slag; dk.gy, platey.		1.78	9.92	56
	01.0 02.0	"		2.23	11.90	71
	02.0 03.0	"		2.45	11.15	88
	03.0 04.0	"		2.27	9.95	71
	04.0 05.0	"		2.25	17.29	68
	05.0 06.0	"		1.99	10.32	77
	06.0 07.0	"		1.85	11.15	68
	07.0 08.0	"		2.30	9.21	68
	08.0 09.0	Base of Slag; 9.0m. approx. (Poss. 9.05m)		1.78	9.94	72
	09.0 11.0	Soil; dk. brn, damp.				
		E/H. 11m.				
	04.0 05.0	Duplicate sample. Method 104		2.35	16.83	71
		617			14.50	
			9.0m	2.10	11.20	71

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: —90 Azm: —

Date: 09 SEP 90

Co-ordinates

8,350.6 m N/S

2815.4 m E/W

173.8 R.L.

HOLE No. ZAC 06

SAMPLING RECORD

Material: ....

Lab.Req.No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368095

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE		DESCRIPTION		ANALYTICAL DATA (ppm) Pb%	Zn%	Ag (g/t)
ZAC 07	00.0 TO	01.0	Slag; dk.gy; platey. Minor soil – Top 0.3cm. may have been spread.		2.05	11.52	73
	01.0	02.0	"		1.85	9.35	66
	02.0	03.0	"		1.85	10.10	65
	03.0	04.0	"		2.14	9.63	66
	04.0	05.0	"		1.68	9.20	67
	05.0	06.0	"		1.76	8.94	75
	06.0	07.0	"		1.64	8.48	64
	07.0	07.5	Platey slag; minor soil; wet; Base of Slag 7.4m Approx.		1.43	7.45	66
	07.5	09.0	Soil; dk.brn.				
			E/H: 09.0m.				
	01.0	02.0	Duplicate Sample. Zn by 104		1.80	10.10	63
			Zn by 617			12.30	
				7.5m.	1.82	9.45	67

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 09 SEP 90

Co-ordinates: 8328.7 m N/S; 2851.6 m E/W

174.3 R.L

HOLE No. ZAC 07

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368096

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb%	Zn%	Ag (g/t)
ZAC 08	00.0	TO	01.0	Slag; dk.gy, platey.		3.54	10.80	100
	01.0		02.0	"		2.25	11.60	72
	02.0		03.0	"		1.95	12.68	65
	03.0		04.0	"		1.74	12.83	56
	04.0		05.0	"		1.72	10.79	66
	05.0		06.0	"		2.05	11.50	70
	06.0		07.0	"		1.72	9.98	78
	07.0		08.0	Platey slag + minor soil and water. Base of slag 7.8m Approx.		1.79	9.13	83
	08.0		10.0	Soil; dk.brn; heavy water.				
				E/H. 10.0m.				
					8.0m	2.09	11.16	72

DRILLING RECORD		
Drill Type: Mantis 200 Air Core	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8345.7 m N/S	ZAC 08
Date: 09 SEP 90.	2841.9 m E/W	
	174.0 R.L.	

SAMPLING RECORD	
Material:	Sampled By:
Lab. Req. No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368097

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb %	Zn %	Ag (g/t)
ZAC 09	00.0	TO	01.0	Slag; dk.gy; platey		1.91	12.96	73
	01.0		02.0	"		1.29	13.60	56
	02.0		03.0	"		1.24	12.58	54
	03.0		04.0	"		1.70	12.32	60
	04.0		05.0	"		1.48	13.24	52
	05.0		06.0	"		1.96	13.40	66
	06.0		07.0	"		1.56	12.20	75
	07.0		07.5	Platey slag + wet soil. Base slag 7.3m. approx.		1.55	10.61	73
	07.5		09.0	Soil; brn, moist.				
				E/H: 09.0.				
					7.5m	1.58	12.74	63

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: -

Date: 09 SEP 90

Co-ordinates

8339.2 m N/S

2867.5 m E/W

174.2 R.L.

HOLE No. ZAC 09

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD — SAMPLE DATA SHEET

368098

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		Pb	Zn	Ag.
ZAC 10	00.0	TO	01.0	Dk. gy. platey Slag		1.43	15.00	55
	01.0		02.0	" "		1.43	16.15	55
	02.0		03.0	" "		1.30	18.03	52
	03.0		04.0	" "		1.12	16.25	60
	04.0		05.0	" "		1.15	13.54	71
	05.0		06.0	" "		1.24	17.0	54
	06.0		07.0	" "		1.54	16.62	48
	07.0		08.0	" " ; Very damp sample.		3.95	7.64	105
	08.0		09.0	" " Sample very wet. Base of Slag approx 8.8		2.78	5.15	84
				Brown soupy water made bedrock determination difficult.				
	09.0		11.0	Bedrock sandstones, qtzites; Very wet sample.				
				E/H : 11.0m.				
					9.0m	1.77	13.93	64

DRILLING RECORD

Drill Type: Walls Mantis 200 A.C.
Dip: -90° Azm: -
Date: 05 Sept. 90

Co-ordinates
8227.56 m N/S
2796.74 m E/W
171.8 R.L.

HOLE No. ZAC 10

SAMPLING RECORD

Material: ....
Lab. Req. No. ....
Sampled By: ....
Date: ....

PROJECT

Project: ....
Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368099

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 11	00.0	TO	01.0	Platey Slag; Very hard 0.2-0.5m.		1.75	16.40	79
	01.0		02.0	" " ;		1.60	19.55	70
	02.0		03.0	" "		2.18	13.53	72
	03.0		04.0	" "		2.40	15.75	59
	04.0		05.0	" "		1.86	11.18	69
	05.0		06.0	" "		4.20	10.80	110
	06.0		06.8	" " Base of Slag 6.8m.		3.37	9.25	97
	06.8		09.0	White sands; Brown soil.				
				E/H 9.0m.				
					6.8m.	2.45	13.91	78

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: –

Date: 05 SEP 90

Co-ordinates

8,211.4 m N/S

2,808.6 m E/W

172.0 R.L.

HOLE No. ZAC 11

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD — SAMPLE DATA SHEET

368100

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE		DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 12	00.0	TO 01.0	Dk. gy., platey slag. Very hard 0.2–0.4m.		2.38	11.20	43
	01.0	02.0	"		3.09	16.54	55
	02.0	03.0	" ; Base of slag 03.0m. Approx.		3.05	13.04	53
	03.0	05.0	White sand, bedrock				
	01.0	02.0	Duplicate Sample Zn by 104		2.84	15.96	50
			Zn by 617			15.40	
				3.0m	2.82	13.59	50

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 0

Co-ordinates: 8,195.3 m N/S; 2,820.4 m E/W

172.4 R.L.

HOLE No. ZAC 12

SAMPLING RECORD

Material:

Lab. Req. No.

Sampled By:

Date:

PROJECT

Project:

Cost Code:

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368101

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 13	00.0	TO	01.0	Dk. gy. platey slag : No hard sections		2.32	13.95	60
	01.0		02.0	" "		2.30	11.36	47
	02.0		03.0	" "		3.20	12.26	36
	03.0		04.0	" "		2.97	11.97	24
	04.0		05.0	" "		3.20	10.41	25
	05.0		06.0	" " ; Base of Slag 6.0m .		2.39	9.69	20
	06.0		08.0	Sandy white- brown soil and sandstones.				
					6.0m.	2.73	11.60	35

DRILLING RECORD		
Drill Type: Mantis 200; AirCore	Co-ordinates	HOLE No.
Dip: – 90 Azm: —	8179.2 m N/S	ZAC
Date: 05 SEP 90	2832.3 m E/W	13
	172.4 R.L.	

SAMPLING RECORD	
Material:	Sampled By:
Lab. Req. No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD — SAMPLE DATA SHEET

368102

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE				DESCRIPTION			ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 14	00.0	TO	01.0		DK. gy slag ; coarse but not ultrahard.			1.48	13.90	44
	01.0	TO	02.0					1.50	14.56	51
	02.0	TO	03.0					1.75	14.78	60
	03.0		04.0					1.73	13.51	61
	04.0		05.0					1.78	12.37	76
	05.0		06.0					1.55	11.30	62
	06.0		07.0	A	}			2.10	10.92	60
	06.0		07.0	B	} Duplicate Sample					
	07.0		07.6		Base of slag 7.6m.			1.56	8.80	30
	07.6		09.0		Clay, white, puggy, + sst. fragments					
					E/H. 09.0 m.					
							7.6m	1.68	12.71	56
	06.0		07.0		Duplicate Sample	Zn by 104		2.00	10.46	55
						Zn by 617			11.50	

DRILLING RECORD		
Drill Type: Mantis 200 AirCore	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8163.1 m N/S	ZAC
Date: 06SEP90	2844.1 m E/W	14
	172.3 R.L.	

SAMPLING RECORD	
Material:	Sampled By:
Lab. Req. No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD — SAMPLE DATA SHEET

368103

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 15	00.0	TO	01.0	DK gray platey slag.		1.85	14.04	47
	01.0		02.0	" "		1.80	15.35	65
	02.0		03.0	" "		1.64	13.57	75
	03.0		04.0	" "		1.34	15.20	53
	04.0		05.0	" "		1.50	12.96	52
	05.0		06.0	"		1.66	13.75	60
	06.0		07.0	"		1.69	12.23	56
	07.0		08.0	"		1.49	12.44	66
	08.0		08.5	Base of Slag 8.4m. approx.		1.62	12.36	75
	08.5		10.5	Brown soil; mud; White Sandstone.				
				E/H. 10.5m.				
					8.5m	1.62	13.61	60

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: − 90 Azm: ~~0~~

Date: 06 SEP 90.

Co-ordinates: 8147.4 m N/S; 2856.6 m E/W; 172.3 R.L.

HOLE No. ZAC 15

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD — SAMPLE DATA SHEET

368104

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE	DESCRIPTION		Pb	Zn	Ag
ZAC 16	00.0 TO 01.0	DK gy platey slag.		1.30	12.41	54
	01.0 02.0	"		1.21	12.66	43
	02.0 03.0	"		1.40	13.65	48
	03.0 04.0	"		1.20	11.10	43
	04.0 05.0	" Slag finer than previous holes		1.10	8.47	34
	05.0 06.0	" but probably due to different		1.62	10.23	33
	06.0 07.0	" drill bit.		1.34	11.57	41
	07.0 08.0	" Still all platey.		1.67	12.27	56
	08.0 09.0	"		1.80	12.05	55
	09.0 09.8	Base of Slag		2.33	12.54	73
	09.8 11.8	Clay, gy., blue; plus brown soil.				
		E/H. 11.8				
		Note: Hole 3.0m South (grid drill line) from Surveyed Site.				
			9.8m.	1.48	11.67	47

ANALYTICAL DATA (ppm)

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 06 SEP 90

Co-ordinates: 8131.9 m N/S; 2842.3 m E/W; 172.2 R.L.

HOLE No. ZAC 16

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD SAMPLE DATA SHEET 368105

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 17	00.00	TO	01.0	Slag, dk.gy, platey, Very hard in first metre		2.07	11.60	92
	01.0		02.0	" " "		1.18	11.20	57
	02.0		03.0			1.32	12.35	56
	03.0		04.0			1.38	11.15	50
	04.0		05.0	} Duplicate Samples		1.40	11.15	52
	04.0		05.0					
	05.0		06.0			1.60	11.80	66
	06.0		07.0			1.50	10.72	45
	07.0		08.0			1.66	10.25	50
	08.0		09.0			2.39	13.30	82
	09.0		10.0			2.46	12.35	105
	10.0		10.6	Base of Slag 10.5m. approx.		2.23	11.32	75
	10.6		12.0	Brown soil; light brown sand and sst.				
				E/H. 12.0m.				
	04.0		05.0	Duplicate Sample Zn by 104		1.43	10.94	50
				Zn by 617			12.20	
					10.6m	1.72	11.57	66

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: ——

Date: 06 SEP 90

Co-ordinates: 8151.3 m N/S; 2828.0 m E/W

172.7 R.L.

HOLE No. ZAC 17

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368106

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 18	00.0	TO	01.0	Slag; dkgy, platey. Very hard first metre		2.33	10.90	92
	01.0		02.0	" "		2.60	11.27	87
	02.0		03.0	"		3.05	13.88	74
	03.0		04.0	"		3.24	13.70	68
	04.0		05.0	"		2.83	10.85	47
	05.0		06.0	" Very large chips (3-4cms)		3.07	9.45	53
	06.0		07.0	" due to different bit.		2.70	10.50	55
	07.0		08.0	" Variable sample sizes		3.10	10.20	60
	08.0		09.0	" suggest some cavities.		3.60	9.38	56
	09.0		10.0	Base of Slag 9.8m. Approx.		3.48	11.00	72
	10.0		12.0	Soil, dk.brn, damp; sst.chips.				
				E/H. 12m.				
					10.0m.	3.00	11.11	66

DRILLING RECORD		
Drill Type: Mantis 200; Air Core	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8167.4 m N/S	ZAC
Date: 06 SEP 90	2816.1 m E/W	18

172.7 R.L.

SAMPLING RECORD	
Material:	Sampled By:
Lab.Req.No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD — SAMPLE DATA SHEET

368107

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 19	00.0	TO	01.0	Dk. gy. platey Slag.		3.10	10.96	89
	01.0		02.0	"		2.30	10.21	86
	02.0		03.0	"		2.70	10.98	88
	03.0		04.0	"		2.40	11.33	83
	04.0		05.0	"		2.31	12.07	75
	05.0		06.0	"		1.95	11.23	79
	06.0		07.0	"		1.98	10.76	75
	07.0		08.0	"		1.83	9.60	68
	08.0		09.0	"		1.94	10.10	45
	09.0		10.0	" ; About 70% normal sample size		1.40	8.70	30
	10.0		11.0	Base of Slag ; " and damp.		2.15	9.40	32
	11.0		12.0	Soil, light brown ; qtzite ; Damp.				
				E/H ; 12m.				
	04.0		05.0	Duplicate Sample Zn by 104		2.20	12.22	70
				Zn by 617			12.10	
					11.0m	2.18	10.48	68

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 06 SEP 90

Co-ordinates: 8183.5 m N/S; 2804.3 m E/W; 172.7 R.L.

HOLE No. ZAC 19

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368108

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 20	00.0	TO	01.0	Slag: dK-gy platey;		1.35	12.95	60
	01.0		02.0	"		1.48	12.34	69
	02.0		03.0	"		1.43	10.71	65
	03.0		04.0	"		1.52	10.35	69
	04.0		05.0	"		1.45	10.79	90
	05.0		06.0	"		1.55	9.85	54
	06.0		07.0	"		1.85	11.73	73
	07.0		08.0	"		1.90	9.20	79
	08.0		08.8	Hit steel; bit would not penetrate:		2.17	12.50	71
				Hole stopped an estimated 1-1.5m short of base of slag.				
					8.8m	1.62	11.12	69

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 07 SEP 90

Co-ordinates

8,200.3 m N/S

2,792.8 m E/W

HOLE No. ZAC 20

SAMPLING RECORD

Material:

Lab. Req. No.

Sampled By:

Date:

PROJECT

Project:

Cost Code:

DRAGON RESOURCES LTD — SAMPLE DATA SHEET — 368109

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE	DESCRIPTION		Pb	Zn	Ag
ZAC 21	00.0 TO 01.0	Slag: dk-gy, Platey.		1.40	16.40	55
	01.0 02.0	"		1.40	14.30	50
	02.0 03.0	"		1.47	16.80	56
	03.0 04.0	"		1.60	15.70	62
	04.0 05.0	"		1.35	15.58	43
	05.0 06.0	"		1.25	14.50	45
	06.0 07.0	"		1.39	14.80	65
	07.0 08.0	"		1.65	12.05	56
	08.0 09.0	"		4.05	10.70	72
	09.0 10.0	Base of slag 9.8m. Approx } Samples about 60% normal size		3.75	15.25	93
	10.0 12.0	Soil; soft-brn. and wet.				
		E/H: 12m.				
	04.0 TO 05.0	Duplicate sample Zn by 104		1.24	15.32	40
		Zn by 617			16.70	
			10.0m	1.90	14.60	59

ANALYTICAL DATA (ppm)

DRILLING RECORD

Drill Type: Mantis 200 Air Core
Dip: -90 Azm: —
Date: 07 SEP 90

Co-ordinates
8,215.7 m N/S
2,780.6 m E/W
171.9 R.L.

HOLE No. ZAC 21

SAMPLING RECORD

Material: ....
Lab. Req. No. ....
Sampled By: ....
Date: ....

PROJECT

Project: ....
Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368110

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		Pb	Zn	Ag
ZAC 22	00.0	TO	01.0	Slag; dk-gy, platey		1.40	15.34	54
	01.0		02.0	"		1.45	16.04	52
	02.0		03.0	"		1.25	15.64	53
	03.0		04.0	"		1.30	16.82	61
	04.0		05.0	"		1.35	15.48	50
	05.0		06.0	"		1.55	15.74	69
	06.0		07.0	"		1.46	17.75	65
	08.0		08.0	"		1.60	18.60	58
	08.0		09.0	Slag; black, finely granular and unconsolidated.		3.35	12.85	60
	09.0		10.0	Base of granular slag		4.50	11.50	60
	10.0		10.4	Mixed granular slag and soil.		3.12	7.50	45
	10.4		12.0	Soil, brown, damp; sst chips.				
				E/H: 12m				
					10.4m	1.96	15.26	57

ANALYTICAL DATA (ppm)

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: –

Date: 07 SEP 90

Co-ordinates: 8,228.1 m N/S; 2,772.4 m E/W

171.6 R.L.

HOLE No. ZAC 22

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD SAMPLE DATA SHEET 368111

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 23	00.0	TO	01.0	Slag, dk. gy, platey.		3.40	14.99	109
	01.0		02.0	"		1.55	12.65	39
	02.0		03.0	"		1.90	12.93	45
	03.0		04.0	"		1.94	15.80	54
	04.0		05.0	"		1.88	15.78	56
	05.0		06.0	"		2.60	14.20	88
	06.0		07.0	"		1.60	14.00	70
	07.0		08.0	Slag, black, finely granular and unconsolidated		2.05	11.91	77
	08.0		09.0	"		1.65	13.00	65
	09.0		10.0	"		3.17	11.56	57
	10.0		11.0	Base of granular slag		3.52	10.65	45
	11.0		11.8	Mixed granular slag and soil.		2.85	8.80	37
	11.8		14.0	Light brn. soil and sandstone chips.				
				E/H. 14.0.				
	04.0		05.0	Duplicate Sample Zn by 104		1.75	15.92	52
				Zn by 617			15.6	
					11.8m	2.33	13.09	62

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 07 SEP 90

Co-ordinates

8,204.3 m N/S

2,765.1 m E/W

171.9 R.L.

HOLE No. ZAC 23

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368112

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 24	00.0	TO	01.0	Slag, dk. gy. platey		1.60	11.20	49
	01.0		02.0	"		1.30	13.90	60
	02.0		03.0	"		1.75	12.78	59
	03.0		04.0	"		1.91	10.72	67
	04.0		05.0	"		2.12	11.89	65
	05.0		06.0	"		2.18	14.95	64
	06.0		07.0	"		2.50	12.82	77
	07.0		08.0	"		2.55	10.54	56
	08.0		09.0	Slag, black, finely granular and unconsolidated.		2.82	11.60	82
	09.0		10.0	"		3.70	12.32	84
	10.0		11.0	"		2.95	12.16	70
	11.0		12.0	Base of granulated slag.		3.17	13.46	59
	12.0		12.7	Mixed granulated slag and soil.		2.46	8.94	39
	12.7		14.0	Soil, Light brown; plus sst. chips.				
				E/H: 14m				
					12.7m	2.38	12.17	64

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: −90 Azm: —

Date: 07SEP90

Co-ordinates

8187.8 m N/S

2776.3 m E/W

172.2 R.L.

HOLE No. ZAC 24

SAMPLING RECORD

Material:

Lab. Req. No.

Sampled By:

Date:

PROJECT

Project:

Cost Code:

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368113

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE	DESCRIPTION		ANALYTICAL DATA (ppm) Pb	Zn	Ag
ZAC 25	00.0 TO 01.0	Slag; dk.gy, platey		1.30	13.82	41
	01.0 02.0	"		1.70	13.50	36
	02.0 03.0	"		1.58	12.85	51
	03.0 04.0	"		1.55	12.69	45
	04.0 05.0	"		1.30	13.05	45
	05.0 06.0	"		1.25	12.25	37
	06.0 07.0	"		1.45	12.05	40
	07.0 08.0	"		1.75	12.42	41
	08.0 09.0	"		1.65	11.00	46
	09.0 10.0	"		2.48	11.00	70
	10.0 11.0	"		3.10	10.78	70
	11.0 12.0	"		3.20	10.40	50
	12.0 13.0	Base of slag. 12.8m. Approx.		3.20	8.62	63
	13.0 13.5	Zone of mixed soil+slag; wet.		2.01	8.60	52
	13.5 15.0	Mud and brn. sand.				
		E/H. 15.0m.				
	09.0 10.0	Duplicate Sample. Zn by 104		2.34	11.00	75
		Zn by 617			12.6	
			13.5m.	1.96	11.75	48

DRILLING RECORD		
Drill Type: Mantis 200 Air Core	Co-ordinates	HOLE No.
Dip: -90 Azm: -	8172.3 m N/S	ZAC
Date: 07 SEP 90	2789.6 m E/W	25
	172.5 R.L.	

SAMPLING RECORD	
Material:	Sampled By:
Lab. Req. No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368114

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE		DESCRIPTION		ANALYTICAL DATA (ppm) Pb%	Zn%	Ag (g/t)
ZAC 26	00.0	TO 01.0	Slag; dk.gy, platey.		1.36	16.20	48
	01.0	02.0	"		1.12	14.80	40
	02.0	03.0	"		1.05	15.47	31
	03.0	04.0	"		1.27	16.35	34
	04.0	05.0	"		1.30	17.31	39
	05.0	06.0	"		1.15	16.60	33
	06.0	07.0	"		1.30	15.50	37
	07.0	08.0	"		1.24	14.88	32
	08.0	09.0	"		1.40	15.86	35
	09.0	10.0	"		1.35	15.80	40
	10.0	11.0	"		1.55	17.10	42
	11.0	12.0	"		1.45	13.80	39
	12.0	13.0	"		1.45	14.67	43
	13.0	14.0	"		1.50	13.40	47
	14.0	15.0	Base of Slag ; Very strong water flow 15.0m		1.48	9.44	46
	15.0	16.0			1.95	11.20	69
	16.0	17.0			2.03	9.97	79
	17.0	18.0			2.50	10.00	48
	18.0	19.7	Hard dk. gy sltst. with narrow qtz. veins.				
			E/H 19.7 m.				
				18.0m.	1.46	14.35	43

DRILLING RECORD

Drill Type: Mantis 200 AirCore.
Dip: −90 Azm: —
Date: 07 SEP 90

Co-ordinates
8,155.6 m N/S
2,800.0 m E/W
172.4 R.L.

HOLE No.
ZAC
26.

SAMPLING RECORD

Material: ....
Lab. Req. No. ....
Sampled By: ....
Date: ....

PROJECT

Project: ....
Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368115

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE	DESCRIPTION		Pb %	Zn %	Ag (g/t)	
ZAC 27	00.0 TO 01.0	Slag: dk.gy., platey		1.66	13.65	46	
	01.0 02.0	"		1.47	14.80	41	
	02.0 03.0	"		1.67	14.00	45	
	03.0 04.0	"		1.20	15.40	38	
	04.0 05.0	"		1.50	16.33	43	
	05.0 06.0	"		1.45	14.60	44	
	06.0 07.0	"		1.72	16.18	41	
	07.0 08.0	"		1.25	18.05	40	
	08.0 09.0	"		1.06	15.36	38	
	09.0 10.0	"		1.04	15.32	41	
	10.0 11.0	"		1.38	16.03	49	
	11.0 12.0	"		1.27	15.50	40	
	12.0 13.0	"		1.52	15.00	41	
	13.0 14.0	"		1.26	14.50	36	
	14.0 15.0	Very wet sample; coarse, dk gy platey slag.		1.67	14.90	41	
	15.0 16.0	"		1.78	11.05	63	
	16.0 17.0	" Base of Slag 17.0m.		1.55	10.48	62	
	17.0 18.0	Large water inflows; poor sample; hole stopped.		(1.40	1.75	53)	Not Slag
		E/H: 18.0m.					
	02.0 03.0	Duplicate sample. Zn by 104		1.61	14.68	47	
		Zn by 617			15.6		
			17.0m	1.43	14.77	44	

DRILLING RECORD

Drill Type: Mantis 200 Air Core	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8138.3 m N/S	ZAC
Date: 08 SEP 90	28122 m E/W	27
	172.4 R.L.	

SAMPLING RECORD

Material: ....
Sampled By: ....
Lab. Req. No. ....
Date: ....

PROJECT

Project: ....
Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368116

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE		DESCRIPTION		ANALYTICAL DATA (ppm) % Pb	% Zn	Ag (ppm)
ZAC 29	00.0	TO 01.0	Slag: Dk. gy, platey	1	1.60	16.00	55
	01.0	02.0	"		1.48	15.75	56
	02.0	03.0	"		1.56	15.64	48
	03.0	04.0	"		1.77	15.75	48
	04.0	05.0	"		1.56	15.54	48
	05.0	06.0	"		1.40	15.38	45
	06.0	07.0	"		2.02	16.40	43
	07.0	08.0	"		1.99	14.30	41
	08.0	09.0	"		1.43	16.30	41
	09.0	10.0	"		1.66	13.40	37
	10.0	11.0	"		1.71	14.91	35
	11.0	12.0	"		1.40	15.30	41
	12.0	13.0	"		1.33	15.20	56
	13.0	14.0	"		1.34	15.92	48
	14.0	15.0	" ; sample size 50% normal and damp.		1.69	13.09	37
	15.0	16.0	Very wet samples; strong water inflows; dk. gy. platey slag.		1.70	12.65	33
	16.0	17.0	" " "		1.52	15.50	40
	17.0	18.0	" " "		1.81	15.69	52
	18.0	19.0	" " "		1.50	15.24	49
	19.0	20.0	Possibly dk. sltst. with thin qtz. veins; poss. bedrock? } No		1.50	13.49	51
	20.0	21.0	" " " " } Slag.		1.13	10.86	40
			Base Slag 21.0m Approx.				
			E/H. 21.0m.				
			Zn by 104		1.27	16.57	41
	08.0	09.0	Duplicate Sample Zn by 617			17.0	
				21.0m	1.57	14.87	44

DRILLING RECORD		
Drill Type: Mantis 200 Air Core	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8,127.6 m N/S	ZAC
Date: 08 SEP 90.	2,795.8 m E/W	29
	172.3 R.L	

SAMPLING RECORD	
Material:	Sampled By:
Lab. Req. No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD — SAMPLE DATA SHEET

368117

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE	DESCRIPTION		ANALYTICAL DATA (ppm) Pb%	Zn%	Ag (g/t)
ZAC 28	00.0 TO 01.0	Slag: dk. gy, platey		0.51	15.42	45
	01.0 02.0	"		1.54	14.92	49
	02.0 03.0	"		1.47	15.86	48
	03.0 04.0	"		1.15	17.30	45
	04.0 05.0	"		1.37	16.55	57
	05.0 06.0	"		1.47	17.10	60
	06.0 07.0	"		1.55	14.60	48
	07.0 08.0	"		1.90	14.07	38
	08.0 09.0	"		1.77	13.52	35
	09.0 10.0	"		1.29	16.80	50
	10.0 11.0	"		1.52	15.15	57
	11.0 12.0	"		1.48	14.52	44
	12.0 13.0	"		1.47	14.67	42
	13.0 14.0	"		1.52	16.36	47
	14.0 15.0	Platey slag; Samples very wet — strong water inflows.		1.69	14.81	59
	15.0 16.0	" " "		1.57	15.00	53
	16.0 17.0	" " "		1.59	13.56	44
	17.0 18.0	Some qtz. chips amongst platey slag; possible Bedrock?		1.76	10.08	70
		Base Slag 18.0m Approx.				
		E/H: 18m.				
	09.0 10.0	Duplicate sample Zn by 104		1.18	17.10	56
		Zn by 617			16.8	
			18.0m	1.47	15.01	49

DRILLING RECORD

Drill Type: Mantis 200 Air Core
Dip: -90 Azm: —
Date: 08 SEP 90

Co-ordinates
8,125.5 m N/S
2823.1 m E/W
172.3 RL

HOLE No. ZAC 28

SAMPLING RECORD

Material:
Lab. Req. No.
Sampled By:
Date:

PROJECT

Project:
Cost Code:

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368118

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm) Pb%	Zn%	Ag(ppm.)
ZAC 30	00.00	TO	01.0	Slag; dk.gy, platey.		1.60	15.57	59
	01.0		02.0	"		1.39	16.50	39
	02.0		03.0	"		1.55	15.97	34
	03.0		04.0	"		1.03	14.90	32
	04.0		05.0	"		1.28	14.37	34
	05.0		06.0	"		1.13	16.60	49
	06.0		07.0	"		1.21	15.36	59
	07.0		08.0	"		1.40	14.25	39
	08.0		09.0	"		1.29	14.43	32
	09.0		10.0	"		1.39	15.50	36
	10.0		11.0	"		1.43	15.35	42
	11.0		12.0	"		1.50	14.90	43
	12.0		13.0	"		1.69	15.20	79
	13.0		13.4	Platey slag + dk. brn. soil. Bedrock. Base of Slag. 13.2m. Approx.				
	13.4		15.0	DK. brn. mud and clay.				
				E/H. 15.0				
					13.0m	1.37	15.30	44

DRILLING RECORD		
Drill Type: Mantis 200 AirCore	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8143.7 m N/S	ZAC 30
Date: 08 SEP 90.	2783.9 m E/W 172.1 R.L.	

SAMPLING RECORD	
Material:	Sampled By:
Lab. Req. No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368119

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE		DESCRIPTION		ANALYTICAL DATA (ppm) Pb %	Zn %	Ag (g/t)
ZAC 31	00.0 TO	01.0	Slag; dk.gy. platey.		1.48	29.50	59
	01.0	02.0	"		1.82	26.60	43
	02.0	03.0	"		1.35	27.80	30
	03.0	04.0	"		1.08	15.46	42
	04.0	05.0	"		1.30	16.49	43
	05.0	06.0	"		1.36	16.23	40
	06.0	07.0	"		1.42	14.75	40
	07.0	08.0	"		1.45	15.40	31
	08.0	09.0	"		1.14	14.49	35
	09.0	10.0	"		1.28	14.25	37
	10.0	11.0	"		1.65	14.90	46
	11.0	12.0	"		1.75	17.20	58
	12.0	12.8	Base of Slag; Mixture of slag + lt.brn.soil.		1.40	9.50	44
	12.8	15.0	DK. brn. damp clay.				
			E/H. 15.0m.				
						*	
	01.0	02.0	Duplicate Sample. Zn by 104		1.72	28.3	41
			Zn by 617			15.1	
				12.8m	1.42	18.02	42

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 08 SEP 90

Co-ordinates: 8159.8 m N/S; 2772.1 m E/W

172.3 R.L.

HOLE No. ZAC 31

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368120

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm)		
						Pb%	Zn%	Ag (g/t)
ZAC 32	00.0	TO	01.0	Dk. gy. platey slag.		1.94	15.52	70
	01.0		02.0	"		1.02	15.00	53
	02.0		03.0	"		1.30	14.20	59
	03.0		04.0	"		0.82	15.30	41
	04.0		05.0	"		1.54	16.15	47
	05.0		06.0	"		1.65	15.45	36
	06.0		07.0	"		1.40	15.08	50
	07.0		08.0	"		1.31	11.23	52
	08.0		09.0	"		1.60	10.18	41
	09.0		10.0	" } Samples only 70%		2.00	11.64	59
	10.0		11.0	" } Approx. of normal size.		1.87	12.50	70
	11.0		12.0	Granular slag from 11.2 – 12.0		1.43	11.40	46
	12.0		12.8	Base of Granular Slag; minor cl. and soil.		1.65	11.70	54
	12.8		15.0	Clay (damp.) and dk. brn soil.				
				E/H. 15m.				
	04.0		05.0	Duplicate sample. Zn by 104		1.50	16.60	49
				Zn by 617			16.9	
					12.8	1.50	13.51	52

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: –90 Azm: —

Date: 08 SEP 90

Co-ordinates

8176.7 m N/S

2761.5 m E/W

172.3 R.L.

HOLE No. ZAC 32

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368121

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE	DESCRIPTION		ANALYTICAL DATA (ppm) Pb %	Zn %	Ag(g/t)
ZAC 33	00.0 TO 01.0	Slag; dk.gy, platey		1.40	16.60	54
	01.0 02.0	"		1.46	15.68	49
	02.0 03.0	"		1.32	15.29	45
	03.0 04.0	"		1.03	15.10	50
	04.0 05.0	"		1.22	14.75	55
	05.0 06.0	"		1.19	14.94	54
	06.0 07.0	"		1.20	15.44	57
	07.0 08.0	"		1.10	15.25	54
	08.0 09.0	"		1.07	15.24	48
	09.0 10.0	" } Samples 70% of normal		1.45	15.30	64
	10.0 11.0	" } size		1.30	16.50	44
	11.0 12.0	"		1.40	16.05	51
	12.0 13.0	"		1.38	16.45	42
	13.0 14.0	Base of Slag; mixed platey slag; gran.slag and brn soil.		1.20	15.40	41
	14.0 15.0	Moist dk. brn. clayey soils.				
		E/H: 15.0				
			14.0m.	1.26	15.57	50

DRILLING RECORD		
Drill Type: Mantis 200 Air Core	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8,148.5 m N/S	ZAC
Date: 08 SEP 90	2,756.5 m E/W	33
	172.2 R.L.	

SAMPLING RECORD	
Material:	Sampled By:
Lab. Req. No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD SAMPLE DATA SHEET

368122

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE		DESCRIPTION		ANALYTICAL DATA (ppm) Pb %	Zn %	Ag (g/t)
ZAC 34	00.00	TO 01.0	Slag; dk.gy, platey.		1.40	16.93	56
	01.00	02.0	"		1.40	17.23	60
	02.00	03.0	"		1.60	17.41	65
	03.0	04.0	"		1.47	16.65	63
	04.0	05.0	"		1.25	15.55	64
	05.0	06.0	"		1.22	15.36	58
	06.0	07.0	"		1.15	15.75	58
	07.0	08.0	"		1.21	15.50	50
	08.0	09.0	"		1.30	15.05	50
	09.0	10.0	"		0.95	15.67	39
	10.0	11.0	"		1.05	16.12	51
	11.0	12.0	"		1.52	15.70	48
	12.0	13.0	"		1.26	16.20	41
	13.0	14.0	"		1.34	16.54	35
	14.0	15.0	Base of Slag; Minor dk. brn. soil and clay.		0.80	10.34	17
	15.0	17.0	Clay, dk. brn., soil; sst. chips; very wet.				
			E/H. 17.0m.				
	04.0	05.0	Duplicate Sample. Zn by 104		1.24	15.50	60
			Zn by 617			16.3.	
				15.0m.	1.26	15.73	50

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 09 SEP 90

Co-ordinates: 8133.4 m N/S; 2767.8 m E/W

HOLE No. ZAC 34

172.182

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

DRAGON RESOURCES LTD SAMPLE DATA SHEET 368123

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE			DESCRIPTION		ANALYTICAL DATA (ppm)		
						Pb %	Zn %	Ag (g/t)
ZAC 35	00.0	TO	01.0	Slag; black granular, unconsolidated.		2.53	10.97	40
	01.0		02.0	Granular slag + minor soil; Base slag 1.8m. approx.		1.82	9.84	17
	02.0		03.0	Soil; brown.				
				E/H : 3.0m.				
					2.0m	2.17	10.40	28

DRILLING RECORD		
Drill Type: Mantis 200 Air Core	Co-ordinates	HOLE No.
Dip: -90 Azm: —	8216.8 m N/S	ZAC
Date: 10 SEP 90	2753.2 m E/W	35
	162.3 RL	

SAMPLING RECORD	
Material:	Sampled By:
Lab. Req. No.	Date:

PROJECT
Project:
Cost Code:

DRAGON RESOURCES LTD

SAMPLE DATA SHEET

368124

SAMPLE NUMBER	DRILL HOLE DEPTH or SAMPLE CO ORDINATE	DESCRIPTION		Pb %	Zn %	Ag(g/t)
ZAC 36	00.0 TO 01.0	Slag; black, granular, unconsolidated.		1.58	10.27	36
	01.0 01.5	Granular slag; minor soil.; Base slag 1.4m. approx.		1.30	7.10	25
	01.5 03.0	Soil; brown and gray clay.				
		E/H: 3.0m.				
			2.0m.	1.44	8.68	30

ANALYTICAL DATA (ppm)

DRILLING RECORD

Drill Type: Mantis 200 Air Core

Dip: -90 Azm: —

Date: 10 SEP 90

Co-ordinates

8156.2 m N/S

2728.2 m E/W

160.1 R.L.

HOLE No. ZAC 36

SAMPLING RECORD

Material: ....

Lab. Req. No. ....

Sampled By: ....

Date: ....

PROJECT

Project: ....

Cost Code: ....

APPENDIX B

RESOURCE SERVICE GROUP MEMORANDUM

Resource Service Group PTY. LTD. Inc. in W.A.

MEMORANDUM

TO : STEVEN STONE - JOINT MANAGING DIRECTOR DRAGON MINING LTD

FROM : JULIAN BARNES

DATE : 14 DECEMBER 1990

SUBJECT : ZEEHAN DUMPS BLOCK MODELLING

Block modelling has been undertaken on both the north and south dumps at Zeehan. Table 1 displays the modelling parameters used.

Variography was carried out on both dumps using uncomposited data. Variography was principally undertaken on the zinc assay data and was used to determine ranges. Statistical analysis (summarised in Table 2) has indicated that cutting of higher grades does not appear to be warranted (namely the close similarity between the arithmetic mean and Sichels T). No compositing of the data was carried out prior to block modelling.

An inverse distance squared weighting algorithm has been used rather than kriging due to time limitations. Given the smooth distribution of all three elements, it is believed that the inverse distance squared estimate will give a good approximation of the grade distribution within the dumps.

Table 3 displays a comparison between the digital terrain modelled volume with mean grade data from the raw data set compared to the block modelling volumes and grades. A density of 3 tonnes per cubic metre has been used to calculate the tonnages. As is evident, the block sizes used (10 metres northing, 10 metres easting and 2 metres RL for the south dump, and 5 metres northing, 5 metres easting and 2 metres RL for the north dump) have enabled close approximations to the DTM volumes.

Table 4 displays the grade tonnage breakdown for the north and south dumps using zinc percentage as the category element.

An antipathetic relationship between lead and zinc is evident in the south dump (and to a lesser extent in the north dump).

90 BROOKMAN STREET, KALGOORLIE, WESTERN AUSTRALIA 6430. P.O. BOX 1138, KALGOORLIE, W.A. 6430. TEL.: (090) 21 4700. FAX.: (090) 21 2050

The block modelling exercise is believed to have produced a good estimation of the tonnage and grade within the Zeehan dumps, however, the brief study has a number of limitations which should be rectified for a full feasibility analysis:-

(i) The granular and platey slags in the south dump have not been modelled separately.

(ii) Variography was not carried out extensively on lead and silver, and hence the precise ranges of influence for these two elements are not known in detail.

(iii) The ranges determined for zinc have been used to model all three elements.

(iv) Kriging has not been carried out to date.

(v) Sub-blocking has not been used (and would allow greater accuracy in volume determination, although the technique cannot be used in kriging).

(vi) Density data has not been modelled and density has been assigned using a conservative factor of 3 g/t.

(vii) The effect of compositing has not been determined.

(viii) Block value plots have not been produced yet (although they can be created quickly).

Notwithstanding these limitations, it is believed that the fourteen level plans included with this memorandum will allow Dragon Mining Ltd to build a greater understanding of the grade distribution within the Zeehan dumps. It is evident that the dumps have high grade zones of which exploitation would clearly benefit early cash flow.

If you require it, I can compile all work carried out to date into a formal report.

Please do not hesitate to contact me if you have any queries.

With best regards,

Julian

Julian

TABLE 1

ZEEHAN DUMPS
BLOCK MODELLING PARAMETERS

	SOUTH DUMP	NORTH DUMP
Easting Origin	362705	362780
Northing Origin	358080	358280
RL Origin	153	165
Easting Block Size	10	5
Easting Blocks	18	25
Northing Block Size	10	5
Northing Blocks	18	25
RL Block Size	2	2
RL Blocks	10	5
East Search Radius	50	30
North Search Radius	50	30
RL Search Radius	5	2
Horizontal Skew	Ø	Ø
Vertical Dip	Ø	Ø
Inverse Power	2	2
Calculate No. of Points	Yes	Yes
Calculate Standard Deviation	Yes	Yes
Constrained by DTM Volume	Yes	Yes

ZEEHAN STATISTICAL SUMMARY TABLE 2
WHOLE DATA SET

Dump	Element	No. Of Samples	Min	Max	Mean	95% Confidence Limits	Standard Deviation	Variance	Coefficient of Variation	Geometric Mean	LNSD	LNVAR	Sichels t
Sth Dump	Pb	324	0.00	4.50	1.63	0.09	0.7854	0.6168	0.48	1.66	0.3257	0.1061	1.75
Sth Dump	Zn	324	0.00	29.50	12.68	0.50	4.5952	21.1159	0.36	13.35	0.2429	0.0590	13.75
Sth Dump	Ag	324	0.00	109	49	2.00	20.7100	429.0500	0.42	51	0.3000	0.0900	53
Nth Dump	Pb	84	0.00	3.54	1.64	0.15	0.6716	0.4511	0.41	1.80	0.1965	0.0386	1.84
Nth Dump	Zn	84	0.00	17.04	9.82	0.89	4.0796	16.6428	0.42	10.75	0.2173	0.0472	10.97
Nth Dump	Ag	84	0.00	100	55	5.00	22.4100	502.3000	0.41	61	0.2000	0.0400	61

ZEEHAN STATISTICAL SUMMARY
MINERALISED INTERVAL SAMPLES ONLY

Dump	Element	No. Of Samples	Min	Max	Mean	95% Confidence Limits	Standard Deviation	Variance	Coefficient of Variation	Geometric Mean	LNSD	LNVAR	Sichels t
Nth Dump	Pb	75	1.00	3.54	1.84	0.09	0.3739	0.1398	0.20	1.80	0.1965	0.0386	1.84
Nth Dump	Zn	75	6.23	17.04	11.00	0.54	2.3499	5.5220	0.21	10.75	0.2173	0.0472	10.97
Nth Dump	Ag	75	35	100	62	3	12.23	149.55	0.20	61	0.20	0.04	62
Sth Dump	Pb	300	0.51	4.50	1.76	0.07	0.6600	0.4356	0.25	1.66	0.3257	0.1061	1.75
Sth Dump	Zn	300	1.75	29.50	13.70	0.34	2.9775	8.8658	0.22	13.35	0.2429	0.0590	13.75
Sth Dump	Ag	300	17	109	53	2	15.86	251.45	0.30	51	0.30	0.09	53
Sth Dump	Pb	280	0.51	4.20	1.70	0.70	0.6028	0.3634	0.35	1.62	0.3067	0.0941	1.70
Platey Slag	Zn	280	1.75	29.50	13.89	0.35	2.9556	8.7356	0.21	13.54	0.2404	0.0578	13.95
	Ag	280	17	109	53	2	15.70	246.49	0.30	51	0.29	0.08	53
Sth Dump	Pb	20	1.30	4.50	2.56	0.42	0.8942	0.7996	0.35	2.41	0.3650	0.1332	2.55
Granular	Zn	20	7.10	14.00	11.08	0.87	1.8693	3.4943	0.17	10.91	0.1836	0.0337	11.13
Slag	Ag	20	17	84	53	9	18.37	337.62	0.35	50	0.40	0.16	54

Note: All populations approximate lognormal distribution.
Statistics calculated on uncomposited and uncut data

TABLE 3

ZEEHAN DUMPS
GRADE AND TONNAGE COMPARISONS

Dump	DTM/Section Volume	Density	Tonnes	Stats Grades			Block Model Volume	Density	Tonnes	Block Model Grades		
				Zn%	Pb%	Ag (ppm)				Zn%	Pb%	Ag (ppm)
South Dump	125333	3.0	375999	13.70	1.76	53	123200	3	369600	13.92	1.69	52
North Dump	26381	3.0	79143	11.00	1.84	62	27050	3	81150	10.83	1.85	62

368131

TABLE 4

ZEEHAN DUMPS
GRADE TONNAGE DATA

SOUTH DUMP

From	To	Volume	Tonnes	Zn	Pb	Ag	Cum. Vol	Cum. Tonnes	Zn	Pb	Ag
10	11	1800	5400	10.60	1.91	47	1800	5400	10.60	1.91	47
11	12	10400	31200	11.66	2.08	57	12200	36600	11.50	2.06	55
12	14	49400	148200	12.98	1.86	56	61600	184800	12.68	1.90	52
14	16	56400	169200	14.98	1.49	48	118000	354000	13.78	1.70	52
16	18	4400	13200	16.56	1.39	50	122400	367200	13.88	1.69	52
>18		800	2400	20.17	1.44	45	123200	369600	13.92	1.69	52

NORTH DUMP

From	To	Volume	Tonnes	Zn	Pb	Ag	Cum. Vol	Cum. Tonnes	Zn	Pb	Ag
0	10	7100	21300	9.33	1.86	59	7100	21300	9.33	1.86	59
10	11	8000	24000	10.54	1.88	65	15100	45300	9.97	1.87	62
11	12	7850	23550	11.46	1.88	64	22950	68850	10.48	1.88	63
12	14	3850	11550	12.73	1.72	55	26800	80400	10.80	1.85	62
14	16	250	750	14.24	1.69	50	27050	81150	10.83	1.85	62

Note: Zn% used as Grade Tonnage category control. Block modelled by inverse distance squared.

APPENDIX C

DESIGN CRITERIA

C.1 Site Date

C.2 Climatic Conditions

C.3 Plant Operations

C.4 Slag Feed

C.5 Coal Feed

C.6 Process Criteria

C.7 Products

C.0 DESIGN CRITERIA

The design criteria presented in this Appendix are those used applicable to the calculation by Ausmelt of operating and capital costs for Process Options A-D.

C.1 SITE DATA

(a) Location	Tasmanian Smelting Co Site, Zeehan, Tasmania 2.5 km SSE of Zeehan Township Latitude 41.53 S Longitude 145.20 E
(b) Elevation	150 - 200 m AHD
(c) Townsites	Rosebery 24 km NE Queenstown 40 km SE Burnie 150 km NNE Hobart 295 km SE
(d) Communications	Post service through Australia Post at Zeehan Courier services available via local agents. Telephone through Telecom at Zeehan, no service to site.
(e) Road Access	The site adjoins a sealed roadway.
(f) Rail Access	A Pasminco owned rail line runs from Burnie and terminates at Melba Flats, approximately 12km NW of the site.
(g) Air Services	A small airstrip is located at Zeehan, but is used infrequently.
(h) Power	No power is available at the site.
(i) Water	Town water is not available at the site.

C.2 CLIMATIC CONDITIONS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum Temperature												
High	24.4	24.9	21.1	18.8	15.2	13.3	12.4	13.7	14.9	18.2	18.6	21.2
Low	16.4	15.3	15.6	12.6	11.4	9.4	9.1	9.1	10.6	11.1	13.3	15.0
Ave	19.5	20.2	18.4	15.4	13.2	11.2	10.8	11.5	13.3	14.9	16.3	18.2
Minimum Temperature												
High	11.1	12.1	10.5	9.3	7.8	6.8	6.0	5.6	6.4	7.9	9.0	11.1
Low	6.2	7.7	6.4	4.5	2.2	-1.8	1.3	0.8	3.2	1.6	4.4	5.2
Ave	8.8	9.5	8.4	6.9	5.5	3.8	3.4	3.8	4.8	5.7	6.9	8.2
Rainfall												
Mean (mm)	139	114	151	216	240	252	265	263	230	221	190	165
Median (mm)	133	106	153	207	226	247	255	254	218	218	187	159
Mean Raindays	17	14	18	20	21	20	23	24	22	22	20	18
Wind (km/h)												
at 0900 hours												
Range - Min	1	1	1	1	1	1	1	1	1	1	1	1
- Max	50	50	>50	>50	50	50	>50	>50	>50	50	>50	50
Median	10	10	10	5	10	5	10	5	10	10	20	10
at 1500 hours												
Range - Min	1	1	1	1	1	1	1	1	1	1	1	1
- Max	50	50	>50	>50	50	50	>50	>50	>50	50	>50	50
Median	20	20	10	10	10	10	10	10	10	10	20	20

C.3 PLANT OPERATIONS

(a) Availability

Operating Mode	Continuous or batch
Effective Operating Hours	7,500 h/a

(b) Slag Treatment Rate 15 t/h
112,500 t/a

(c) Resource

Stock Size	450,750 t
Project Life	4 years

C.4 SLAG FEED

(a) Analysis

Zn (average of whole dump)	13.64%
Pb "	1.72%
Ag "	54 ppm
Cu	2238 ppm
Bi	100 ppm
Ni	81 ppm
Co	63 ppm
Au	0.138 ppm
Cd	4.9 ppm
S	3.33%
Ge	9.51 ppm
CaO	11.35%
SiO_2	19.96%
Fe_2O_3	32.08%
Al_2O_3	3.78%
MgO	1.30%
LOI	4.74%
As	350 ppm
Sb	380 ppm
Sn	384 ppm
Na_2O	0.07%
K_2O	0.56%
MnO	7.46%
P_2O_5	0.12%
TiO_2	0.17%

(b) Sizing

In Dump	<300 mm
Furnace Feed	<40 mm

(c) Density

Bulk	1.6 to 1.9 t/m^3

C.5 COAL FEED

(a) Source	Merrywood Coal Company
(b) Sizing	-35mm, d50 = 10mm
(c) Moisture	10% (as rec'd)
(d) Proximate Analysis	**Ad Wt%**
Moisture	5.0
Ash	23.2
VM	28.8
Fixed C	48.0
S	0.43
P	-
(e) Ash Analysis	Wt%
SiO_2	60.9
Al_2O_3	32.6
Fe_2O_3	3.14
CaO	0.99
MgO	0.72
TiO_2	1.32
Na_2O	0.11
K_2O	0.89
P_2O_5	0.12
Mn_3O_4	0.05
So_3	0.31

C.6 FURNACE CRITERIA

(a) Furnace Approximate Dimensions

		A	B	C	D
SMELT	Internal Diam.(m)	3.5	4.0	4.7	4.0
	Height (m)	7.0	7.0	7.8	7.0
REDUCE	Internal Diam.(m)	2.9	-	-	-
	Height (m)	4.8	-	-	-

(b) Lining

Lower Refractory Type	Chrome Mag. Brick
Thickness	250 mm
Upper Refractory Type	Chrome Bonded Castable
Thickness	250 mm
Insulation Lining Type	Insulating Board or Blanket
Thickness	25 mm

C.7 MASS AND ENERGY BALANCE

See Tables 7-9.

C.8 PRODUCTS

See Tables 18-20.

APPENDIX D
PLANT DESCRIPTION

D.0 PLANT DESCRIPTION

The Plant Description given here is that prepared by BHP for a 10t/h single furnace plant operating to a discard slag level of 3% zinc.

In the discussion of the plant, refer to Figure (Drawing E200-400-001), the Conceptual Process Flowsheet.

The 15t/hr plant proposed by Ausmelt would be virtually identical in all but scale and output.

D.1 PLANT LOCATION

The plant for retreating the slag was taken as being at the slag dump site, at Zeehan. The evaluation of other sites was outside the scope of this study.

The siting of the plant at the slag dump has a number of advantages.

- Feed slag does not have to be transported and stockpiled.
- Discard slag does not have to be transported to a dump site.
- Infrastructure requirements at the Zeehan site are not excessive.
- Water is readily available at the Zeehan site.
- There is no necessity to purchase or lease land for the plant.
- There should be very little impact of the plant on the environment and the site is remote from any settlements.

Were the slag to be transported any distance for treatment at an alternative source then this would have a significant negative impact on project returns. A coastal site would be advantageous for bringing in additional feeds for the plant at a later date but this would probably involve locating the smelter close to a population centre which is not desirable.

D.2 INFRASTRUCTURE

D.2.1 Communications

There is no telephone service available near to the site. The site would require a radio service link via Zeehan.

D.2.2 Access

Good road access is available, a sealed road adjoins the site. There is good access to Burnie, NW ports and Hobart via the main highway network.

The Emu Bay Railway terminates at Melba Flats, approximately 12 km NW of the site. This is a private rail line used by Pasminco and Aberfoyle.

Airlines of Tasmania and local charter services operate to Queenstown. A small airstrip is located at Zeehan, however, it is used infrequently.

D.2.3 Power

No power is available at the site. The nearest HEC substation is at Zeehan, approximately 2 km from the site.

To supply power to the site a line would be run from Zeehan.

Two commercial tariffs for power are available, however the tariff applied to the project would be subject to negotiation with HEC.

Tariff No 22:

Daily Charge	\$0.2/day
Unit Charge	\$0.1333/kWh
Government Charge	5% of total

Tariff No 83:

Daily Charge	\$0.709/day
Unit Charge	\$0.0533/kWh
Demand Charge	\$36.88/kWh peak demand/quarter
Government Charge	5% of total

D.2.4 Water

Town water is not available at the site.

Water will need to be abstracted from either Austral Creek or the Little Henty River. In both cases, approval is required from the Rivers and Water Supply Commission. Austral Creek is adjacent to the site and would require the installation of a weir and associated headworks.

Portable water is assumed to be drawn from the creek.

The Little Hentry River is approximately 1.5km to the east of the site. A weir, headworks and power to the site would be required.

D.3 FEED PREPARATION AND HANDLING

The proposed Sirosmelt plant will be sited adjacent to the slag dumps, 100SP01. The slag will be recovered from the dumps by front end loader, 100ME01.

Coal will be received by truck and stockpiled, 100SP02, on site. At 25t/truck, between 2 and 3 trucks per day will be required. The as received coal will be -35mm and no size reduction will be required.

The coal and slag will be delivered to the dump hopper, 100DH01, by the front end loader. A static grizzly, 100SC01, will retain any lumps greater than 300mm. Lumps larger than 300mm will be broken up or removed by the front end loader.

The sizer/crusher, 100CR01, will crush the slag to -40mm. The slag will then travel via conveyor 100CV01, bucket elevator 100BE01, and conveyer 200CV02 to the crushed slag bin 200BN03.

The coal will pass through the crusher and travel via 100CV01, 100BE01 to 200CV02. Conveyor 200CV02 is a reversing conveyor, loading slag one way and coal the other. From 200CV02 the coal is fed onto a single deck screen, 200SC02 screening at 10mm. The -10mm coal passes to the fine coal bin 200BN01 and the + 10mm fraction passes to the lump coal bin 200BN02.

A tramp iron magnet 100MA01 will remove any scrap iron that enters the system, prior to 100BE01.

Crushed slag and reductant coal will be continuously proportioned by weigh feeders 200CV02 and 200CV03, respectively, onto the furnace feed conveyor 200CV05. The plant operator will set the proportions required based on analysis of the feed slag zinc content. The feed mix of slag and reductant will be elevated to the furnace feed port by the furnace feed bucket elevator 200BE02.

The discharge from the fine coal bin will be metered by a rotary valve 200RV04. The fine coal will feed the coal mill which will crush the coal to -250 micron. The coal will then be pneumatically transported to the furnace.

D.4 FURNACE AREA

The slag and reductant charge drop into the furnace through a seal valve 300RV01.

The furnace, 300FU01, is cylindrical in shape. The furnace is lined with chrome-magnesite bricks and backed by an insulating lining. The outer shell of the furnace is steel, which is shower cooled. The upper part of the furnace and the exit duct is chrome bonded or similar castable refractory. This area is also backed by insulating material.

The top of the furnace includes ports for the lance, 300LA01, and sampling. The off-take flue is a conical section on top of the furnace, which connects to the gas handling train.

The lance consists of two annular tubes. Finely ground coal is pneumatically conveyed down the inner tube. Combustion air is carried in the annulus between the inner and outer tube. The combustion air acts as a coolant for the lance and is assisted by swirlers located in the annulus between the inner and outer tuber. A solidified layer of slag builds up on the outer surface of the lance, and this provides the protection required from the molten slag.

At the top of the lance there is a third concentric tube, that extends only part way down the lance. This allows the entry of the after burner air to the furnace. This air cools the top portion of the lance and also provides oxygen for the after burner reactions.

The lances are patented items and would be supplied under arrangement with Ausmelt. As the lances are not consumable items, it is expected that only three lances will be required. The lance can bend and thus may periodically require straightening. Also, damage can occur to the lance tip, which may require repair. This involves cutting off the worn or damaged tip and welding on a new section.

Two hoists are provided for lance handling. The main hoist, 300HT01, has a 2 tonne capacity and is used to position and hold the lance in the furnace. A second hoist, 300HT02, is provided for maintenance and to raise and lower spare lances from the lance rack.

The fuel coal is ground in the coal mill, 200CM01. The ground coal is conveyed down the lance from the coal pump, 300PC01. The conveying air is part of the air provided as combustion air. The high pressure blower, 300CP02, provides the combustion air for the process. The after burner air is provided by a low pressure blower, 300CP01.

D.5 DISCARD SLAG HANDLING

Depending on the slag properties, the discard slag will be either continuously tapped or batch tapped from the furnace. The slag will be tapped through a water cooled copper tapping block, 300TB01. It will then pass down a launder, 400LU01, and into a stream of water. The granulated slag will accumulate in the granulating pit. The accumulated slag will be periodically removed from the pit by temporarily stopping the slag flow, draining the pit and removing the slag by front end loader.

The discard slag has no value and could be used as land fill or to rebuild the dumps.

D.6 GAS AND PRODUCT HANDLING

The fume and off gases are drawn off the furnace through a refractory lined duct. This gas can have a temperature of around 1700°C and is cooled by water in a gas cooler. The cooling water is sprayed into the gas stream at the top of the cooler, the evaporation of the water providing the cooling to reduce the temperature to about 200°C.

Cooling the gas to about 200°C is required for the baghouse 500BH01, which will remove the metal oxide fume from the gas stream. The fume will collect in the bottom of the baghouse.

The off gas exiting the baghouse will be essentially N_2, CO_2 and water vapour. The furnace draught will be provided by an ID fan, 500CP05. The off gas will be discharged to the atmosphere via a stack, 500ST01.

The fume could require densification to meet the specification of the smelters. This would be done by drawing the fume from the baghouse through an air lock, 500RV03, into a pug mill, 500PM01. A controlled amount of water added to the pug mill would agglomerate the fume to 1 to 6mm diameter pellets.

The densified fume could discharge from the pug mill directly into a bagging station before transport to the refinery. The load out operation will only be carried out on day shift.

D.7 ELECTRICAL AND INSTRUMENTATION

For electrical power distribution to the plant, refer to Drawing No E200-400-005.

The 3.3kV switchboard will supply the following:

1) The 1.2 MW combustion air blower.

2) The furnace feed MCC, via a 250KVA 3.3/.44kV transformer. This MCC controls the coal and slag handling and the raw material storage and furnace feed equipment.

3) The furnace and product handling MCC via a 1000 kVA 3.3/.44 kV transformer. This MCC controls the equipment in the furnace, slag handling and gas and product handling areas.

   A further 415 V power distribution panel is connected to the furnace and product handling MCC to provide lighting and small power distribution around the site, the plant compressor station and water pumps.

   Two separate panels provide the necessary operator controls:

   1) Compressor House Control Panel comprising start/stop controls, valve controls and indication for the compressors and Id fan.

   2) Main Plant Control comprising start/stop controls, local/remote selection and process controls. This panel will control all drives in the Furnace Feed, Furnace and Product Handling areas of the plant.

   All 415 V drives will have a field mounted local isolator/start/stop station.

   Plant electrical control functions are relatively simple and will be carried out by an inexpensive but rugged PLC system suitable for operations in the environment expected.

   Process controls will be a combination of manual and automatic functions. Individual loop controllers will be provided to maintain such variables as gas cooling water flow rate, furnace draught through the Id fan control dampers, fuel addition rate to maintain furnace temperature, reductant to slag ratio etc., while the operator will set such variables as furnace temperature, slag feed rate, air pressure, etc. In addition, the operator will take regular samples of feed and waste slag and analyse these for zinc content on a small x-ray fluorescence analyser, to allow him to adjust reductant feed rate, fuming conditions, etc.

D.8 PLANT SERVICES

A compressor, accumulator and air drier have been specified to provide plant air for the baghouse, instruments and water spray atomization.

Office accommodation has been allocated, along with provision for a store and small workshop. An amenities block is also provided.

D.9 PRELIMINARY PLANT DESIGN

Based on the Conceptual Process Flow Diagram, E200-400-001, a preliminary plant layout was designed. Drawing E200-400-002 shows that GA Elevation and section Drawing E200-400-003 shows the GA Plan for the proposed plant.

A simple plant layout was adopted for this study. No attempt was made to optimise the layout, shorten duct length and conveyor runs. The design is however functional.

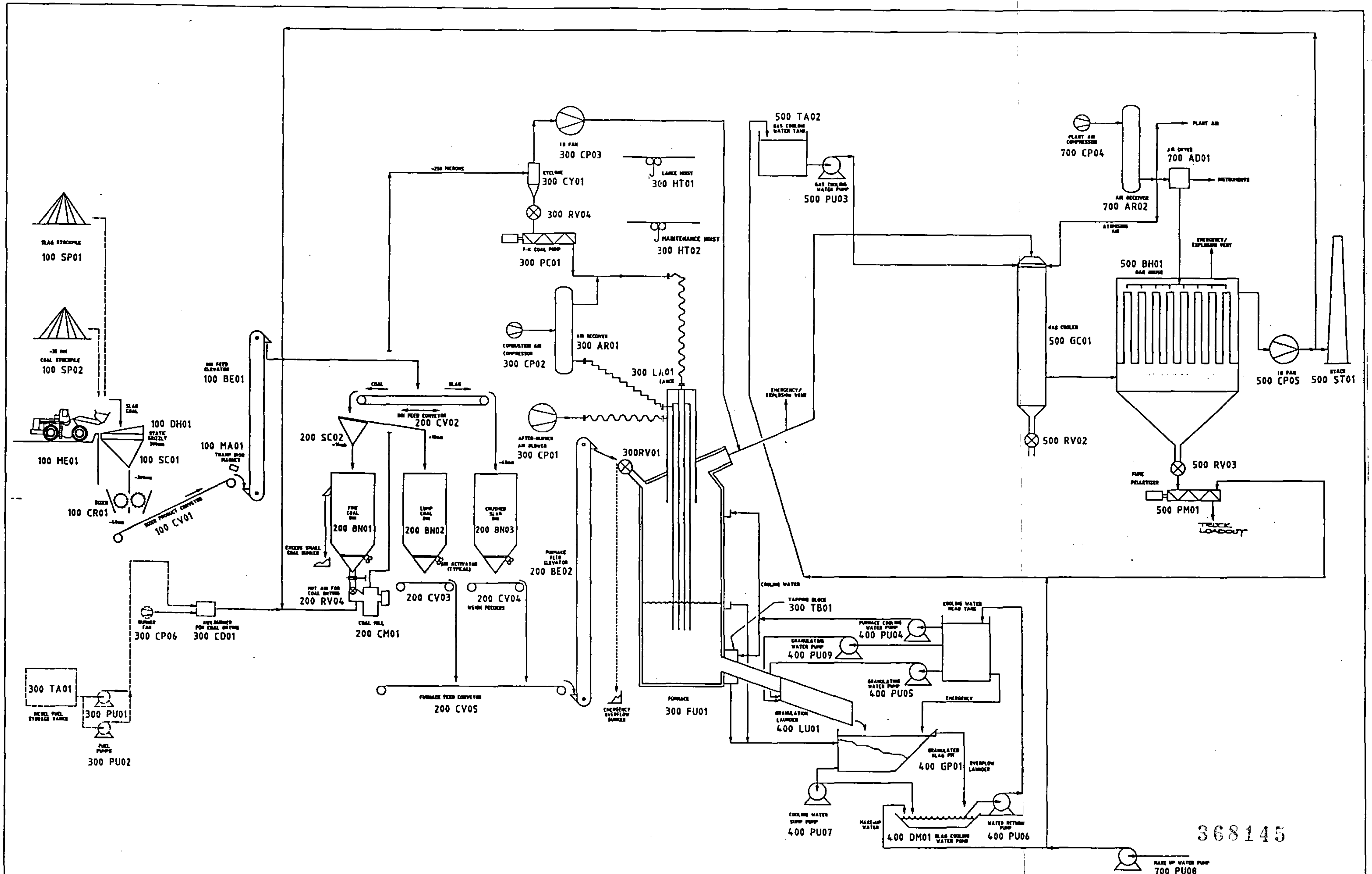
Bin sizes has been selected to keep structural and civil costs to a minimum.

Only very preliminary estimates were made of the furnace size, to allow structural and layout estimates. It would be necessary to improve the design input into this area in a more detailed study.

Cooler and baghouse capacities were designed with input from equipment suppliers, based on the design criteria.

The proposed plant design has been tentatively placed on a site plan as shown in Drawing E200-400-004. The site plan shows that the plant can be located on the terrace above the slag dumps, with access to the main road.

While no plant layout or arrangements have been prepared for a dual furnace plant, the layout would be basically similar, with the furnaces alongside one another. They would have separate gas handling and fume collection systems.



CAD AREA= MMINGOLD
CAD FILE NO.= E2004001.DGN
JOB NO.= E200/400

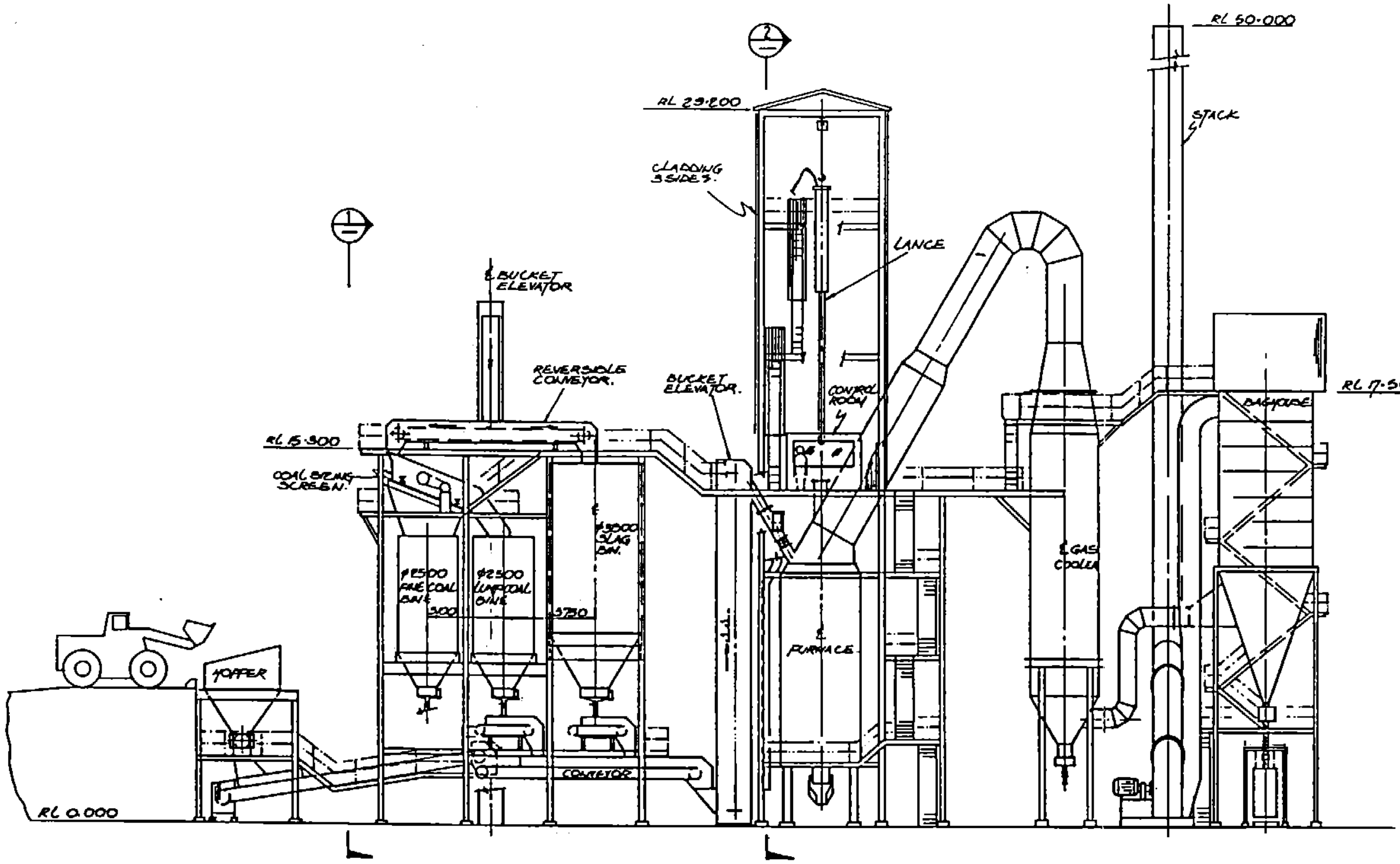
No	DATE	BY	CHK	DESCRIPTION	BHP	CLIENT	DRAWING No	TITLE
A	11-10-90	ETH		ISSUED FOR COMMENT				

REVISIONS | APPROVAL | REFERENCE DRAWINGS

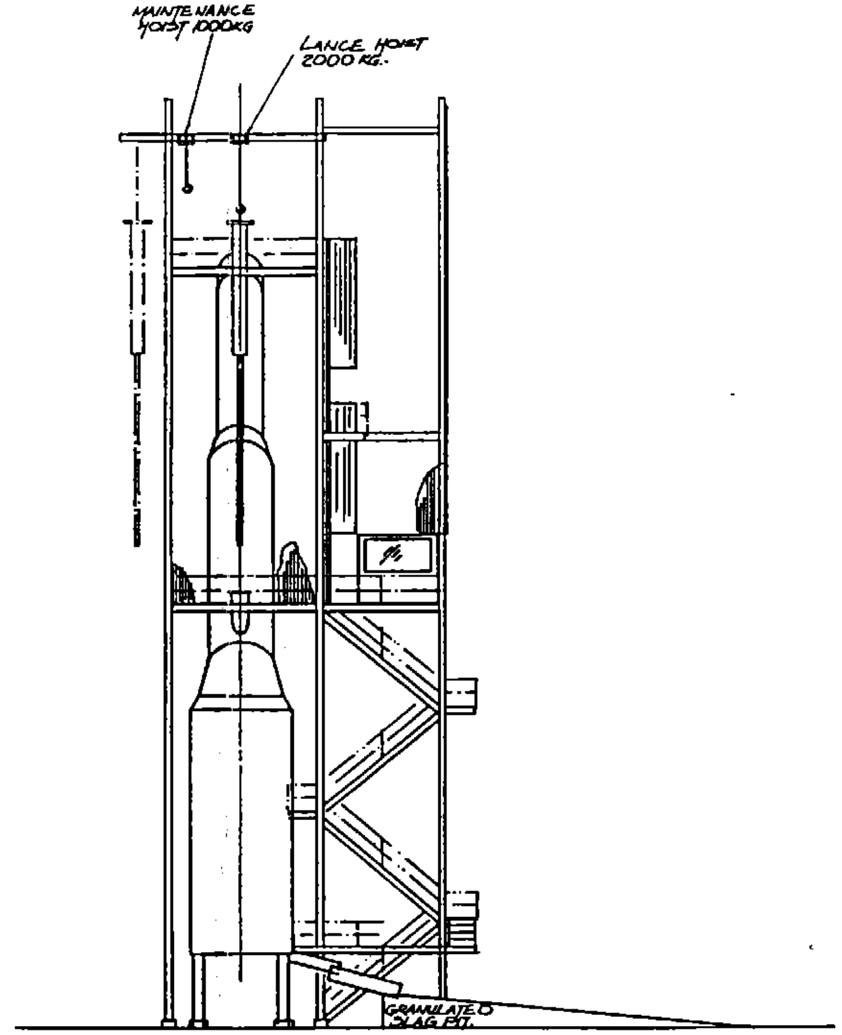
BHP Engineering - PERTH

PYROSMELT N.L.
ZEEHAN SLAG RETREATMENT
CONCEPTUAL PROCESS DIAGRAM

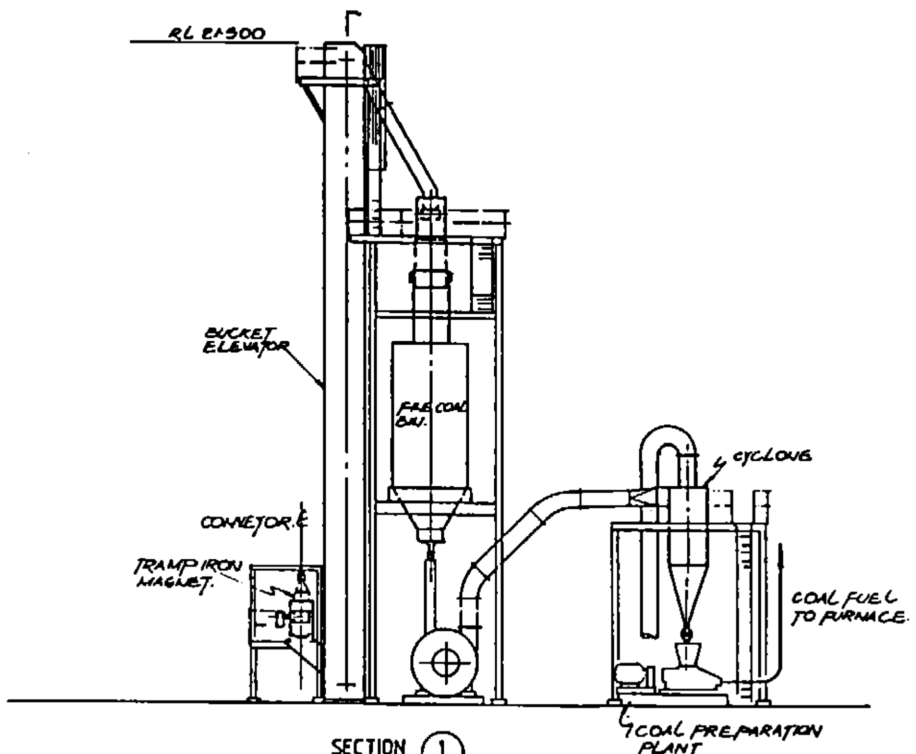
SCALE | DATE 2-10-90 | B1 | DRG No E200-400-001 | /A



ELEVATION



SECTION 2



SECTION 1

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5 cm

REV	DATE	BY	CHK	DESCRIPTION
A	19·10·90			ISSUED FOR COMMENT

REVISIONS | APPROVAL | REFERENCE DRAWINGS

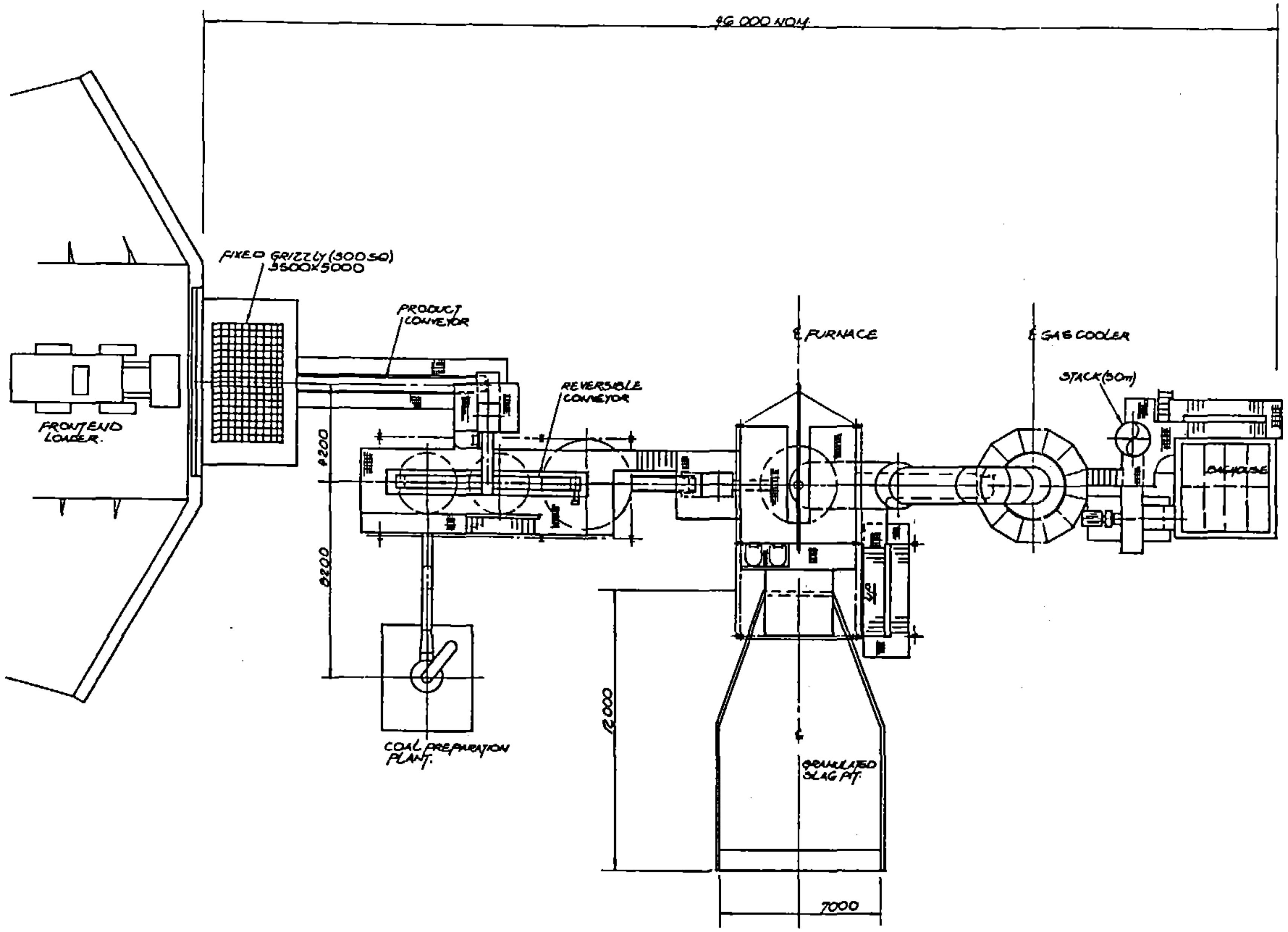
SIGNED .... DATE ....

DRAWN E.H 17.10.90

BHP Engineering – PERTH

PYROSMELT N.L.
ZEEHAN SLAG RETREATMENT
GENERAL ARRANGEMENT
ELEVATION & SECTIONS

SCALE 1:100 | DATE | B1 | DRG Nº E200-400-002 /A



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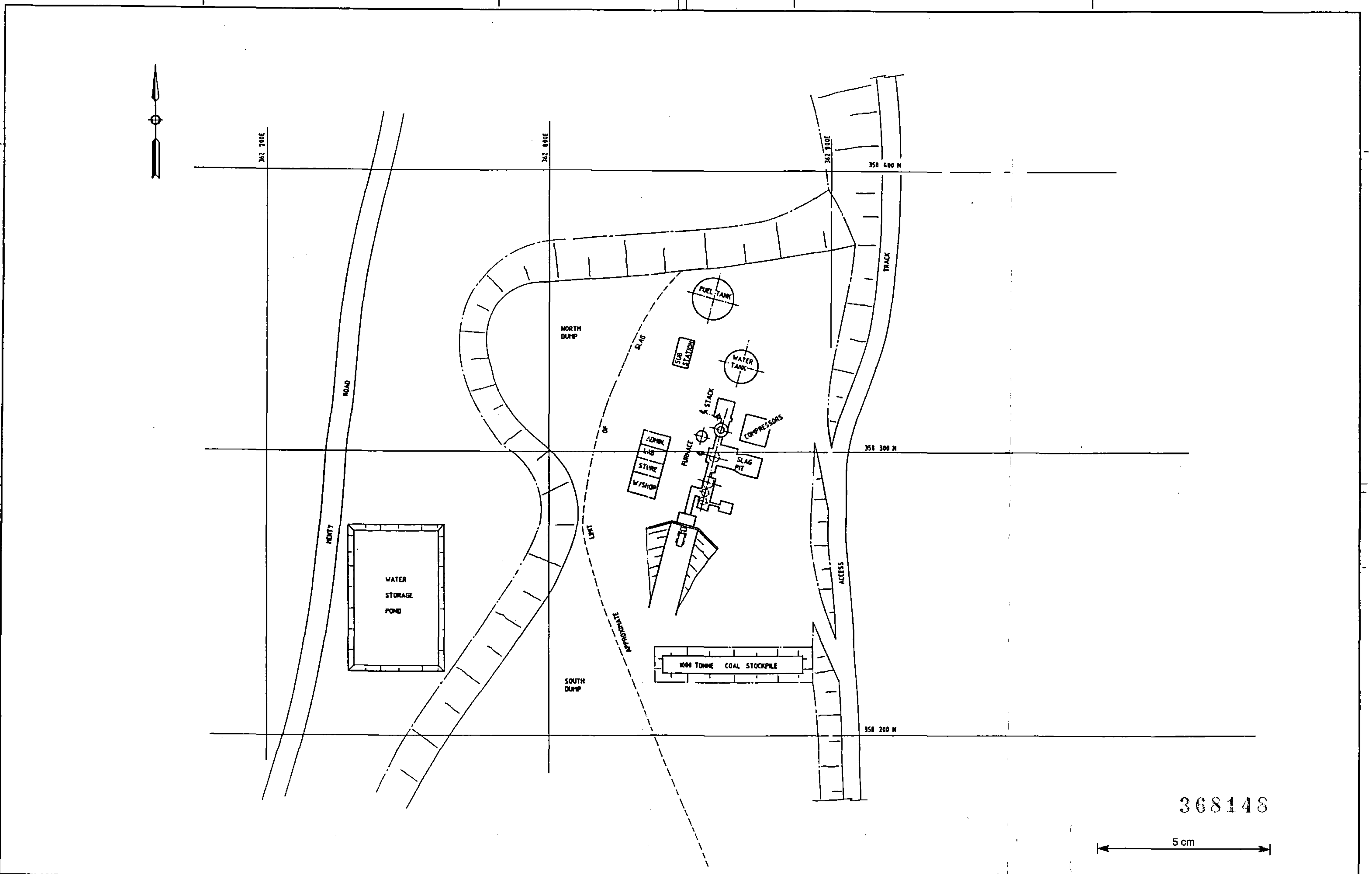
REVISIONS | APPROVAL | REFERENCE DRAWINGS

SIGNED .... DATE ....

BHP Engineering – PERTH

PYROSMELT N.L.
ZEEHAN SLAG RETREATMENT
GENERAL ARRANGEMENT
PLAN

SCALE 1:100 | DATE | B1 | DRG No E200-400-003 /A



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B	NOV'90	R.G.		SITE PLAN REDRAWN

REVISIONS | APPROVAL | REFERENCE DRAWINGS

SIGNED .... DATE ....

	R.J.D.	NOV'90

BHP Engineering – PERTH

PYROSMELT N.L.
ZEEHAN SLAG RETREATMENT
SITE PLAN

SCALE	DATE		DRG Nº
1 : 500	NOV. 90	B1	E 200 – 400 – 004 / B

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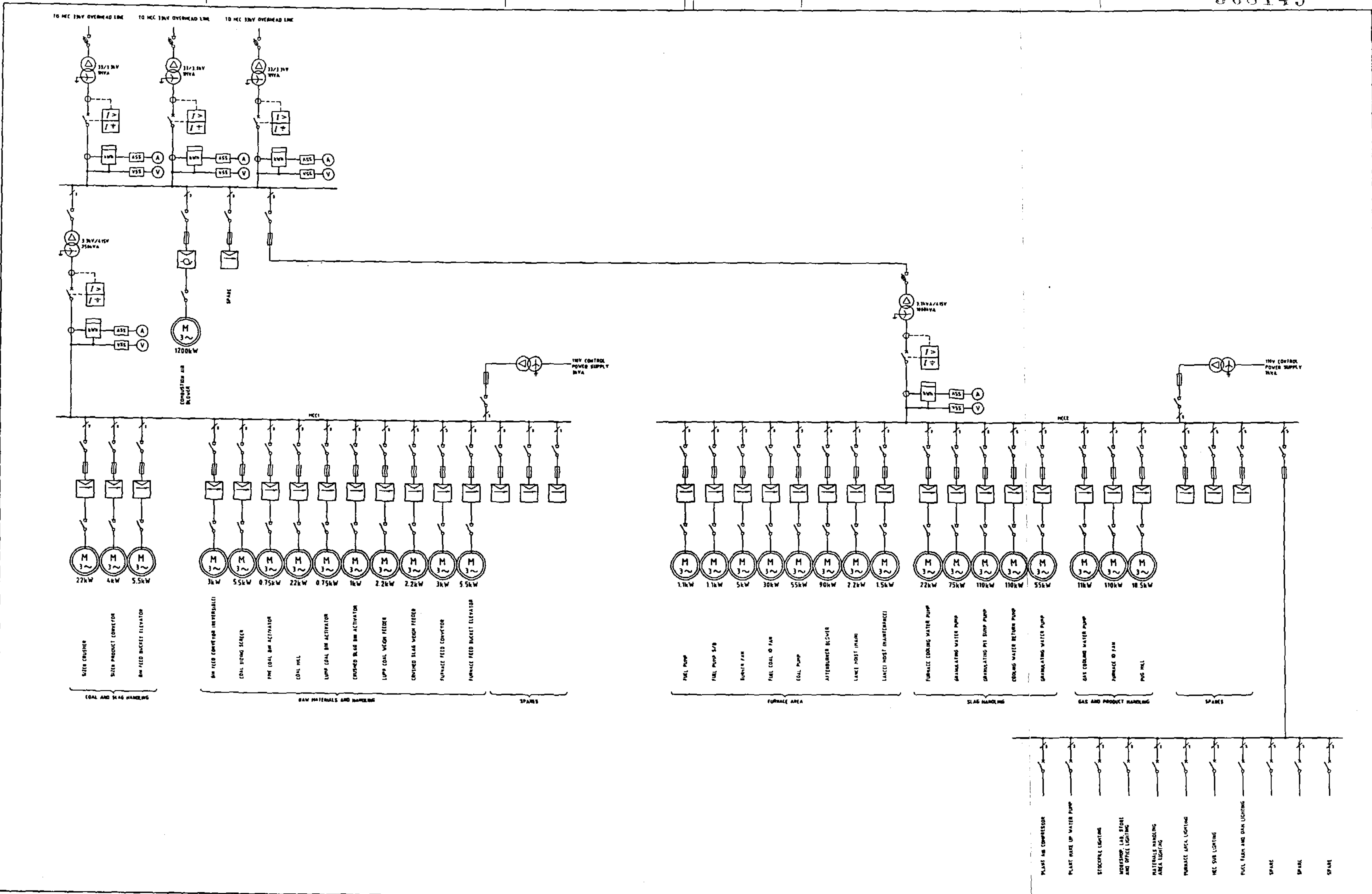

A	26.10.90	BM		ISSUED FOR TENDER	
REVISIONS					
APPROVAL					
REFERENCE DRAWINGS					

BHP Engineering – PERTH

ZEEHAN SLAG RETREATMENT PLANT
ELECTRICAL SINGLE LINE DIAGRAM

SCALE	DATE		DRG NO
N.T.S	26.10.90	B1	E200-400-005/A

APPENDIX E

EQUIPMENT LIST

E.0 EQUIPMENT LIST

The detailed equipment list given here is that prepared by BHP for a 10t/h single furnace plant operating to a discard slag level of 3% zinc. It is the equipment list for the plant described in Appendix D.

The 15t/hr plant proposed in this report is identical in all but scale and output.

Project : Zeehan Slag Dumps Retreatment - Prefeasibility Study
Description : EQUIPMENT LIST - SINGLE FURNACE OPERATION, 10 t/h

Equipment Area Tag	Equipment Item	Size	Installed Power kW	Supplier
100	COAL AND SLAG HANDLING			
100 SP01	Slag Stockpiles			
100 SP02	Coal Stockpile			
100 ME01	Front End Loader	Cat 936E		Westrac
100 DH01	Dump Hopper	5 x 3 x 2 m		
100 SC01	Feed Grizzly	300 mm		
100 CR01	Sizer Crusher		22.00	MMD
100 CU01	Sizer Discharge Chute			
100 CV01	Sizer Product Conveyor		4.00	Transmin P/1
100 CU02	Conveyor Head Chute			
100 MA01	Tramp Iron Magnet	SP 640 Perm Mag		Eriez Mags P/1
100 BE01	Bin Feed Bucket Elevator		5.50	Mat Handling
100 CU03	BE Discharge Chute			
200	RAW MATERIAL STORAGE AND FEED			
200 CV02	Bin Feed Conveyor (reversible)		3.00	Tansmin P/1
200 CU04	Slag Bin Feed Chute			
200 CU05	Coal Screen Feed Chute			
200 SC02	Coal Sizing Screen	2x3 m	5.50	
200 CU06	Lump Coal Chute			
200 CU07	Fine Coal Chute			
200 BN01	Fine Coal Bin	20 m3 - 9n		
200 BA01	Fine Coal Bin Activator		0.75	Transmin P/t
200 CU08	Fine Coal Overflow Chute			
200 CU09	Coal Mill Feed Chute			
200 RV04	Coal Mill Feed Valve		0.25	
200 CM01	Coal Mill	0 - 5 t/h	22.00	
200 DU01	Milled Coal Transfer Duct			
200 BN02	Lump Coal Bin	20 m3 -24h		
200 BA02	Lump Coal Bin Activator		0.75	Transmin P/t

200 BN03	Crushed Slag Bin	70 m3 - 12h		
200 BA03	Crushed Slag Bin Activator		1.00	Tasnsmin P/t
200 CV03	Lump Coal Weight Feeder	0 - 1 t/h	2.20	Transmin P/l
200 CV04	Crushed Slag Weigh Feeder	0 - 15 t/h	2.20	Transmin P/l
200 CV05	Furnace Feed Conveyor	0 - 20 t/h	3.00	Transmin P/l
200 CU10	Furn. Feed Conveyor Head Chute			
200 BE02	Furnace Feed Bucket Elevator	0 - 20 t/h	5.50	Mat Handling
200 CU11	Furn. Feed BE Head Chute			
300	FURNACE AREA			
300 TA01	Deisel Fuel Storage Tank			
300 PU01	Fuel Pump		1.10	Blakers
300 PU02	Fuel Pump S/B		1.10	
300 CP06	Burner Fan		5.00	
300 CD01	Aux Coal Drier Burner			
300 CP03	Fuel Coal ID Fan		30.00	
300 CY01	Air Disengaging Cyclone			
300 RV04	Coal Pump Feed Valve		0.25	
300 PC01	Coal Pump	0 - 5 t/h	55.00	Fuller FL Smidt
300 CP02	Cumbustion Air Blower	15000 Nm3/h @250kPa	1200.00	Ingessol Rand
300 AR01	Combustion Air Receiver	10 m3		CAPS
300 AR01	Afterburner Blower	10000 Nm3/h @20kPa		90.00 Reliant Air
300 RV01	Furnace Feed Valve		0.25	
300 PI01	Flexible Air Piping			
300 LA01	Lance			
300 FU01	Furnace	2250mm ID x 6115mm		
300 DU02	Furnace - Cooler Flue/Duct			
300 DA01	Tertiary Air Damper			
300 VE01	Emerg. Bypass/Explosion Vent			
300 TB01	Tapping Block			
300 HT01	Lance Hoist (main)	2000 kg	2.20	Lloyds British
300 HT02	Lance Hoist (maintenance)	1000 kg	1.50	Lloyds British
400	SLAG HANDLING			
400 PU04	Furnace Cooling Water Pump	110 m3/h	22.00	
400 PU05	Granulating Water Pump	370 m3/h @400kPaG		75
400 TA03	Cooling Water Head Tank			
400 LU01	Slag Launder			
400 GP01	Granulation Pit	8 x 12 x 3 m		
400 PU07	Granulation Pit Sump Pump	100 m3/h	110.00	
400 PU06	Cooling Water Return Pump	100 m3/h	110.00	
400 DM01	Cooling Water Dam	60 x 25 x 3m		
400 PI02	Water Piping			
400 PU09	Granulation Water Pump		55.00	
500	GAS AND PRODUCT HANDLING			
500 TA02	Gas Cooling Water Tank	20 m3		
500 PU03	Gas Cooling Water Pump	0 - 10 m3/h	11.00	
500 CS01	Gas Cooler Sprays			Envirocare
500 GC01	Gas Cooler			
500 RV02	Gas Cooler Rotary Valve		0.25	
500 DU03	Cooler - Baghouse Duct			
500 DA02	Baghouse Inlet Dampers			
500 BH01	Bag House	35000Nm3/h & 1.5t/h		Clyde Caruthers

500 DA04	Baghouse Outlet Dampers			
500 DU04	Baghouse - Fan Duct			
500 CP05	Furnace ID fan	35000Nm3/h 8 SWG	110.00	Clyde Caruthers
500 DU05	Fan - Stack Duct			
500 ST01	Stack			
500 RV03	Product Rotary Valve		0.25	
500 PM01	Pug Mill	0 - 1.5 t/h	18.50	
500 BM01	Fume Bagging Machine	0 - 1.5 t/h		
500 ME02	Front End Loader	Cat 936E		Westrac
600	ELECTRICAL AND INSTRUMENTATION			
600 TF01	33kV/3.3kV Transformer			
600 SB01	3.3kV Switchboard			
600 TF02	3.3kV/415V Transformer			
600 MC01	415V MCC			
600 PA01	415V Power Distribution Panel			
600 PA02	L&SP Distribution Boards			
600 PA03	PLC Panel and Equipment			
600 PA04	Operators Panels			
600 PA05	Feild Marshalling Boxes			
600 CA02	Cables			
600 LI01	Lighting		30.00	
600 SA01	Water sampler			
600 SA02	SO2 monitor			
600 XR01	XRF Analyser			
700	SERVICES			
700 CP04	Plant Air Compressor	780 Nm3/h @750kPa		82.50 CAPS
700 AR02	Plant Air Receiver	3 m3		CAPS
700 AD01	Air Drier			
700 PI03	Plant Piping			
700 EQ01	Fire Fighting/Safety Gear			
700 BU01	Office Block		5.00	
700 BU02	Office Furnature/Equipment			
700 TS01	Telephone System			
700 BU03	Workshop Store		7.50	
700 EQ02	Workshop/Store Equipment			
700 SS01	Sewerage and Drainage			
700 BU04	Amenities Block		7.50	
700 BU05	Cladding For Furnace Building			
700 BU06	HV Substation			
700 BU07	MCC Enclosure			
700 PU08	Plant Make Up Water Pump		75.00	

Total Installed Power 2183.55 kW

APPENDIX F

AUSMELT/CSIRO REPORT - PROCESSING ZINC OXIDE FUME

6. Fume Treatment

6.1 Marketing Options

Table 8 shows the expected fume composition from the base case flowsheet of the commercial plant which is a high temperature operation without production of bullion or recycle of fume leach residue. The liquor from leaching tests was assayed and those data are incorporated in the table.

There are a number of possible products from the smelter. They are listed in order of increasing value added in Table 9.

Sale of raw fume would result in the lowest capital expenditure but would depend on the terms that could be negotiated for its sale. Typical bulk sulphide concentrate terms include a smelting charge of $220 per tonne and payment for 85% of the zinc, 95% of the lead and 95% of the silver. If a transport cost of $100 per tonne is assumed then the cost to the project of these terms would be $13.1m. However, the raw fume is a premium product when compared with sulphide concentrates and strong technical representations may result in significantly better terms. The major impurity, lead, is easily separated by leaching and the leach liquor could be fed directly into the purification circuit of on electrolytic zinc refinery.

Roasting of the raw fume would produce a zinc oxide product containing 0.1% Pb and most of the silver. The costs have not been accurately estimated but the capital will be of the order of $0.5m for the roaster and its associated baghouse and the operating costs about $25 per tonne. This totals $1.2m over the life of the project to which would have to be added the realisation costs.

6.2 Fume Leaching

Production of the other materials listed in Table 9 starts with a sulphuric acid leach of the fume. Detailed testwork on a sample of the fume produced in the pilot plant trials was commissioned by Ausmelt and conducted by Dr J Canterford of the Commonwealth Scientific and Industrial Research Organisation, Division of Mineral Chemistry. The report on this work is attached as Appendix II.

Leaching the fume would produce a pregnant liquor containing about 120 g/l of zinc and a residue comprised mostly of lead sulphate but also containing the silver and any gold reporting to fume. Concentrations of the metals in the liquor and leach residue are shown in Table 8. Assay data has been used for the head slag and the leach liquor and the compositions of the intermediate species have been calculated. The calculated compositions are in agreement with those assays available for the intermediates. Note that the target concentration of zinc in leach liquor on a commercial plant is 120 g/l rather than the 68 g/l which was produced in the leaching tests. The concentration of the other components in the liquor would increase correspondingly over the values shown in Table 8.

Four treatment routes were identified for the pregnant liquor and estimates of capital and operating costs for the two most promising were commissioned by Ausmelt to Mr M.C. Walton of Refractory and Metallurgical Services. The report on this is give in Appendix III. The four routes were precipitation of basic zinc sulphate, pressure crystallisation of zinc sulphate monohydrate, spray roasting to produce pure zinc oxide and electrowining of zinc metal of which the first two were costed.

The first route is the precipitation of basic zinc sulphate using sodium hydroxide as the neutralising reagent. The sodium hydroxide would be regenerated from the spent liquor by reacting it with limestone. The precipitate would be filtered then dried in a rotary kiln to reduce the moisture content prior to transportation. The estimate of capital cost is $2.9m with operating costs of $4.0m per annum. A substantial part of the operating cost is in sulphuric acid and limestone which form alkaline gypsum which must be disposed of. The final product will contain about 40% Zn which is only twice the level in the initial slag.

The second route to be estimated was the pressure crystallisation of zinc sulphate monohydrate. In this route the pregnant liquor is heated and pressurised under conditions which cause the monohydrate to crystallise. The capital cost estimate came to $2.3m with operating costs of $3.6m. The product contains 35% zinc so that the transport costs from Silver Spur would be very high. This route has been tested on a laboratory scale but has not yet been operated on a commercial plant.

An alternative method of making zinc oxide to roasting the fume is to spray roast the sulphate liquor from a leaching stage. The capital cost would be about $1m in addition to the leaching plant and the operating cost would be of the order of $0.5m per annum. These costs have not been estimated in detail and more work is required if this route appears attractive.

Zinc metal production would require the construction of an electrowin plant, the capital cost of which has been estimated to be between $7m and $10m.

In each of these alternatives a lead containing material is produced which must be sold or smelted. Smelting of lead bullion would involve a capital cost of about $0.5m and operating costs of about $0.4m per annum based on a small, dedicated Sirosmelter. Recycling leach residue through the main smelter would also produce bullion but there would be associated capital and operating costs due to the decreased througput compared with smelting slag alone.

An alternative treatment route would be to establish a fume treatment plant close to the point of sale to leach the raw fume. Spent electrowin liquor from the customer could be used as the leachant and a relatively pure liquor could be sold. The leach residue could be sold separately, returned to the main smelter or smelted locally in a small Sirosmelter. This alternative would minimise capital expenditure as well as transport and operating costs should the terms for sale of raw fume be too onerous.

MCC 648

CSIRO

Institute of Energy and Earth Resources

Division of Mineral Chemistry

PROCESSING ZINC OXIDE FUME

J.H. Canterford and C. Moorrees

July 1985

Mineral Chemistry Communication

Division of Mineral Chemistry,
P.O. Box 124, Port Melbourne,
Victoria 3207, Australia

368159

PROCESSING ZINC OXIDE FUME

INTRODUCTION

At the request of Ausmelt Pty Ltd, the CSIRO Division of Mineral Chemistry has undertaken a preliminary laboratory-scale study on potential processes for producing a high-grade zinc product from a fume derived from Sirosmelting a slag dump material. The Division of Mineral Chemistry was advised that cathode zinc was not the desired product and that 10 000-20 000 t/annum fume would be produced. Initial discussions with Ausmelt Pty Ltd indicated that zinc oxide, zinc sulphate or basic zinc sulphate would be a suitable product.

The results of the preliminary study are presented here. It is to be noted that the results obtained refer specifically to the sample studied although, in view of the method of producing the fume, it is not unreasonable to assume that fume produced on the commercial scale will be similar to that studied here. It should also be pointed out that actual continuous fume-processing conditions, such as retention time, reagent requirements, energy requirements, etc., are likely to be slightly different to those of the batch tests carried out to date.

PROCESS OPTIONS

Table 1 gives the approximate chemical composition expected for the fume mixture, together with the data for the zinc fume produced by ER&S [1], BHAS [2] and Asarco [3]. The fume presently being examined has a composition similar to that produced by BHAS at Port Pirie although the zinc and lead contents are lower and higher, respectively. In contrast to the ER&S fume, the Ausmelt product can be expected to be free of refractory phases such as ferrites, tin oxide and sulphides.

By their very mode of formation, fumes have a very fine particle size and so a large surface area. Provided that the zinc is not present as a refractory phase such as ferrite, then it would be expected that the zinc content of the fume would be in a chemically reactive form and so readily dissolved under relatively mild leaching conditions.

Numerous studies have been reported in the literature covering both hydrometallurgical and pyrometallurgical routes for processing zinc oxide-containing materials, particularly fumes, dusts and residues [1-17]. Recovery of the final zinc product is, as usual, by hydrometallurgical routes. In determining the most appropriate method of processing the fume under consideration, it is necessary to consider the following points.

- Origin of the fume
- Composition of the fume
- Scale of operation
- Desired products
- Treatment of byproducts
- Reagent and energy requirements

In the present case, the fume is derived by Sirosmelting slag dump material containing approximately 20% zinc, 3.5% lead and minor amounts of copper, silver and gold. The slag is essentially arsenic-free. On the basis of zinc and lead prices of A$1200 and A$550 per tonne, respectively, the total realizable value of the zinc and lead components of the slag feed is of the order of A$240 + A$20 = A$260/tonne.

Sirosmelting will produce lead metal, which acts as a collector for the copper, silver and gold, as well as a zinc-rich fume. It is logical to use a hydrometallurgical process to treat the fume that selectively dissolves the zinc component so that the small amount of lead in the fume can be returned to the Sirosmelting stage. For this reason, leachants such as sodium hydroxide or acidic sodium chloride solutions can be excluded, since these leachants dissolve both the lead and the zinc.

The logical, commercially practical leachant is sulphuric acid. This is a readily available reagent and, importantly, dissolution of the fume in sulphuric acid is a commercially practised process. Thus BHAS leach fume, similar in composition to that under consideration, in spent zinc electrolyte containing 180 g/litre sulphuric acid and 150 g/litre zinc sulphate. Leaching is carried out in two stages, the first at pH 1, the second at pH 4. In both cases, the temperature is 85°C, pH control being achieved by addition of fume. The total retention time is

2 h. The zinc in the fume is converted to soluble zinc sulphate, whereas the lead reports as insoluble lead sulphate.

$$ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O \quad (1)$$

$$PbO + H_2SO_4 \rightarrow PbSO_4 + H_2O \quad (2)$$

Provided the pH of the second-stage leach slurry is maintained at about 3.5-4.5, there will be minimal iron(III) dissolution and no precipitation of insoluble zinc salts. Acid will be consumed by the dissolution of impurities such as sodium, potassium, magnesium and calcium. Small amounts of other impurity elements in the fume such as phosphorus, arsenic, etc., may also dissolve. The extent of dissolution of the impurities will need to be assessed. The insoluble lead sulphate plus other insolubles would be readily removed from the pregnant zinc sulphate leach liquor by conventional solid-liquid separation techniques such as CCD thickening, drum filters, etc. The solids would be returned to the Sirosmelting stage.

By controlling the free acidity, total acid consumption will be minimized and will also maximize zinc sulphate solubility. Because of the high solubility of zinc sulphate in solutions containing a low concentration of free sulphuric acid (see below), it will be possible to leach at a high initial pulp density. This means that leach tank and downstream capacity is minimized, as will be the energy required to maintain the leach slurry at the desired temperature. In the present case, rubber-lined, covered, agitated tanks will be satisfactory. Waste heat from the Sirosmelting stage will be used to maintain the leach pulp temperature.

On the basis of reactions (1) and (2) and assuming commercial concentrated sulphuric acid (96-98%) to have a specific gravity of 1.8, acid requirement would be approximately 0.95 tonne H_2SO_4/tonne fume. Because of other dissolution reactions, actual consumption would probably be of the order of 1.0-1.2 tonne/tonne.*

*Acid consumption data based on calculated composition of the fume mixture.

Following solid-liquid separation, there are three relatively simple routes for recovering a saleable product from the zinc sulphate leach liquor: direct spray roasting to produce zinc oxide, crystallization of hydrated zinc sulphate, and precipitation of basic zinc sulphate. As noted previously, Ausmelt Pty Ltd advised that cathode (electrowon) zinc is not regarded as an appropriate product - the proposed scale of operation would most likely preclude this technology in terms of both operating and capital cost terms. Thus pregnant leach liquor purification, possibly by solvent extraction, and zinc electrowinning are excluded from the present discussion. Figure 1 shows a simplified flowsheet for treating the slag by Sirosmelting followed by sulphuric acid fume leaching.

Spray roasting of the pregnant zinc sulphate liquor would have to be carried out in an Aman-type reactor [18,19] at temperatures of 900-1000°C. Wet sulphur dioxide would constitute the off-gases. Because of the energy required, it would be essential to combine Sirosmelting and spray roasting to ensure efficient waste heat usage. Disposal of the sulphur dioxide-containing off-gases in an environmentally acceptable manner must be carried out. Although it would be logical to recover this sulphur dioxide and convert it to sulphuric acid for return to the leaching circuit, the scale of operation and the costs involved would probably be commercially unattractive.

Zinc sulphate has a high solubility in water - at 25°C a saturated solution contains approximately 37 g $ZnSO_4$/100 g solution, the solid phase being $ZnSO_4 \cdot 7H_2O$ [20]. As the temperature is increased, solubility increases to a maximum of about 49 g $ZnSO_4$/100 g solution at 75°C and then decreases. $ZnSO_4 \cdot 6H_2O$ and $ZnSO_4 \cdot H_2O$ are the major solid phases at elevated temperatures, although $ZnSO_4 \cdot 4H_2O$ and $ZnSO_4 \cdot 2H_2O$ are metastable. As expected, the solubility of zinc sulphate decreases as the sulphuric acid concentration increases. Thus, at 25°C, the solubility decreases from 37 g $ZnSO_4$/100 g solution to 25 g $ZnSO_4$/100 g solution to 2 g $ZnSO_4$/100 g solution as the H_2SO_4 concentration is increased from 0 to 18.7 to 50.1 wt.% [20]. Crystallization of hydrated zinc sulphate would best be carried out at elevated temperatures and pressures to reduce the water of hydration content of the product as well as precipitate a greater amount of zinc, thereby reducing the amount of zinc in the recycle liquor. At 250°C, the solubility of zinc sulphate is about 5 g $ZnSO_4$/100 g solution, the solid phase being $ZnSO_4 \cdot H_2O$ [20].

Addition of alkali to an acidic solution of zinc sulphate initially results in the precipitation of basic zinc sulphate (BZS) at a pH of 6.2-6.5 [21]. The actual composition of the precipitated sulphate varies considerably, and stoichiometric salts are difficult to prepare. The study by Scanlon [21] suggests that only the four following separate phases exist, all other products being mixtures.

$$ZnSO_4 \cdot Zn(OH)_2$$
$$ZnSO_4 \cdot 2.3Zn(OH)_2$$
$$ZnSO_4 \cdot 5Zn(OH)_2 \cdot 3.5H_2O$$
$$5ZnSO_4 \cdot 18Zn(OH)_2 \cdot 20H_2O$$

If further alkali is added to the slurry of basic zinc sulphate, dissolution occurs via the formation of the soluble zincate ion, ZnO_2^{2-}. At a pH of greater than 9, zinc hydroxide begins to precipitate.

A range of alkaline reagents can be considered for basic zinc sulphate precipitation. Lime is not practical because addition will result in the precipitation of gypsum, $CaSO_4 \cdot 2H_2O$, which will contaminate the BZS product. Magnesia (calcined magnesite) could be used since magnesium sulphate is soluble. The magnesia must be caustic-calcined to have the appropriate reactivity. Ammonia is not practical because of the formation of double salts and/or ammonia complexes. Fume itself could be used, except this will result in the contamination of the BZS product by the lead in the fume. Sodium carbonate (soda ash) and sodium hydroxide (caustic soda) are the only commercially practical neutralizing/precipitating agents. The latter is preferred since with the former there will be significant carbon dioxide evolution. Neutralization of a zinc sulphate solution with sodium hydroxide leads to the precipitation of finely divided and difficult-to-settle basic zinc sulphate precipitates. Dewatering on the commercial scale could well be difficult.

The choice between the three product options shown in Fig. 1 will obviously depend upon market targets and it could well be that more than one product should be produced. Whatever route is chosen, it is to be noted that a reliable source of clean process water is required. The process water should have a low total dissolved solids content since saline water could cause processing problems. For example, if the chloride ion content is high, then a basic zinc chloride is likely to precipitate at about pH 5.5. A certain amount of process water recycling will be possible. However, it will be necessary to bleed out and dispose of a reasonable volume of process water to maintain soluble impurity concentrations at or below a set value. The necessary extent of recycling versus bleeding will only be established by continuous testwork on the pilot scale, using actual process water.

EXPERIMENTAL

Approximately 20 kg of fume was provided by Ausmelt Pty Ltd, who also advised that leach tests should be carried out using a mixture of 31 parts smelting fume (55.3% Zn, 17.0% Pb, 39 g/t Ag) and 7 parts reduction fume (64.0% Zn, 11.3% Pb, 44 g/t Ag).* The mixture was prepared by rolling followed by riffling (8 passes) and re-rolling. The calculated composition of the mixture was 56.9% Zn and 16.0% Pb. However, a riffled sample of the mix analysed at the CSIRO Division of Mineral Chemistry assayed 65.1% Zn and 15.4% Pb. The reason for this discrepancy has not been elucidated. The CSIRO data are used for calculation of leach efficiencies, etc. Dry screen analysis showed the fume to be 100% −76 µm and approximately 90% −53 µm. Prior to receiving the advice as to the composition of the fume mixture to be used, several tests were carried out using the reduction fume as the leach feed.

Leach tests were carried out in a glass Quickfit reaction vessel fitted with a water condenser. Agitation was via a magnetic stirrer bar.† Initial tests showed that the dissolution reaction was highly exothermic and that, for most of the planned tests, heating would not be required. At the completion of each test, the reaction mixture was cooled as rapidly as possible to room temperature, the pH measured, and the leach residue removed by vacuum filtration. The residues were

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*Assay data provided by Ausmelt Pty Ltd.

†The required weight of fume was placed in the reaction vessel, followed by the required volume of cold diluted sulphuric acid.

washed with 3 bed volumes of cold distilled water prior to drying at 105°C for 24 h. The filtrate and washings were made up to 500 ml for analysis.

Crystallization of hydrated zinc sulphate and precipitation of basic zinc sulphates were carried out using standard laboratory techniques using both "synthetic" and "real" leach liquors.

RESULTS AND DISCUSSION

Table 2 summarizes the results of the preliminary leach tests. As noted previously, the leach reaction proved to be highly exothermic. Table 3 gives the temperature profiles for leach tests 3 and 4. The very rapid heat generation is immediately apparent. This results from the dissolution reaction and not the dilution of the acid used, since premixed (diluted) sulphuric acid was used in all cases. The exothermic nature of the leaching reaction is extremely beneficial since this will reduce energy consumption. Using both the batch and continuous leaching modes, it would be relatively easy to control the leach pulp temperature at the desired level, probably 60-80°C, by controlled addition of fume.

The data in Table 2 show that provided excess acid is used and the solubility of zinc sulphate is not exceeded, then greater than 95% of the zinc component of the fume mixture is readily dissolved at temperatures of 60-80°C in about 0.25 h. As expected, there are only nominal amounts of soluble lead and silver. Problems associated with a deficiency of acid and solubility of zinc sulphate were avoided in tests 9 and 10 where a slight excess of acid and a reduced pulp density were used. In each case, the residue was essentially pure lead sulphate, $PbSO_4$, together with >99% of the silver in the fume.* Thus sulphuric acid leaching, under the appropriate conditions, results in a "total" separation of the zinc, lead and silver components of the feeds, the former going into solution, the lead and silver making up the residue.

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*The theoretical Pb content of $PbSO_4$ is 68.3%, which is to be compared with experimental values of ~70%. Coprecipitation of silver with lead sulphate is expected.

The absence of any other major or minor phase in the leach residue was confirmed by X-ray diffraction. As indicated in Fig. 1, the lead-silver sulphate residue is returned to the smelter for final recovery as bullion.

At the present time, the behaviour of impurities in the fume during leaching and subsequent processing have not been established. This is regarded as an essential feature of the next stage of process development. In addition, minimum acid addition and maximum pulp density need to be determined more precisely.

Table 4 gives typical data for the precipitation of basic zinc sulphate and zinc hydroxide, in this case using 100 ml of 0.1M $ZnSO_4$ solution as the starting solution and 0.1M NaOH as the neutralizing-precipitating agent. Precipitation of basic zinc sulphate commences as soon as the pH is increased above about 5.5. The form of the precipitation plot is essentially the same as that reported by Scanlon [21]. A similar type of plot was obtained using 100 ml of liquor derived from leach test 4 and 2M NaOH as the precipitant. In this case, considerably more NaOH (on a molar basis) was required since the leach solution contained excess sulphuric acid.

Both precipitation tests were repeated with addition of NaOH being terminated at pH 7.1, that is under conditions where "complete" zinc precipitation had occurred. The precipitates formed were very fine and difficult to filter and wash. Analysis of the filtrates confirmed that in excess of 99% of the zinc had been precipitated when the addition of NaOH was terminated. The X-ray diffraction patterns of the dried precipitates were poorly resolved, but were diagnostic of a mixture of basic zinc sulphates.

The only crystallization test carried out involved the reduction of 100 ml of leach liquor from test 4 to about 50 ml by controlled boiling in a covered vessel. On cooling to room temperature, a mass of acicular crystals of $ZnSO_4 \cdot 7H_2O$ readily formed. These were readily recovered from the crystallization vessel. Only about 10 ml of "free" liquor was recovered. The crystals were air-dried at ambient temperature (not washed), the dried product weighing ~40 g. This corresponds to crystallization of about 70% of the soluble zinc. No attempt was made to crystallize hydrated zinc sulphate at elevated temperatures and pressures. However, it is not unreasonable to assume that greater than 85% of the zinc could be precipitated under these conditions. The remaining soluble zinc would be returned to the leaching circuit, as shown in Fig. 1.

GENERAL COMMENTS

The present, preliminary test-work clearly indicates that it is possible to readily leach the bulk of the zinc from the fume using a slight excess of sulphuric acid. In order to prevent formation of an insoluble intermediate such as a basic zinc sulphate, sufficient acid should be added to ensure the final pH is in the range 3.5-4.5. Under these conditions there should be little soluble iron. The actual fume/acid ratio will depend on the lead plus zinc contents, as well as on the level of impurities such as sodium, potassium, magnesium, calcium, aluminium, etc., since these will form either soluble or insoluble sulphates. The behaviour of all impurities needs to be evaluated since this will have a significant bearing on downstream processing.

Leaching is relatively straightforward in equipment requirement terms, and is not energy-intensive. As indicated previously, it is already carried out on the commercial scale, so that "new and novel" technology is not involved.

Considerably more work is required on downstream processing of the clarified zinc sulphate solution. Market requirements will have a considerable bearing on which of the three routes to follow. As indicated previously, it may be appropriate to produce more than one product. It is considered that zinc oxide formed by spray roasting the clarified pregnant zinc sulphate solution is the most straightforward downstream processing technique provided it is not necessary to process the sulphur dioxide-containing off-gases.

CAPITAL AND OPERATING COST ESTIMATES

Insufficient data are available for the derivation of reliable cost estimates. However, a "ball park" estimation could be carried out using the following approximate data. It must be stressed that the data are of a preliminary nature and require considerable refinement.

Feed: 1 tonne fume containing 70% ZnO, 20% PbO

Leach Circuit:

Feed: 1 tonne

Leach efficiency: 95%

Time: 0.5 h

Temperature: ~50°C

Head input: nominal

H_2SO_4 (98%, density = 1.84): 1.0-1.2 tonne = 0.55-0.65 m^3

Recycle liquor + make-up water (density = 1.2):

5 tonne = 4.2 m^3 (assumed to be zinc-free)

Total volume of aqueous phase: 4.75-4.85 m^3

Terminal pH: 3.5-4.5

Pregnant leach liquor: 0.533 tonne Zn in 4.75-4.85 m^3

=110 g Zn/litre

Residue: $PbSO_4$

Residue weight: 270 kg (assume 80% of feed is soluble)

Spray Roasting:

Feed: 0.533 tonne Zn in 4.75-4.85 m^3 liquor

Temperature: 1000°C

Efficiency: 100%

Product: ZnO

Product weight: 0.665 tonne

High temperature-pressure crystallization:

Feed: 0.533 tonne Zn in 4.75-4.85 m^3 liquor

Temperature: 250°C

Efficiency: 85%

Product: $ZnSO_4 \cdot H_2O$

Product weight: 1.246 tonne

Basic zinc sulphate precipitation:

Feed: 0.533 tonne Zn in 4.75-4.85 m^3 liquor

Precipitant: 0.490 tonne solid NaOH (1.5 mole NaOH/mole Zn)

Temperature: 20°C

Terminal pH: 7.0

Efficiency: 100%

Product: $xZnSO_4 \cdot yZn(OH)_2 \cdot zH_2O$

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Table 1. Composition (%) of zinc fumes.

	Ausmelt*	ER&S†	BHAS	Asarco
ZnO	70.8	44	85	92
PbO	17.2	21	10.8	4.3

*Contains minor amounts of Cu, P, Sb, As, Ag, etc. Prepared from 31 parts smelting fume + 7 parts reduction fume. Calculated data from assays of smelting and reduction fumes provided by Ausmelt Pty Ltd. Experimentally determined data (CSIRO) 81% ZnO and 16.6% PbO.

†ER&S produced a wide range of fumes, many of which had a higher PbO content.

Table 2. Results of fume leach tests.

		Test → 1	2	3	4	5	6	7	8	9	10
		Feed → Reduction	Reduction	Reduction	Mixture	Mixture	Mixture	Mixture	Mixture	Mixture	Mixture
Fume (g)		100	100	100	100	100	100	100	100	50	50
H_2SO_4 (g)		75	85	120	120	120	120	120	120	60	60
H_2O (g)		250	250	250	250	350	200	250	250	250	250
Initial temp. (°C)		20	20	20	50	50	50	50	50	50	20
Maximum temp. (°C)		85	83	80	102	102	102	102	102	80	62
Time (min)		30	30	30	30	30	30	15	60	30	30
Final pH		5.3	5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Residue weight (g)		63.1	44.6	24.2	22.7	23.7	43.2	25.7	26.4	11.2	11.3
Liquor composition (g/litre)*	Zn	88.5	†	†	137	142	†	132	†	68	67.3
	SO_4	124.6	†	†	225.6	228.0	†	221.2	†	114	110
(mg/litre)	Pb	7	†	†	7	7	†	7	†	7	5
	Ag	<0.1	†	†	<0.1	<0.1	†	<0.1	†	<0.1	<0.1
Zinc dissolution (%)		70	†	†	>95	>95	†	>95	†	>95	>95
Residue composition (%)	Zn	35	†	†	0.68	2.15	†	5.1	†	0.41	0.56
	Pb	~23	†	†	~70	~70	†	~65	†	~70	~70
(ppm)	Ag	750	†	†	1800	1750	†	1600	†	1850	1800
Comment#		a	a	b	b	b	b,c	b,c	b,c	b	

*Concentration of filtrate + washings (500 ml). The analytical totals are in all tests, with the exception of test 1, greater than 100%. The greatest error is with test 6 with the liquor plus residue analyses equivalent to 110% recovery. This probably has arisen because of errors associated with the determination of concentrated solutions by AAS.

†Not determined.

#a – Deficiency of acid. b – Excess acid. c – Solubility of $ZnSO_4 \cdot 7H_2O$ exceeded.

Table 3. Leach test temperature profiles.

Time (min)	Temperature (°C)	
	Test 3	Test 4
0	20	50
1	80	102
3	70	87
5	58	76
10	46	64
20	39	59
30	37	55

Table 4. Precipitation of basic zinc sulphate and zinc hydroxide.

Vol. 0.1M NaOH (ml)	pH	Comment
0	4.2	$ZnSO_4$ solution
2	6.0	White precipitate (BZS)
50	6.3	
100	6.5	
140	7.0	
145	7.1	BZS pptn complete
150	8.1	$Zn(OH)_2$ pptn commences
155	9.9	
160	10.5	
170	11.0	
180	11.4	
200	12.0	$Zn(OH)_2$ pptn complete
210	12.3	$Zn(OH)_2$ dissoln commences

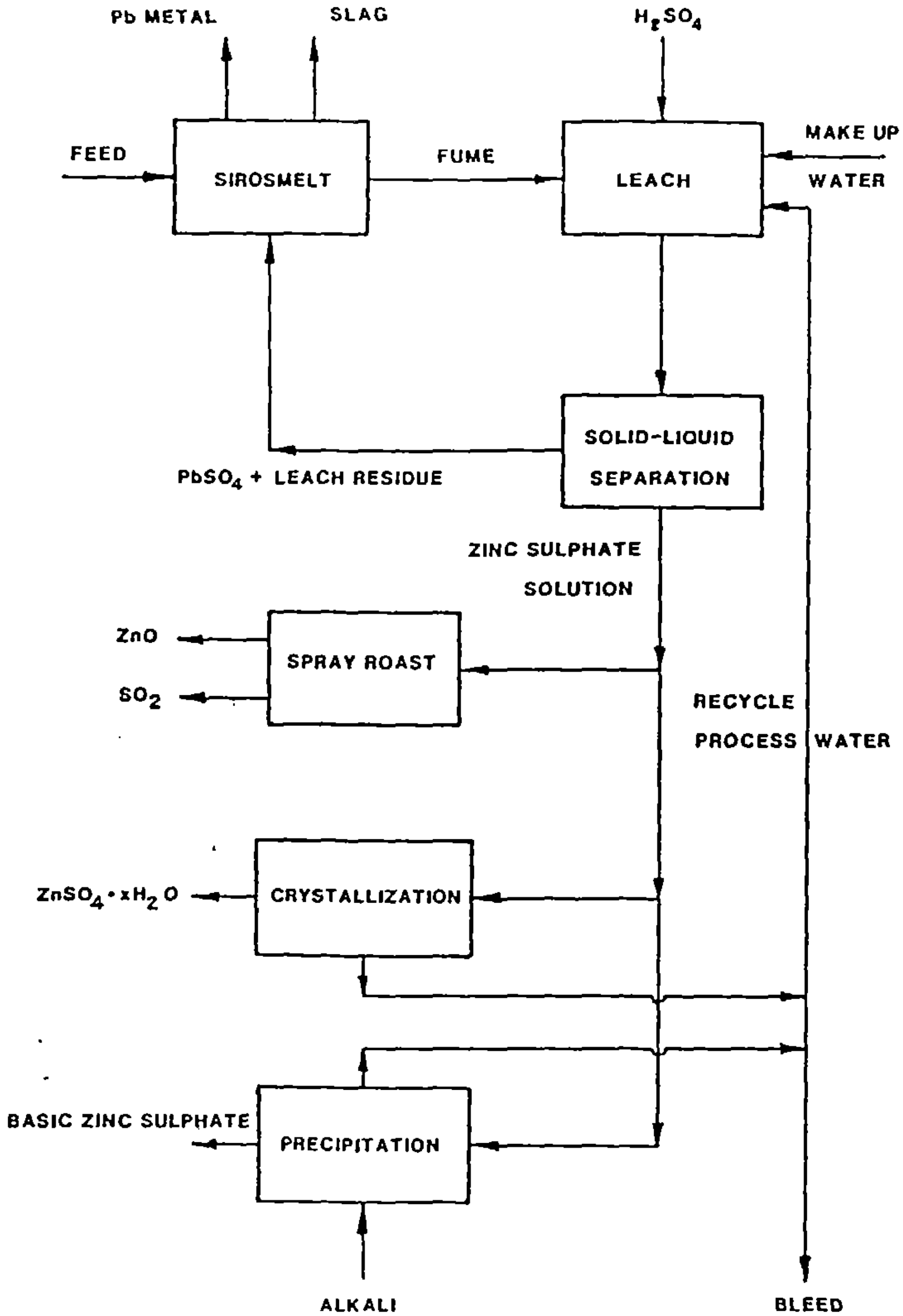

Fig. 1. Simplified flowsheet for processing zinc oxide fume.

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APPENDIX III

FUME LEACHING

CAPITAL AND OPERATING

COST ESTIMATES

APPENDIX G

RMS REPORT - PROCESSING ZINC OXIDE FUME
CAPITAL & OPERATING COST ESTIMATES

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LEACHING OF ZINC CONTAINING FUME & CRYSTALLISATION
PRELIMINARY FEASIBILITY STUDY

CAPITAL AND OPERATING COST ESTIMATES

Prepared for :- AUSMELT (PTY) LTD.

By :- REFRACTORY AND METALLURGICAL SERVICES

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SUMMARY

Two alternative routes for further processing of a zinc oxide fume produced by slag retreatment have been evaluated. Case A involves the production of basic zinc sulphate by neutralisation of the pregnant liquor. The most likely capital cost of this option has been estimated at \$2·89 million and the operating cost at \$4·0 million per year. Case B produces a hydrated zinc sulphate product by use of a pressure crystalliser. This has an estimated capital cost of \$2·27 million with operating costs of \$3·6 million per year.

Case A has potential environmental problems to be overcome in addition to its higher cost. Case B has the risk attached to, as yet, unproven technology in this specific application.

Due to the limited information available, the study is based on a number of assumptions and excludes from its scope items not directly related to the process options. The accuracy of these estimates is + 30% - 20%.

1. INTRODUCTION

Refractory and Metallurgical Services has been retained by Ausmelt(Pty)Ltd to produce order of magnitude capital and operating cost estimates for two process options for the recovery of zinc from the acid leach of fume by precipitation. To do this reference has been made to the CSIRO report[1] on leach testwork, also commissioned by Ausmelt. The fume is produced from a slag reduction process, carried out in a SIROSMELT vessel and is contaminated with other volatile heavy metals. The Zinc oxide is however, significantly more soluble in dilute sulphuric acid than other contaminants which are removed via the leach residue.

2. SCOPE OF WORK

2.1 Leaching

Zinc oxide fume is fed from the baghouse into a mixing tank below. A measured quantity of water is added to make a slurry of 40% pulp density for transport to the leaching tanks. There are two leaching tanks provided to accomodate batch leaching and to give additional surge capacity required by the cyclic nature of the smelting operations.

In the leach tanks, the slurry is mixed with sulphuric acid at a strength of 40%-50%. The main chemical reaction in this unit can be described by:

$$ZnO + H_2SO_4 = ZnSO_4 + H_2O$$

The acid is delivered at 98% strength to a site storage tank. From here it is diluted to 40% with water and pumped to the leach tanks via a heat exchanger to remove the heat generated in dilution. The leach slurry, after a thirty minute residence time in the tanks, is pumped to the thickener with the pH at about 4·0. The thickener underflow contains the residue which is recovered by a pressure filter and is suitable feed for further pyrometallurgical processing. Wash liquor from the filter is recycled. The process flowsheet is illustrated in figure 1.

2.2 Basic Sulphate Precipitation (Case A)

Thickener overflow (pregnant liquor) is pumped to a neutralising tank into which a 50% sodium hydroxide solution is added. The alkali can be supplied dry or in the required strength in road tankers. Thus either storage or mixing facilities are required. The former have been included in this estimate. Basic Zinc sulphate precipitates at a pH of 6-6·5 according to the following reaction:

$$4ZnSO_4 + 6NaOH = 3Na_2SO_4 + ZnSO_4.3Zn(OH)_2$$

The resulting slurry is then thickened and filtered.

The neutralised barren liquor is pumped to a regeneration stage where limestone is added, and the following reaction occurs:

$$Na_2SO_4 + CaCO_3 + H_2O = CaSO_4 + CO_2 + 2NaOH$$

Gypsum is precipitated in this process. Due to the potential environmental problems in disposing of alkaline gypsum slurries, and the need to recover the regenerated sodium hydroxide, the gypsum is removed by thickening and filtering. The water balance indicates that up to 50% of the regenerated solution must be bled from the system.

The basic sulphate produced is dried in a small rotary kiln, heated by hot air recuperated from the furnace off-gases. The cost of this recuperation system is not included in the estimate. The processes included in this option are shown in figure 2.

2.3 Pressure Crystallisation (Case B)

In this option, the pregnant liquor from leaching is pumped as thickener overflow into a stainless steel autoclave. This vessel is steam heated. The steam is generated by a packaged boiler(oil-fired). Testwork carried out by the C.S.I.R.O indicates that up to 95% of the zinc dissolved can be precipitated as crystalline sulphate at a temperature of about 250°C at moderate pressures. The slurry has a residence time in the autoclave of only about ten minutes before being passed to a flash tank where the superheated water boils off to be recondensed and recycled to the leach circuit.

The crystalline sulphate is dried in a rotary kiln to reduce the shipping moisture. The flowsheet is shown in figure 2.

3.COST ESTIMATES

3.1 Capital Costs

The capital estimates have been formulated using the installed cost of the process equipment as a base, adding appropriate percentages of this cost to cover electrics, piping and instrumentation. Indirect costs were also estimated in this manner.

A small construction camp and facilities have been included in both cases. Engineering design and project management costs have been treated in a similar way. A list of major equipment items is given in appendix 1. Details of the capital cost estimates for both cases are shown in table 1. A contingency of 10% has been included in these estimates.

3.2 Operating Costs

The operating costs have been considered as incremental to an existing operation. A minimum level of manpower has been included, i.e. eight man-years, excluding holiday or sick leave. This reflects the expected need for one operator and one tradesman per shift. In case B, the manning requirement of the steam generation plant is included in the unit cost of steam production. The cost of consumables includes the following:

Case A
- Sulphuric acid
- Sodium hydroxide
- Flocculants
- Make-up water
- Gypsum disposal
- Product transport
- Limestone

Case B
- Sulphuric acid
- Steam
- Product transport
- Boiler fuel (included in unit steam cost)

Power costs are based on an estimate of installed power requirements and a diversity factor of 80% in both cases.

Engineering maintenance spares have been included at 5% of direct capital costs. An allowance of $500 per man-year has been included for safety equipment and miscellaneous costs.

A summary of operating costs is shown in table 2. This data includes a contingency of 10%. The quantities and rates used in these costs are detailed in appendices 2 & 3.

3.3 Exclusions

The following areas or items have been excluded from the estimates as being outside the scope of work.

- Infra structure
- Water supply and treatment
- Tailings dams
- Buildings
- Contractor & consultants profits or fees
- Centralised process control systems

.Recruitment & training of staff
.Incremental administration costs
.Mobile equipment

3.4 Accuracy
With this estimating method it is not possible to claim the accuracies required for board appropriation. For this study the capital and operating costs have a 95% probability of being within +30% and -20% of the most likely costs quoted in tables 1&2. These extremes should only be used as sensitivities in a financial analysis.

4.DISCUSSION

The apparent advantages of Case B with its lower capital and operating costs must be viewed with caution as this option contains most process risk. The process indicated has been evaluated only from laboratory scale test results which may not be applicable to a commercial plant. No allowance has been included for this technological risk. The process route in option A, however, is used extensively in Zinc plants throughout the world on scales similar to that in this study and the costs of this case should be used to assess project viability.

The capital costs also include a large allowance for engineering design and project management. This allowance would probably be reduced by up to 33% by judicious planning and use of in-house personnel. The major items in the operating costs are consumables and transport. The latter assumes that the products are to be transported for further processing within 500Km (e.g.Port Pirie). A further distance would significantly increase this cost (ie Cockle Creek).

In Case A front-end loaders disposal of gypsum has been allowed for. There are potential environmental problems associated with gypsum disposal, which have not been addressed in this study. Similar problems could occur with the liquor bleed in the regeneration step, also in Case A.

5. CONCLUSIONS

The most likely capital costs of the two process options have been estimated to be:

	Cost ($000)	Range ($000)
Case A	2894	2410-3762
Case B	2274	1895-2960

Similarly the annual operating costs have been estimated at:

	Cost ($000/y)	Range
Case A	3978	3315-5171
Case B	3587	2989-4663

Despite the lower costs, Case B involves significant technological risks and the results for Case A should be used to assess project viability at this stage.

6. REFERENCE

Canterford, J.H & Moorrees, C Processing Zinc Oxide Fume CSIRO report ref.No MCC 648, July 1985

TABLE 1

CAPITAL COST ESTIMATES

	CASE A ($000)	CASE B ($000)
INSTALLED EQUIPMENT	1467	1170
ELECTRICS	158	120
INSTRUMENTATION	210	134
PIPING	370	273
CONSTRUCTION FACILITIES	134	102
Sub-Total	2339	1799
ENGINEERING DESIGN & PROJECT MANAGEMENT	555	475
TOTAL	2894	2274

TABLE 2

OPERATING COST ESTIMATES

	CASE A ($000)	CASE B ($000)
MANPOWER	264	264
ELECTRICAL POWER	352	264
CONSUMABLES	1432	1160
ENGINEERING SPARES	110	88
PRODUCT TRANSPORT	1705	1804
WASTE REMOVAL	110	-
MISCELLANEOUS	5	7
	3978	3587

* Cost includes manning and power requirements of steam generation in unit rate

APPENDIX I

CASE A- MAJOR EQUIPMENT LIST

Item	TA01	TA02	TA03	HE01	TA04	TH01	TA06	FL01	TA07	TA08	FL02	TA09	TA10	FL03	DR01
Size	300m³	12m³	22m³	-	12m³	10mø	16m³	8m²	22m³	8mø	10m²	12m³	8mø	10m²	5møx8m
Power	-	-	15kW	-	15kW	15kW	10kW	5kW	15kW	10kW	5kW	15kW	10kW	5kW	100kW
No.	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1

CASE B- MAJOR EQUIPMENT LIST

Item	TA01	TA02	TA03	HE01	TA04	TH01	TA06	FL01	HE03	PV01	PV02	B01	DR02
Size	ALL AS CASE A								-	15m³	25m³	5MW	5møx8m
Power									-	-	5kW	-	100kW
No									1	1	1	1	1

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APPENDIX 2

CALCULATED QUANTITIES

LEACHING

Sulphuric Acid	17000 t/y
Flocculant	15 t/y
Leach Residue	8000 t/y

CASE A

Basic Zinc Sulphate	23000 t/y
Gypsum	20000 t/y
Water Make-up	46000 m^3/y
Limestone	12000 t/y
Sodium Hydroxide	5000 t/y

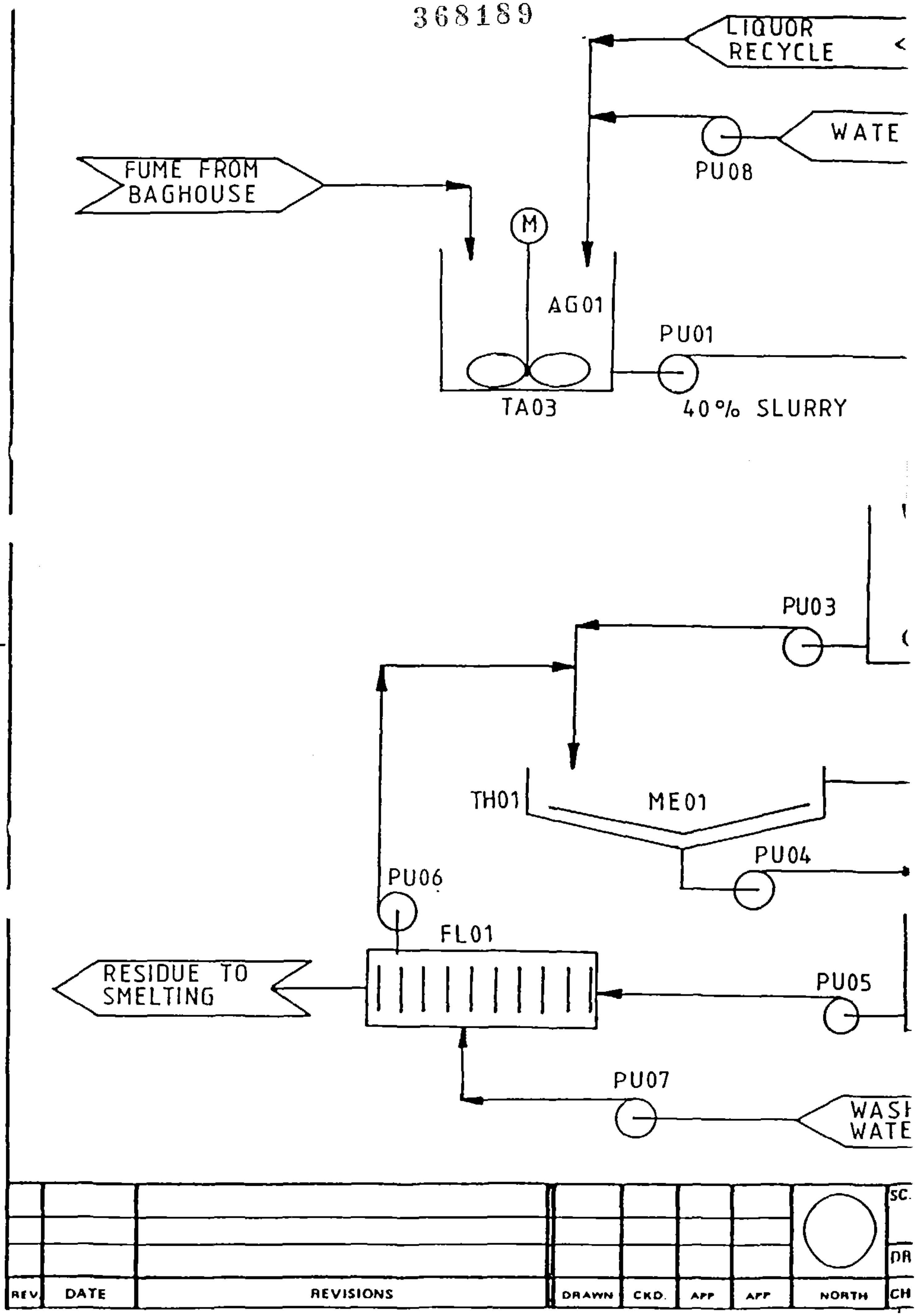
CASE B

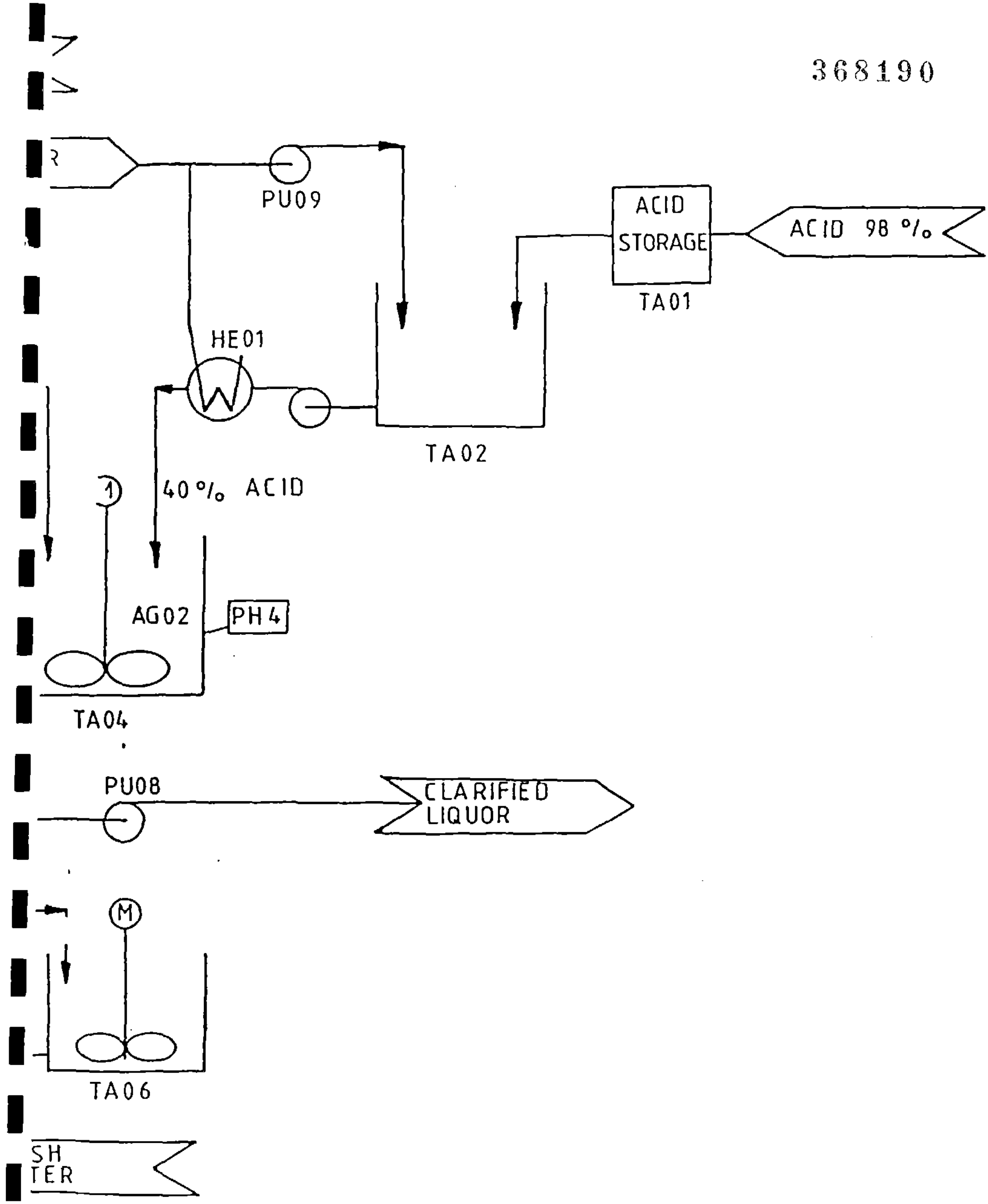
Crystalline Sulphate	24800 t/y
Water Make-up	25000 m^3/y
Steam Generated	48000 t/y

APPENDIX 3

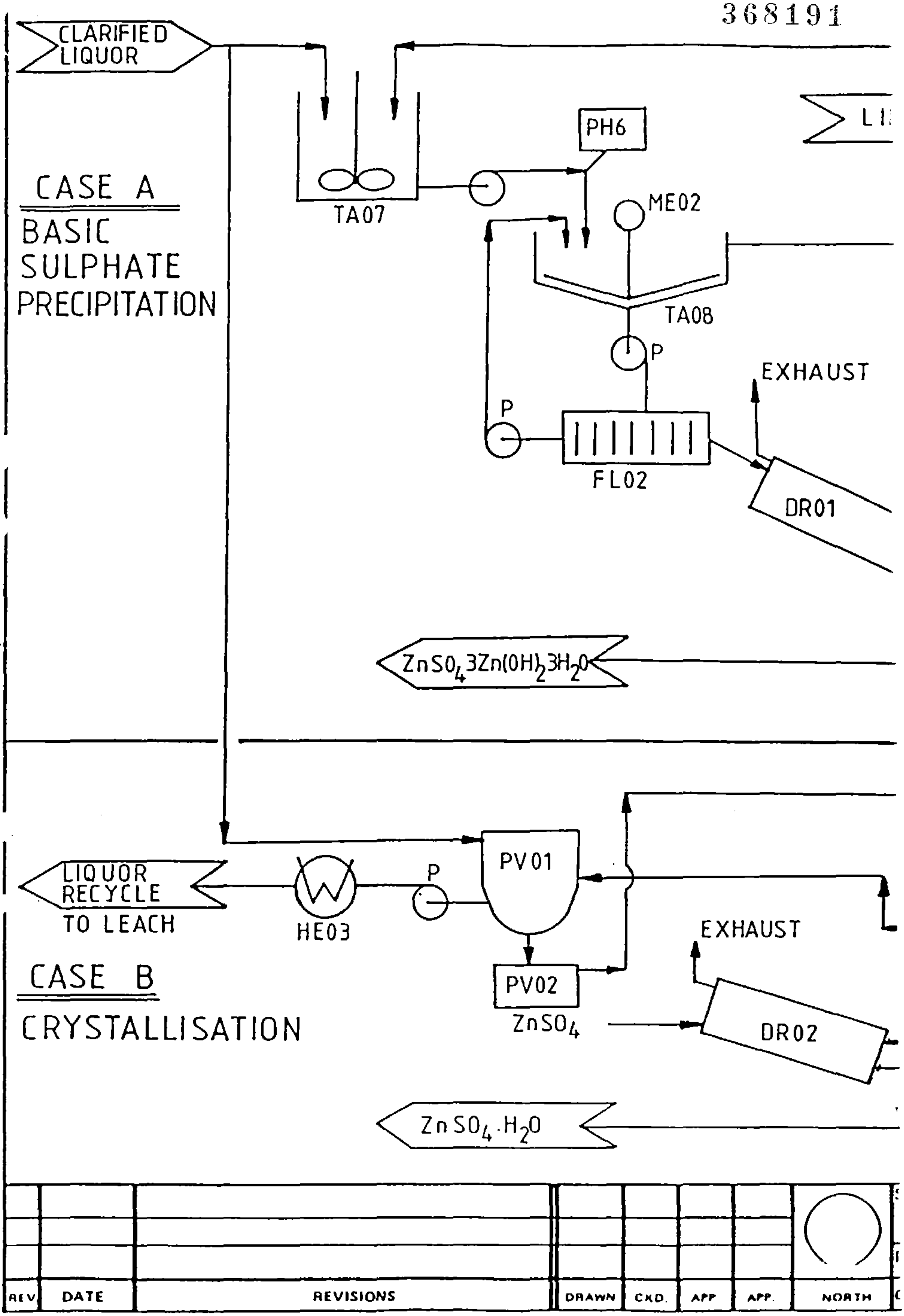
UNIT RATES

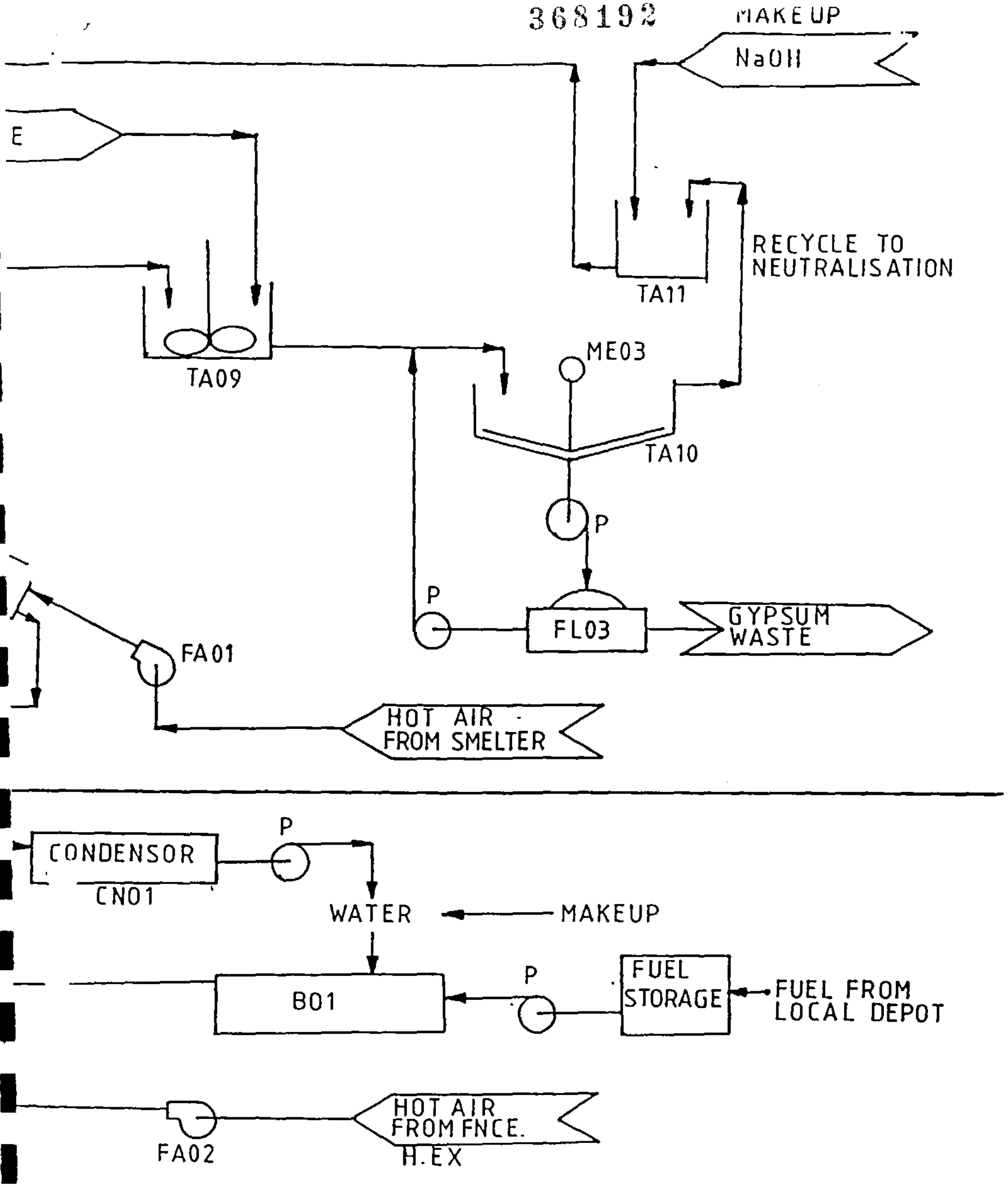
	UNIT	RATE ($)
MANPOWER	ea	30000
SULPHURIC ACID	t	50
WATER	m^3	0·6
POWER	kWh	0·1
LIMESTONE	t	75
SODIUM HYDROXIDE	t	500
FLOCCULANTS	t	2000
PRODUCT TRANSPORT	t	50
GYPSUM DISPOSAL	t	5


LIQUOR RECYCLE
WATE
PU08
FUME FROM BAGHOUSE
M
AG01
PU01
TA03
40% SLURRY
PU03
TH01
ME01
PU04
PU06
FL01
RESIDUE TO SMELTING
PU05
PU07
WASH WATE
SC.
DR
CH
REV.
DATE
REVISIONS
DRAWN
CKD.
APP
APP
NORTH



SCALE	REFRACTORY & METALLURGICAL SERVICES ENGINEERING CONSULTANTS	AUSMELT PTY. LTD.
DRAWN GEORGE VOGDANOS	DATE AUG 1985	LEACHING CIRCUIT
CHECKED G. V.	APPROVED MCW 7-8-85	FIGURE 1


CLARIFIED LIQUOR
CASE A
BASIC SULPHATE PRECIPITATION
TA07
PH6
ME02
TA08
P
EXHAUST
P
FL02
DR01
ZnSO4 3Zn(OH)2 3H2O
PV01
LIQUOR RECYCLE
TO LEACH
HE03
P
EXHAUST
CASE B
CRYSTALLISATION
PV02
ZnSO4
DR02
ZnSO4·H2O
REV
DATE
REVISIONS
DRAWN
CKD.
APP
APP.
NORTH



ALE	REFRACTORY & METALLURGICAL SERVICES ENGINEERING CONSULTANTS	AUSMELT PTY. LTD.
RAWN GEORGE VOGDANOS	DATE 5 8 85	RECOVERY PROCESS OPTIONS
ECKED G.V.	APPROVED MCW 7-8-85	FIGURE 2

APPENDIX H

ENVIRONMENTAL SCOPING STUDY

BHP Engineering

ZEEHAN RETREATMENT PROJECT

PRELIMINARY INFORMATION

FOR THE

OFFICE OF ENVIRONMENT

Ref: PS:VH:E200/391
Report No: EP-R2948
October 1990

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CONTENTS

1.0 INTRODUCTION

To assist the Office of Environment in fulfilling its obligations in setting guidelines for the preparation of a Development Proposal and Environmental Management Plan (DPEMP), BHP Engineering has prepared the following information, on behalf of Pyrosmelt NL.

The information is, of necessity, preliminary as the project has not yet advanced beyond the prefeasibility stage. However it is recognised by Pyrosmelt NL that the environmental aspects need to be examined as part of the prefeasibility study to provide the necessary input to the plant design, layout and operating parameters.

Data presented is the best available to the project at this stage and is not expected to change significantly for the final plant though it will be refined during the detailed design phases of the project. Layouts shown in the sketch maps are indicative only and are not based on detailed engineering data so may need to be altered. However given the nature of the equipment the limiting factors in the layout of the site are access to the existing slag dumps, suitable areas for stockpiling of raw materials and new waste dump locations.

The information and interpretations presented in this report are based on data gathered from a variety of sources including:

Pyrosmelt NL
Dragon Resources
Ausmelt Pty Ltd
BHP Engineering Pty Ltd
Zeehan Municipal Council
HEC (& RWSC)
School of Mines Museum (Zeehan)
Pasminco Limited – Roseberry
Mt Lyell Mining Company – Queenstown
Bureau of Meteorology
Site Visits

This information is provided to enable the Office of Environment and associated Government agencies to base the requirements for a DP & EMP on the latest information available to the proponents.

2.0 PROJECT DESCRIPTION

2.1 BACKGROUND

Pyrosmelt NL intends to reprocess the waste slag dumps at the 'Zeehan Smelter Site' which accumulated over three distinct operating periods during the period 1898 to 1946. Most of the slag was probably produced during the period 1898 to 1914 with lesser quantities during the second period of operations from 1924 to 1930 during which it appears that roasting was the main activity followed by flotation.

The process proposed to recover the zinc and lead is 'Sirosmelt' which is a small scale submerged combustion process originally developed by the CSIRO and now marketed by Ausmelt Pty Ltd and MIM Limited. Various plants have operated over the past ten or so years on materials ranging from tin, lead, zinc and copper concentrates to residual slags from traditional smelting processes. Plants are currently operated at:

- Mt Isa (3 plants)
- Port Pirie, SA
- Newcastle, NSW
- Arhnem, Netherlands

The scale of these plants range from a few tonne per hour to 24 tonne per hour. A plant was also operated in Sydney processing tin ores in the late 70's until poor economics forced its closure. Commercial plants have operated since 1978 and a number of plants are planned or being constructed worldwide.

The smelter site is covered by a mining lease held by Pasminco Mining who have entered into the appropriate agreements with Dragon Resources to allow Dragon Resources Limited and Pyrosmelt NL access to the slag dumps.

2.2 PROCESS TECHNOLOGY

The Sirosmelt process is a submerged combustion process where air and fuel are injected below the surface of a liquid slag via a hollow lance. Combustion of the fuel within the slag provides both the heat to melt more slag and the heat required for the reduction reactions. Cold feed and reductant (coal) are added in lump form through a feed port in the top of the furnace with the lump material rapidly consumed in the slag bath due to the intense stirring of the bath by the injected air.

The zinc oxide together with the oxides of lead and other minor elements are reduced and volatilised. The intense stirring and flushing action of the process gas removes the reduced metals from the bath. Above the bath the metals are rapidly reoxidised by supplementary air entry through the top of the lance. The oxidised fume produced is then collected in a baghouse.

Zinc in its metallic form has a boiling point of 907°C. The operating temperature for melting the slag is 1200°C and this provides the mechanism for the fuming of zinc metal. The zinc oxide in the slag has first to be reduced before fuming and this is achieved by the addition of coal to the molten slag bath. Reduction of zinc is thought to occur by a number of mechanisms, the most important being:

$$ZnO + C - Zn + CO$$

The vaporised zinc metal is oxidised with air above the bath and the resultant fume is collected by a baghouse after the gas cooler. The fume is then bagged, ready for sale to the market.

The plant can be run in either batch mode or continuously, however a decision has not yet been made as to the mode of operation for this project. There are no significant differences in emissions or plant design between the continuous and batch modes. The final selection is more dependent on parameters such as ease of winning the slag and arrangements for plant operators, however it is expected that the plant will run 24 hours a day, seven days a week.

2.3 PROCESS STEPS

To describe the individual steps in converting the waste slag to zinc oxide it is easier to consider the batch method. There are six steps in the process:

- slag smelting
- slag reduction
- after burning
- gas handling
- slag handling
- furnace standby

2.3.1 Slag Smelting

At the beginning of each cycle a bed of molten slag is present from the previous batch which helps maintain the necessary temperatures in the furnace. Fine coal is fed through the lance with air to provide the energy source and lump slag is added and melted together with lump coal which acts as the reductant.

This step removes most of the zinc from the slag typically reducing the zinc content below 5% and typically takes 4 to 5 hours at the scale of operation considered here.

2.3.2 Slag Reduction

During this step the zinc content is further reduced by the addition of more coal both as reductant and fuel but no further slag is added. The temperature of the bath is raised to about 1300°C from 1200°C with the zinc content reduced below 2% over some 1.5 to 2 hours.

2.3.3 After-Burning

After-burning occurs during both the above stages by the addition of air in the upper region of the furnace. The air converts the metals to their oxides, CO to CO_2, and the coal volatiles to CO_2 and water.

2.3.4 Gas Handling and Fume Collection

The after burning process is highly exothermic and temperatures of 1700°C are expected at the top of the furnace vessel. Gases are cooled by a water spray gas cooling tower. The cooled gases (200°C) are then led to a filter baghouse where the product is separated from the air stream.

The remainder of the gases (CO_2, H_2O, N_2, SO_2) are then emitted via a stack to the atmosphere.

2.3.5 Slag Handling

Reduced slag, now depleted of zinc, lead and minor constituents, is tapped from the furnace and granulated by a high pressure water jet. The fine granulated slag is useful for sandblasting, roadmaking or fill and can be stockpiled for later use. Alternatively this inert material can be placed in a new dump and rehabilitated. Slag tapping occurs once per cycle.

2.3.6 Furnace Standby

At various times the furnace will not be smelting or reducing slag but will be kept at the required operating temperature. This will occur during slag tapping, or during minor disruptions to the process. Coal is added as the fuel source to meet the temperature requirements.

3.0 INFRASTRUCTURE REQUIREMENTS

3.1 RAW MATERIALS SUPPLY

Coal and slag are the two major raw materials required for the process. The slag is obviously available on site whilst the coal is expected to be obtained from the east Tasmanian coal field.

Slag will be won by front end loader or a large backhoe. A dozer may also be required. Due to a comparatively small scale of operation the equipment required will be smaller than that normally associated with mining type procedures. It is unclear what pretreatment (crushing, screening) will be required to prepare the slag for feeding to the furnace.

Coal will be stockpiled on site to the extent required to ensure the furnace is kept supplied. A nominal one week stockpile of 1500 tonne is envisaged. Some treatment of the coal will be required to produce the fine and lump coal fractions. Sizing and pulverising equipment will be required for this process. All runoff from the stockpile area will be directed to the site water dam and used in the process to lessen the requirement for make up water. Dust control will be exercised through normal handling practices and also by keeping the coal damp if stored for extended periods.

3.2 Water Supply

Water is required for three principle functions in the plant being:

- gas cooling
- furnace cooling
- slag granulation

An additional quantity is also required for general housekeeping and dust control around the site.

There is expected to be a net loss of water in the order of 55 m^3/hr or 1320 m^3/day with the major consumption being for gas cooling. There will be a recirculating water load for slag granulation and furnace cooling which will pass though a cooling water pond to settle out solids. Runoff from the site will also be directed to this pond to reduce make up requirements from other sources. Should there be an excess of water it will overflow the settling pond and be directed to the natural drainage systems.

The required water is expected to be obtained from either Austral Creek which passes just below the site or from the Little Henty River which is 1 km to the east. Austral Creek was the water source for the original smelters which used three steam driven pumps to lift the water to head tanks above the smelter complex. Initial calculations based on catchment area, rainfall and runoff estimates indicate that the required quantity of water can be supplied from either stream.

Abstraction of water will require the permission of the Rivers and Water Supply Commission. The discussions with the RWSC to date have been to determine whether streamflow data exists for the Little Henty and Austral Creeks.

3.3 Power Requirements

A plant of the size anticipated will require approximately 2 MW with the primary use being the fan, air compressors, crushing and screening plant and the various pumps. No power is available at the site, the closest connection point being Zeehan.

3.4 Air Supply

One of the key aspects of the process is the injection of air to combust the coal and provide the intense agitation required. The air requirements are met by compressors located near the furnace which supply both high pressure air (250 kPa) for the lance and low pressure (20 kPa) for the after burner. It is expected that a number of smaller compressors will be used rather than one large unit for reliability.

3.5 Workforce

The anticipated workforce is in the range of 15 to 25 but cannot be determined more definitely at this stage. Most of the workforce is expected to reside in Zeehan.

3.6 Transport

Transport options for coal supply and product shipment have not been investigated in any detail as yet. However adequate transportation infrastructure is apparently available according to discussions with Zeehan contacts.

4.0 ENVIRONMENTAL FACTORS

4.1 EXISTING SITE

This site has seen intermittent use as a mineral processing site since the late 1890's. First as a roaster and blast furnace and later as a roaster and concentrator. During the construction and operation of the site extensive changes occurred to the surrounding environment as a result of physical disturbance during building, the extraction of limerock, disposal of waste solids and the emissions from the roasters. Natural revegetation of the site has been slow, due in part to the coarse nature of the weathered siltstone and sandstones on the hills.

The vegetation bordering Austral Creek is considerably more diverse than that on the hillsides with a variety of tall shrubs and trees including Eucalypts, Banksias and Acacias. Also present are blackberry and other introduced species. The project is not expected to infringe on this area except as may be required to install pumping equipment. The tailings encroach on to this area and appear to be slowly smothering vegetation as the tailings are eroded.

The existing physical and biological environment of the site has been degraded and the site is basically unstable and would require time and effort to stabilise the site. This project can provide some measure of improvement through the appropriate layout and operation of the plant which will remove potential long term pollution sources. The new slag will have lower metal levels, be effectively inert and a potentially useful product in its own right.

Factors which have the potential to impact the environment are discussed below. It is the proponents view that each of these can be managed to provide adequate protection of the environment. It is also important to recognise that the project life is about 3 to 4 years at which time the plant is expected to be relocated.

4.2 EMISSIONS – WATER

Under normal operating conditions no water will leave the site as there is a net water loss due to cooling requirements. Site runoff will be directed to the cooling water pond which also acts as a sediment trap. During heavy rainfall events, especially when the plant is not operating, the cooling pond will overflow to the creek. As the process adds no metals to the water and the runoff would otherwise report to the creek in an uncontrolled manner, this arrangement is likely to improve water management on the site from the existing uncontrolled drainage.

Drainage from the new slag dumps is not expected to contain metals above the background as the slag is virtually inert. Similar Sirosmelt product from zinc slag has passed both the US EPA and Dutch leaching tests. The existing slag does not appear to be leaching to an appreciable extent with no evidence of vegetation damage immediately downtoe of the dumps. Some gypsum crystal growth is evident in the southern dump which may be due to the presence of other material (tailings, untreated ore) in the dump. Subsurface samples have been collected from beneath slag and these will provide additional data on contamination from leaching of the slag.

4.3 EMISSIONS – SOLIDS

The major solid waste will be the new slag which is a glass like siliceous material that is highly resistant to degradation making it a good material for sand blasting, road fill and similar construction purposes. The new slag dump could be placed so as to facilitate access to the material by potential consumers with ready access from the main road.

Alternatively the dumps can be located and managed for an end goal of a rehabilitated landform. The obvious locations for the new dumps are either immediately north or south of the existing dumps. In both cases the new dumps would be battered to a nominal three to one slope to facilitate rehabilitation. This activity would also soften the appearance of the site which has numerous high benches facing the main road.

Whilst the existing dumps have minimal vegetation this is apparently due to the lack of fine material to hold moisture and permit the development of root systems. In those locations where fine, granulated, slag has had eroded material washed over the surface, grasses have established voluntarily.

General solid wastes from the operation would best be disposed of in a controlled municipal waste dump. The Zeehan Municipal dump is approximately 1 km north of the smelter site and appears to take a wide variety of residential and light industrial wastes.

4.4 EMISSIONS – NOISE

The smelter itself is not expected to be a significant source of noise with the fan and compressors being the major sources together with the lance when it is just removed from the bath. However these factors have been effectively controlled by appropriate design as evidenced by the operating plants in Arhnem and the plant that used to operate in Sydney. General noise will also be emitted by the equipment used to recover the slag.

The nearest residence is approximately 1500 m from the site and shielded by two hills so should not be appreciably affected.

4.5 EMISSIONS – AIR

Emissions to the atmosphere from the process comprise the off gases from the furnace after passing through the baghouse. The main constituents will be N_2, O_2, CO_2, H_2O and SO_2 emitted in an air stream of 120,000 Nm^3/hr with an elevated temperature of approximately 150°C.

Emissions of sulphur dioxide are recognised to be of concern to the regulatory agencies and preliminary calculations have been prepared to show the likely ambient concentrations. The calculations are based on conservative data and use recognised formulae for the prediction of ground level concentrations and plume rise.

The ground level concentrations have been predicted for the nearest residence which is 1500 m north of the site. A range of atmospheric stability classes have been used following the approach of Turner (1969). Class A is the most unstable, Class D is neutral and Class F strongly stable. With the general climatic conditions of Zeehan the dominant class is expected to be neutral (Class D) with stable conditions also common (Classes E & F). The unstable conditions are expected to be infrequent probably occurring for less than 5% of the time.

The high frequency of neutral conditions (Class D) are the result of overcast and/or windy conditions. Unstable conditions are principally the result of thermally driven turbulence and these conditions are not expected to be common occurrences.

The results of the calculations are presented in Table 2 and show that for an emission rate of 40 g/s of SO_2, the concentrations are all below the annual average of 50 ug/m^3. The actual concentrations experienced at the residence would be considerably less due to the variability of the wind direction. The predicted concentrations approximate a 10 minute sampling period.

The sulphur dioxide emission rate depends on the amount of sulphur in the slag and coal and the retention rate in the new slag and product. Ausmelt have advised that they expect 70% of the sulphur to be retained. This is based on their extensive experience in testing of similar slags for treatment.

Due to the use of water for cooling the gas there will be a visible plume from the stack.

Minor constituents of the slag (As, Sb etc) are expected to report to the fume and will not present an environmental hazard.

5.0 HERITAGE VALUES

Three locations near the site have been nominated for the Register of the National Estate as items of geological importance. One of the locations is immediately south of the slag dumps and encroaches on the southern dump and includes most of the tailings. The nomination information indicates that the item of significance is the rock formation on the ridge running south of the old smelter where past activity has exposed geological stratigraphy of interest.

This issue is being addressed through the AHC however the proponents consider that the item of apparent interest is unlikely to be disturbed. Some of the area nominated would be disturbed in winning the slag but would not impact on the geological setting.

6.0 CONCLUSIONS

The information presented is the latest available to the proponents and is considered to be conservative in those areas where detailed data is unavailable. The proponents are committed to the responsible management of the site and recognise the need to incorporate environmental factors in the design of the project.

The proponents believe that the project will have a minimal and readily managed environmental impact which will be limited to the duration of the project. Some aspects of the project are expected to lead to a long term improvement in the environmental status of the site such as the removal of residual metal values from the slag and the granulated slag is expected to rehabilitate more successfully than the platey slag.

A prefeasibility study has recently been commissioned and will be prepared in conjunction with the DPEMP for the project to ensure environmental factors are incorporated in the design and layout of the plant.

Of the anticipated impacts, sulphur dioxide emissions in particular, have been evaluated in a preliminary manner and have been shown to be well within he appropriate standards. The proponents do not consider that modelling is required beyond the approach presented in this preliminary report.

TABLE 1

Key to Stability Classes for Calculations

Windspeed (m/s)	Day: Incoming Solar Radiation — Strong (1)	Moderate (2)	Slight (3)	Night: Cloud Cover — Mostly Overcast (4)	Mostly Clear
<2	A	A-B	B	E	F
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

After D.B.Turner. "Workbook of Atmospheric Dispersion Estimates." Washington, D.C. HEW, 1969.

(1) Clear skies, solar altitude greater than 60 degrees above the horizontal, typical of a sunny summer afternoon. Very convective atmosphere.
(2) Summer day with a few broken clouds.
(3) Typical of a sunny autumn afternoon, summer day with broken low clouds, or a summer day with clear skies and a solar altitude of 15 to 35 degrees above horizontal.
(4) Can also be used for a winter day.

TABLE 2

Typical Ground Level Sulphur Dioxide Concentrations for Stability Classes Listed in Table 1.

Windspeed (m/s)	Ground Level SO2 Concentration (g/m^3) SO2 emission rate 40 g/s				
1.5	22.6	0.8	0.8	0.0	0.1
2.5	14.0	14.0	0.1	0.0	2.3
4.0	29.5	4.9	4.9	0.0	0.0
5.5	15.9	0.0	0.0	0.0	0.0
6.5	22.6	0.1	0.1	0.1	0.1

Note:Where a range of stabilities is listed in Table 1, the class resulting in the higher concentration was used.

TABLE 3

Data for Calculation of Ground Level Concentrations

Emission Rate (g/s)	40
Distance to Receptor (m)	1500
Physical Stack Height (m)	50
Exhaust Temperature (C)	150
Ambient Temperature (C)	10
Stack Diameter (m)	1.75
Exit Velocity (m/s)	20
Gas Volume (Nm^3/s)	33

Standard Deviations for 1500m

Class	A	B	C	D	E	F
Sigma y	306	224	149	98	73	49
Sigma z	1065	171	88	42	29	19

TABLE 4

Wind Speed and Direction Summary - Zeehan (seven years of records)

	Calm	N	NE	E	SE	S	SW	W
% Average of all observations	8	11	8	3	11	5	15	7

	Calm to	0.3 1.4	1.7 2.8	3.1 5.6	5.8 8.3	8.6 11.1	11.4 13.9	14.2 +
% Average of all observations	8	18	30	25	9	5	3	1

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CALCULATION SHEET

PROJECT Zeehan Retreatment Project	SHEET No. 1	AMDT
PROJECT UNIT Sketch Map	DATE 2/10/90	
DEPARTMENT	AUTH JOB No.	PREPARED BY P.S.