Ausenco

GLENCORE
TECHNOLOGY

17631-01-00000-18172-001
Revision Number 1

Glencore Technology
ESG Study

Jameson vs Conventional Flotation Concentrators
25th October 2023

Ausenco

GLENCORE TECHNOLOGY

Revision Status

Revision	Date	Description	Author		Approver	
			Name	**Position Title**	**Name**	**Position Title**
A	24/8/23	Internal Review	Sam Crane	Process Engineer	Grant Ballantyne	Technical Director
B	8/09/23	Draft Report	Sam Crane	Process Engineer	Grant Ballantyne	Technical Director
C	10/10/23	Final Report	Sam Crane	Process Engineer	Grant Ballantyne	Technical Director
0	16/10/23	Final Report - Updates	Sam Crane	Process Engineer	Grant Ballantyne	Technical Director
1	25/10/23	Final Report - Updates	Sam Crane	Process Engineer	Grant Ballantyne	Technical Director

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Disclaimer

This document and its contents are for the private information and benefit only of Glencore Technology, for whom it was prepared and for the particular purpose which Glencore Technology previously described to [Ausenco Services Pty Ltd (**Ausenco Services**)]. The contents of this document are not to be reused in whole or in part, by or for the benefit of others without prior adaptation by, and the prior specific written permission of, Ausenco Services.

Particular financial and other projections, analysis and conclusions set out in this document, to the extent they are based on assumptions or concern future events and circumstances over which Ausenco Services has no control are by their nature uncertain and are to be treated accordingly. Ausenco Services makes no warranty regarding any of these projections, analysis and conclusions. Ausenco Services, its affiliates and subsidiaries and their respective officers, directors, employees and agents assume no responsibility for reliance on this document or on any of its contents by any party other than Glencore Technology.

The contents of this document are Copyright, © [2023] Ausenco Services. All rights are reserved.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Table of Contents

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

1 Executive summary

1.1 Context

Glencore Technology has engaged the services of Ausenco to perform a comparative analysis between the Jameson Cells and conventional flotation methods, using a plant capacity of 14 Mt/y as a benchmark. The study aims to compare two concentrators on capital costs, operating costs, and carbon footprint.

The 2 circuits compared have the following major equipment:

1. Jameson Concentrator:
    - Jameson rougher and rougher scavenger
    - IsaMill
    - Jameson cell cleaning circuit
2. Conventional Concentrator
    - tank cell roughers
    - vertical stirred mill
    - tank cell cleaning circuit

Process flow diagrams can be viewed in Appendix A.

1.2 Conclusions

Key findings and conclusions from the study include CAPEX, OPEX and carbon footprint:

1.2.1 CAPEX and OPEX

1. The capital cost for each of the concentrator designs were estimated to +30 -20% level of accuracy. Budget pricing was used for major equipment and database pricing was used for lower cost items.

   The capital cost of the conventional concentrator equipment was 11% lower than the Jameson cells. However, the total direct cost was 25% higher due to the larger footprint and structural steel requirement (Table 1).

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Table 1 Capital Cost Summary (A$M)

Description	Conventional Concentrator	Jameson Concentrator
Mechanical Equipment Cost	24.3	26.3
Structural Steel	7.9	1.6
Platework	1.9	1.7
Concrete	15.4	8.4
Pipework	6.4	5.0
E&I	7.7	5.5
Total Direct Cost	63.6	48.6

2. The operational cost of the conventional concentrator was almost twice that of the Jameson Concentrator. This is due to the larger power demand and the consideration of the impeller replacement costs required in the Conventional Concentrator.

Table 2 Operating Cost Summary (A$M/yr)

Description	Conventional Concentrator	Jameson Concentrator
Power	5.2	3.3
Consumables	1.9	0.4
TOTAL	7.1	3.7

1.2.2 Carbon footprint

Ausenco conducted an analysis of the greenhouse gas (GHG) emissions associated with the two concentrators. The study focused on evaluating the environmental performance of these concentrators by quantifying direct and indirect GHG emissions across the entire life cycle, encompassing both construction and operational phases.

1. The Scope 3 emissions during construction activities were halved for the Jameson Concentrator due to reductions in structural steel and concrete (see Figure 1).

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

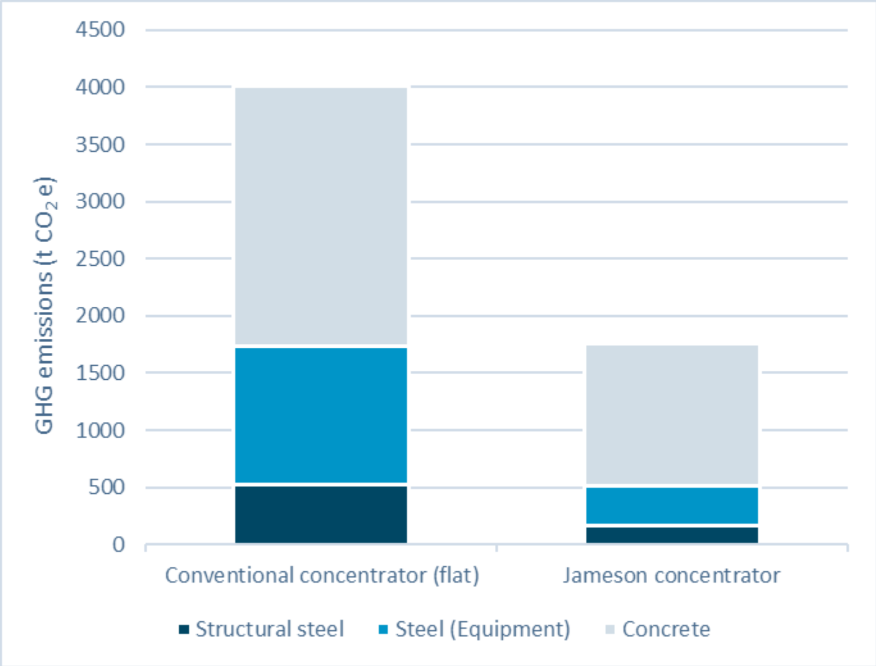


Figure 1 Scope 3 emissions associated with a Conventional and Jameson Concentrator

2. The Jameson Concentrator consumes 1 kWh/t less electrical energy in comparison to the Conventional Concentrator. This was due to the elimination of impellers and blowers in the Jameson Concentrator, and the scalping of rougher concentrate to final concentrate reducing the regrind energy.

3. The emissions associated with the media manufacturing and transport that is consumed in the regrind mills is 50% lower in the Jameson Concentrator due to the reduced regrind power and the use of ceramic media.

4. The operational emissions for the Jameson Concentrator is 40% lower than the Conventional Concentrator.

5. The operating emissions in one year are 3.2 and 3.7 times greater than all the emissions in construction for the conventional and Jameson Concentrators, respectively. Over the life of mine, the operational emissions will dwarf the construction emissions (see Figure 2).

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

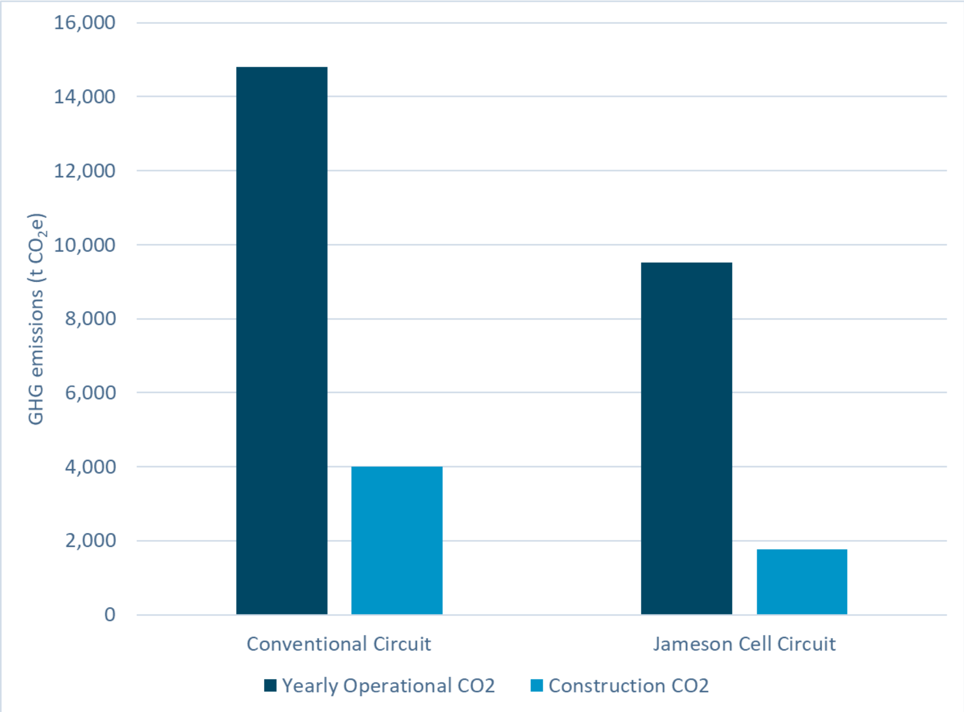


Figure 2 Operational and construction GHG emissions of conventional & Jameson Concentrators

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

2 Recommendations

Ausenco recommends the following actions following this study:

1. Investigate opportunities to reduce the height of the Jameson cells and hence the total steel required. Ausenco is exploring this on the Santo Domingo Project.
2. Identify opportunities for further reducing GHG emissions, specifically improving energy efficiency within the concentrators.
3. The accuracy of the concrete quantities for both concentrators should be improved to increase the accuracy of the GHG emissions associated.
4. The conventional cleaning circuit equipment selection should be revisited and optimised based on steel requirements, power consumption and CAPEX.
5. The GHG emissions relating to the production of ceramic media should be further investigated.
6. The impact of the concentrator configuration on the optimum grind size, recovery and concentrate grade should be assessed as this will impact the total processing plant emissions.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

3 Introduction

This report examines the greenhouse gas (GHG) emissions linked to both flotation equipment types, in partnership with Glencore Technology. Ausenco has conducted an analysis of the environmental efficiency of the Jameson cell and the conventional cell.

Through a systematic approach, Ausenco have quantified direct and indirect GHG emissions throughout the life cycle of each equipment type. Ausenco conducted detailed life cycle assessments including construction, and operation, to determine their respective carbon footprints.

The basis of design for both concentrators is a 14 Mt/y plant with a life of mine of 15 years. The equipment for each of the flotation plants were selected using the process design criteria seen in Appendix B.

The carbon footprint analysis was conducted, finding the Scope 2 and Scope 3 emissions related to each of the concentrators. These were analysed over both the construction and operational periods. The quantities used for this analysis came from reference projects. The reference projects modified for the conventional cell were built on a sloped terrain to save on quantities and pumping requirements. These quantities and power requirements have been modified to assess both concentrators on a flat terrain.

A capital and operating cost estimate was also completed. The capital costs for each of the concentrator designs were estimated to class 4 level of accuracy. Budget pricing was obtained for major equipment and database pricing was used for lower cost items. The operational cost estimate was assembled considering the power required, grinding media, consumables, and the maintenance materials for each of the concentrators.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

4 Methodology

4.1 Process design criteria establishment

- Basis of design agreed upon; throughput, LOM and reference projects
- Study scope and battery limits identified
- Ore characteristics and the selection of the ore design criteria review
- Feed grade and rougher concentrate grade established
- Process design criteria creation.

4.2 Equipment selection & process description

- Compare the Jameson Concentrator with the Conventional Concentrator using a flat terrain and sloped terrain that a conventional concentrator is typically laid out on. The justification to this new approach was that Glencore Technology has recently worked on a few projects on a flat terrain. This sparked the enquiry about the comparison of the Conventional Concentrator laid out on a flat terrain.
  - Basic engineering & 3D model
  - Class 4 estimate level quantities
  - Capital costs estimates
  - Operating costs estimates.

4.2.1 Capital cost estimate methodology

The capital costs for the concentrator designs were estimated to an accuracy level equivalent to the lower end of a class 4 estimate (+30-20%) level of accuracy. Budget pricing was obtained for major equipment. Details of the capital estimate classification can be viewed in Appendix 3.

Steel and concrete material take-offs have been developed using a combination of 3-D models and previous copper concentrators built by Ausenco. The concrete, steel and labour rates have come from an Ausenco DFS from 2023 in NSW.

An allowance was made for low capital cost items using Ausenco's database. The installation has been factored against mechanical equipment to get the total direct costs based on Ausenco benchmarks. No allowance for any project indirects have been included (i.e. temporary facilities, EPCM costs, owners cost, contingency).

4.2.2 Operating cost estimate methodology

The operating costs of the concentrator configurations were determined using budget pricing, Ausenco's database and the process design criteria. Reagent consumption was neglected from the study since it is assumed that they would be similar across both the Jameson and Conventional Concentrators. The operating costs Ausenco focused on were power consumption, media consumption, maintenance, and consumables, all of which would contribute to a differential in the operating cost and carbon footprint.

4.3 GHG emission estimate

- Identify sources of CO_2 and factor quantities based on throughput, equipment selection and layout. Sources of CO_2 assessed include:

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

   - Construction phase - steel and concrete
   - Operation phase - power consumption, regrind mill media consumption and transportation.
- Build Class 4 level model of CO_2e emissions for each of the concentrators using the reference projects and Ausenco's database. Carbon dioxide equivalent or CO_2e means the number of metric tons of CO_2 emissions with the same global warming potential as one metric ton of another greenhouse gas.
- Discuss preliminary results and pivot to flat terrain concentrator design

The high-level methodology is summarised in Figure 3.

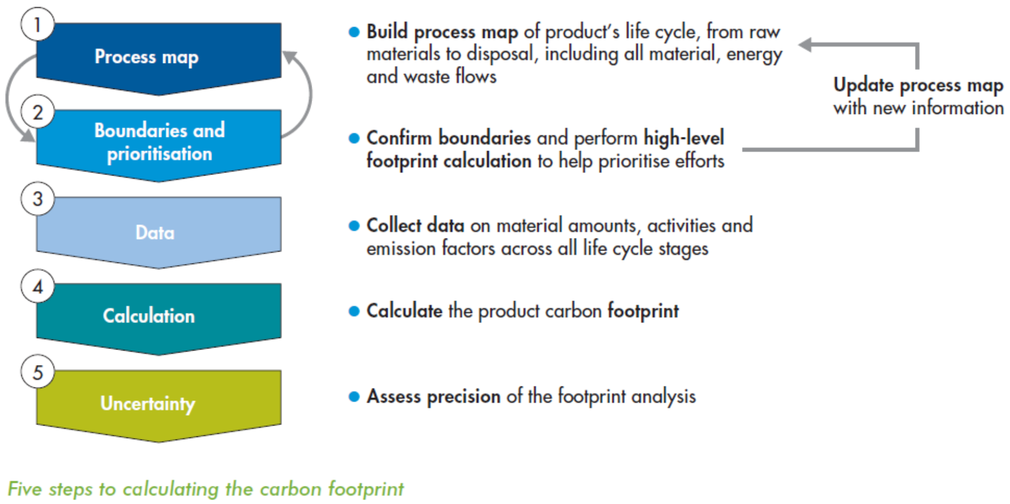


Figure 3 High level greenhouse gas emissions methodology [1]

[1] https://www.bsigroup.com/globalassets/localfiles/en-th/carbon-footprint/pas-2050-2011-guide.pdf

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

5 Process design criteria establishment

5.1 Equipment description

5.1.1 Jameson Cell

The design of the Jameson Cell is unique in that it combines key elements: a downcomer, the collection zone, and a separation tank. The Jameson Cell's design aims to maximize the contact between fine air bubbles and mineral particles, leading to efficient flotation. The use of a high-velocity jet of air in the downcomer helps create small bubbles, which enhances the attachment of these bubbles to the mineral surfaces. This design can result in improved recovery rates and selectivity compared to conventional flotation methods. Jameson cells do not have any moving parts, with the pump providing the only energy input. In addition, the air is entrained naturally through the venturi effect in the downcomer, so no blower is required.

5.1.2 Conventional flotation

The conventional flotation technology considered in the study was a tank cell. They are designed to handle high volumes of ore and 630 m^3 cells were chosen for this study. Tank cells employ a combination of mechanical agitation and forced air. The agitator has multiple (sometimes competing) purposes: suspending the mineral particles, generating bubbles, and contacting the bubbles and particles for collection.

5.2 User requirements

Glencore Technology has provided a list of requirements for this study to direct areas of focus as well as constraints for the analysis. These requirements can be seen in Appendix 2.

A summary of some of the requirements can be seen in the following table.

Table 3 Glencore Technology Study Requirements

Criteria	Unit	Conventional Concentrator	Jameson Concentrator
Feed rate	Mt/y	14	14
Life of mine (LOM)	y	15	15
Rougher Cell	-	TCe630	B8500/12
Flotation Scale-up Factor	-	2.5	-
Gas hold-up	%	15	-
Regrind Technology	-	Vertimill	IsaMill

5.3 Process design criteria

The process design criteria can be seen in Appendix D. A summary of some key inputs can be seen in Table 4

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Table 4 Process Design Criteria Summary

Criteria	Unit	Conventional Concentrator
Operational availability	%	91.3
Feed grade, Average	%Cu	0.39
Feed grade, Design	%Cu	0.79
Copper recovery, Design	%	91.0
Concentrate grade, nominal	%Cu	26.0
Ore specific gravity	t/m³	2.73
Regrind feed size, F_{80}	µm	75
Regrind product size, P_{80}	µm	40
Regrind Specific grinding energy	kWh/t	7.8
Regrind media consumption (steel media)	g/kWh	6.5
Regrind media consumption (ceramic media)	g/kWh	8.5

5.4 Project basis and throughput

The basis for the Jameson Concentrator is Copper Concentrator 1 project using a modified throughput. For the Conventional Concentrator, Copper Concentrator 3 and Copper Concentrator 2 are used.

Table 5 List of Project References

	Copper Concentrator 1	Copper Concentrator 2	Copper Concentrator 3
Feed rate (Mt/y)	20	30	25
Rougher Cells	6 x Z8500/12 Jameson cells	10 x TCe630 Tank cells	N/A
Regrind Mill	Isamill M7500	VTM3000	N/A
Cleaner Cells	3 x 5400/18 Jameson cells	N/A	12 x TCe130 Tank cells 2 x Column cells

5.4.1 Operational considerations

Flotation impellors are typically stored as critical spares and sites usually run these units close to mechanical failure. According to a study by Metso[2] their flotation mixing mechanism, FloatForce, needs replacement every 15 months to maintain the same metallurgical benefits. Therefore, the replacement expense is included within the operational expenditure estimate for the conventional concentrator. A more thorough assessment of the maintenance costs

[2] https://www.metso.com/insights/case-studies/mining-and-metals/flotation-upgrade-at-nui-phao/

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

for both scenarios is recommended to provide an accurate representation of the operating costs.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

6 Equipment selection & process description

6.1 Conventional concentrator

A single bank of five TCe630 rougher flotation cells were selected from Copper Concentrator 2 reference project to account for the reduced tonnage in this study of 14 Mt/y, down from 30 Mt/y. The basis used was a design target regrind size of 40 µm, sufficient to produce copper concentrate grades of 26% concentration.

For the flat terrain scenario, the rougher flotation bank has been elevated to support the gravity flow between each of the cells. Assuming this plant was built in Australia, elevating on steel frames is a cost savings approach which allows for reduced schedule using prefabricated frames. In a country with less expensive concrete, concrete supports would be selected.

Each cell was staggered in pairs to reduce the steel required. The height of the structure was set by the final rougher cell gravity line to the tailings thickener. The tailings thickener is outside of the scope of this study. There is an opportunity to reduce the height of the rougher cells and pump the rougher tailings to the thickener. This option would reduce the steel required in the rougher area by roughly 40% and increase the power required by the circuit.

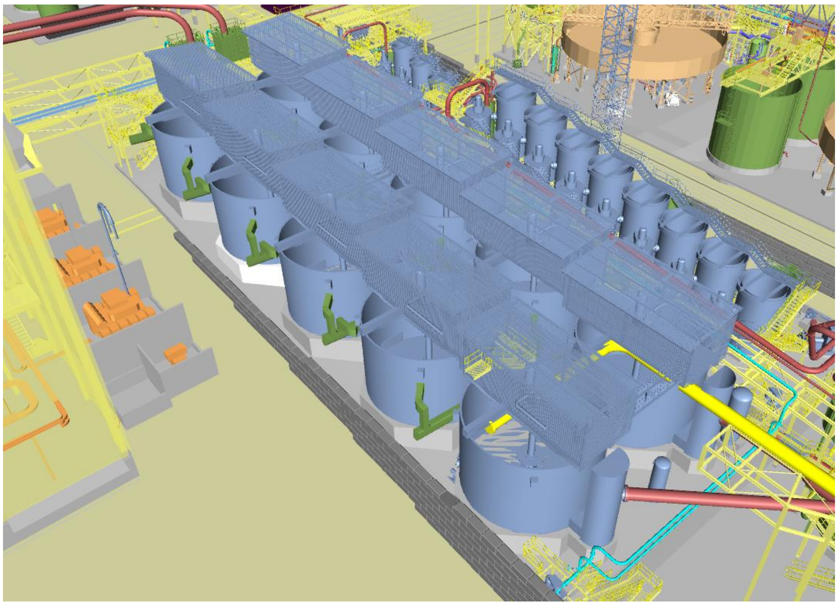


Figure 4 Copper Concentrator 2 Rougher Flotation Bank

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

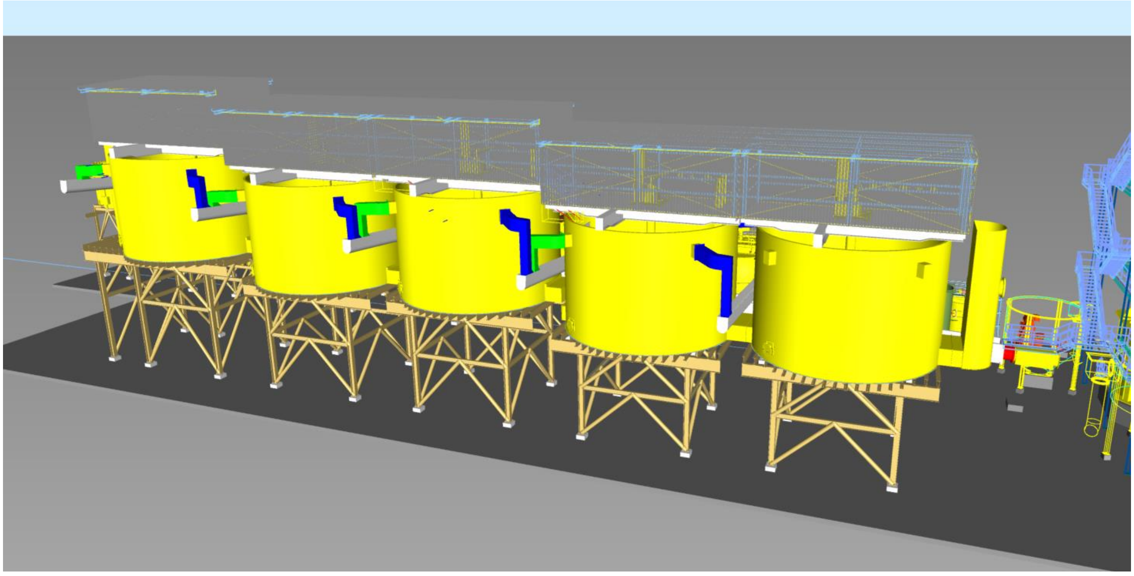


Figure 5 Conventional Flotation Rougher Bank (Flat Terrain)

The regrind milling circuit is designed to achieve a target P_{80} of 40 µm, sufficient to produce copper concentrate grades of 26%. A Metso VTM-3000 regrind mill was selected for the regrind duty as seen in Table 6 and Figure 6.

Table 6 Conventional Concentrator Regrind Mill

Criteria	Unit	Conventional Concentrator
Throughput	t/h	258
Regrind feed size, F_{80}	µm	75
Regrind product size, P_{80}	µm	40
Regrind Specific grinding energy	kWh/t	7.8
Installed power	kW	2237

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

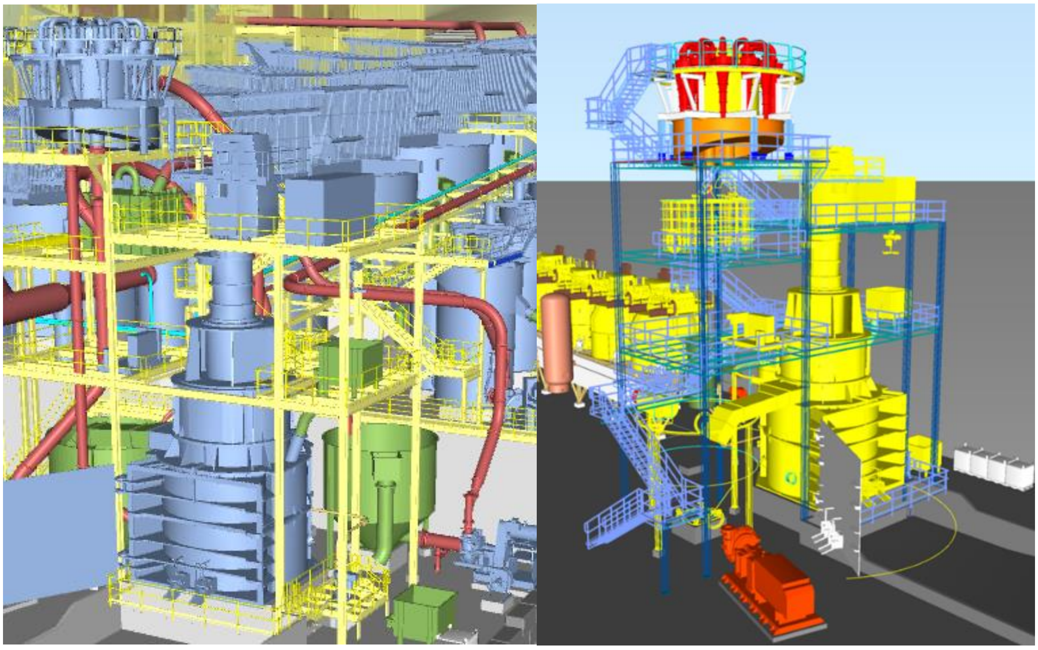


Figure 6 Copper Concentrator 2 Regrind Mill (Sloped) and Flat Terrain Regrind Mill (Right)

The cleaner circuit used for the conventional flotation sloped case was based off Copper Concentrator 3 seen in Figure 7.

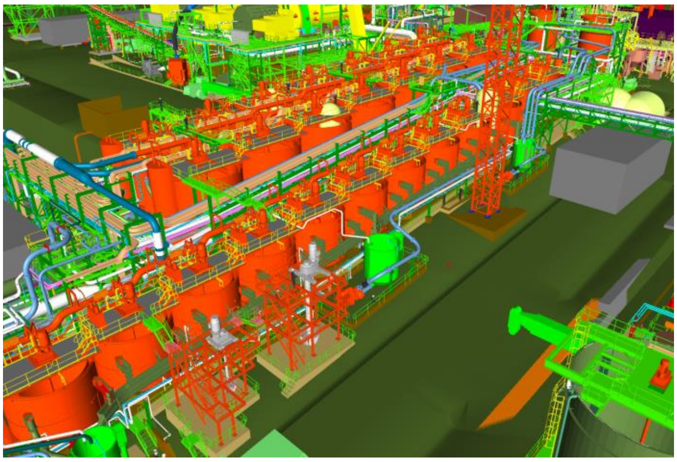


Figure 7 Copper Concentrator 3 Cleaning Circuit

The cleaner circuit designed for the standard flotation scenario has been appropriately designed to accommodate the processing capacity at the highest feed grade. The following tanks have been selected.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Table 7 Conventional Concentrator Cleaner cell selection

Duty	Cell Type	Quantity	Residence time (min)
Cleaner Scavenger	TCe70	5	20
Cleaner 1	TCe70	4	10
Cleaner 2	TCe70	3	8
Cleaner 3	TCe20	3	35

The arrangement on the level terrain facilitates the flow of tailings from each cleaning tank into the next cell through gravity shown in Figure 8. The final cleaner scavenger height was dictated allowing the tails to gravity flow to the tailings thickener. Like the rougher bank, there is an opportunity to reduce the total height of this structure. The final cleaner scavenger cell would be at ground height. Tailings pumping would be required, but this would account for roughly a 40% reduction in steel requirement for the cleaner area.

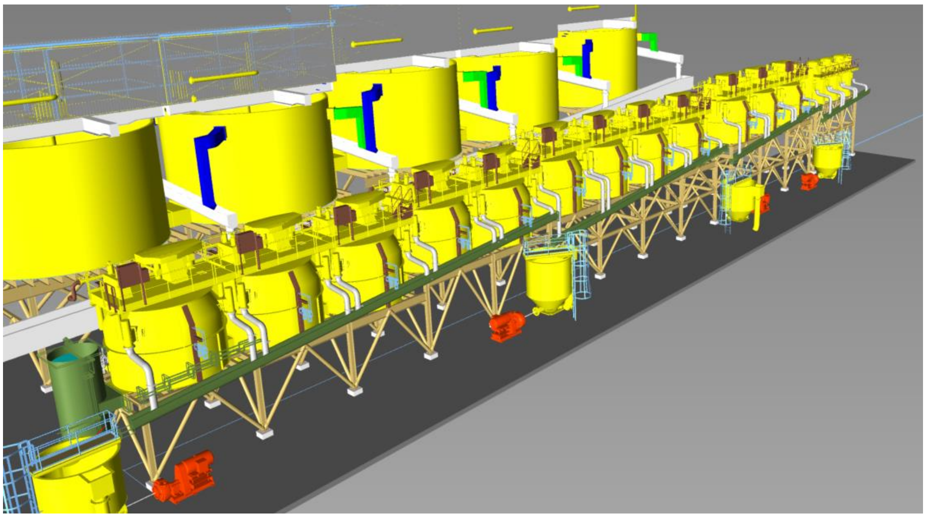


Figure 8 Conventional Flotation Cleaner Circuit on Flat Terrain

6.2 Jameson concentrator

The Jameson concentrator has been provided by Glencore and consists of 2 off B8500 ERM-Less cells.

The concentrator feed is processed in a rougher-scalper arrangement. The rougher is operated with a deep froth and high wash-water rate to produce a final concentrate grade product. The rougher scalper tail stream is operated with a low froth depth and high air rate to produce a high mass pull and low tailings grade.

Ausenco is currently investigating a Jameson Concentrator on a major copper project in Chile. Ausenco has made changes to this circuit using the B8500 ERM-less cell to reduce the structural steel required and the pumping head required.

There is an opportunity to rotate the orientation of the feed pump discharge to reduce the overall head height required of the cells. This reduction could be as large as a few metres.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

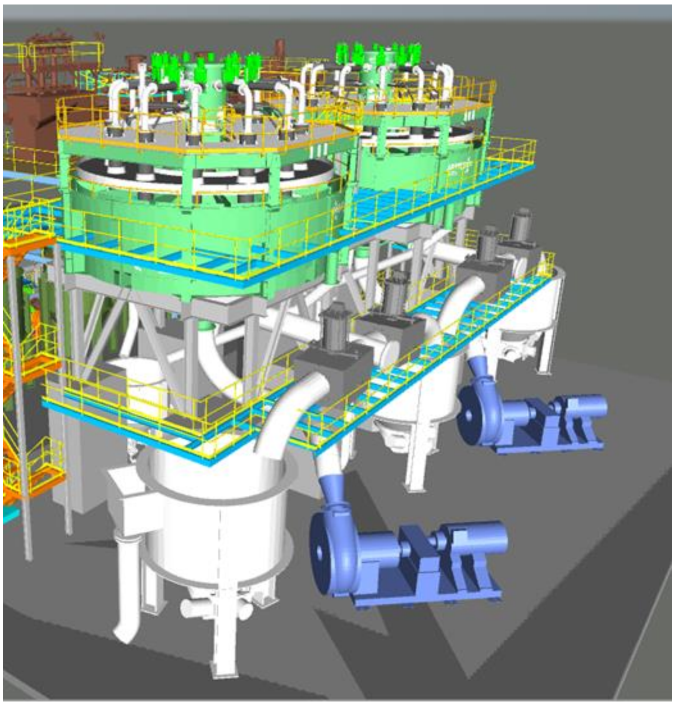


Figure 9 Jameson Cell Rougher Circuit

The regrind mill is set up in an open circuit configuration with a cyclone and is designated as an M7,500 primarily because of the substantial volumetric flow rate it handles. This can be seen in Figure 10.

Its low specific grinding energy of 7.8 kWh/t implies that, under normal operating conditions, the mill will consume 729 kW, and under design mass pull conditions, it will require 1131 kW. To achieve this, 5 mm ceramic media is employed to reduce the feed size from an initial F80 of 75 microns to a final P80 of 45 microns.

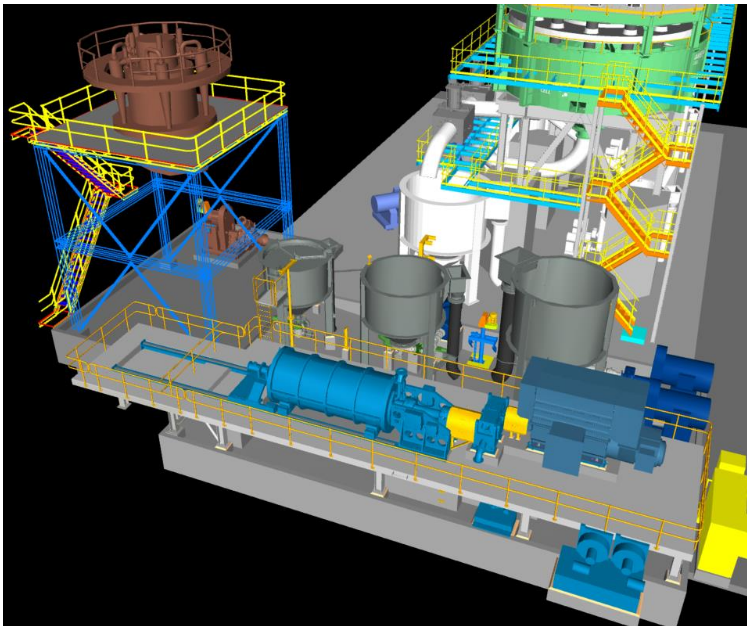


Figure 10 Jameson Concentrator Regrind Mill Area

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

The cleaner flotation cells in Table 8 have been selected and the layout can be viewed in Figure 11.

Table 8 Flotation Cells Selected for the Jameson Cleaning Circuit

Duty	Cell Type	Quantity
Cleaner 1	B4500/12	1
Cleaner Scavenger	B4500/12	1
Recleaner	E2514/3	1

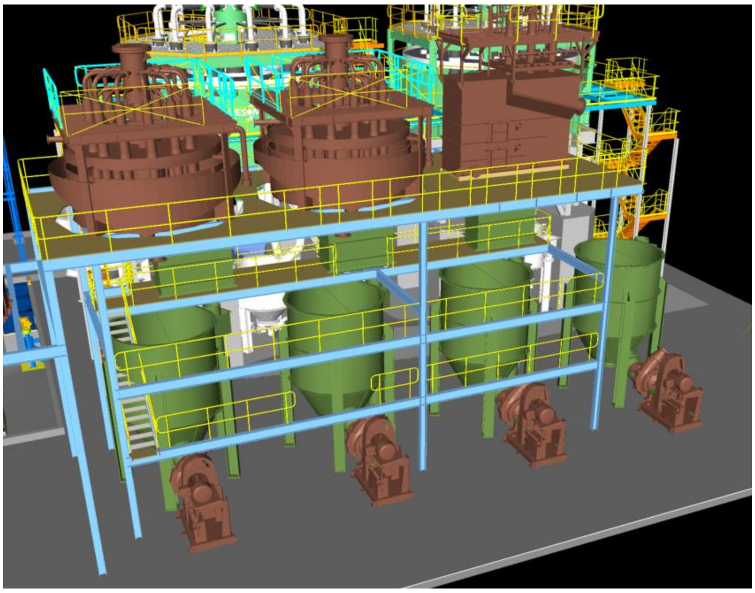


Figure 11 Jameson Flotation Cleaning Circuit

The regrind product is directed to feed a B4500/12 Jameson Cell. This Jameson Cell operates with a deep froth and a substantial wash water flow rate, facilitating the separation of newly liberated material and the production of a final concentrate.

The remaining middlings particles found in the tailings of the cleaner-scalper are then introduced into the cleaner-scavenger Jameson Cell. In this configuration, the cell is operated aggressively, without the use of wash water, and maintains a low froth depth while employing a high air rate. This approach is designed to achieve a high mass pull and a low cleaner tails grade.

Subsequently, the resulting concentrate is transferred to a smaller E2514/3 Jameson Cell. This cell operates with a high froth depth and utilizes wash water to produce a concentrate from the middlings material, which can later be blended into the final concentrate.

A key feature of the resulting concentrator is that each cell has been given only one function in the circuit; either grade-focussed, or recovery-focussed. This means that each cell can be set up with appropriate operating conditions and can make use of the Jameson Cell's tails recycle mechanism to absorb a wide range of feed fluctuations to maintain overall circuit stability despite any fluctuations in feed grade and mass pull.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

7 Capital cost estimate

The capital costs for the concentrator designs were estimated to an accuracy level equivalent to the lower end of a class 4 estimate level of accuracy in term 3 of 2023.

The price of steel and concrete used was $18,603 per tonne and $3,553 per cubic metre, respectively.

Budget pricing was obtained for major equipment. An allowance was made for low capital cost items using Ausenco's database. The installation including all other disciplines have been factored against mechanical equipment to get the total direct costs. No allowance for any project indirects have been included (i.e. temporary facilities, EPCM costs, owners cost, contingency).

Table 9 Capital Cost Summary (A$M)

Description	Conventional Concentrator	Jameson Concentrator
Mechanical Equipment Cost	24.3	26.3
Structural Steel	7.9	1.6
Platework	1.9	1.7
Concrete	15.4	8.4
Pipework	6.4	5.0
E&I	7.7	5.5
Total Direct Cost	63.6	48.6

The capital cost of the conventional concentrator equipment was 8% lower than the Jameson cells.

However, the total direct cost was 25% higher due to the increased footprint and structural steel required for the flat terrain scenario.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

8 Operating cost estimate

Operating costs for the process plant were estimated on an annual basis for following cost centres in the flotation and regrind circuits:

- Power – The electrical power draw was derived from the electrical load list.
- Grinding media and consumables – costs associated with grinding mill liners & grinding media. The consumption rates and unit pricing were provided by the design criteria and vendor budget quotations.
- Reagents – Both technologies should theoretically use similar reagents and consumptions, so the operating costs haven't been considered in this study.

Table 10 Processing Plant Operating Cost Summary by Category

Area	LOM Costs (A$M/y)	LOM Costs (A$/t)	% of Costs	LOM Costs (A$M/y)	LOM Costs (A$/t)	% of Costs
	Conventional Concentrator			**Jameson Concentrator**		
Power	5.2	0.37	73	3.3	0.24	89
Consumables	1.9	0.13	27	0.4	0.03	11
Total	7.1	0.50	100	3.7	0.27	100

8.1.1 Power costs

The power cost utilised for the study is A$0.137/kWh. The power requirements for the plant were developed from the electrical load list generated combining the impellor, blowers, pumping requirements and the regrind mill.

The largest contribution of power was the impeller in the Conventional Concentrator and the pumping requirements in the Jameson Concentrator.

Power from each area was calculated, and the kilowatt hour rate per plant feed tonne is presented in Table 11.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Table 11 Annual power consumption for each of the plants

Area	Unit	Conventional Concentrator	Jameson Concentrator
Impellors	kWh/t	1.44	-
Blowers	kWh/t	0.36	-
Pumps	kWh/t	0.35	1.31
Regrind Mill	kWh/t	0.55	0.42
Total	kWh/t	2.70	1.73

8.1.2 Consumables costs

The main operating and maintenance supplies include grinding media, mill wear liners and the flotation impeller replacement.

The costs of consumables for the process plant were derived from the consumption rates agreed upon in the process design criteria. Grinding media consumption rates were estimated from the ore abrasion index and the expected average mill power draws. The regrind media costs were derived from recent budget pricing.

Consumables related to equipment were sourced from vendors as part of the capital estimate. The expected frequency of liner replacement for components associated with the regrind mill were estimated from Ausenco's database on typical wear rates for similar style operations or vendor recommended change-out frequency based on the specified duty. Information from vendors was also assessed for accuracy based on Ausenco experience.

Sites usually run mixing mechanisms units close to mechanical failure. According to a study by Metso[3] they're flotation mixing mechanism, FloatForce, needs replacement every 15 months to provide the same metallurgical benefit. Therefore, Glencore Technology would like to take this extra cost into account within the operational cost section of the report.

A breakdown of the consumable operating costs can be viewed in Table 12.

[3] (https://www.metso.com/insights/casestudies/mining-and-metals/flotation-upgrade-at-nui-phao/)

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Table 12 Consumable Operating Cost Summary by Plant

Area	Annual Cost (A$M/y)	Cost (A$/t)	% of Costs	Annual Cost (A$M/y)	Cost (A$/t)	% of Costs
	Conventional Concentrator			**Jameson Concentrator**		
Regrind Mill Media	0.1	0.01	5	0.2	0.01	42
Regrind Mill Liner	0.7	0.05	38	0.2	0.02	58
FloatForce	1.1	0.08	56	-	-	-
Total	1.9	0.13	100	0.4	0.03	100

8.1.3 Summary

The operational cost of the conventional concentrator was almost twice that of the Jameson concentrator. This is due to the larger power demand and the consideration of the impeller replacement costs required in the Conventional Concentrator.

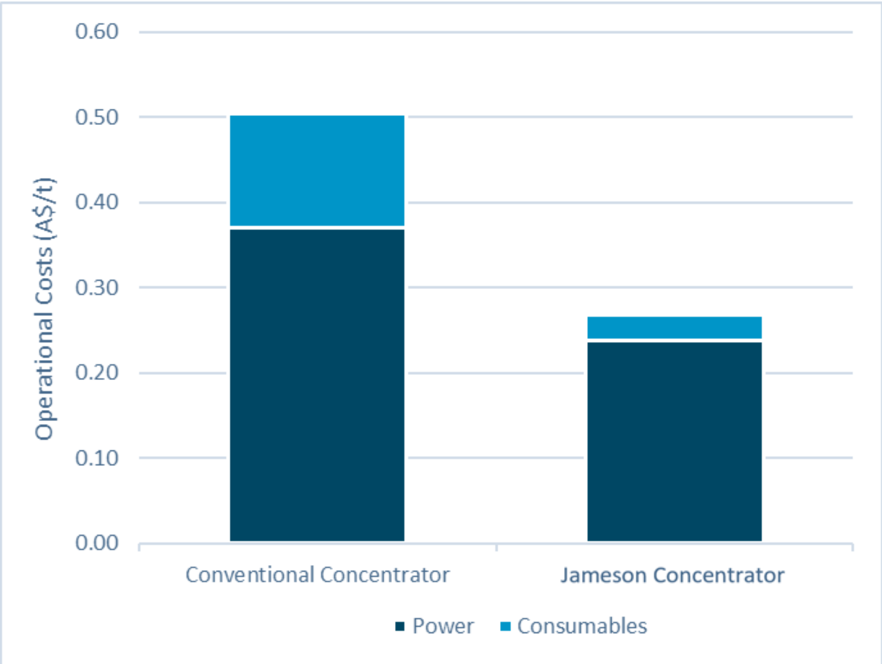


Figure 12 Operational Costs of Conventional & Jameson Concentrators

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

9 Greenhouse gas emission estimates

9.1 Objective

The aim of this project phase was to assess CO_2 emissions based on quantities, on both a flat and sloped terrain. CO_2 emissions have been analysed over the proposed LOM (15 years) using a model that divides emission sources into two phases: construction and operation as per Phase 2.

9.2 Approach

The approach used was per the PAS 2050 assessment process presented in Figure 13.

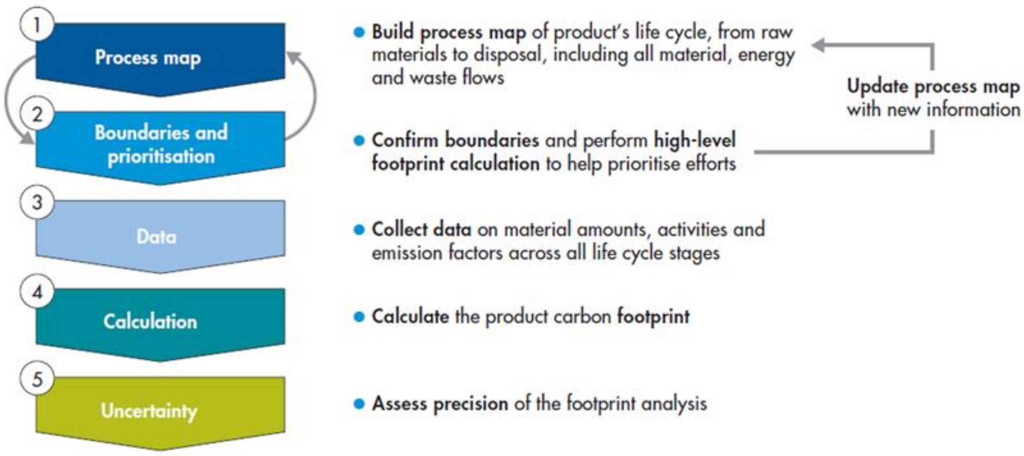


Figure 13 Five steps used to calculate the carbon footprint[4]

The US EPA provides guidance on the Green House Gas (GHG) protocol scopes and emissions across a value chain as per Figure 14.

Scope 1 emissions are not considered in this report as they would be similar for both flowsheets, within the accuracy of the data available.

Scope 2 emissions are related to electrical energy use. These are expected to differ across the options considered in this report.

Scope 3 emissions in operations relate principally to steel media and liner consumption in the regrind mill.

Scope 3 emissions in construction phase relate principally to concrete and steel consumption. Fuel consumption in both earthworks and construction support are relatively minor components of GHG emissions when compared to the energy embedded in steel and concrete and are considered similar across the options considered.

[4] https://www.bsigroup.com/globalassets/localfiles/en-th/carbon-footprint/pas-2050-2011-guide.pdf

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

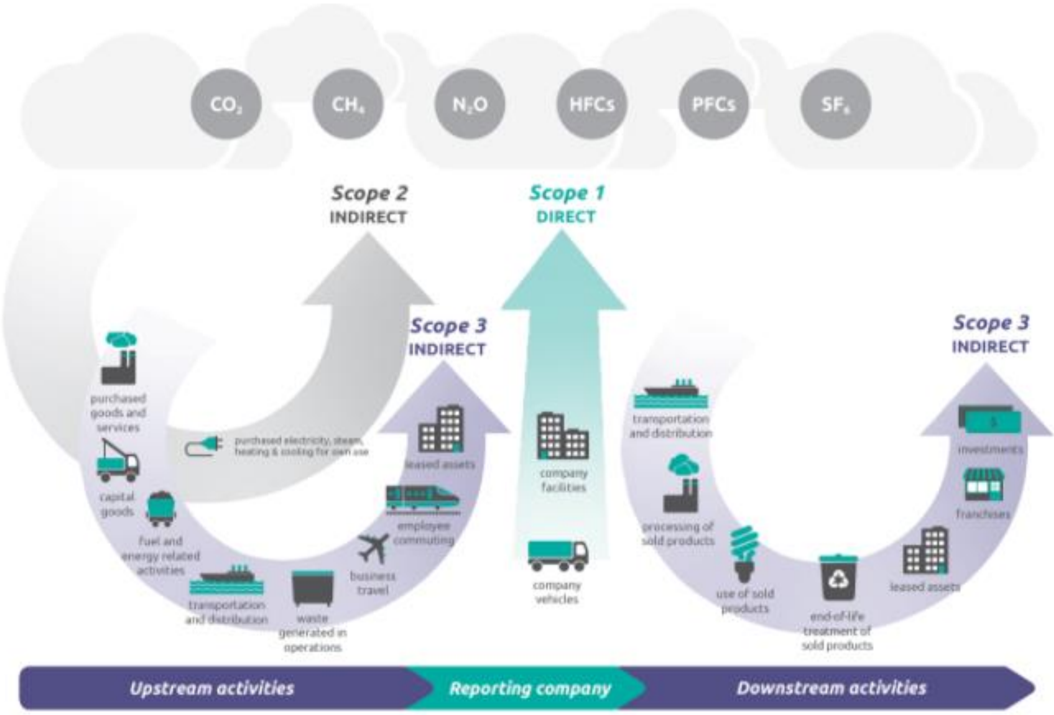


Figure 14 Overview of GHG protocol scopes and emissions across the value chain[5]

The aim is to use the Inventory of Carbon & Energy (ICE) version 2.0 factors. These were used to develop the GHG emissions for each of the reference projects and the numbers were factored again based on the studies throughput, equipment requirements and footprint.

9.3 Construction phase

Ausenco has previously conducted a GHG emissions analysis based on the bulk materials used in plant construction for a 25 Mt/y project. It was found that copper in motors resulted in about 2% of GHG emissions when compared to the steel and concrete. For this reason, copper hasn't been considered in this study.

Steel mass considered for this phase of the study is comprised of structural steel and mechanical equipment.

9.3.1 Basis of estimate

Steel mass considered for this phase of the study is comprised of structural steel and mechanical equipment.

A summary of the mechanical equipment masses can be seen in Table 14.

[5] www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Figure 15 Mechanical equipment total mass in tonnes

Equipment	Conventional Concentrator (t)	Jameson Concentrator (t)	Quantity
B8500/12		72	2
B4500/12		16	2
E2514/3		7	1
TCe630	70		5
TCe70	21		12
TCe20	11		3
Total	641	183	

Estimates of the quantities for the Conventional Concentrator and Jameson Concentrator are presented below in Table 13.

Table 13 Steel Quantities for Conventional Concentrator vs Jameson Concentrator

Quantity	Units	Conventional Concentrator (Sloped)	Conventional Concentrator (Flat)	Jameson Concentrator
Structural	t	185	276	87
Equipment	t	641	641	183
Total	t	826	917	270

The estimated total steel required in the Conventional Concentrator is 3.2 times that of the steel required for the Jameson Concentrator.

Concrete quantities for the flat terrain were factored based on the number of cells required from benchmarked data and can be seen Table 14. There is an estimated 55% reduction in concrete required for the Jameson Concentrator compared to the Conventional Concentrator.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Table 14 Concrete Quantity for Conventional Concentrator and Jameson Concentrator

Quantity	Units	Conventional Concentrator (Slope)	Conventional Concentrator (Flat)	Jameson Concentrator
Concrete	m^3	4329	4329	2366

9.3.2 Construction GHG emission factors

The GHG emissions factors used are listed in Table 15. These were obtained from the Inventory of Carbon & Energy (ICE) version 2.0[6].

Table 15 GHG emissions factors used for quantities

Commodity	Units	Value
Steel	$kgCO_2e/kg$	1.89
Concrete	$kgCO_2e/kg$	0.22

9.3.3 Construction GHG emission outcomes

The commodity splits between each of the concentrators have been used to calculate the total Scope 3 GHG emissions. The total Scope 3 emissions produced in the Conventional Concentrator is twice that of the emissions associated with a Jameson Concentrator. The equivalent tonnes of CO_2 totals are provided in Table 16.

Table 16 Scope 3 GHG emissions associated with the concentrator summary

Source	Units	Conventional Concentrator (Slope)	Conventional Concentrator (Flat)	Jameson Concentrator
Structural steel	t CO_2e	350	522	164
Steel (Equipment)	t CO_2e	1,211	1,211	347
Concrete	t CO_2e	2,278	2,278	1,245
TOTAL	t CO_2e	3,838	4,011	1,756

[6] Hammond, G.P. and Jones, C.I., 2008. Embodied energy and carbon in construction materials. *Proceedings of the Institution of Civil Engineers-Energy*, *161*(2), pp.87-98.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

9.4 Operational phase

9.4.1 Calculation basis

The assessment of greenhouse gas (GHG) emissions was conducted, focusing on both Scope 2 and Scope 3 emissions. Scope 2 emissions were exclusively derived from electrical energy calculations, while Scope 3 emissions encompassed the evaluation of steel and ceramic media consumption, along with transportation.

To undertake this analysis, several key inputs were taken into consideration, and their relevant summaries are presented in Table 17.

The quantity of electrical energy consumed by each of the flotation plant areas was assessed to quantify the Scope 2 emissions.

Within Scope 3 emissions, the study considered the consumption of steel and ceramic grinding media. Assessments were conducted to quantify the emissions associated with the production and consumption of these media.

A media supplier was consulted to determine CO_2 emissions associated with the production of ceramic grinding media. 0.97 $kgCO_2/kg$ was concluded using a combination of the electricity and natural gas required in the production of the media.

The CO_2 emissions associated with the production of steel grinding media used was 1.82 $kgCO_2/kg$ as per the Inventory of Carbon & Energy (Hammond & Jones, 2008)[3].

The transportation of grinding media from their respective production facilities to the plant site was also considered within the Scope 3 emissions. This aspect will have a varied implication depending on the transportation distance for a particular project. For this study 718 km was used, which is the distance from an Ausenco project to the nearest port. 0.14 tCO_2e produced per 100 km of travel was used assuming the transport is within a 40 t articulated truck.

Table 17 Summary Operating Emission key Inputs

Parameter	Units	Value	Source
Distance for media transport	km	718	-
Media transport	tCO_2e/100 km/truck	0.14	(Hammond & Jones, 2008)[3]
Steel (media)	$kgCO_2e/kg$	1.82	
Ceramic (media)	$kgCO_2e/kg$	0.97	Calculation
Electrical energy	$kgCO_2e/kWh$	0.39	[7]

[7] https://carbonfund.org/

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Scope 2 - electrical energy related emissions

The Scope 2 GHG emissions were calculated based on data sourced from Carbon Fund. They calculate emissions from electricity generation with the EPA's eGRID emission factors[8] based on 2021 data republished in 2023, using the US average electricity source emissions of 0.39 kgCO_2e/kWh.

Plant electrical energy consumption is summarised in Table 11 and the associated GHG emissions presented in Table 18.

Table 18 Operational Scope 2 GHG emissions summary

	Units	Conventional Concentrator (slope)	Conventional Concentrator (flat)	Jameson Concentrator
Electrical energy	tCO_2/y	14,076	14,704	9,480

The energy requirement in the Conventional Concentrator on the flat terrain required slightly more power due to pumping requirements. The 36% reduction in scope 2 emissions in the Jameson Concentrator is due to the Jameson Cell not requiring blowers and impellors.

Scope 3 operating GHG emissions

The Scope 3 GHG emissions related principally to steel and ceramic consumption as grinding media for the regrind circuit. A summary of the steel consumption is provided in Table 19.

Table 19 Comminution steel consumption

	Units	Conventional Concentrator	Jameson Concentrator
Media consumption	g/kWh	6.5	8.0
Mill power consumption	MWh/y	7.7	5.8
Annual consumption	t/y	50	47

The outcome highlights a very similar regrind mill media consumption in the Jameson Concentrator compared to the Conventional Concentrator.

The calculated Scope 3 GHG emissions are summarised in Table 20.

[8] Hammond, G.P. and Jones, C.I., 2008. Embodied energy and carbon in construction materials. *Proceedings of the Institution of Civil Engineers-Energy*, *161*(2), pp.87-98.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Table 20 Scope 3 GHG emissions Summary in the operation phase

Consumable	Units	Conventional Concentrator	Jameson Concentrator
Regrind Media	t CO_2/y	92	45
Media Transport	t CO_2/y	1.3	1.2
Total	t CO_2/y	93	46

9.5 GHG summary

The total GHG emissions for both scope 2 and 3 are summarised in Table 21.

Table 21 Total Scope 2 and 3 emissions for construction and operational phases

GHG	Units	Conventional Concentrator (slope)	Conventional Concentrator (flat)	Jameson Concentrator
Scope 2 Operating	t CO_2/y	14,076	14,704	9,480
Scope 3 Operating	t CO_2/y	92	92	45
Scope 3 Construction	t CO_2	3,838	4,011	1,756

Notably, the annual Scope 2 emissions, associated with electricity required in the conventional flat concentrator resulted in a 55% increase when compared to the Jameson Concentrator. This increase was predominantly related to the agitation power required in the tank cells.

The conventional concentrator, while offering similar consumption of regrind media, has led to double the GHG emissions because of the lower embodied emissions of the ceramic media.

The increase in footprint and structure required in the conventional concentrator option resulted in more than double the GHG emissions in the construction phase than the Jameson Concentrator.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

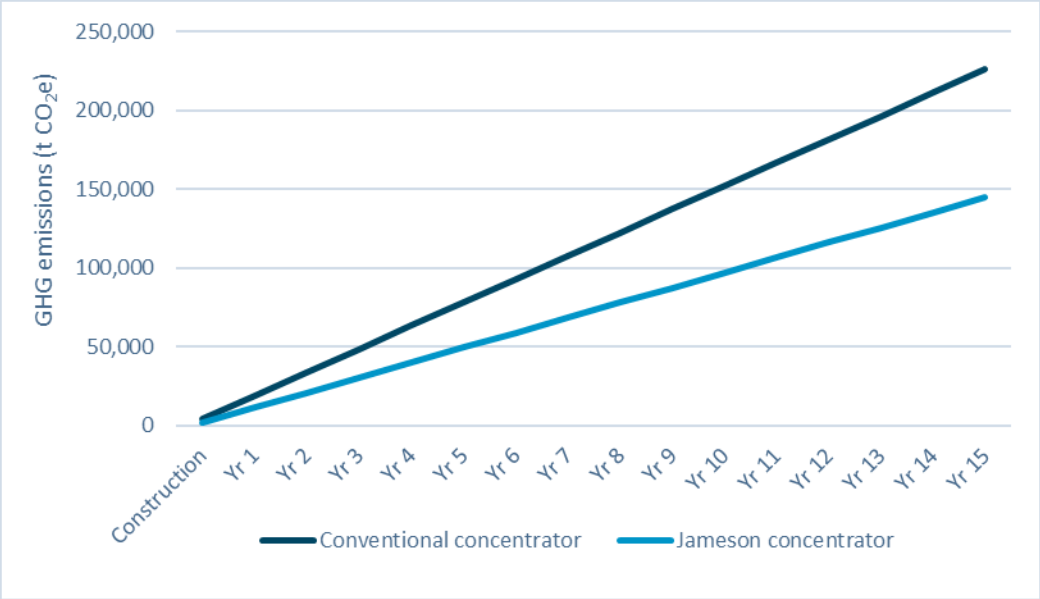


Figure 16 Cumulative GHG emissions over 15-year LOM

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

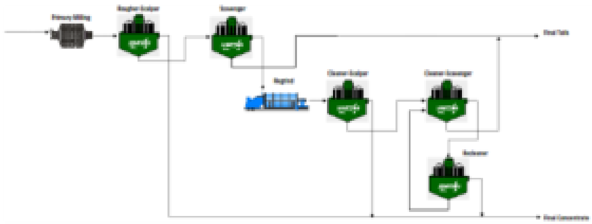
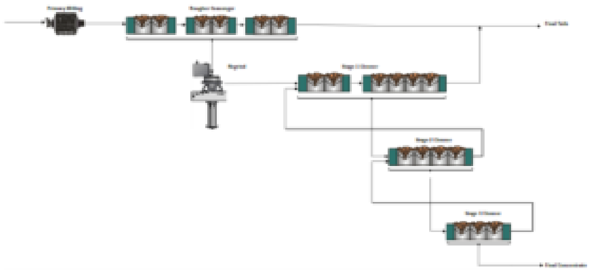
Appendix 1 – User requirements

DESCRIPTION	GLENCORE REQUIREMENTS
Throughput	Throughput should be 14 Mtpa - equivalent to a single bank of 2 x B8500/12 cells operating at 40% solids
Jameson Cell Selection (B vs Z)	Study should be based on the B8500/12, ERM-less design. This design is equivalent to the Z8500/12, however the feed box of the pump is separated from the cell and made cylindrical. This greatly reduces the quantity of bracing and steel required, without affecting the height of the unit compared to the Z cell. GT are currently developing the preliminary 3D model for this option and will provide this to Ausenco in the next 1-2 weeks.
Conventional Cell Selection (300 vs 630 m3)	GT agrees with the basis of the 630 m3 tank cells, however the concerns regarding the low carrying capacity of the cells further down the bank must be noted in the study. **There are currently no 630 m^3 cells operating in a scavenging capacity and this should be explicitly noted in the study.**

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

DESCRIPTION	GLENCORE REQUIREMENTS
Number of Cells in Series (Conventional)	The impact of the number of cells in series is well understood. A simple tanks-in-series model demonstrates that reducing the number of cells in series from the industry standard of 6 cells, reduces the recovery achievable by approximately ~1% per cell removed for the same residence time. Ausenco points out that this can be compensated by adding additional residence time over and above the standard lab scale x 2.5 factor, however the amount of residence time to achieve 1 % additional recovery may be substantial depending on the kinetic curve of the material. Similarly, Wood[1] (2002) argued that a large deviation from equal recovery in each cell would invalidate this approach. The requirement for this study is that the cells in series should be not less than 5 cells, and that the residence time used to target this recovery must exceed the laboratory requirement x 2.5 scale up factor. Gas hold-up must be a minimum of 15% used in sizing.
Concrete vs Steel	The B8500/12 cells should be supported by a small steel frame which is mounted on a concrete plinth. The plinth will require a cut out along the centre for the distributor feed line (GT to provide sketch – refer item 3)
Regrind Technology	The regrind technology for the Jameson Concentrator is the IsaMill. The regrind technology for the conventional concentrator should be a Tower Mill or HIG mill of equivalent kWh/t processed
Scalping	A key advantage of the Jameson Concentrator is the ability to scalp final concentrate from both the rougher feed and cleaner feed. This removes liberated material from the mill circuit product and frees up the remainder of the circuit to focus on middlings particles. Scalping is generally not possible in a conventional circuit design due to the poor upgrading in conventional cells unless multiple stages of cleaning are applied.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

DESCRIPTION	GLENCORE REQUIREMENTS
Circuit configuration	The following circuit is recommended for the Jameson Concentrator:  The following circuit is recommended for the Conventional Concentrator: 
OPEX	Flotation mixing mechanisms are typically not listed as operational but rather as critical spares. Sites usually run these units close to mechanical failure. According to a study by Metso (https://www.metso.com/insights/case-studies/mining-and-metals/flotation-upgrade-at-nui-phao/), their flotation mixing mechanism, FloatForce, needs replacement every 15 months to provide the same metallurgical benefits. Therefore, we recommend that Ausenco takes this extra cost into account in the OPEX for mechanical cells.
Rubber Lining	As Jameson Cells are offered with rubber lining by default, it is expected that the tank cells chosen will be rubber lined as well to provide a fair comparison.

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Appendix 2 – Process design criteria

Area	Description	Units	Basis	Source	Rev
	Context This process design criteria is to define the design basis to enable comparison of flotation technologies for a theoretical copper concentrator. Values provided have been based on prior Ausenco projects and Glencore Technology. This will be used to compare a conventional flotation circuit with a vertimill to a Jameson Cell circuit with an IsaMill.				
0000	**Plant Operating Summary**				
	Mine Design Basis				
	Plant design capacity	Mt/y	14	8	A
	Life of mine (LOM)	y	15	8	A
	Plant Operating Basis				
	Flotation				
	operating days per year	d/y	365	4	A
	shifts per day	-	2	4	A
	hours per shift	h	12	4	A
	operating availability	%	91.3	4	A
	Plant Feed Grade				
	copper, max for design	%	0.79	8	A
	copper, average	%	0.39	8	A
	Concentrate Grades and Recoveries				
	Mass recoveries, nominal	% new feed	1.36	8	A
	Design	% new feed	2.75	8	A
	Metal recoveries, design	%	91	8	A
	Concentrate grades, nominal	%	26	8	A
0000	**Ore Characteristics**				
	Crushed Ore Characteristics				
	Specific gravity				
	average for mass balance	-	2.73	8	A
	Moisture, % H_2O				
	nominal	w/w	3	8	A

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

3250 Copper Flotation

Copper Rougher - Conventional

Cell type	-	ınk cell, forced ε	8	A
No. of lines	-	1	8	A
Units per line	-	5	8	A
Feed pulp density, nominal	% solids (w/w)	34	8	A
Design		28	8	A
Residence time from laboratory batch test	min	10	8	A
Residence time, scale-up	-	2.7	8	A
Residence time, design	min	27	8	A
Lip loading	t/h/m	1.5	8	A
Froth carrying capacity	$t/m^2/h$	1.5	8	A
Aeration hold-up factor in flotation cell	%	15	1	A
Stage recovery				
copper, nominal	%	93	8	A
mass, max for design	%	12	8	A
Concentrate grade				
copper, nominal	%	4.0	8	A
copper, max for design	%	5.0	8	A
Concentrate solids specific gravity, nominal	-	3	8	A
Concentrate pulp density, nominal	% solids (w/w)	32	8	A

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Copper Rougher/Scavenger - Jameson Cell

Cell type	-	Jameson Cell	1	A
No. of lines	-	1	1	A
Number of cells (per line)	-	2	1	A
Feed pulp density, nominal	% solids (w/w)	40	1	B
Jameson cell model		B8500/12	1	A
Orifice size	mm	90	8	A
Feed pressure	kPa	150	8	A
Wash water bias, for design	-	1.2	8	A
Stage recovery				
copper, max for design	%	95	1	A
mass, max for design	%	8	8	A
Rougher concentrate grade				
copper, nominal	%	27	1	B
copper, max for design	%	27	1	B
Scavenger concentrate grade				
copper, nominal	%	2.6	1	B
copper, max for design	%	3.26	1	B
Concentrate solids specific gravity, nominal	-	3.2	1	A
Concentrate pulp density, nominal	% solids (w/w)	25	1	A

Copper Regrind Cyclones - Conventional Circuit

Number of cyclone clusters, per regrind mill		1	8	A
Circuit configuration	open/closed	closed	8	A
Cyclone underflow pulp density, nominal	% solids (w/w)	65	8	A
Feed size, P_{80}	µm	75	8	A
Product size, P_{80}	µm	40	8	A

Copper Regrind Cyclones - IsaMill Circuit

Number of cyclone clusters, per regrind mill		1	8	B
Circuit configuration	open/closed	open	8	B
Cyclone underflow pulp density, nominal	% solids (w/w)	44	1	B
Feed size, P_{80}	µm	75	8	B
Product size, P_{80}	µm	40	8	B

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Copper Regrind Mill - Conventional Flotation

Mill type	-	VTM-3000	8	B
Number of mills	-	1	8	A
Mill motor power, installed	kW	2235	8	B
Circuit feed rate, nominal (dry)	t/h	158	8	B
Specific energy, for rougher concentrate only				
range	kWh/t	5.5 - 9	9	A
nominal, for design	kWh/t	7.8	9	A
Circulating load, nominal	%	170	8	A
Circulating load, max for design	%	220	8	A

Copper Regrind Mill - Jameson Flotation

Mill type	-	M7500	9	B
Number of mills	-	1	8	A
Mill motor power, installed	kW	2235	9	B
Circuit feed rate, nominal (dry)	t/h	94	1	B
Specific energy, for rougher concentrate only				
range	kWh/t	5.5 - 9	9	A
nominal, for design	kWh/t	7.8	9	A

Copper Regrind Mill Media - VTM-1500

Media type	-	cylpebs	8	A
Media diameter	mm	12.7	8	A
Package form	-	bulk bag	8	A
Media consumption, nominal	kg/kWh	0.0065	8	A
Ball charging system	-	ıll kibble and ho	8	A
Addition point	-	rind mill feed ch	8	A

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Ausenco

GLENCORE TECHNOLOGY

Copper Regrind Mill Media - IsaMill

Media type	-	Ceramic beads	8	A
Media diameter	mm	2-6	8	A
Media consumption, nominal	kg/kWh	0.008	8	B
Ball charging system	-	st and bag brea	8	A
Addition point	-	ind mill feed hoj	8	A

Copper Cleaner 1 - Conventional

Cell type	-	forced air	8	A
Number of units	-	4	8	A
Cell Size	m^3	70	8	B
Feed pulp density, nominal	% solids (w/w)	25	8	A
Pulp pH	-	11	8	A
Residence time from laboratory batch test	min	4	8	A
Residence time, design	min	10	8	A
Lip loading	t/h/m	2	8	A
Froth carrying capacity	$t/m^2/h$	2	8	A
Aeration hold-up factor in flotation cell	%	15	8	A
Stage recovery			8	A
copper, at average grade	%	85	8	A
mass, at average grade	%	25.8	8	A
Concentrate grade				
copper, at average grade	%	15	8	A
Concentrate solids specific gravity, nominal	-	3.48	8	A
Concentrate pulp density, nominal	% solids (w/w)	25	8	A

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Copper Cleaner Scavenger - Conventional

Cell type	-	forced air	8	A
Number of units	-	5	8	A
Cell Size	m³	70	8	B
Feed pulp density, nominal	% solids (w/w)	24.5	8	A
Residence time from laboratory batch test	min	8	8	A
Residence time, design	min	20	8	A
Lip loading, max for design	t/h/m	0.5	8	A
Froth carrying capacity	$t/m^2/h$	0.7	8	A
Aeration hold-up factor in flotation cell	%	15	8	A
Stage recovery				
copper, at average grade	%	91.9	8	A
mass, at average grade	%	14.1	8	A
Concentrate grade				
copper, at average grade	%	6	8	A
Concentrate solids specific gravity, nominal	-	3.11	8	A
Concentrate pulp density, nominal	% solids (w/w)	20	8	A

Copper Cleaner 2 - Conventional

Cell type	-	forced air	8	A
Number of units	-	3	8	A
Cell Size	m³	70	8	B
Feed pulp density, nominal	% solids (w/w)	20.9	8	A
Residence time from laboratory batch test	min	3	8	A
Residence time, design	min	8	8	A
Lip loading, max for design	t/h/m	2	8	A
Froth carrying capacity, max for design	$t/m^2/h$	2	8	A
Aeration hold-up factor in flotation cell	%	15	8	A
Stage recovery				
copper, at average grade	%	80	8	A
mass, at average grade	%	52.7	8	A

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Concentrate grade				
copper, at average grade	%	20.5	8	A
Concentrate solids specific gravity, nominal	-	3.73	8	A
Concentrate pulp density, nominal	% solids (w/w)	30	8	A

Copper Cleaner 3 - Conventional

Cell type	-	forced air	8	A
Number of units	-	3	8	A
Cell Size	m^3	20	8	B
Feed pulp density, nominal	% solids (w/w)	29.5	8	A
Pulp pH	-	11	8	A
Residence time from laboratory batch test	min	3	8	A
Residence time, design	min	35	8	A
Lip loading, max for design	t/h/m	2.02	8	A
Froth carrying capacity, max for design	$t/m^2/h$	2.25	8	A
Aeration hold-up factor in flotation cell	%	10	8	A
Stage recovery				
copper, at average grade	%	80	8	A
mass, at average grade	%	63.7	8	A
Concentrate grade				
copper, at average grade	%	25.8	8	A
Concentrate solids specific gravity, nominal	-	4.1	8	A
Concentrate pulp density, nominal	% solids (w/w)	33	8	A

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Appendix 3 – Estimate classification detail

Estimate Classification and Industry Comparison							
Estimate Class:		Class 5		Class 4	Class 3	Class 2	Class 1
Scope Definition Stage:		**Order of Magnitude**	**Conceptual**	**Pre-feasibility**	**Feasibility**	**Control, Trend, FEED**	**Definitive**
Methodology		Capacity factored Parametric models Judgement or analogy Stochastic estimating approach	Equipment factored Major equipment quotes Benchmarked or parametric models	Semi-detailed - mixture of material take-offs (MTOs) and minor factoring assembly level line items Gross WBS and work packages Budget vendor quotations	Detailed MTOs - unit costs with some forced detailed take-offs Minimal undefined scopes of work Planning Defined work packages - some firm bids/tenders form basis Execution strategy concerning Procurement and Contracts - well defined (not fixed)	Detailed MTOs and unit costs High % of IFC design completion Execution strategy concerning Procurement and Contracts - well defined and fixed	Methodology
Level of Engineering Definition		0%	0% to 5%	2% to 10%	5% to 30%	40% to 60%	60% to 100%
Engineering Review Gates				10% to 20%	20% to 40%	40% to 70%	70% to 100%
Level of Growth		Not evaluated	Applied on some occasions	10% to 20%	8% to 15%	5% to 10%	0% to 5%
Level of Total Contingency (@ P50 excludes finance and other owner-specific items)		35% to 55% or more	30% to 45%	15% to 25%	10% to 15% based on contingency risk analysis		0% to 10% based on contingency risk analysis
Predicted Accuracy Range	**High**	+30% to +100%	+20% to +50%	+10% to +30%	+10% to +15%		+5% to +10%
	Low	-20% to -50%	-15% to -30%	-5% to -20%	-5% to -15%		-5% to -10%
Basis of Capital Cost Estimates							
General Project Definition							
Location		Assumed	Assumed	Optimal	Specific	Specific	Specific
Scope of Work		General	General	Preliminary	Detailed and defined	Well defined	Specific
Facility Breakdown Structure		Outline	Outline	Preliminary	Complete	Complete	Complete
Maps and Surveys		None	None	Some detail	Detailed	Detailed	Specific

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Estimate Classification and Industry Comparison						
Estimate Class:	Class 5		Class 4	Class 3	Class 2	Class 1
Scope Definition Stage:	**Order of Magnitude**	**Conceptual**	**Pre-feasibility**	**Feasibility**	**Control, Trend, FEED**	**Definitive**
Soil Tests and Geotechnical	Assumed	Assumed	Defined or preliminary	Defined	Detailed and well defined	Complete
Site Visits	None	None	Preferred	Essential	Essential	Construction commenced
Constructability Issues	None	None	Initial strategy	Detailed	Updated - detailed	Final
Construction Site Agreement	None	None	Typical for area	Draft agreement	Update - draft agreement	Final/in place
Delivery Strategy	Assumed	Assumed	Initial strategy	Specific	Updated - specific	Specific
Mining						
Site Visits	Desirable	Desirable	Essential	Frequent	Frequent	Frequent
Maps and Surveys	Required	Good quality	Detailed	Detailed	Detailed	Detailed
Drilling	Exploration	Exploration	Delineation	Delineation	Grade control	Grade control
Resource Estimate	Exploration target	Inferred	Mostly indicated	Measured/indicated	Measured	Measured
Reserve Estimate	Hypothetical	Hypothetical	Probable	Proved/probable	Proved	Proved
Mining Method	Assumed	Preliminary	Optimised	Finalised	Finalised	Finalised
Mining Schedule	By analogy	Preliminary	Preliminary	Detailed	Finalised	Finalised
Mine Geotechnical and Hydrology	Assumed	Preliminary	Preliminary	Detailed	Finalised	Finalised
Equipment Selection	Not essential	Preliminary	Type and capacity	Make and model	Make and model	Make and model
Process						
Plant Capacity	Assumed	Preliminary	Defined	Final	Updated to current design	Final
Ore Samples	N/A	Initial samples	Preliminary sampling campaign	Sufficient samples for flowsheet development and geometallurgical modelling	-	-
Metallurgical Testwork	Zero	Preliminary bench scale testwork where available	Preliminary engineering and flowsheet testwork	Final flowsheet and engineering testwork; pilot plant/s (where required)	-	-

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Estimate Classification and Industry Comparison						
Estimate Class:	**Class 5**		**Class 4**	**Class 3**	**Class 2**	**Class 1**
Scope Definition Stage:	**Order of Magnitude**	**Conceptual**	**Pre-feasibility**	**Feasibility**	**Control, Trend, FEED**	**Definitive**
Pilot Plant	Bench scale	Bench scale	Where new technology is being considered	Where new technology is being considered	-	-
Control Philosophy	None	None	Outlined	Detailed	Updated to current design	Finalised
Energy and Material Balance	Estimated	Estimated	Preliminary	Optimised	Updated to current design	Complete
P&IDs	None	None	Preliminary instrumentation drawings where required	As per project requirements	Updated to current design	Complete
Block Flow Diagrams (BFDs)	Preliminary	Preliminary	Detailed	Optimised and final	Updated to current design	Complete
Process Flow Diagrams (PFDs)	Outlined	Outlined	Preliminary	Optimised and final	Updated to current design	Complete
Definition						
Plot Plans	None	None	Preliminary	Detailed	Updated to current design	Complete
Process	BFD	BFD	PFD	PFD	PFD	PFD
GA Drawing by Area/Facility	Sketch/none	Sketch/ None	Preliminary	Detailed	Updated to current design	Complete
Equipment List	None	Assumed – major equipment only	Preliminary list	Detailed	Updated to current design	Complete
Motor List	None	Preliminary sizing	Preliminary list	Detailed	Updated to current design	Complete
GA – Mechanical	None	None	Preliminary	Approved for design	Updated to current design	Complete
Mechanical/Piping Drawings	None	Single line	Some detail	Advanced	Updated to current design	Complete
Civil/Structural Drawings	None	None	Preliminary	Advanced	Updated to current design	Complete
Electrical Drawings	None	None	SLD (HV only)	SLD as required	Updated to current design	Advanced/complete
Electrical Single Line Drawings (SLDs)	None	None	Preliminary	Some detail	Detailed	Complete
Design Criteria	Outlined	Outlined	Preliminary	Optimised and final	Final	Complete
Specifications/Data Sheets	None	Assumed	Short form equipment specification only	Preliminary/detailed	Detailed	Complete

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

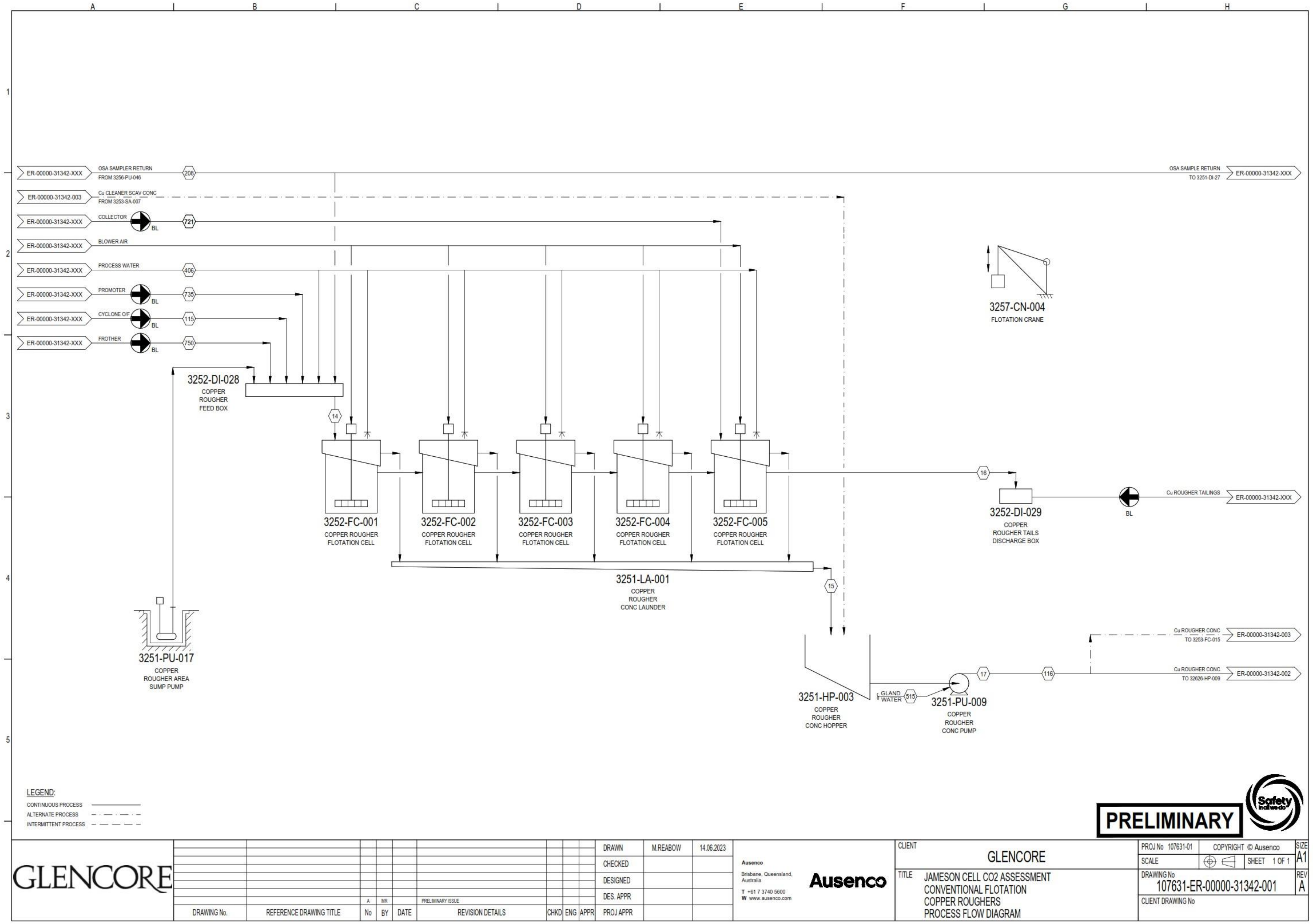
Estimate Classification and Industry Comparison						
Estimate Class:	**Class 5**		**Class 4**	**Class 3**	**Class 2**	**Class 1**
Scope Definition Stage:	**Order of Magnitude**	**Conceptual**	**Pre-feasibility**	**Feasibility**	**Control, Trend, FEED**	**Definitive**
Capital Cost Estimate						
Infrastructure Costs: Power, Water, Roads, Rail	Assumed	Investigated	Preliminary	Detailed	Finalised	Finalised
Vendor Selection	None	None	Major equipment only	Selected for major equipment Other mostly complete	Updated to current design and project philosophy	Complete
Mechanical Equipment	Data bank/factored	Benchmark project factored Preliminary list, major equipment	Budget quote Preliminary list	Multiple source vendor budget quotes for major and some minor equipment Tenders where appropriate Detailed list	Updated to current design and project philosophy	Purchase order complete
Electrical Equipment	Factored price	Benchmark project factored Preliminary list, major equipment	Multiple source budget quote Preliminary list	Multiple source vendor budget quotes for major and some minor equipment Tenders where appropriate Detailed list	Updated to current design and project philosophy	Bids/POs/tenders complete
Electrical Bulks	Factored price	Benchmark project factored	Factored estimate or budget quote Factored MTOs	Budget quote Factored MTOs	Updated to current design and project philosophy	Final quotes Final MTO
Civil Work	Factored price	Benchmark project factored	Unit Rates/built-up rates MTOs plus allowances	Built-up rates MTOs	Updated to current design and project philosophy	Final quotes Final MTO
Structural Work	$/unit volume/factored pricing	$/unit volume/unit rates Preliminary MTOs/ factored	Preliminary in-house pricing from database MTO sketches plus allowances	Budget quotations and in-house pricing MTOs	Updated to current design and project philosophy	Tender prices Final MTO from AFC drawings

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

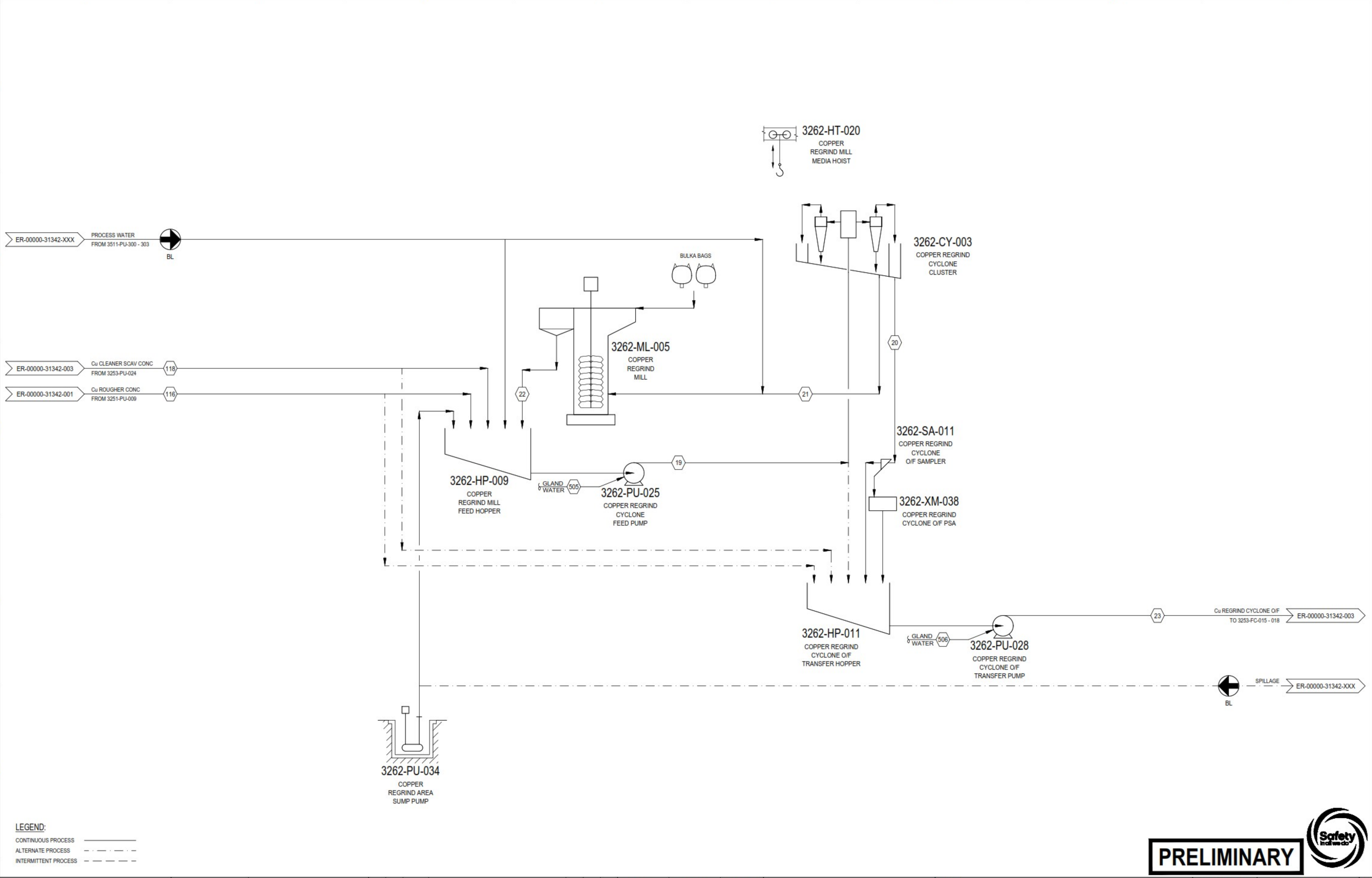
Estimate Classification and Industry Comparison						
Estimate Class:	Class 5		Class 4	Class 3	Class 2	Class 1
Scope Definition Stage:	**Order of Magnitude**	**Conceptual**	**Pre-feasibility**	**Feasibility**	**Control, Trend, FEED**	**Definitive**
Piping and Instrumentation	Factored % mechanical equipment	Factored % Mechanical equipment	Factored estimate or budget quote Factored MTOs	Budget/firm quotations Take-off large and small bore	Updated to current design and project philosophy	Tender prices Final MTO
Installation Labour	Factored	Factored	Factored or work hours	Work hours Specific site agreement	Updated to current design and project philosophy	Work hours Contracts
Indirect Costs	% of total	% of total	Preliminary calculation or factored	Detailed calculation	Updated to current design and project philosophy	Detailed calculation
EPCM Costs	Factored off direct cost or total installed cost (TIC)	Factored off direct cost or TIC	% direct or TIC Preliminary estimate	Detailed estimate	Updated to current design and project philosophy	Detailed estimate
Spare Parts	% of total or % of electrical, mechanical equipment	% of total or % of electrical, mechanical equipment	% of total or % of electrical, mechanical equipment	% of electrical, mechanical equipment plus spares list	Updated to current design and project philosophy	Substantially complete
Owner's Costs	Factored off direct cost or TIC	Factored off direct cost or TIC	Direct or TIC Preliminary estimate	Detailed estimate	Updated to current design and project philosophy	Detailed estimate
Contingency	Factored off direct cost or TIC	Factored off direct cost or TIC	Factored off direct cost or TIC Calculated from deterministic or probabilistic model	Probabilistic risk model	Updated to current design and project philosophy	Probabilistic risk model
Inflation/Escalation	Factored off TIC	Factored off TIC	Factored off TIC Based on preliminary schedule	Calculation based on project schedule and cash flow	Updated to current design and project philosophy	Calculation based on project schedule and cash flow

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Appendix 4 – Process Flow Diagrams & Mass Balance – Conventional Concentrator



Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.



GLENCORE			A	MR		PRELIMINARY ISSUE			
	DRAWING No.	REFERENCE DRAWING TITLE	No	BY	DATE	REVISION DETAILS	CHKD	ENG	APPR

DRAWN	M.REABOW	14.06.2023
CHECKED		
DESIGNED		
DES. APPR		
PROJ APPR		

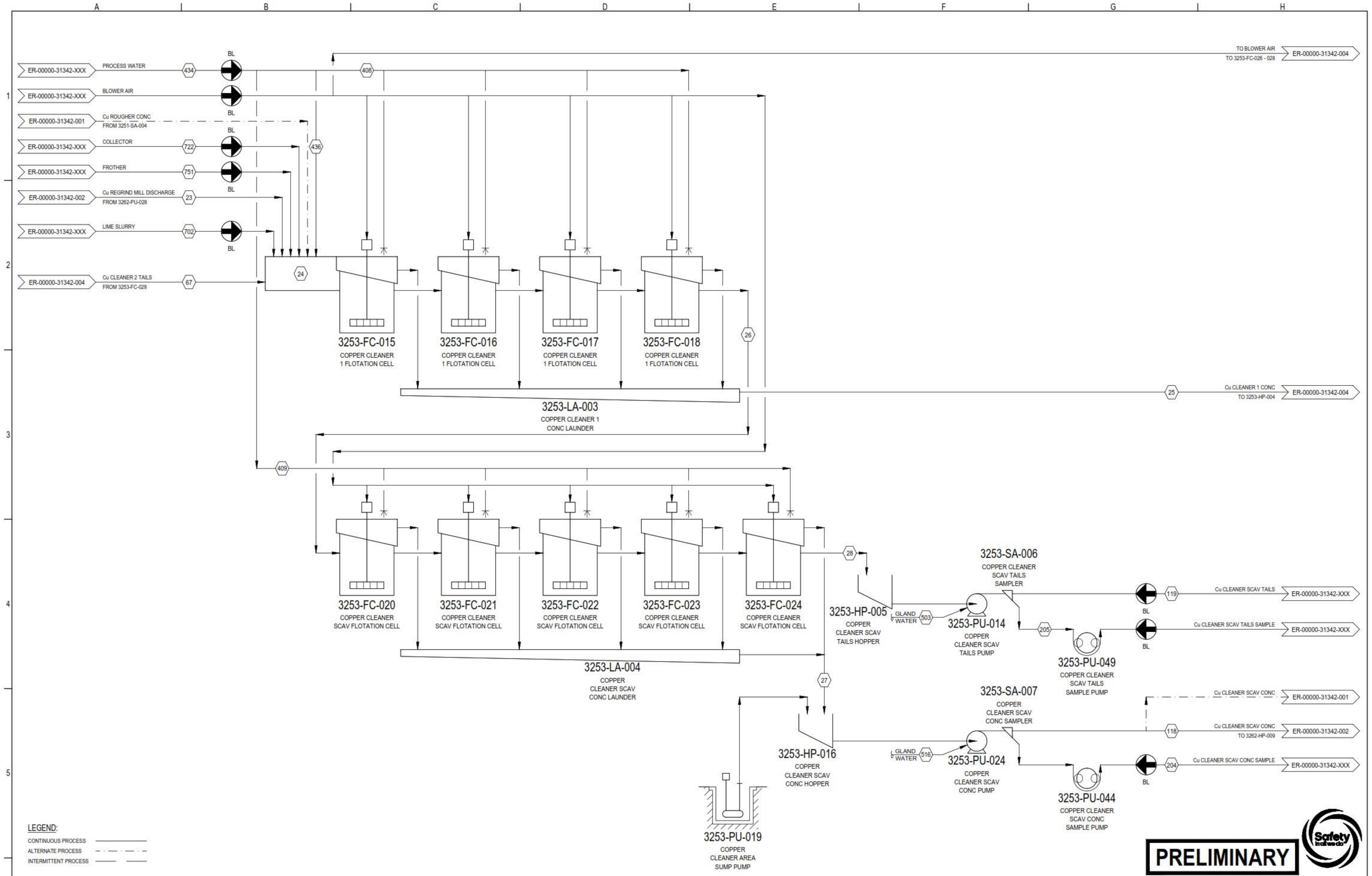
Ausenco
Brisbane, Queensland, Australia
T +61 7 3740 5600
W www.ausenco.com

CLIENT: GLENCORE

TITLE: JAMESON CELL CO2 ASSESSMENT
CONVENTIONAL FLOTATION
COPPER REGRIND
PROCESS FLOW DIAGRAM

PROJ No 107631-01 | COPYRIGHT © Ausenco | SIZE A1
SCALE | SHEET 1 OF 1
DRAWING No 107631-ER-00000-31342-002 | REV A
CLIENT DRAWING No

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.



DRAWN	M.REABOW 14.06.2023
CHECKED	
DESIGNED	
DES. APPR	
PROJ APPR	

GLENCORE

A MR PRELIMINARY ISSUE

DRAWING No. | REFERENCE DRAWING TITLE | No | BY | DATE | REVISION DETAILS | CHKD | ENG | APPR

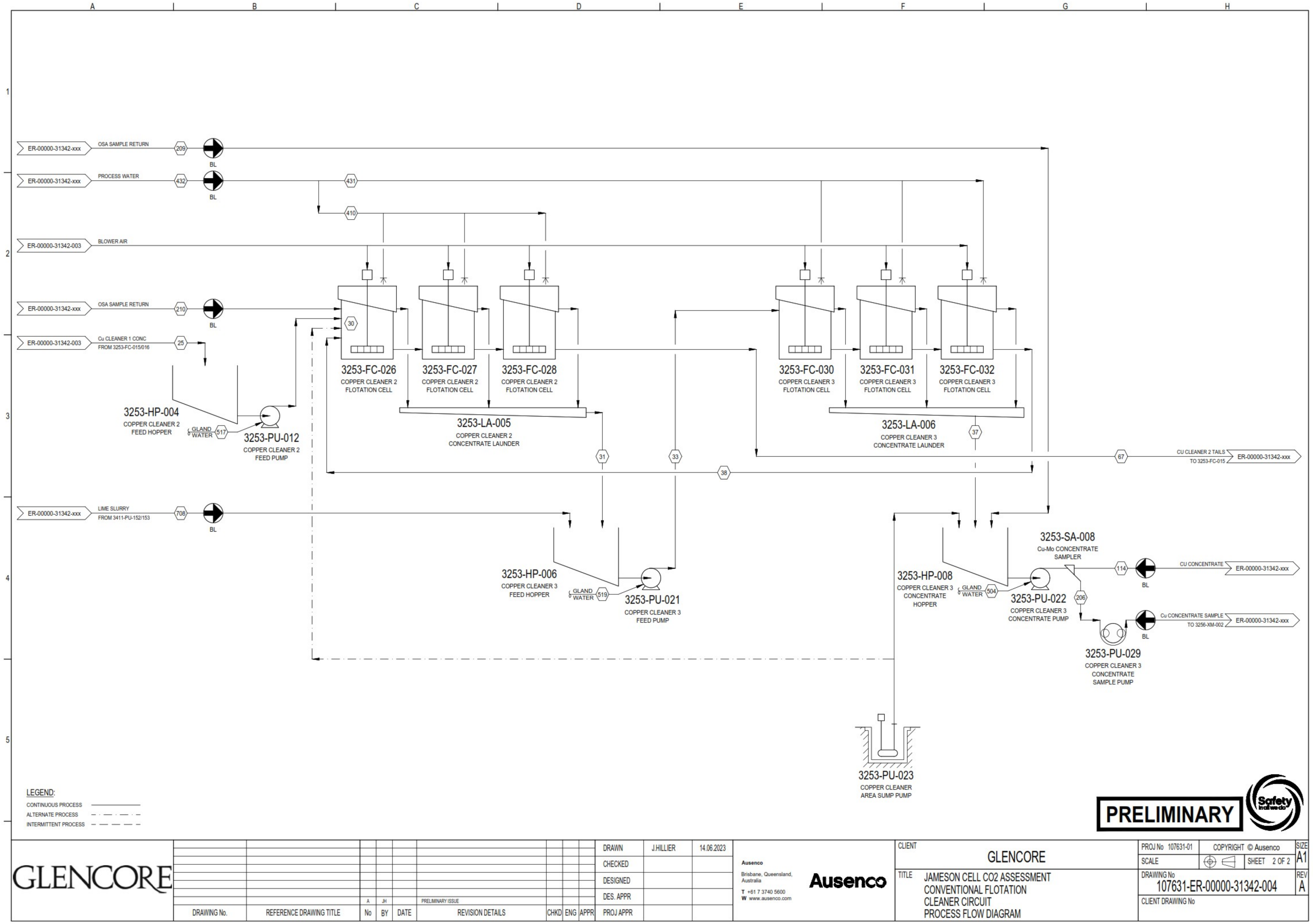
Ausenco
Brisbane, Queensland, Australia
T +61 7 3740 5600
W www.ausenco.com

CLIENT: GLENCORE

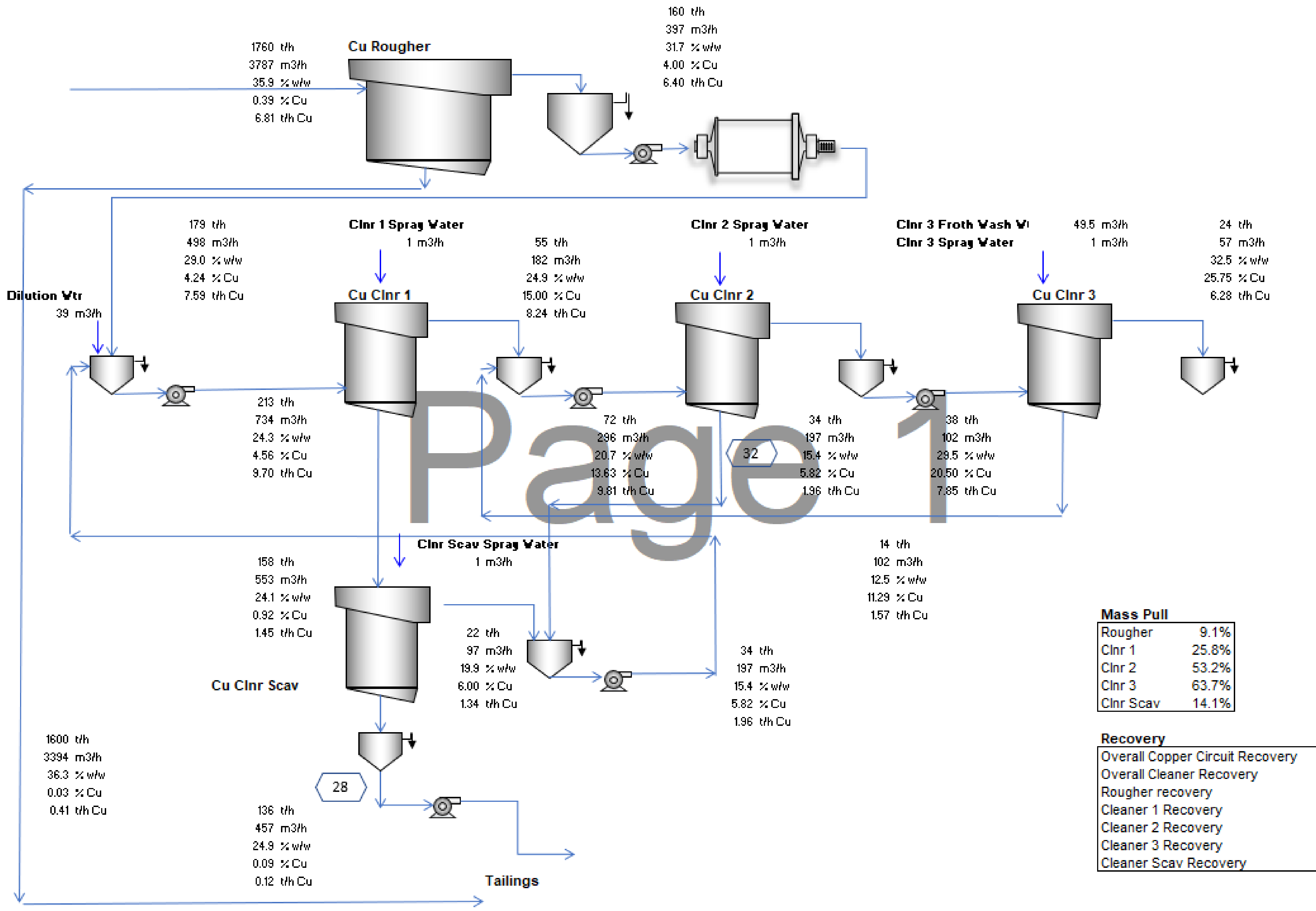
TITLE: JAMESON CELL CO2 ASSESSMENT
CONVENTIONAL FLOTATION
CLEANER CIRCUIT
PROCESS FLOW DIAGRAM

PROJ No 107631-01 | COPYRIGHT © Ausenco | SIZE A1
SCALE | SHEET 1 OF 2
DRAWING No 107631-ER-00000-31342-003 | REV A
CLIENT DRAWING No

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.



Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.



Mass Pull

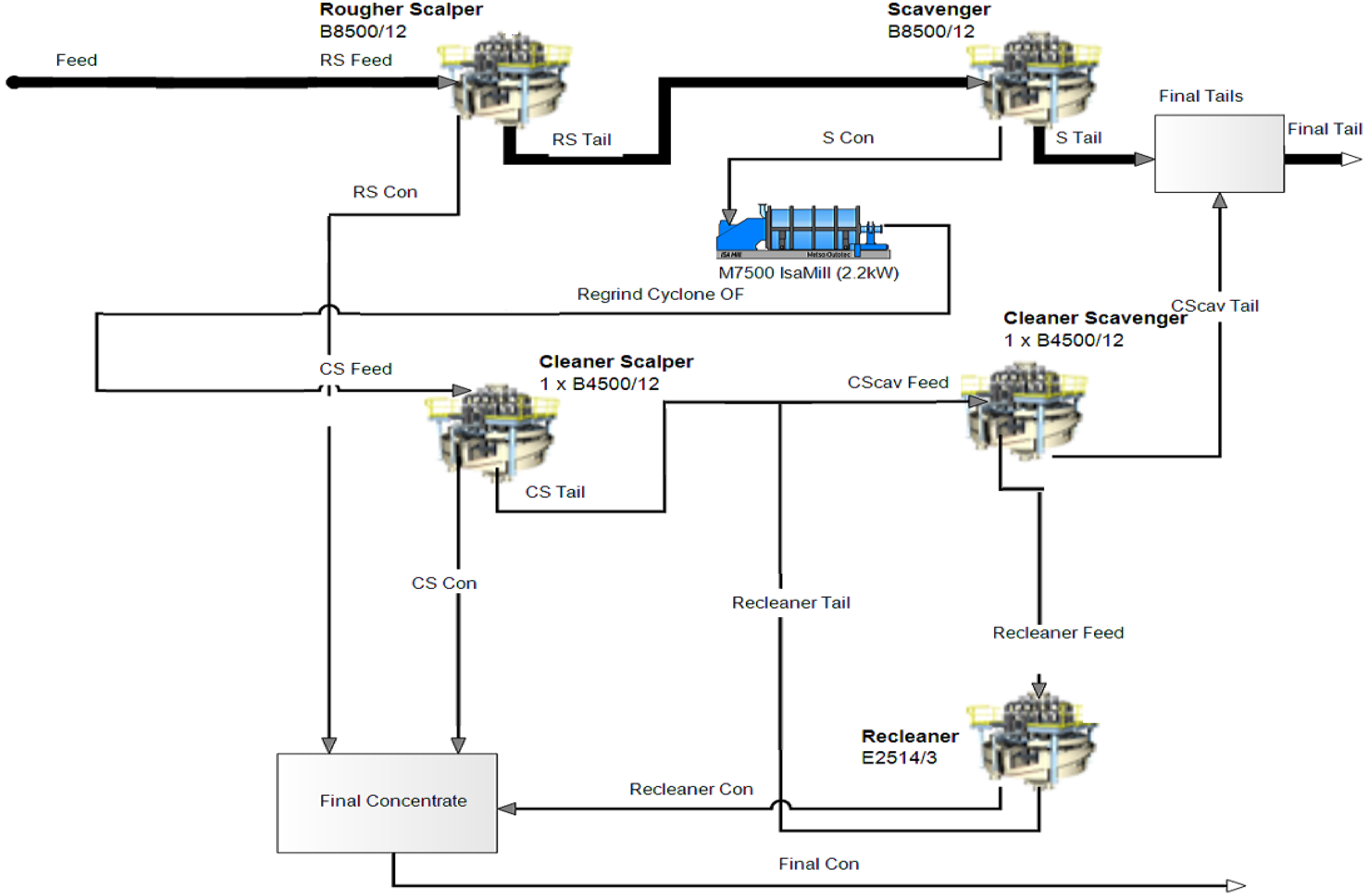
Rougher	9.1%
Clnr 1	25.8%
Clnr 2	53.2%
Clnr 3	63.7%
Clnr Scav	14.1%

Recovery

Overall Copper Circuit Recovery	92.3%
Overall Cleaner Recovery	82.8%
Rougher recovery	94.0%
Cleaner 1 Recovery	85.0%
Cleaner 2 Recovery	80.0%
Cleaner 3 Recovery	80.0%
Cleaner Scav Recovery	92.0%

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Appendix 5 – Process Flow Diagrams & Mass Balance – Jameson Concentrator



Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.

Stream ID		CS Dilution Water	CS Wash Water	Feed	RC Wash Water	Recleaner Dilution Water	RS Wash Water	Final Con	Final Tail	CS Con	CS Feed	CS Tail
Total Solids Flow	t/h	0.00	0.00	1 760.00	0.00	0.00	0.00	24.60	1 735.40	5.38	93.54	88.16
Total Liquid Flow	t/h	187.28	10.85	2 640.00	7.29	37.23	30.41	49.20	2 863.87	10.76	374.35	374.45
Pulp Mass Flow	t/h	187.28	10.85	4 400.00	7.29	37.23	30.41	73.80	4 599.27	16.14	467.89	462.60
Pulp Volumetric Flow	m^3/h	187.84	10.89	3 309.15	7.31	37.34	30.50	55.93	3 527.10	12.20	409.74	408.43
Solids SG	g/cm3	0.00	0.00	2.66	0.00	0.00	0.00	3.74	2.65	3.81	2.73	2.68
Liquid SG	g/cm3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Pulp SG	g/cm3	1.00	1.00	1.33	1.00	1.00	1.00	1.32	1.30	1.32	1.14	1.13
% Solids	wt-%	0.00	0.00	40.00	0.00	0.00	0.00	33.33	37.73	33.33	19.99	19.06
Cu	wt-%	0.00	0.00	0.39	0.00	0.00	0.00	25.75	0.03	27.00	2.59	1.10
Cu	Rec-%	0.00	0.00	100.00	0.00	0.00	0.00	92.28	7.72	21.16	35.26	14.10

Stream ID		CScav Con	CScav Feed	CScav Tail	Recleaner Con	Recleaner Feed	Recleaner Tail	Regrind Cyclone OF	RS Con	RS Feed	RS Tail	S Con	S Tail
Total Solids Flow	t/h	18.61	102.73	84.12	4.04	18.61	14.57	93.54	15.18	1 760.00	1 744.82	93.54	1 651.28
Total Liquid Flow	t/h	37.22	448.12	410.89	8.08	74.46	73.67	187.07	30.36	2 640.00	2 640.04	187.07	2 452.97
Pulp Mass Flow	t/h	55.84	550.85	495.01	12.12	93.07	88.24	280.61	45.55	4 400.00	4 384.86	280.61	4 104.25
Pulp Volumetric Flow	m^3/h	43.88	487.67	443.79	9.29	81.23	79.25	221.90	34.44	3 309.15	3 305.21	221.90	3 083.31
Solids SG	g/cm3	2.84	2.69	2.66	3.39	2.84	2.72	2.73	3.81	2.66	2.65	2.73	2.65
Liquid SG	g/cm3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Pulp SG	g/cm3	1.27	1.13	1.12	1.30	1.15	1.11	1.26	1.32	1.33	1.33	1.26	1.33
% Solids	wt-%	33.33	18.65	16.99	33.33	20.00	16.51	33.33	33.33	40.00	39.79	33.33	40.23
Cu	wt-%	6.00	1.27	0.22	19.35	6.00	2.30	2.59	27.01	0.39	0.16	2.59	0.02
Cu	Rec-%	16.27	18.98	2.72	11.39	16.27	4.88	35.26	59.74	100.00	40.26	35.26	5.00

Copyright © 2022 Ausenco Pty Ltd. The Ausenco name and wordmark are registered trademarks of Ausenco Pty Ltd. Ausenco refers to Ausenco Pty Ltd. and its global affiliates. All rights reserved.