Technical Note 01 - Implementation of centrifuges for water recovery and tailings management dated 18 January 2021 (Technical Note)

Expert Witness Statement of Ivan Saracik

8 February 2021

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1. APPOINTMENT

In a letter dated 2 February 2021, White & Case acting as legal advisors to Kalbar Operations Pty Ltd (Kalbar), the proponent of the Fingerboards mineral sands project (Project), commissioned me to prepare an expert witness statement and potentially present evidence at the inquiry hearing to be held in relation to the environment effects statement (EES) prepared for the Project pursuant to the Environment Effects Act 1978 (Vic), in relation to Kalbar's proposal to use centrifuges in the Project.

2. SCOPE

The Scope provided requires me to act as an independent expert to:

- (a) prepare an expert witness statement in which I
  - (i) set out my background and relevant expertise;
  - (ii) review the Technical Note and set out my expert opinion on the appropriateness or otherwise of including the centrifuges in the Project to enhance water recovery from tailings;
  - (iii) describe if I agree with the contents of the Technical Note and, if I disagree with any aspect of it, set out which parts of the Technical Note I disagree with, with an explanation as to why;
  - (iv) assume the use of anionic polyacrylamide flocculants in the centrifuges, and comment on whether I agree or disagree with the use of such flocculants, or recommend the use of other types of flocculants; and
- (b) if required, prepare and present expert evidence at the panel/inquiry hearing.

The documents I have had regard to in preparing this statement are:

- Technical Note 01: Implementation of centrifuges for water recovery and tailings management
- Report from Alfa Laval Australia Pty Ltd dated 8 October 2018. A copy of this report is at Appendix B
- Nalco Testwork Report Slimes Flocculant Screening Tests and WATERSHED Tails Dewatering Technology Assessment dated 5 May 2015. A copy of this report is at Appendix C
- East Gippsland Water – Water Quality Annual Report 2019/20
- Alfa Laval Solid Bowl Centrifuge Installation List – Tailings and Minerals Processing Waste Residue projects is at Appendix D.

3. EXPERT WITNESS BACKGROUND AND RELEVANT EXPERTISE

3.1 Scope (a) (i) – my background and expertise

I have a diploma in mechanical engineering awarded in 1969 and have undertaken extractive metallurgical studies at West Australian Institute of Technology (now Curtin University).

I have been working in the mining industry continuously since 1970 have been the Managing Director of an EPCM Organisation within a major international group and since 1987 have been managing Epac undertaking mining development projects developing new process plants and mines in a great many minerals and metals and relevant to this review in mineral sands.

I have first-hand and direct recent experience in dealing with mining projects with both shortage of water issues and excess water to be evaporated without deleterious effects to the environment.

In the many mining projects where I have had involvement in studies and projects, the high capital cost of centrifuges has overridden the benefits of centrifuging versus filtration. For this reason, including a project now being developed in Australia co-disposal has been selected. An active non-disclosure agreement prevents me naming the project as I am unable to provide any details.

My detailed résumé, comprising 11 pages, is attached at Appendix A.

4. REVIEW OF TECHNICAL NOTE

I have reviewed the Technical Note and in doing so have responded to the requirements of the Scope Requirements set out in 2 above.

Scope item (a) (iii) is interpreted by me to encompass all the aspects of the Technical Note and item (a) (ii) to be more specific and to concentrate only on the issues of centrifuge applicability.

Therefore, in this Report I have altered the sequence and am responding to sub clauses ((iii) followed by (ii) and then by (iv).

4.1 Scope (a) (iii) – Review of Technical Note

4.1.1 <u>Technical Note Paragraphs 1 and 2.</u>

The reported percentages, by mass, of materials mined from the pit over the mine life are fine tailings (defined as <38 µm in diameter) – 21%, coarse tailings (defined as >38 µm in diameter) – 74%, and Heavy Mineral Concentrate (Product) – 5%.

The fine tailings has been successfully thickened to achieve a density of 30-35% solids from the thickener underflow. This slurry is then able to increase the solids content by allowing time for entrained water to be released. The solids content increases to approximately 55% solids in a short period of up to 3 days, and then in a further period of between 4 and 10 months the slurry density increases to achieve a solids content of 70 - 72%.

The coarse tailings were fed through dewatering cyclones and achieved a solids content of 65 - 75%, at which density the tailings are suitable for trucking and directly backfilling a mining void. Once dumped, these tailings continue to dewater with free water drainage, increasing the solids content of the tails to between 80 and 90 % in a period of 20 to 30 days. The drained water is captured in drains to maximise the amount of this water that is returned to the wet concentrator plant.

Water losses in the coarse tailings stream are presented as 45% of total water losses, with the balance of 55% lost in the fine tailings. It can therefore be seen and easily understood that 21% of the total material (the fines tailings) is responsible for the loss of 55% of the total water losses, and 45% of the water losses are lost in 74% of the material (the coarse tailings).

The fines tailings requiring the stated 4 to 10 months to drain is concerning as this is too large a range and this suggests that there is no certainty on what the real number is. No evidence had been presented that provides comfort 10 months could not be exceeded or that this fine material will dry completely in any period.

From this summary situation description, I am able to support, without reservation, the conclusion drawn in the Technical Note that:

"A method of tailings management that accelerates dewatering of the fine tailings will therefore result in greater certainty about the ability to recover water for process reuse".

4.1.2 Technical Note Paragraph 3.

Due to the inherent nature and fineness of the tailings, the steps necessary to dewater these tailings and thereby maximise water recovery are evident as described in this paragraph.

To achieve the best possible drainage, the operation of the fines TSF as described in the EES would necessitate placing of layers no more than 1.0 m thick, so necessitating frequent change to discharge points. The drainage period per lift is determined to be up to 10 months.

The implication of this is that, compared to a tailings storage facility where materials that are coarser and therefore more readily drained, the total footprint of the TSF increases greatly considering the moderate tonnage placed compared to a TSF storing coarser tailings.

That, in turn, delays relocation of materials to the pit, so preventing topsoil replacement and rehabilitation and necessitating double handling of material.

Additionally, during mining operations truck haulage distances increase as overburden has to be hauled longer distances to areas open for overburden replacement. With the far larger TSF temporarily occupying pit area and precluding access to ore and therefore mined out pit volumes, trucks are compelled to circumvent the TSF to locate areas to dump. A further totally proportional negative outcome is an increase in dust and noise pollution.

The concluding sentence in Section 3 in the Technical Note states:

"A method of tailings management that accelerates the commencement of backfilling operations and rehabilitation will have a corresponding reduction in truck haul distance."

For the reasons stated above I not only agree with the fact that haulage distance is decreased, but for the purposes of this Review, the other benefits of an alternative tailings management plan covered elsewhere in the Technical Note, are pertinent. These are minimising water losses, avoidance of a TSF, potentially no or far less double handling, less noise and dust as well as better operability and productivity.

4.2 Scope (a) (ii) – Inclusion of centrifuges in the Project

4.2.1 Enhancement of water recovery

The Technical Note sets out a compelling argument as to the negative factors relating to the current tailings disposal system proposed for the Project and incorporated in the EES.

It also is unambiguous on the need to enhance and maximise the recovery of water from tailings.

In the opinion of the authors of the Technical Note, the tailings disposal system proposed by the EES is flawed to the extent that it adopted a water recovery figure for the fines tailings that is more aggressive than could be achieved in practice. I agree with this assessment, but I would also add that the Technical Note has not paid sufficient attention to the extent of TSF area and the time that would be required to recover all water that might drain naturally if a centrifuge wasn't used (as explained above). The EES proposed the use of mechanical units (amphirols) to operate on soft tailings using twin rotating scrolls and assist in releasing water from solids. These are known to improve water extraction, though to a limited degree with very fine material as evident on the Project.

I believe an alternative approach is required to recover the maximum amount of water achievable in a practical manner to allow the Project to operate significantly more efficiently than would be the case retaining the current system necessitating using a TSF.

The International Council on Mining and Metals (ICMM) developed a universal standard for tailings management, entitled the Global Industry Standard on Tailings Management (GSTM), which was launched in August 2020. The proposed TSFs should be constructed and operated in accordance with industry standards and norms, including the GSTM. Additionally it is mandated by the GSTM, that proponents have to consider alternatives that minimise the volume of tailings and water placed in external tailings facilities.

I therefore agree that both technically and operationally, a tailings processing circuit that produces a dry cake from fine tailings and dispenses with the need for TSF storage, as proposed by the Technical Note, is a preferable solution.

4.2.2 Incorporation of centrifuges in the Project

The Technical Note has proposed the incorporation of centrifuge units in two insulated buildings located in the proximity of the two MUP units.

As set out in Section 6 of the Technical Note, four decanter centrifuges will be housed proximate to each of the two MUPs. One standby and three operating units will be located in each building.

These units are the most efficient equipment for separating fine solids from liquid. They generate g-forces to as high as 1,800 g, and all free water (that which is not inherently entrained in the solid structure) will be removed. This minimises the extent of water percolation into groundwater when the tailings is deposited in the pit.

Filters of any sort viz. belt, plate and frame, candle, disc or tower press filter are unable to achieve the levels of water extraction generated by a decanter centrifuge.

4.2.3 Summary of slimes test report from Alfa Laval[1]

I have reviewed a laboratory slimes test report prepared by Alfa Laval which evaluated the suitability of using centrifuges for fine tailings for the Project, and summarise below the pertinent points and findings.

Project slimes samples were tested to confirm suitability for dewatering in large scale Alfa Laval P3 mining decanter centrifuges.

Laboratory scale testing indicated that the slurry can be dewatered in a decanter centrifuge to form a firm, spadeable, transportable cake of around 70% wt total solids (suspended + any dissolved solids).

It is estimated that the centrate, which is the water discharge from the centrifuge, clarity will be in the order of 0.2% to 0.8% suspended solids.

The sample supplied was diluted with potable Perth water for purposes of testing. Tests indicated that dilution to 25-30% wt solids would be beneficial for solids recovery and flocculant dose without impacting on the installed capital price, and this should be considered in any project optimisation.

Laboratory testing indicated that approximately 340 g active flocculant per tonne of suspended solids is needed to form strong, shear resistant flocs and recover the ultra-fine material as part of the cake.

Flocculant was not screened and that used was the same as optimised for thickener testwork.

These laboratory scale determinations and previous installations/ trials on similar slurries indicate that it is suitable for further development work as decanter centrifuges.

[1] Alfa Laval Australia Pty Ltd Laboratory Spin Test Report – Mineral Sands Slimes Tailings Dewatering test for Decanter Centrifuge - 8 October 2018

4.2.4 Opinion

Sections 4.2.1 to 4.2.3 above set out the need to enhance water recovery, some detail and discussion in relation to centrifuges and alternate equipment and an extract from an Alfa Laval submission.

Alfa Laval is recognised as a leading supplier of decanter centrifuges in the mining sector. Their submission provides comfort of their capability but other suppliers including Andritz and Flottweg would no doubt have been considered as alternative suppliers.

Technically and operationally, there is a clear case for incorporation of this technology and decanter centrifuges in particular to process the fines tailings.

There are a considerable number of mines that include centrifuges operating on tailings duties. A list of those supplied by Alfa Laval is included as Appendix D[2]. They include many mines in Australia and Canada treating tailings in the coal and tar sands Industries. There are also international operations in nickel and borax. These are relevant to the Project.

A gold mine in Patagonia, Argentina has four decanter centrifuges describing a process directly comparable to that on the Project. The parameters set are less demanding than that on the Project with a lower target solids content. This operation is described in https://papers.acg.uwa.edu.au/d/2052_26_Klug/26_Klug.pdf .

The exact scope, detailed operating parameters that may be achieved in practice and economic implications on the Project can only be determined after detailed design and cost estimating work is completed.

I regard the work to design and construct a facility to deliver its objective as a normal engineering task, with no known impediments to success.

4.3 Scope (a) (iv) - Flocculants

4.3.1 Suitability of anionic polyacrylamide flocculants for use in centrifuges

Ore is mined and screened in the pit area to remove oversize material. The balance of the ore is fed to the WCP and economic materials are removed as product. There are two tailings streams generated, of which only the fines tailings is proposed as feed to centrifuge circuits.

A thickener processes the fines tailings, also referred to as the slimes, generated in the WCP to recover clarified water overflow. This is achieved by increasing the density of the fines tailings discharge. To enhance this recovery, a flocculant is added to the fines tailings stream entering the thickener feed well.

The initial flocculant selection was made after conducting a testwork program[3]. Preliminary screening showed that several of the widely used

[2] Alfa Laval Solid Bowl Centrifuge Installation List – Tailings and Minerals Processing Waste Residue projects

[3] Nalco Testwork Report Slimes Flocculant Screening Tests and Nalco WATERSHED Tails Dewatering Technology Assessment 5 May 2015

Nalco conventional Polyacrylamide (PAM) flocculants including 83372, 83374, 83376 and 83384 provided effective flocculation. Thereafter, two flocculants were tested further and as 83384 delivered the best result giving a rapid settling rate at a low dosage rate of 130g/t for all 7 samples tested, this was the selected flocculant.

It is now proposed that the fines tailings discharge from the thickener is to be further thickened utilising decanter centrifuges. The fundamental purpose of the thickener and the centrifuges is the same, namely to extract the maximum possible amount of water from the stream by maximising the density or solids content of the solids discharge, within the capability of the different process units. In the case of the centrifuges, this is as a dry cake, where that of the thickener is a slurry. The operating principle of the centrifuges is to force solids to one end of the machine by a rotating scroll, with a solid restriction in the unit to increase hydro-static pressure on the solids to remove free water, leaving only inherent moisture in the solids structure when they are discharged. I am not aware of any other mechanical unit that can achieve the high water recoveries achievable by a decanter centrifuge with flocculant addition.

Due to the selected flocculant for the thickening circuit being an anionic polyacrylamide, the same flocculant was utilised for the centrifuge testwork carried out by Alfa Laval. The result of this testwork was positive. This is summarised in section 4.2.3 herein.

Opinion

I agree with the use of anionic polyacrylamide flocculants in the centrifuges for the reasons that they are technically effective in assisting in the production of a clear overflow or centrate, as shown in testwork for the Project.

I am further persuaded to the view that this is a responsible approach as these and similar reagents are used in agricultural operations and water supply treatment plants commonly, and it is also suitable to use for them for the Project.

Anioinic flocculants have a long history of use in both the agricultural and mining industries, and are often preferred to cationic flocculants. Anionic polymers act as true flocculants and bind suspended particles together to form larger particles that settle out of solution more rapidly, while cationic polymers act as coagulants[4]. Further, the existing aquatic toxicity information indicates that the anionic class has a relatively low toxicity to aquatic organisms, while the cationic class is at least 100 times more toxic[5]. The flocculating performance of anionic flocculants are well proven.

Anionic polyacrylamide (PAM) has been sold since 1995 to reduce irrigation-induced erosion and enhance infiltration. Its soil stabilizing and flocculating properties improve runoff water quality by reducing sediments, N, dissolved

[4] Polyacrylamide in Agriculture and Environmental Land R. E. Sojka, D. L. Bjorneberg, J. A. Entry, R. D. Lentz and W. J. Orts - 2007

[5] Ecotoxicological assessment of a polyelectrolyte flocculant - Harford AJ, Hogan AC & van Dam RA June 2010

reactive phosphorus (DRP) and total P, chemical oxygen demand (COD), pesticides, weed seeds, and microorganisms in runoff.

Flocculants and coagulants are used in drinking water treatment plants worldwide to achieve similar objectives to those on the Project. East Gippsland Water, in their 2019 Drinking Water Quality Annual Report[6] table that they add Polymer LT 27 to their centrifuge circuits for Bairnsdale and other localities as a flocculation aid to increase settlement rate of suspended solids in the coagulation process. Polymer LT 27 is Magnafloc LT27, an anionic polyacrylamide flocculant.

It is therefore with absolute confidence that I say if the product is safe to be added to the Bairnsdale drinking water, it must be safe too to add to the centrifuge circuit on the Project.

4.4 EES tailings storage philosophy

The Technical Note contains further details of content of the EES and I will summarise these and offer comments as considered to be valid.

4.4.1 Technical Note Paragraphs 1 and 2.

The Project concept adopted provides for both tailings and overburden generated by the mining operation to be returned to the mine void as soon as sufficient volumes are mined out.

Prior to sufficient volume being available to receive tailings, the sequencing as embodied in the EES, provided for fine tailings, also referred to as slimes, and coarse tailings, also referred to as coarse sand, is to be managed differently.

The coarse and the fine tailings generated in the WCP have been processed in water only circuits and no reagents have been utilised. Coarse tailings are pumped to dewatering cyclones and a spigot product at 65% - 75% solids is produced. Fine tailings are processed through a thickener, where an anionic polyacrylamide flocculant, discussed further in section 4.3, is used to dose the tailings to increase settlement of solid particles.

The Project provides for a temporary tailings storage facility (TSF) comprising multiple cells. The TSF is located within the ultimate pit extremities and tailings will be relocated to mined out sections of the pit.

4.4.2 Technical Note Paragraph 3.

Due to the inherent nature and fineness of the tailings, the dewatering of these and the maximising of water recovery is extremely difficult. Paragraph 3 describes the steps that have to be taken to operate the system and is focussed on the extent of the footprint of the mining and tailings areas operating at any one time.

The fines TSF as described in the EES would necessitate placing of layers in no more than 1.0 m thickness, so necessitating frequent change to

[6] East Gippsland Water – Water Quality Annual Report 2019/20

discharge points. The drainage period per lift is determined to be up to 10 months.

The implication of this is that the total footprint of the TSF is increased greatly for the tonnage deposited.

That, in turn, delays relocation of materials to the pit, delaying topsoil replacement and rehabilitation.

Finally, during mining operations truck haulage distances increase as overburden has to be hauled to areas open for overburden replacement circumventing the TSF. A further negative outcome directly proportional to haulage distance increase is an increase in dust and noise pollution.

5. DECLARATIONS AND SIGNATURE PAGE

- I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.
- The preparation and submission of this Statement, was to review and set out my expert opinion in relation to Technical Note 01 - Implementation of centrifuges for water recovery and tailings management dated 18 January 2021 (Technical Note) as set out in section 2 herein. I have not been involved in the preparation of the EES or studies and assessments that underpin it (together with a draft planning scheme amendment and application for an EPA works approval) that were publicly exhibited in September – October 2020. I have referred to the authors of the Technical Note for clarifications and working documents where I required these to be able to properly review and express an opinion as required to do. I am satisfied that I have stated the basis and sources of information used in preparing this Statement.

SIGNED:

8th February 2021

IVAN SARACIK   DATE

6/47 Havelock Street,

West Perth

WA 6005

APPENDIX A – DETAILED RÉSUMÉ

IVAN SARACIK

QUALIFICATIONS

National Diploma for Mechanical Engineers (1969)
Graded Arbitrator - Institute of Arbitrators & Mediators Australia
Adjudicator - Construction Contracts Act 2004 (WA)
Accredited Mediator - Institute of Arbitrators & Mediators Australia

PROFESSIONAL AFFILIATIONS

All formerly held memberships, but not retained:

Fellow - Australasian Institute of Mining and Metallurgy - FAusIMM, CPMan
Member - Mineral Industry Consultants Association
Fellow - Institute of Company Directors
Member - Institute of Arbitrators & Mediators Australia
Member - South African Institution of Mechanical Engineers

WORK EXPERIENCE

December 1986 - Present

Epac Pty Ltd / Epac Associates Pty Ltd

Managing Director

Responsible as Principal of Epac for the establishment, operation and profitability of the Company. Epac activities encompass engineering, project and concepts in the mining and industrial sectors.

Experience includes:

Owner's Representative – Gold Project – Brazil (Nov 2019 – Dec 2020)

Initially compilation of the DFS reports and thereafter acting as the dedicated Owner's Representative with on-going development through 2020. The work entailed optimisation and consideration of options to improve the robustness of the prospective project.

Consultant – Mineral Sands Project – NSW (4th quarter 2020 – current)

Preparation of enquiry for mining works for a new mining project comprising two deposits incorporating screening units and alternative mining methods for the mining areas.

Miscellaneous consulting briefs from 2016 to 2020

The work below is generally, if not all, commercially sensitive and under confidentiality agreements. It includes:

- Coordination and preparation of Feasibility Study and Group Management documentation preparation for a West Australian mineral sands development. The tasks comprised intimate involvement in mining, processing project execution and overall Study Report document preparation.
- Contributing to scope and cost estimates for a potential energy project in Australia for production of hydrogen used in power generation offshore.
- Services preparing the Executive Summary processing and infrastructure components of the Feasibility Study assisting a major engineering group working on an Asian major base metal project in Myanmar.
- Technical writing, on behalf of the EPCM Contractor, parts of the Feasibility Study for a major lithium development in WA.
- Preparation of Feasibility Study documentation for an underground base metal development, producing concentrates as a final product. The Project is in Northern Italy.
- Provision of mentoring and Feasibility Study documentation writing services for two West African Bauxite Studies.
- For a graphite mining project East Africa, carried out the pre-qualification process and short listing of prospective mining contractors.
- Prepared mining pre-qualification and bidding documentation for the Boonanarring mineral sands project in Western Australia. This is since developed and operating.
- Consulting on the Altura Pilgangoora lithium projects entailing execution and contracting strategies, facilitation of HAZID/HAZOP and review works.
- Consulting on the Arcadia Petalite Lithium Project.

Bald Hill – Lithium/Tantalum Project – WA (Apr – Sept 2017)

This Project was one of the first into production, remains commercially sensitive and Epac is subject to a Confidentiality Deed.

I was employed to provide significant part-time Project Sponsor services to appoint a Project Manager and then reduce input. The Company then appointed me as full time Project Manager for the four months short duration availability period to stabilise the Team and to get the Project functioning. I then departed on a pre-arranged European trip and was pleased to see the Project successfully implemented.

Tiger Resources Limited – Kipoi Project – DRC (2013 - 2016)

From 2013 to 2014, provided extended part-time services to Tiger on the 25,000 tpa SX/EW Project including consideration of expansion and debottlenecking options going forward.

From 2015 to 2016 was the Project Manager for the Debottlenecking Project which comprised high grade tailings recovery, slurrying and pumping, 320,000 tpa tank leach, CCD and tailings dam.

Perseus Mining Limited – Sissingué Gold Project – Côte d'Ivoire (2015)

Short term consulting brief assisting the Owner in identifying the most appropriate and economic contracting option for the Project.

Indochine Mining Limited – Mt Kare Gold Project – PNG (2012 - 2013)

Study Manager for the PFS.

PT Agincourt Resources – Martabe Gold Project Sumatra (2011 - 2012)

Consulting services for mining alliance for mining and major civil construction works associated with tailings storage facilities and access road systems.

First Quantum Minerals (Australia) – Ravensthorpe Nickel Project (2010 - 2011)

Project Manager for the upgrade, construction and re-commissioning of the Ravensthorpe laterite nickel Project the major new work primarily comprising rebuilding upgraded comminution circuits, beneficiation plant new works, major earthworks construction comprising storage ponds, additional tailings storage works, and evaporation pond works, new power generation facilities, product screening, reject removal circuits and final product bagging and containerisation facilities.

Bannerman Resources Limited – Etango Uranium Project Namibia (2009 - 2010)

Study Manager for PFS for 15 MTPA uranium project with direct management of unique process development and costing work. Responsible for all aspects of the overall project as the Study Manager.

Anvil Mining Limited – Kinsevere Stage 2 Project D.R. Congo (2007 - 2008)

Project Consultant assisting the CEO, CFO and Project Director in project design and execution phases. Contractual negotiations and preparation of contractual documentation. Acting in Project roles when required to do so.

Olympus Pacific Minerals Inc - Phuoc Son Gold Project, Vietnam (2006 - 2008)

Providing consulting services reporting to the in-country executive and board members. Compiling documentation comprising feasibility study and information memorandum. Training local and third world expatriate professional staff in feasibility study preparation and drafting.

Anvil Mining Limited - Copper operations in D.R. Congo (2006 - 2007)

Governance and compliance documentation – preparation of individual guidelines, charters, policies and procedures.

Preparation of an assembled Governance Manual for the Corporation

Leighton Asia (Northern) Limited - Corporate and Divisional Mining Advice (2006 - 2007)

- Facilitating a meeting to devise a business strategy plan for regional mining. Assisting with the preparation, issue and implementation of the plan in a mentoring role.
- Evaluating and reporting on a large gold mining project as an ownership participation prospect.
- Facilitating a four day alliance workshop.

Lynas Corporation Ltd - Mt Weld Rare Earths Project, WA (2003, 2006 - 2008)

Preparation of enquiry documentation for construction of a concentration plant to be constructed at Mt Weld in Western Australia.

Provided consultancy services related to establishment of the pit and excavation of mining four years of ore.

From 2006 through to mid-2007, prepared mining enquiry documentation, adjudication and award of contract to the selected contractor.

Provided assistance to the Owner corporate office with establishment of its Project Team. Advising the executive on West Australian operations.

During 2003, contractual and contract management advice to the Owner when the strategy included the construction of a mineral processing facility in Australia, designed by a West Australian engineering company.

Tiomin Resources Inc - Kwale Mineral Sands Project, Kenya (2003 - 2007)

From 2004 to 2006, Owner's Representative assisting Tiomin with its overall project management to define the development scope for the Project. Worked closely with financing organisations, commercial and legal advisors to assist Tiomin to close finance for the prospective implementation. Became familiar and was closely involved with preparation of technical reports to satisfy the requirements of the Ontario Securities Commission and the National Instrument 43-101. Negotiated and drafted the EPCM Contract for the Project on behalf of the Owner.

In 2007 have advised Tiomin in respect of commercial matters relating to contracts and assisted with a potential legal dispute.

During 2003 / 2004, as the Ausenco Limited Project Manager, responsible for the 2004 Project Review of this significant green fields project incorporating dry mining, wet and dry plants, infrastructure and a new port facility at Likoni, Mombasa. Was the primary author of the resultant document.

Bass Minerals - Que River Project, Tasmania (2006 - 2007)

- Evaluated options for the company to develop its Que River Project.

- Providing high level project development advice to the Executive and primary author for preparing a Feasibility Study Report on the Project.

Lovno Nickel Project - Western Russia (2002 - 2006)

Pursued acquisition of this property and then, as one of five directors of Polar Gold Pty Ltd acquired the foreign shareholding. After considering many possibilities, including investigating an AIM listing, successfully farmed out a controlling interest to a listed West Australian mining company. In July 2006, resigned as a director and retained a small shareholding in Polar Gold. Since relinquished.

Carnegie Minerals Plc - Brufut & Sanyang Projects, Gambia (2002 - 2006)

Carnegie Minerals and its predecessor have been active with mineral sands deposits in The Gambia and have provided services as follows:

- In 2005/2006, management services to Carnegie; dealing with its JV partner, project management leading to commercial mining of the three ore bodies comprising the Sanyang Project and coordination of operating aspects.
- Trial mining and processing 2004/2005 of the Sanyang mineral sands deposit.
- Owner's Representative during 2002/2003 assisting in the processing and export to China of zircon concentrates from a stockpile at Brufut.

St Ives Gold Project, WA **(2002 - 200**7**)**

St Ives Open Pit Mining Alliance.

- Facilitated the meetings to agree the parameters for this Alliance and then authored the document through to execution.
- Was called in on a number of occasions to resolve issues that arose under the Alliance, in all cases doing so without the necessity for either party to issue any contractual letters.

St Ives Underground Mining Alliance.

- Facilitated meetings to determine KPIs and Alliance Agreement changes.
- Authoring the revisions to the Alliance Agreement.

Agnew Gold Project, WA (2005)

Agnew Open Pit Mining Alliance.

- Prepared the Agnew Agreement based on the St Ives Agreement above.
- Was called in to resolve a major cost issue that arose under the Alliance, and was able to bring the parties to an equitable resolution without the issue of any contractual letters.

ProMet Engineers/ OneSteel Limited - Magnet Project, SA (2004-2006)

Project Director For ProMet, the design engineers for the Thiess built magnetite plant. Negotiated establishment of the Contract with Thiess and acted as the mentor for the ProMet Project Manager on the design project.

Highlands Kainantu Limited - Kainantu Project, PNG (2003)

Study Manager for this high grade shrink stope mine in the Eastern Highlands. Considered a diverse range of treatment routes before selecting flotation exporting high grade concentrates.

Sally Malay Mining Limited - Sally Malay Ni/Cu/Co Project (2002 - 2004)

Owner's representation services assisting in the preparation and administration of contract documentation for the open pit, tailings / water storages, plant / infrastructure and power contracts. Through implementation, providing advice to the Owner Project Management Group.

Iluka Limited - New Synthetic Rutile Project (2003)

Project Manager responsible for study activities on a major new project.

Dragon Mining N.L. - Svartliden Project, Sweden (2001- 2004)

Prepared an EPCM Contract for the process plant design and construction by a South African contractor. During implementation assessed progress and reported to the Board. Contractual advice involving contractual matters including legality of the Contractor's execution strategies.

Hillgrove Gold N.L. - NEAMOX Antimony Trioxide Project, NSW (2001)

Owner's Representative responsible for the EPCM Contractor and activities of the Owner's Project Team.

Helix Resources N.L. - Munni Munni Project, WA (2000- 2001)

Project Co-ordinator for a Scoping Study considering open pit and underground mining for this PGM resource.

Moneo Metals Limited - Moneo Nickel Project, New Caledonia (2001)

Project Sponsor assisting the Owner's Team during the BFS phase.

Rothschild Australia Limited - Emily Ann Nickel Project, WA (2001 - 2002)

Lead Independent Technical Expert, responsible for coordination of geology, mining, process and environmental experts.

Services provided for the development phase as well as the completion test on this 250ktpa underground mining Project.

Argosy Minerals Inc - Nakaty Bogota Nickel Project, New Caledonia (2000-2001)

Project Consultant involved in JV contract preparation.

Randgold Resources Ltd - Morila Gold Project, Mali (1999 - 2001)

Project Sponsor, where Epac provided management services to main contractor Metallurgical Design and Management. Prepared EPCM/Lump Sum contract with Principal and construction contracts for earthworks and concrete packages.

Zimbabwe Platinum Mines Ltd - Ngezi Open Pit Project (1999)

Study Manager for this 2MTPA Project with overall responsibility including geology, mining, processing, infrastructure, logistics and economics.

Delta Gold Zimbabwe - Eureka Gold Project, Zimbabwe (1998 - 1999)

Superintendent for the development of this 1.5MTPA Project including preparing the contracts for the plant construction and mining.

SIPA Resources International Ltd - Paraburdoo Gold Project, WA (1999)

Owner's Representative acting for one party in JV meetings during the development and also early operating phases of this project.

Rothschild Australia Limited - Damang Gold Project, Ghana (1997)

Independent Engineer for the construction phase of Abosso's 3MTPA Project.

Ashton Mining Limited - Merlin Diamond Project, NT (1997 - 1999)

Superintendent, involved extensively in all phases and aspects of:

- Scoping Study
- Feasibility Study
- Implementation and commissioning

for this 700 KTPA greenfields multiple pipe open cut kimberlite mining development.

Prepared and administered contracts for the engineering consultants and contractors responsible for plant and infrastructure.

Centaur Mining & Exploration Ltd - Cawse Nickel Project, WA

Senior Project Manager for Kvaerner as part of the Minproc/Kvaerner JV responsible for developing the Cawse Laterite Nickel Project. In an interim role, assisted Kvaerner in appointing and establishing the permanent Kvaerner Project Manager.

Rothschild Australia Limited - Rawas Gold Project, Indonesia (1997)

Independent Engineer for the construction and commissioning of Laverton Gold's Sumatran Project. Responsible for supervising the completion test for the Bank including all aspects of geology, mining, plant and administration.

This followed working for Laverton Gold and demonstrates confidence of both Company and Lenders in the independence of the consultant.

Eyre Resources - Zharkulak/Donarcha Project, Kazakhstan (1997)

Project Consultant devising development strategies for an underground mine.

PT Puncakbaru Jayatama - Gosowong Gold Project, Indonesia (1996 - 1997)

Study Manager for the Kvaerner Davy /Epac Associates JV. The Project includes high grade ore treatment, acid mine drainage and total infrastructure for a very high grade greenfield operation in Maluku Province, since developed.

Menzies Gold NL - Bau Gold Project, Sarawak (1996 - 1997)

Coordinating Planning Engineer for the Scoping and Pre-Feasibility Studies for this complex refractory, multiple pit.

Eyre Resources - Zod Project, Armenia (1997)

Audit of Project parameters and recommendation for Project development.

Golden Shamrock Mines - Siguiri Gold Project, Guinea, West Africa (1996)

Study Manager for Davy John Brown for this 6MTPA facility.

Laverton Gold N.L - Rawas Gold Project, Indonesia (1996 - 1997)

Project Consultant preparing enquiry documentation for the EPCM contract and then adjudication, negotiation and finalisation of the Contract.

Moonstone Holdings Ltd - Akbakai Gold Project, Kazakhstan (1994 - 1995).

Project Coordinator for gold processing plant to produce doré bullion at the Akbakai Concentrator. Primary responsibility for contracts, logistics and construction.

PT Prima Lirang Mining - Kali Kuning Gold Project, Indonesia (1991 - 1992)

Project Manager for the pre-feasibility study, feasibility study and design phases of the Kali Kuning gold project. Then Assistant Project Manager for the development phase. This development is an extension to the Lerokis Project on Wetar Island.

Assistant Project Manager for the construction phase.

Aurora Gold Limited - Mt Muro Gold Project, Indonesia (1992 – 1993)

Project Consultant, providing detailed input into the pre-feasibility and feasibility study phases and materials and contract management support for the implementation phases for this large East Kalimantan Project.

PT Prima Lirang Mining - Lerokis Gold Project, Indonesia (1988 - 1990)

Project Director for the feasibility study phase and then Assistant Project Director on the construction phase of the Lerokis 600,000 tpa project.

P.T. Newmont Minahasa Raya - Minahasa Project, Indonesia (1992 - 1993)

Provided contractual consulting services for this refractory gold Project.

Other Epac co-ordinated detailed involvement in mining projects includes:

- Toka Tindung Project, Sulawesi, Indonesia – Project studies and construction of preliminary infrastructure.
- Kelian Project, East Kalimantan, Indonesia - Fabrication management for the thickeners and construction management for the gold room.
- East Senakin/Sembilang Coal Project, Indonesia - Design management for all in country steelwork fabrication.
- Gunung Pongkor Project, West Java, Indonesia - Sub contract fabrication of the thickener tanks.
- Cikondang Gold Project, West Java, Indonesia - Project management services relating to capital purchases to this gold/base metal project.
- Consulting to PT Kasongan Bumi Kencana on the Mirah gold prospect in Central Kalimantan, Indonesia.
- Consulting to PT Meratus Sumber Mas on the Meratus gold prospect in South Kalimantan, Indonesia.

- Preparing preliminary budgets for Muswellbrook Energy & Minerals' prospective alluvial operation on Sangihe Island, North Sulawesi.
- Consulting on the Mokrsko Gold Project, Czechoslovakia on development of a design and estimate for a 3MTPA CIL gold mining facility bid.
- Consulting project management services for CSR Limited on the pre-feasibility study for the Granny Smith Gold Mine, WA.
- Project and construction management of the Marisa alluvial gold dredge in North Sulawesi for the Independent Resources Limited Group
- Consulting to PT Ampalit Mas Perdana on the Kasongan gold project operating in Central Kalimantan Province, Indonesia.
- Project Manager for PT Lusang Mining 110,000 tpa hard rock u/g gold mining expansion at Lebong Tandai, including shaft re-equipping.
- Project consultancy services on the Karonie 300,000 tpa gold project and the Bow River 4,000 tpd diamond project for Freeport of Australia Inc.
- Feasibility study on the 200,000 tpa heap leach Daveyhurst gold project for Jones Mining NL.

July 1977- December 1986

Barclay-Mowlem Limited Group

October 1983 - December 1986
Proconsult Australia Pty Ltd

Managing Director

Responsible as Executive Director for the marketing, operation and administration of Proconsult in Australia and South-East Asia. Proconsult, as the project management and design arm of the Barclay-Mowlem Limited Group, operated primarily in the mining and metallurgical project sector.

Projects for which direct responsibility and control were held included:

- Lebong Tandai gold mine constructed in Sumatra for CSR Limited. A conventional gold treatment plant utilising clarification and precipitation methods of recovery, infrastructure incorporating power generation, water supply, tailings disposal, workshops and stores as well as access bridge, field supply and housing.
- Bow River alluvial diamond treatment plant designed and supplied for Freeport of Australia Inc. and constructed and operated by group company Minpro P/ L.
- Hannan's South gold project. A final feasibility study was completed for this 140,000 tpa CIP gold plant after which the project was built and commissioned.

Total responsibility was held for management of a multi-discipline design team, administration and personnel functions including salary payments, statutory documentation control as well as marketing and business development.

July 1982 - September 1983
Engineering Management Services Pty Ltd

Director and General Manager

Responsibilities were as per those for Proconsult above. Engineering Management Services was the former Group Design and Project Management Company responsible during this time for the following projects:

- EPCM of the 4,000 tpd Argyle alluvial diamond plant.
- The pilot recovery plant for the Argyle Diamond Mines kimberlite plant facility.
- Lebong Tandai project feasibility study completed for CSR Limited and considering conventional and CIP methods of gold and silver recovery.

October 1980 - June 1982

WA Branch Manager

Responsible for marketing, operation and administration of EMS West Australian operations reporting to a General Manager based in Sydney.

Projects undertaken included:

- Labouchere gold project for Forrest Gold. Initially a feasibility study considering three feed rates was conducted followed by a design and specification brief for a 120,000 tpa CIP plant.
- The 2,000 tpd Argyle alluvial diamond treatment plant design, procurement and commissioning.
- A diamond recovery plant incorporating wet and dry X-ray sorting methods.
- The Argyle 1,350 tpd kimberlite bulk evaluation plant
- Design of the electrical and instrumentation components of the proposed Kwinana tantalum refinery.

December 1979 - September 1980

Development Engineer - Sydney and Perth

In 1979, MCE Limited purchased the rights to the technology of Engineering Management Services Limited, a major South African Project Management Group. As part of this arrangement a senior staff engineer was selected to relocate to Australia and the position of Development Engineer was created. Initial marketing in the diamond mining sector whilst based in Sydney led to opening of the Perth office and transfer to Perth. From a one man operation the organisation developed to a peak of 40 persons.

July 1977 - November 1979

Project Engineer - RSA

Project Engineer for the feasibility study, design, specification, procurement and construction of the Selebi Pikwe copper/nickel smelter in Botswana. The scope included the flash furnace revised feed system using patented technology imported from Finland and Germany.

Project Manager for completion of the 18 million tpa Sishen iron ore mine project for quaternary crushing/screening, thickeners, tailings disposal and load-out systems.

Tender Co-ordinator for the 400 tph Landau coal washery.

February 1973 - June 1977

Fraser and Chalmers SA Pty Ltd
Project Engineer

Project Engineer on the 18MTPA Sishen iron ore export plant seconded to the Owner as Owner's Representative.

Responsible for HMS drum and cyclone plants, quaternary crushing and screening plants, thickeners, tailings disposal, sampling plants and load-out systems.

February 1971 - 1973

GEC Engineering Pty Ltd
Contracts Engineer

Contracts Engineer responsible for the supply and installation contracts on mine winder plant in Southern Africa including a large Koepe winder at Prieska, double drum winders in Zimbabwe and some of the largest conventional winding installations in the world.

July 1970 - January 1971

South Cannon Hydraulics Pty Ltd

Works Engineer responsible for assembly of large hydraulic presses.

January 1970 - June 1970

Mitchell Cotts Engineering Pty Ltd

Works and Development Technician responsible for time and motion study and efficiency improvement in manufacture or Warman pump and Fag flotation cells.

Alfa Laval Australia Pty Ltd
Process Technology

Subject: Laboratory Spin Test Report – Mineral Sands Slimes Tailings Dewatering test for Decanter Centrifuge	Rev A/ 8th Oct 2018
Site: Fingerboards/ Kalbar Resources	
Issued by: Paul Tuckwell/ Alfa Laval Australia (Perth office)	**Class:** Restricted
Keywords: Decanter centrifuge, tailings dewatering	**No. of pages/encl.:10**
Distribute to: Jugal Kar, Paul Tuckwell, Arvin Bangcale (Alfa Laval)	

Summary:

A sample of slimes from the proposed Fingerboards mineral sands minesite was tested for its suitability for dewatering in large scale Alfa Laval P3 mining decanter centrifuges.

Laboratory scale testing indicated that the slurry can be dewatered in a decanter centrifuge to form a firm, spadeable, transportable cake of around 70% wt total solids (suspended + any dissolved solids). In full scale operation the moisture level may be lower or higher depending on machine settings, differential speeds, throughput and G forces used.

It is estimated that the centrate clarity will be in the order of 0.2% to 0.8% suspended solids.

The sample supplied was a thick slurry containing 48.5% solids. This was too thick for mixing with flocculent for the lab test, so was diluted with potable Perth water for purposes of testing (though the high shear environment of an operating decanter centrifuge would improve floc mixing and viability of undiluted feed). Tests indicated that dilution to 25-30% wt solids would be beneficial for solids recovery and floc dose without impacting on the installed capital price, and this should be considered in any project optimisation.

Lab testing indicated that approximately 340 g active flocculent per tonne of suspended solids is needed to form strong, shear resistant flocs and recover the ultra fine material as part of the cake. Flocculent was not screened and only one type was used in the test (as suggested by Wave Engineering based on thickener test work).

This data is based on laboratory scale measurements and observations only. Results and previous installations/ trials on similar slurries indicate that it is suitable for further development work with decanter centrifuges. The ultra fine nature of the tails solids make it particularly suitable for decanter centrifuges compared to other dewatering technologies.

Feed (at 25% solids), flocculated feed, centrate and cake

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1 - Slurry Type/ Description:

1.1 Source of Sample

The slimes sample tested originated from Fingerboards Project test work. The age and origin of the sample is unknown to Alfa Laval, but was tested within 24 hours of receipt. This sample supplied was a very thick paste and was diluted using potable Perth water for testing.

Figure 1: Sample as received at 48.2% suspended solids

Figure 2: Sample diluted to 25.0% suspended solids

1.2 Suspended Solids

The sample supplied contained fine solids. $D_{0.1}$ = 1.37 micron, $d_{0.5}$ = 7.58 micron, P_{80} = 23.19 micron. There was no evidence of grit or larger solids > 100 micron in the sample.

1.3 Dissolved Solids

For the purposes of lab testing, it has been assumed that the sample contained negligible dissolved solids. Dilution of the slurry was undertaken with Perth tap water, which also contains negligible dissolved solids. The pH was approximately 8.0

1.4 Suspended Solids Density and Components

The homogeneous dry suspended solids density was assumed to be approximately 2790kg/m3 as advised. It has been assumed that is consists of extremely fine quartz solids, along with clay and silt.

1.5 Ease of floc formation

Flocculent dosing was tested at both 48.2% dry solids and after dilution to 25.0% dry solids in the slurry.

It was difficult to mix flocculent into the slurry in the thickened state supplied with the sample. Strong, shear resistant flocs formed easily in a jar test at 25% wt suspended solids. The optimum dilution value and floc dose can be optimised during commissioning.

Figure 3: Flocculated solids at 25% wt suspended solids

2 - Testing Aim:

Spin testing at the lab scale is the first practical step in establishing the suitability of dewatering of a slurry with a decanter centrifuge. This enables analysis of the use of centrifugal G forces in dewatering suspended solids. This test aimed to provide an estimate of:

- Cake dryness at typical decanter centrifuge operating conditions
- Suitable feed solids concentration
- Indication of the flocculent dose required under high shear conditions

The results must only be considered as an indication (not a guarantee). In full scale equipment, there are a number of variables available which are not possible to test in a laboratory.

3 - Method:

All suspended solids measurements were undertaken via drying and weighing samples over two days at 110 degC.

A recently prepared sample was delivered by Wave Engineering along with a suggestion of flocculent (Nalco N83384). Flocculent was made up at 0.2% concentration and dosed at this concentration (which is normal for decanter centrifuges). The floc was freshly made at time of testing using potable water, with 2 hrs ageing time.

Slurry was diluted to 25% wt suspended solids using Perth potable tap water.

Flocculent was dosed directly into the diluted slurry with the dose measured. Once strong, shear resistant flocs were obtained, the final dose was recorded.

A spin test using a lab centrifuge was then undertaken using Alfa Laval's high density solid method. This simulates both the G forces the slurry would be exposed to in a full scale tailing decanter centrifuge, and also the shear forces and bowl wall pressure the solids are exposed to. These shear forces are an important mechanism for releasing water from the cake.

Cake dryness and slurry feed concentration were then measured via drying and weighing.

Spin testing without flocculent did not result in good solids recovery due to the ultra fine solids and presumed clay content, as expected. Hence results reported here are for the flocculated slurry only.

4 - Results:

Figure 4: Centrate and cake

4.1 Polymer Test

The polymer used in centrifuge lab test work was recommended by Wave Engineering (Nalco N83384) at 0.2%, made up in Perth tap water.

The polymer dose required for strong, shear resistant flocs was approximately 340 grams active flocculent powder per tonne of dry solids.

This could be optimised/ improved by a proper screening process in combination with flocculent suppliers, and further testing with various flocculents and slurry dilution during a trial/ commissioning.

4.2 Flocculated sample spin test

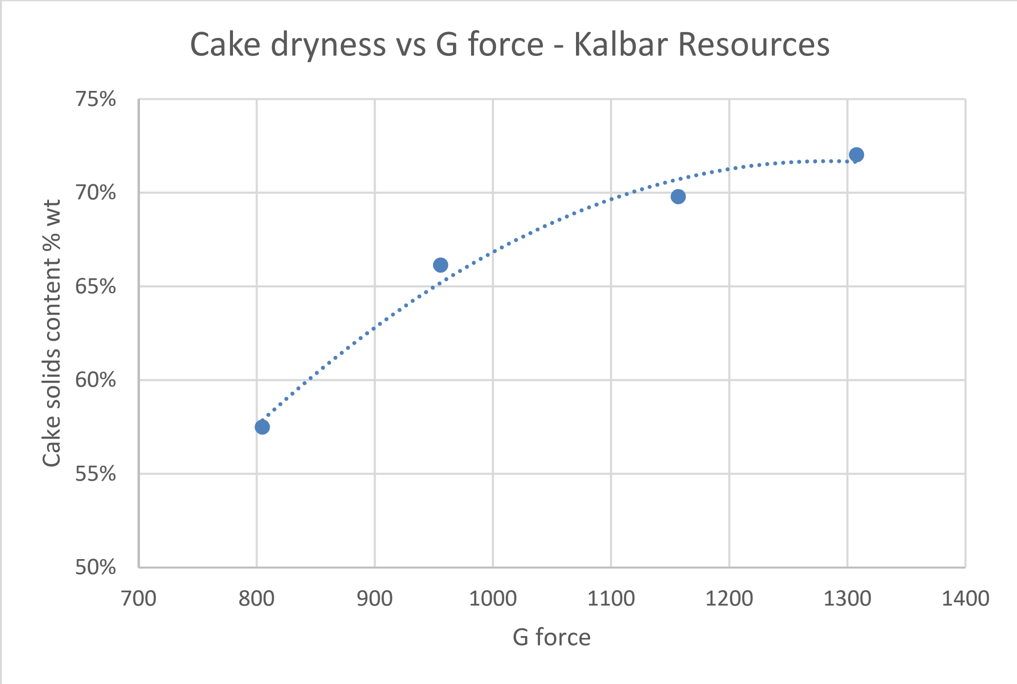

Figure 5 – Cake dryness vs G force

Samples resulting from exposure to different G forces were taken and plotted as shown above. The actual value depends on how the decanter centrifuge is operated, but as a nominal value, 70% wt cake appears to be typical of cake discharged from other decanter centrifuges containing a similar feed and at a similar G force.   This was firm, spadeable and appears suitable for stacking, conveying and transport.

Figure 6: Cake at approximately 70% wt suspended solids

5 - Discussion:

5.1 Flocculent Dose

The flocculent tested appeared to result in strong flocs when the slurry was dosed with a sufficient quantity. However, a screening process should be undertaken with the aid of experienced flocculent suppliers to ensure the best flocculent is selection for high shear applications.

5.2 Cake Dryness

Based on previous spin test vs decanter cake dryness comparisons, it is believed that the cake dryness in an operating decanter centrifuge can be adjusted between 66 and 72% wt suspended solids.

The actual dryness in the cake depends on the G force, which can be tested in the lab, but also some other factors which cannot be tested in the lab but can be varied in decanter centrifuge operation. These include the differential speed of the machine, pond height, variations in feed dilution and additive dosing, pH adjustment and throughput.

At the nominal value of 70% suspended solids, the cake is a firm, spadeable cake. This would be suitable for trucking or conveying and did not present as overly sticky. There was no free water draining from the solid cake.

5.3 Centrate

It is difficult to estimate centrate quality in lab scale testing. However, based on previous experience with ultra fine tailings and operating decanter centrifuges, it is believed that a centrate clarity of 0.2 to 0.8% suspended solids is achievable. Pre-dosing with flocculent will be required to achieve centrate with this clarity.

Figure 7: Estimate of centrate quality

6 - Conclusion

The lab based test results indicated that a mining decanter centrifuge can dewater the supplied slurry to a firm, spadeable consistency. It is estimated that a cake suspended solids content of approximately 70% wt can be achieved. This preliminary test indicates that this application is suitable for decanter centrifuges and should be pursued further.

The ultra fine nature of the solids also indicate that these are difficult to dewater using filtration technologies, and hence would be an especially interesting duty to investigate further using decanter centrifuges. Alfa Laval have several installations with a small particle size distribution which appear to be similar to the Fingerboard slimes.

Dilution of the centrifuge feed to a level of approx. 25-30% is recommended to provide effective flocculent mixing and floc formation.

Further work on the optimisation for flocculent dose should be undertaken, testing the type of flocculent, dilution of floc and feed and the impact of water chemistry.

Confidentiality

Alfa Laval requests that this Spin Test Report is maintained as confidential and remains within the possession of Wave Engineering/ Kalbar Resources. If you intend to pass it on to another party, please contact Alfa Laval. Contact Paul Tuckwell on paul.tuckwell@alfalaval.com or phone 0417 419 680 for more information.

Figure 8: Decanter Centrifuge

Figure 8: Typical cake from a full scale slimes decanter centrifuge

NALCO
An Ecolab Company

Nalco Test Report

KALBAR RESOURCES LTD
GLENALADALE MINERAL SANDS PROJECT

Slimes Flocculant Screening Tests
And
Nalco WATERSHED Tails Dewatering Technology Assessment

05-05-15

Circulation	**Kalbar**	Neil O'Loughlin	
	Nalco	Dan Gregory	Keith Gibbs
		Ed Stucken	James Tudor

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1.0 PROPRIETARY AND CONFIDENTIAL INFORMATION

The attached document contains proprietary and confidential information and is submitted under a confidential relationship for the sole purpose of reporting the findings of a Nalco testwork program together with relevant information for the benefit of the recipient.

By accepting this document, the recipient agrees:

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b) any special features peculiar to the information gained as a result of this document shall be treated as confidential and shall be the property of Ecolab Pty Ltd t/a Nalco Australia and will not be incorporated in whole or in part in other projects unless recipient obtains written permission from Ecolab Pty Ltd t/a Nalco Australia to do so.

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2.0 QUALIFYING STATEMENT

Conceptual mineral processing circuit designs and solid-liquid separation equipment designs proposed by Ecolab Pty Ltd t/a Nalco Australia and described in this report should be considered as preliminary only. These designs are offered for the client's budgetary purposes and should not replace the expert design services of industry recognised consultants or original equipment manufacturers.

The information is provided in good faith in the interests of promoting the products and services of Ecolab Pty Ltd t/a Nalco Australia and based upon the company's extensive experience in mineral processing chemical application can be considered as accurate within the context of a pre-feasibility study.

The information contained in this report is relevant only to the specific design test samples provided to Ecolab Pty Ltd t/a Nalco Australia at the time of the testwork which is taken to be representative of the ore body to be processed. Significant variations in actual ore quality from that of the design test samples will affect the accuracy of the results.

Ecolab Pty Ltd t/a Nalco Australia offers advanced technical support to any client using the company's products and services but does not in any way warrant or guarantee the performance of the client's mineral processing operations.

3.0 EXECUTIVE SUMMARY

Laboratory testwork was carried out by Ecolab Pty Ltd t/a Nalco Australia (Nalco) during May 2015 in support of Kalbar Resources Ltd's proposed Glenaladale mineral sands project with the aim of defining flocculant selection and dosage rates for a range of seven (7) tailings samples.

This report also provides a preliminary tailings thickener design based upon the application of Nalco flocculants and proposes a small cell Tailings Storage Facility (TSF) operational design based upon Nalco's WATERSHED dewatering technology.

By providing these equipment and operations designs, Nalco sets out to ensure the use of our chemicals and services to improve water recovery, TSF life and rehabilitation potential for Glenaladale tailings.

A basic process flow diagram for the Glenaladale tailings circuit has been prepared by Nalco and is illustrated and applied in this report using both client provided and assumed input data combined with data generated from the laboratory testwork.

The work carried out by Nalco has shown that a wide range of Glenaladale tailings can be settled with an average 130gpt (range 100-170gpt) of Nalco 83384 powder flocculant to generate a 0.20 $Tm^{-2}hr^{-1}$ slimes flux rate from which a 48m thickener sizing is derived for a plant feed capacity of 900T/hr.

Typical of mineral sands tailings, the characteristics of Glenaladale slimes create a narrow band of conditions for effective flocculation such that feedwell design factors become critical to ensuring that design throughput can be maintained without excessive flocculant dosing. Specifically, the -63um slimes and silt content of the feed slurry in the center-well must not exceed 3.0%w/w.

The thickener is forecast to achieve an average underflow density of 29%w/w under typical conditions. Assuming the feed parameters summarized in this report, this means that 79% of feedwater will be recovered by the thickener with just over 1,125m^3/hr of water being discharged to tails.

Testwork indicates that Nalco WATERSHED additives may also be used at a dose of 70gpt total dry solids to achieve very rapid recovery of 70% of the water from a 38% solids co-disposed tails.

The capability of WATERSHED to increase tails decant water recovery to 900m^3/hr from an estimated 486m^3/hr from conventional slimes cells and sand stacking operations would reduce plant water demand from 5.7 to 2.8 GL per year and reduce annual tailings cell constructions by almost half.

Accelerated water release would also lead to rapid development of the mechanical strength of the co-disposed tailings and based upon experience, it is predicted that the strength required to support a 3metre overburden placement will be reached within 1-2 weeks.

Chemical application and tailings preparation and placement according to Nalco best practices will be required in order to maintain target outcomes at minimal treatment costs. Nalco propose therefore to continue a close collaboration in designing and potentially implementing Nalco flocculant and WATERSHED programs for the Glenaladale project.

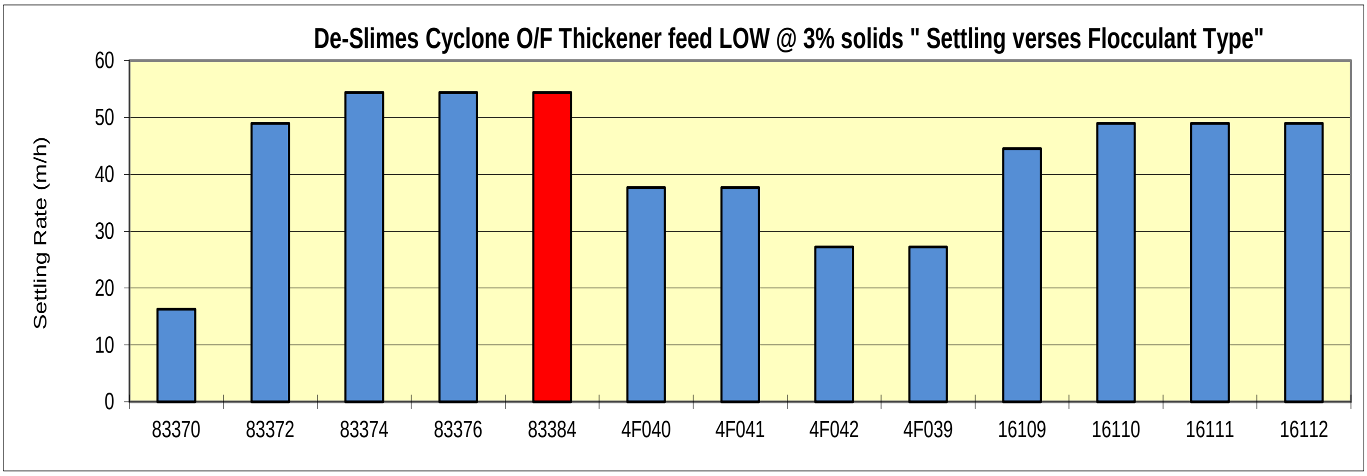
4.0 FLOCCULANT SELECTION

Nalco tested a range of Nalco flocculant products, with all samples prepared at 0.25% under ideal laboratory conditions according to Nalco procedure. [FLOCCULANT TESTING STANDARD WORK INSTRUCTION NON-HAZARDOUS SLURRIES REFERENCE MB2036.docx Rev H Dec 2013]

As illustrated below, preliminary screening shows that several of the widely used Nalco conventional Poly Acrylamide (PAM) flocculants including 83372, 83374, 83376 and 83384 provided effective flocculation and very rapid settling of Glenaladale slimes tailings as provided April 2015.

Nalco 83376 and 83384 were selected for more comprehensive screening tests.

FLOCCULANT SELECTION
30-04-15 (3.0% FEED SOLIDS)



Settling Rate Dose Response Curves

Dose Response curves plotting free settling rate as a function of dose for 3.0% tailings
Slurry samples A-G are plotted overpage.

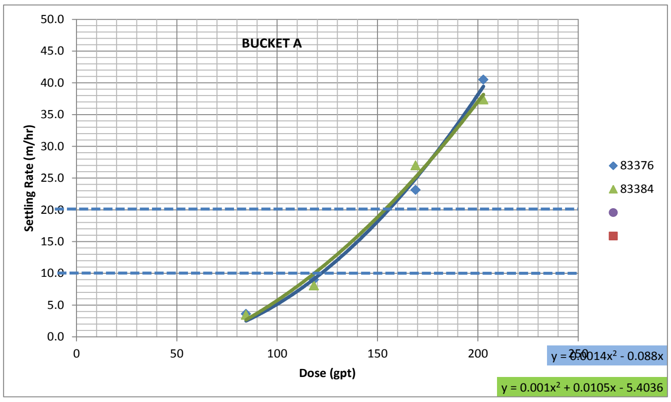
Doses for 83376 and 83384 ranged between 100 and 220gpt which are very typical doses for -38um mineral sands slimes.

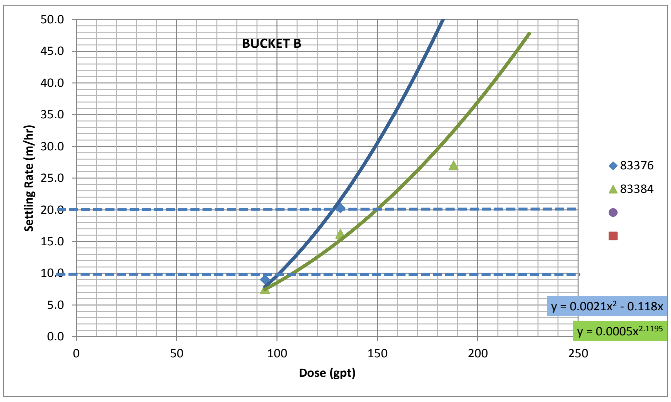
These results indicate 83384 as the product giving a 10m/hr free settling rate at the lowest average dose rate of 130gpt across all seven (7) slurry samples.

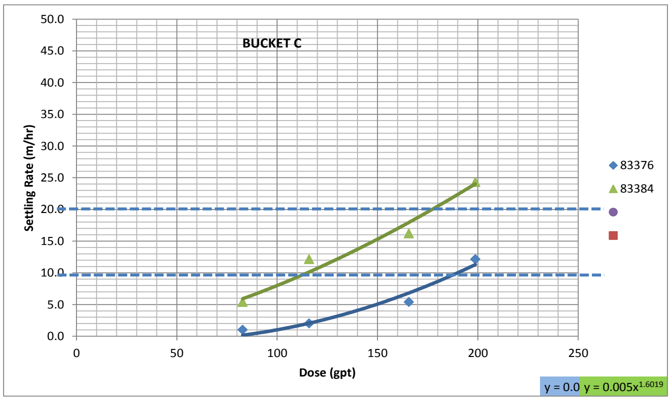
The slurries as provided had very high solids contents (around 30.0%w/w) and it is very important to dilute the slurry as thickener feed, to a -38um slimes content of less than 3.0%w/w.

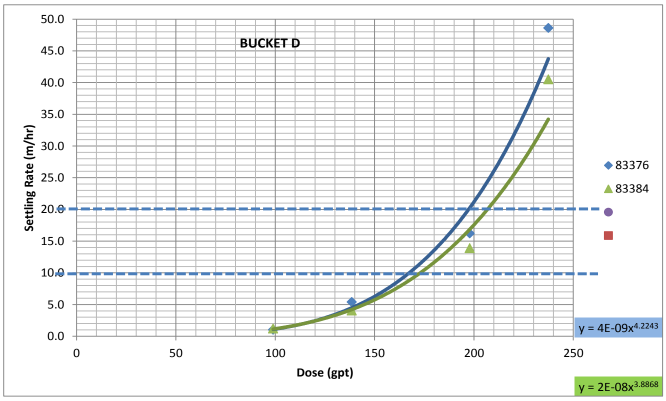
Dose Rates at 10m/hr (gpt)	83376	83384
Bucket A	120	120
Bucket B	100	120
Bucket C	180	120
Bucket D	170	170
Bucket E	180	125
Bucket F	220	140
Bucket G	150	100
Average	160	130

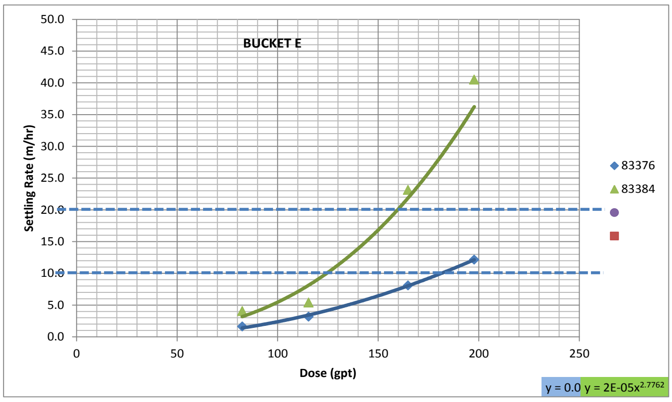
FLOCCULANT SELECTION DOSE RESPONSE CURVES
30-04-15 TAILS (NOMINAL 3.0% FEED SOLIDS)

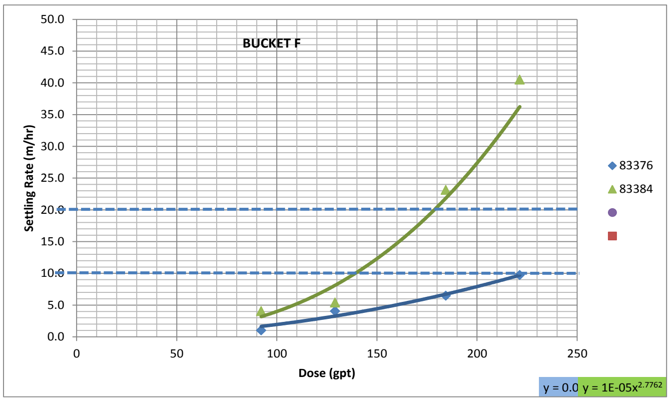


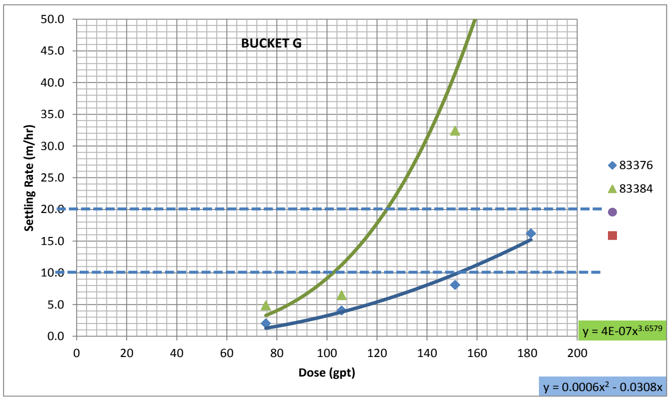








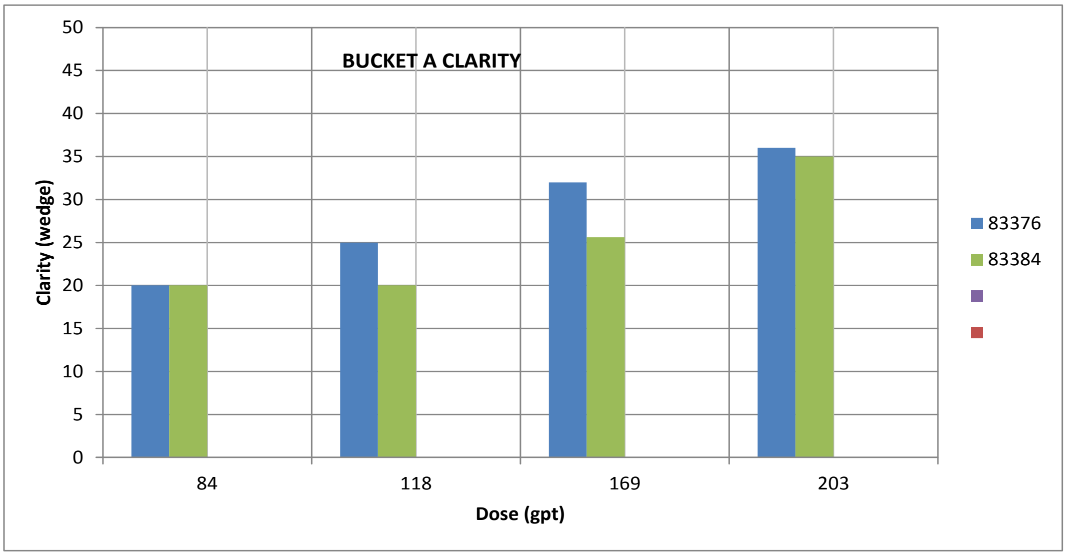




Overflow Clarity

Overflow clarity was observed to be very acceptable at dose rates between 80 and 200gpt for both 83376 and 83384.

As illustrated by example below or Bucket A, Clarity Wedge readings of between 20 and 40 were achieved for all slurry samples A-G at 10m/hr settling rate.



5.0 PRELIMINARY THICKENER DESIGN

Based upon the settling behaviour of each Glenaladale slimes slurry sample and taking slurry A as an example of solids compression characteristics, Nalco have prepared a preliminary thickener design for this project.

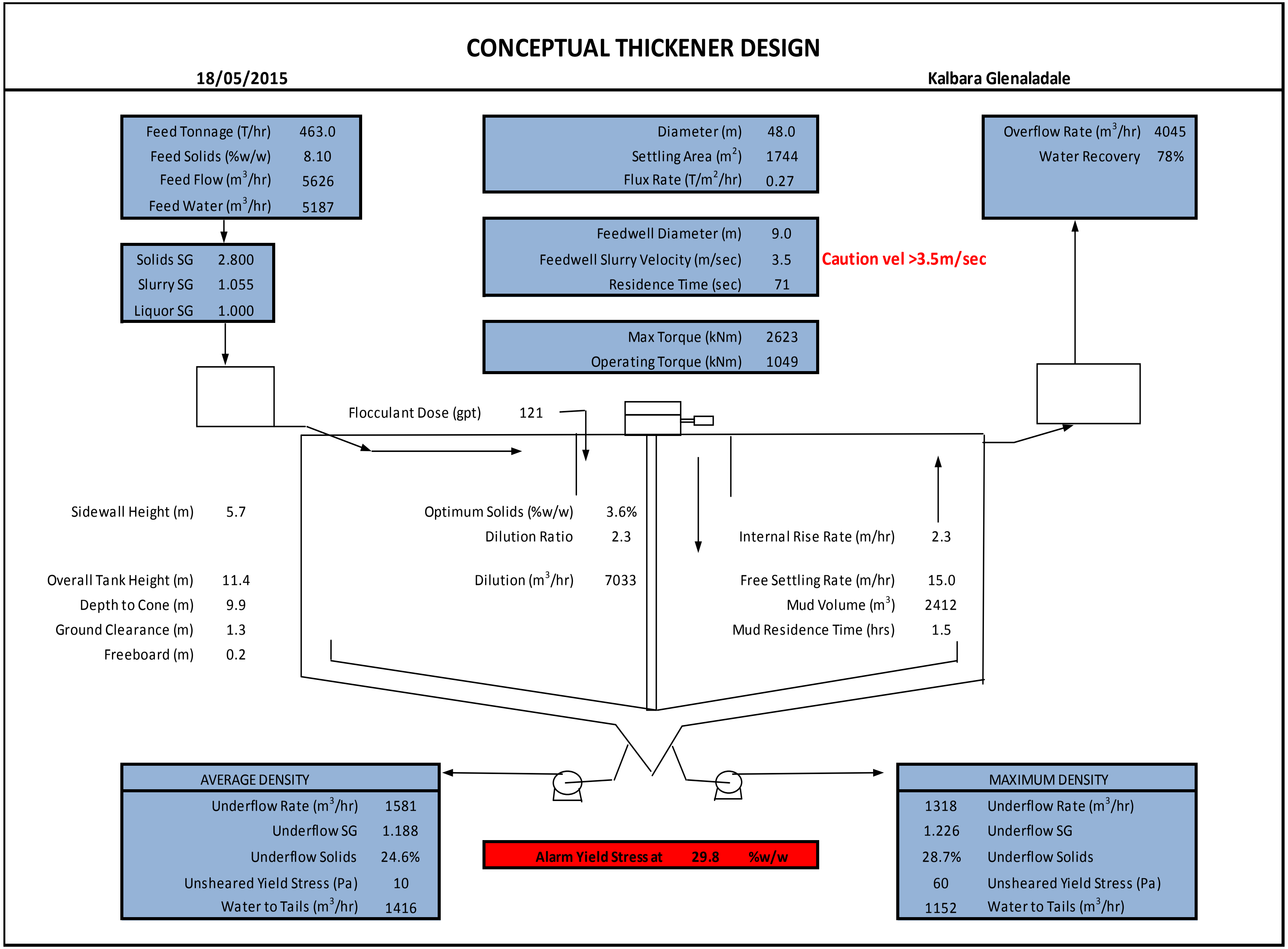
The table below shows the assumptions about the feed rate, moisture, reject and HM product applied by Nalco in preparing the thickener model.

TOTAL PLANT FEED RATE		7.88	MTPA WET	38	CLIENT SLIMES CUT POINT(um)
		900	T/HR SMU WET FEED	91.3%	AVAILABILITY
		855	DRY T/HR INCL REJECT	21.92	HR/DAY
		810	DRY T/HR EXC REJECT	8000	HR/YEAR
2.80	Solid SG	4.2%	PRODUCT	51%	TAILS TO THICKENER
1.000	Liquid SG	38	T/HR	463	T/HR THICKENER FEED
5.0%	MOISTURE	27.8%	SLIMES	54%	OF DRY FEED GOES TO THICKENER
45.0	T/HR MOISTURE	250	T/HR SLIMES	251	T/HR SLIMES TO THICKENER
5.0%	REJECT +3mm	567	T/HR SAND	772	T/HR TOTAL TAILS
45.0	T/HR REJECT			86%	TAILS PERCENT OF TOTAL WET FEED

Further assumptions about the Particle Size Distributions of the Glenaladale feed ore are tabled here.

PARTICLE SIZING DISTRIBUTION (EXCLUDES PRODUCT)					
GRADING	RANGE	SUM%	%	T/Hr	Total
SLIMES + CLAY	0-38um	32.5	32.5	251	251
SILT	38-63um	45	12.5	97	347
FINE SAND	63-200um	95	50	386	734
MED/COARSE SAND	200-2000	100	5	39	772
GRAVEL	+2000um	100	0	0	772
	Total		100	772	
PCP Percent Fines -63umFeed			45	347	
PCP Percent Sand +63umFeed		55%	55	425	

Compression tests and Nalco design models indicate that a 48m thickener will be capable of processing a total of 463T/hr of solids comprising 350T/hr of -63um slimes and silt plus 113T/hr of fine sand from a 900T/Hr wet feed mineral sands operation to generate an underflow density of 29% solids with just under 80% water recovery.


CONCEPTUAL THICKENER DESIGN
18/05/2015
Kalbara Glenaladale
Feed Tonnage (T/hr) 463.0
Feed Solids (%w/w) 8.10
Feed Flow (m3/hr) 5626
Feed Water (m3/hr) 5187
Solids SG 2.800
Slurry SG 1.055
Liquor SG 1.000
Diameter (m) 48.0
Settling Area (m2) 1744
Flux Rate (T/m2/hr) 0.27
Feedwell Diameter (m) 9.0
Feedwell Slurry Velocity (m/sec) 3.5
Residence Time (sec) 71
Caution vel >3.5m/sec
Max Torque (kNm) 2623
Operating Torque (kNm) 1049
Overflow Rate (m3/hr) 4045
Water Recovery 78%
Flocculant Dose (gpt) 121
Sidewall Height (m) 5.7
Overall Tank Height (m) 11.4
Depth to Cone (m) 9.9
Ground Clearance (m) 1.3
Freeboard (m) 0.2
Optimum Solids (%w/w) 3.6%
Dilution Ratio 2.3
Dilution (m3/hr) 7033
Internal Rise Rate (m/hr) 2.3
Free Settling Rate (m/hr) 15.0
Mud Volume (m3) 2412
Mud Residence Time (hrs) 1.5
AVERAGE DENSITY
Underflow Rate (m3/hr) 1581
Underflow SG 1.188
Underflow Solids 24.6%
Unsheared Yield Stress (Pa) 10
Water to Tails (m3/hr) 1416
Alarm Yield Stress at 29.8 %w/w
MAXIMUM DENSITY
1318 Underflow Rate (m3/hr)
1.226 Underflow SG
28.7% Underflow Solids
60 Unsheared Yield Stress (Pa)
1152 Water to Tails (m3/hr)

6.0 NALCO WATERSHED TAILINGS DEWATERING TECHNOLOGY

Nalco WATERSHED additives bind the solids within tailings slurries at discharge to create a free draining structure and provide immediate water release, recovery and reuse.

WATERSHED enhances beaching to maximise tailings storage capacity and generate a load bearing structure.

By allowing beach angles to be controlled anywhere between 2^o and 18^o and because the beached solids have both a high degree of hydraulic conductivity and a hydraulic gradient, rapid water drainage will continue whilst ever there is interstitial free water present with the solids.

Related benefits of a Nalco WATERSHED program include:

- Extend TSF life by more than double
- Uniform deposition of fine and coarse fractions in co-disposal applications
- Improved decant water quality
- Reduce water losses via evaporation or seepage

<u>WATERSHED - Iron Ore Tailings Example</u>

In early 2013, the client's tailings Consultant forecast that the TSF, an open cut mine pit, would be full within three months.

After WATERSHED treatment was commenced in mid-2013, at 130gpt powder equivalent dose, or approximately $0.55 per dry tonne, immediate and progressive water release was established.

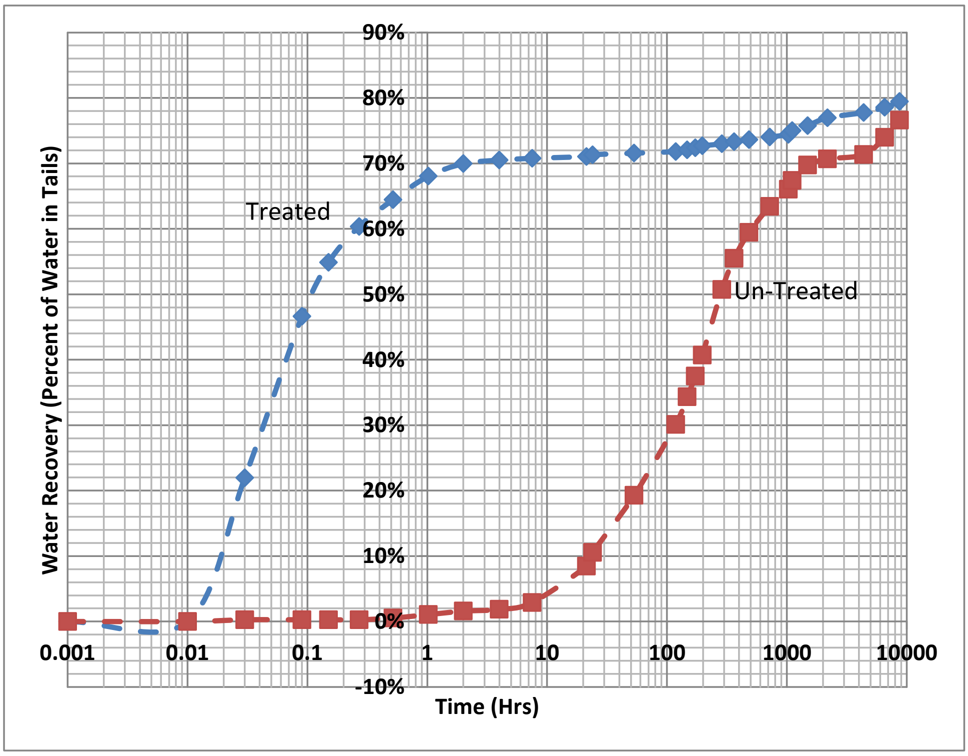
The TSF is currently still filling today.

IRON ORE TAILINGS
WATERSHED EXAMPLE
AUSTRALIAN OPERATION

Prior to startup
Tails depositing as smooth paste
No beaching - No water release

At Startup
OreBind process starting
Water release occurring

WATERSHED provides the very substantial benefit of instantaneous water release compared to untreated tailings dewatering which takes place through consolidation over an extended time period.



7.0 GLENALADALE WATERSHED MODEL

Basic modelling of potential Kalbar Glenaladale Mineral Sands Project Tailings Management System indicate that 770T/hr dry of tails could be discharged to 500x250mx10m deep Tails Cells at 38% solids with the recovery of 900m^3/hr of water which is close to double the estimated water recovery from typical sand stacking and slimes cell operations.

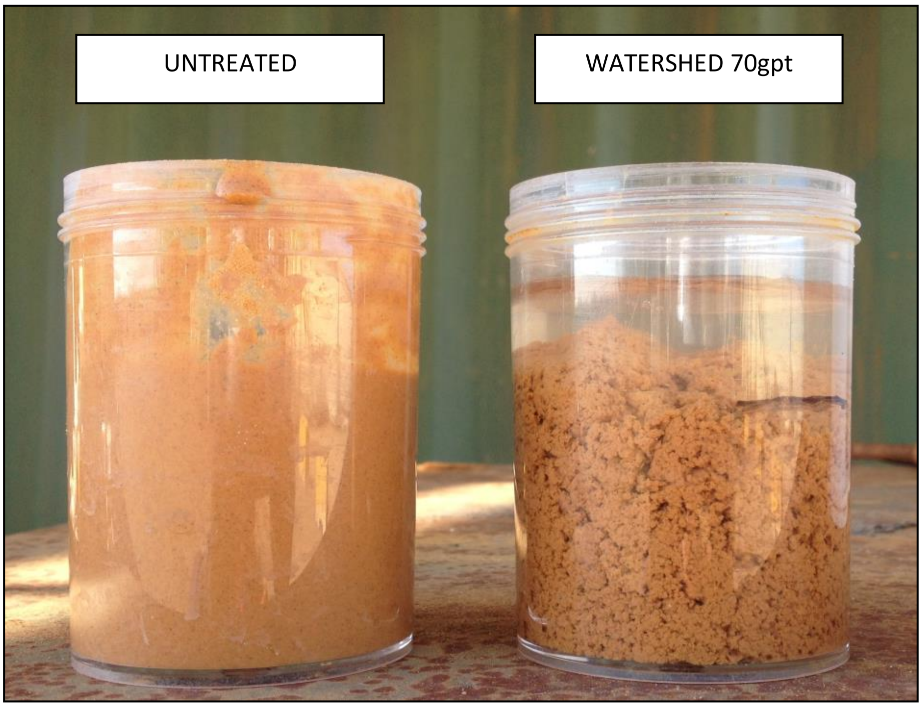
As preliminary and indicative figures, by increasing tails decant to 900m^3/hr, the Glenaladale's external makeup water demand could be reduced from 5.7GL per annum to 2.8GL per annum.

The Models show that cell life can be extended from 55 days to 84 days and cell constructions reduced from 7 per year to 4 per year by using the Nalco WATERSHED program.

Furthermore, because the WATERSHED treated tails will very much more quickly reach a density and mechanical strength suitable for re-capping as compared to untreated slimes which will take many months to dry effectively.

Nalco plant experience for Mineral Sands indicate that WATERSHED treated Cells are ready to re-cap within 2-4 weeks compared to untreated slimes cells which in some cases, cannot be recapped without major reworking efforts over a period of about 1 year.

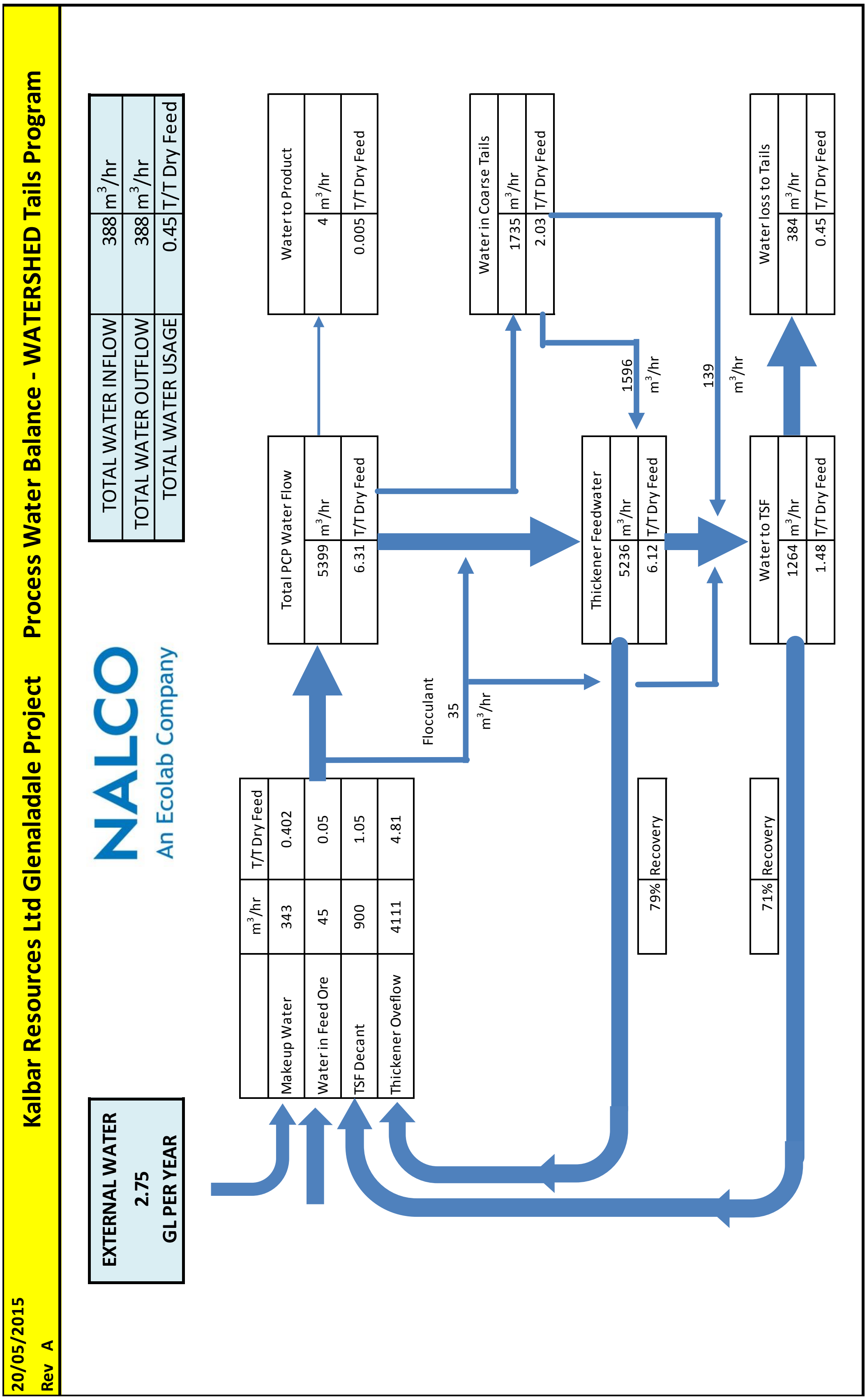
Visual demonstration of the effect of Nalco WATERSHED technology upon water release for Glenaladale tailings with sand and slimes co-disposed at a ratio of 90:10 is shown below.

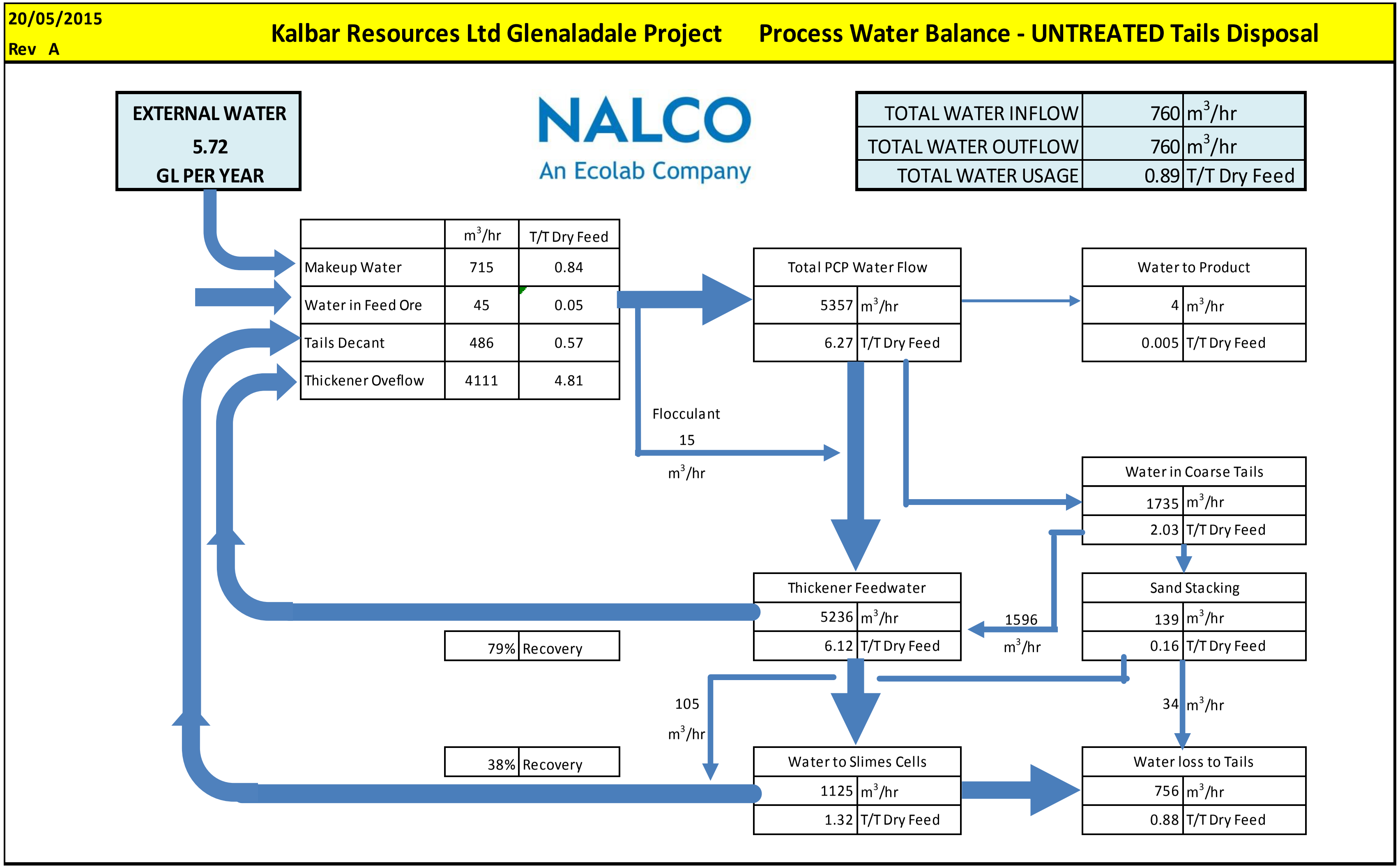


The Nalco Tailings Management Model Process Flow Sheet is presented overpage alongwith summary Plant Water Balance diagrams for both treated and untreated cases.

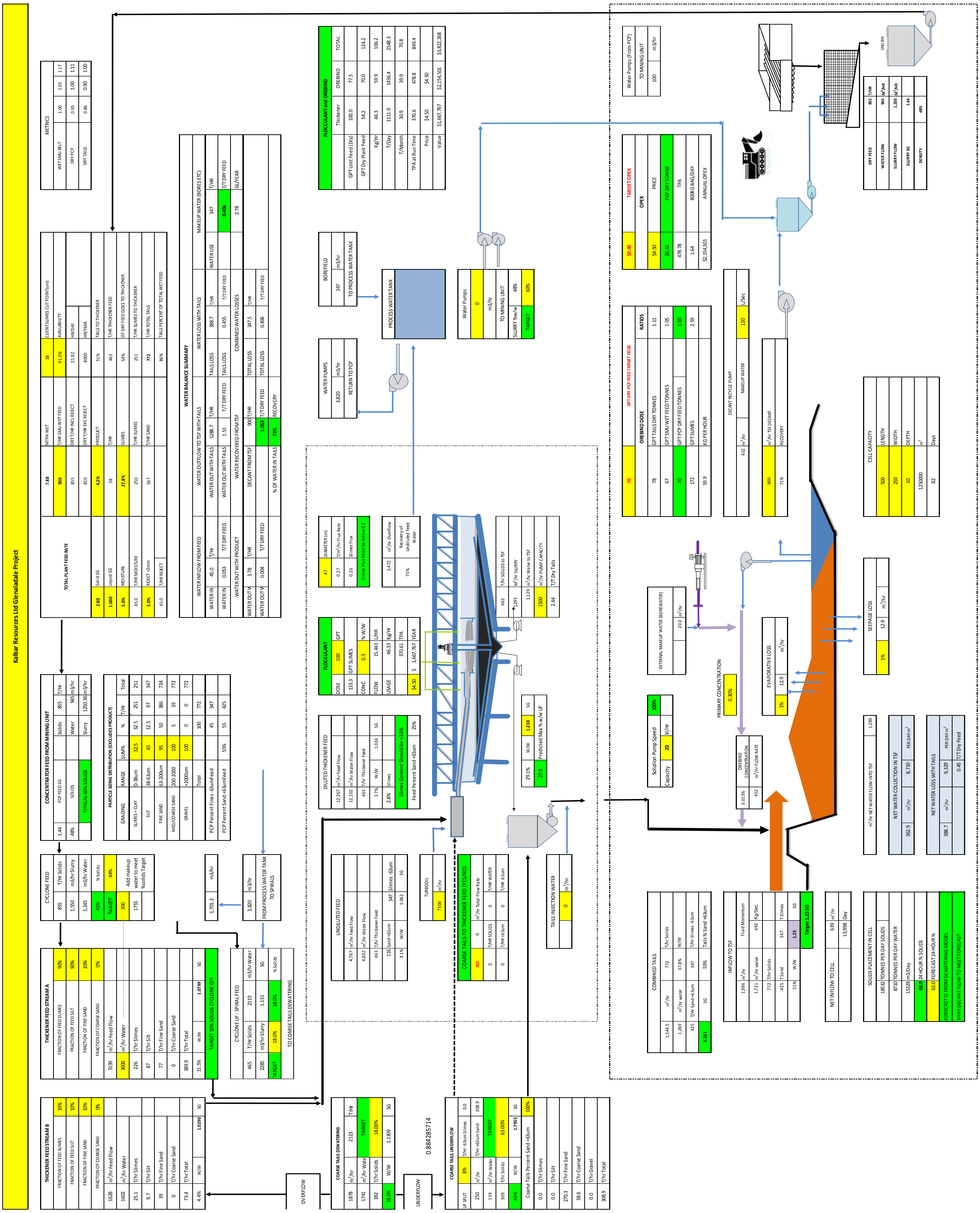
PLANT WATER BALANCE SUMMARY – NALCO WATERSHED TECHNOLOGY

Plant Feed Rate 900 T/Hr Wet				
Water Balance	**M^3/Hr**	**T/T Dry Feed**	**M^3/Hr**	**T/T Dry Feed**
	Nalco WATERSHED Tails Dewatering		**Untreated Tails Disposal**	
Water Recovery From Tails	900	1.05	486	0.57
External Makeup Water Allocation	2.8 GL per Year		5.7 GL per Year	
External Makeup Water Allocation	343	0.40	715	0.84
Water From Feed Ore	45	0.05	45	0.05
Tailings Thickener Overflow	4111	4.81	4111	4.81
Plant Recirculating Water Load	5399	6.31	5399	6.31
Net Water Loss to Tails	384	0.45	756	0.88
Water Loss with Product	4	0.00	4	0.00
Tailings Management System	Co-Disposal into Small Cells		Sand Stacking and Slimes Cells	
Tails Cell Dimensions (m) and Capacity	500 x 250 x 10	1,250,000 m^3	500 x 250 x 10	1,250,000 m^3
Comment			Dry Sand Trucked into Slime Cells	
TSF Cell Life (days)	84		55	
TSF Cells Constructed Per Year	4.4		6.7	


20/05/2015
Rev A
Kalbar Resources Ltd Glenaladale Project
Process Water Balance - WATERSHED Tails Program
EXTERNAL WATER
2.75
GL PER YEAR
NALCO
An Ecolab Company
TOTAL WATER INFLOW 388 m³/hr
TOTAL WATER OUTFLOW 388 m³/hr
TOTAL WATER USAGE 0.45 T/T Dry Feed
m³/hr T/T Dry Feed
Makeup Water 343 0.402
Water in Feed Ore 45 0.05
TSF Decant 900 1.05
Thickener Oveflow 4111 4.81
Flocculant
35
m³/hr
Total PCP Water Flow 5399 m³/hr 6.31 T/T Dry Feed
Water to Product 4 m³/hr 0.005 T/T Dry Feed
Water in Coarse Tails 1735 m³/hr 2.03 T/T Dry Feed
1596
m³/hr
139
m³/hr
Thickener Feedwater 5236 m³/hr 6.12 T/T Dry Feed
Water loss to Tails 384 m³/hr 0.45 T/T Dry Feed
Water to TSF 1264 m³/hr 1.48 T/T Dry Feed
79% Recovery
71% Recovery


20/05/2015
Rev A
Kalbar Resources Ltd Glenaladale Project
Process Water Balance - UNTREATED Tails Disposal
EXTERNAL WATER
5.72
GL PER YEAR
NALCO
An Ecolab Company
TOTAL WATER INFLOW 760 m3/hr
TOTAL WATER OUTFLOW 760 m3/hr
TOTAL WATER USAGE 0.89 T/T Dry Feed
m3/hr T/T Dry Feed
Makeup Water 715 0.84
Water in Feed Ore 45 0.05
Tails Decant 486 0.57
Thickener Oveflow 4111 4.81
Total PCP Water Flow
5357 m3/hr
6.27 T/T Dry Feed
Water to Product
4 m3/hr
0.005 T/T Dry Feed
Flocculant
15
m3/hr
Water in Coarse Tails
1735 m3/hr
2.03 T/T Dry Feed
Thickener Feedwater
5236 m3/hr
6.12 T/T Dry Feed
1596
m3/hr
Sand Stacking
139 m3/hr
0.16 T/T Dry Feed
79% Recovery
105
m3/hr
34 m3/hr
38% Recovery
Water to Slimes Cells
1125 m3/hr
1.32 T/T Dry Feed
Water loss to Tails
756 m3/hr
0.88 T/T Dry Feed

EXAMPLE GLENALADALE PROCESSING CIRCUIT DESIGN MODEL BY NALCO – 900T/HR FEED RATE



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Alfa Laval Solid Bowl Centrifuge Installation List – Tailings and Minerals Processing Waste Residue projects.

List does not include other smaller scale minerals processing separation installations (e.g. yellowcake, copper concentrate. Copper/ calcium carbonate, coal tar, lithium process separation, crud, coal fines, graphite etc)

Rixs Creek, NSW – Coal Tailings installation

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Site	**Model**	**Technology**	**Bowl Diameter**	**Industry**	**Slurry type**	**Status**
Rixs Creek, Bloomfield NSW, Australia	P3-10070	Solid Bowl P3 tailings centrifuge	1000mm	Coal	Coal tails	Operating
Rixs Creek, Bloomfield NSW, Australia	P3-10070	Solid Bowl P3 tailings centrifuge	1000mm	Coal	Coal tails	Operating
Rixs Creek, Bloomfield NSW, Australia	G2-125	Solid Bowl G2 centrifuge (modified for high wear protection)	720mm	Coal	Coal tails	Operating
Rixs Creek, Bloomfield NSW, Australia	G2-125	Solid Bowl G2 centrifuge (modified for high wear protection)	720mm	Coal	Coal tails	Operating
Rixs Creek, Bloomfield NSW, Australia	G2-125	Solid Bowl G2 centrifuge (modified for high wear protection)	720mm	Coal	Coal tails	Operating
Kestrel Coal Mine, QLD, Australia	P3-10070	Solid Bowl P3 tailings centrifuge	1000mm	Coal	Coal tails	Process commissioning January 2020
Kestrel Coal Mine, QLD, Australia	P3-10070	Solid Bowl P3 tailings centrifuge	1000mm	Coal	Coal tails	Process commissioning January 2020
Kestrel Coal Mine, QLD, Australia	P3-10070	Solid Bowl P3 tailings centrifuge	1000mm	Coal	Coal tails	Process commissioning January 2020
Meandu Coal Mine, Stanwell Corporation, QLD, Australia	P3-10070	Solid Bowl P3 tailings centrifuge	1000mm	Coal	Coal tails	Commissioned, process/ floc optimisation ongoing

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Site	Model	Technology	Bowl Diameter	Industry	Slurry type	Status
Meandu Coal Mine, Stanwell Corporation, QLD, Australia	P3-10070	Solid Bowl P3 tailings centrifuge	1000mm	Coal	Coal tails	Commissioned, process/ floc optimisation ongoing
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating

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Site	Model	Technology	Bowl Diameter	Industry	Slurry type	Status
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
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Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating

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Site	Model	Technology	Bowl Diameter	Industry	Slurry type	Status
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Syncrude Tar Sands Mine, Alberta, Canada	P3-10070 (branded as Lynx 1000 but identical)	Solid Bowl tailings centrifuge	1000mm	Tar Sands	Tar sands tailings	Operating
Confidential (NDA in place) - Africa	P3-10070	Solid Bowl tailings centrifuge	1000mm	Base Metal	Tailings from mining of a base metal	Currently being commissioned
BHP Nickel refinery, WA, Australia	P2-505	P2 Solid Bowl Centrifuge	510mm	Nickel refining	Nickel processing residue	Operating
BHP Nickel refinery, WA, Australia	P2-505	P2 Solid Bowl Centrifuge	510mm	Nickel refining	Nickel processing residue	Operating
BHP Nickel refinery, WA, Australia	P2-505	P2 Solid Bowl Centrifuge	510mm	Nickel refining	Nickel processing residue	Operating
Ambatovy Nickel refinery, Madagascar	P2-705	P2 Solid Bowl Centrifuge	650mm	Nickel refining	Nickel processing residue	Operating
Ambatovy Nickel refinery, Madagascar	P2-705	P2 Solid Bowl Centrifuge	650mm	Nickel refining	Nickel processing residue	Operating
Eti Maden, Turkey	P2-800	P2 Solid Bowl Centrifuge	740mm	Borax Mining	Borax Tailings	Operating
Eti Maden, Turkey	P2-800	P2 Solid Bowl Centrifuge	740mm	Borax Mining	Borax Tailings	Operating

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Eti Maden, Turkey	P2-800	P2 Solid Bowl Centrifuge	740mm	Borax Mining	Borax Tailings	Operating
Site	**Model**	**Technology**	**Bowl Diameter**	**Industry**	**Slurry type**	**Status**
Eti Maden, Turkey	P2-800	P2 Solid Bowl Centrifuge	740mm	Borax Mining	Borax Tailings	Operating
Eti Maden, Turkey	P2-800	P2 Solid Bowl Centrifuge	740mm	Borax Mining	Borax Tailings	Operating
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Eti Maden, Turkey	P2-800	P2 Solid Bowl Centrifuge	740mm	Borax Mining	Borax Tailings	Operating
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Eti Maden, Turkey	P2-800	P2 Solid Bowl Centrifuge	740mm	Borax Mining	Borax Tailings	Operating
Eti Maden, Turkey	P2-800	P2 Solid Bowl Centrifuge	740mm	Borax Mining	Borax Tailings	Operating
Eti Maden, Turkey	P2-800	P2 Solid Bowl Centrifuge	740mm	Borax Mining	Borax Tailings	Operating