Fingerboards Mineral Sands Project Inquiry and Advisory Committee
Technical note

TN No: TN 014
Date: 12 March 2021

Subject: Response to IAC Second Request for Information — Centrifuges

Introduction

This technical note responds to IAC's second request for information (25 February 2021, Tabled Document 150), questions C1-C11.

Questions and responses

[The Proponent should provide:]

C1. An overall statement of suggested quantified (where possible) or qualified changes in environment effects (positive and negative) of the Project across the different environment effect areas of the Project.

C2. A summary table of changes to the Project due to the introduction of centrifuges, including information on which technical report conclusions require revisiting to consider centrifuges.

Question C1

The potential changes in environment effects of the Project associated with the use of centrifuges, are set out in the table that was filed on 12 March 2021 in response to Direction 59(c) of 29 January 2021. A copy of this table is included in Appendix 1 for convenience.

As set out in Appendix 1, for most EES study areas, the inclusion of centrifuges will have a positive or neutral impact on the environment effects of the Project. Where there is potential for negative environment effects, the negative effect is expected to be slight and manageable.

Question C2

Changes to the Project due to the introduction of centrifuges are described in the updated Project description (EES, chapter 3) which is Tabled Document 122. The following table summarises the key changes at a high-level:

No.	Changes to Project	Updated project description reference
1	Removal of temporary tailings storage facility (**TSF**) and TSF cells in the mine void.	Section 3.6.
2	Inclusion of centrifuges to dewater fines. Centrifuges will be housed in two relocatable centrifuge buildings, each serving an active mining area and mining unit plant (**MUP**).	Sections 3.4.5 and 3.6.1

3	Flocculant will be added to the centrifuges to increase coagulation of the clay particles. This is the same flocculant that would be used in the thickener and DAF plant.	Section 3.6.1. Refer also to section 3.5.2.
4	Dewatered fines tailings cake will be trucked to the void and backfilled, together with the overburden (rather than delivered as a slurry by pipeline to the temporary TSF or in-pit TSFs).	Section 3.6.1.
5	Two additional front-end loaders will be used for centrifuge cake loading.	Section 3.4.4.
6	Two additional haul trucks will be used to haul centrifuge cake.	Section 3.4.4.
7	Amphirols will no longer be required to dewater fine tailings.	Section 3.4.4.
8	14,000, not 9,000, kVA will be required for the mining unit plants and wet concentrate plant.	Section 3.8.1.

The technical report conclusions that need to be revisited in light of using centrifuges are:

- On first principles, the removal of the TSF will reduce the overall storage available for rain capture, and therefore increase the potential for run off from the Project area. Again on first principles, this could have the potential to result in increased erosion and impacts to the quality of receiving waters if the proposed water management dams are not appropriately sized or positioned. To assist with the detailed design of the water management dams, Kalbar intends to obtain updated hydrological modelling for the Project without the TSF, based on the updated water balance.
- The introduction of centrifuges will mean that additional flocculant will be used for the Project. The flocculant that will be used is anionic polyacrylamide (**PAM**), which degrades to form nitrogen, ammonia, carbon dioxide and water. PAMs are widely used by water authorities and in other industries, and their use in the Project is not considered harmful to aquatic organisms and does not cause long-term adverse effects in the environment. However, the detailed design will determine the concentrations and flux of total nitrogen and ammonia generated if residual PAM degrades in the mine void and seeps into groundwater.
- The detailed design will need to determine the long-term average process water quality for total and dissolved metals, as well as other water quality parameters such as total dissolved solids, nutrients and other solutes that may concentrate over time.
- The dry fine tailings from the centrifuge will be placed in mine voids, and are unlikely to be used in manufacturing subsoils for rehabilitation. However, if this was to be proposed, a procedure will need to be developed for breaking any dried lumps of fine tailings to a finer particle size so they can be mixed with sand tailings. It is likely that the mixing of fine dry tailings of a suitable particle size (probably in the order of <5mm) with sand tailings could be mixed thoroughly and evenly.
- The revised greenhouse gas inventory for the centrifuge scenario to comply with the reporting obligations in the *National Greenhouse Gas and Energy Reporting Act 2007* (Cth).

[The Proponent should provide:]

C3. Further information on how mineral sands processing is proposed to be managed on site should the centrifuges be implemented and unsuccessful at a commercial scale. Technical Note 01 (TN01; Tabled Document 43) states centrifuges have been previously evaluated and trialled but not used in mineral sands applications.

Question C3

The reason centrifuges have not previously been used in mineral sands projects is due to the higher cost of implementing them when compared to tailings storage facilities (**TSFs**), not because of any technical challenges in achieving desired performance.

The operating cost of a typical above ground, unlined, conventional paddock style TSF is approximately $1.50 to $2.00 per tonne of tailings stored. By comparison, the operating cost of the centrifuge operations is in the range of $3.50 to $4.00 per tonne of tailings processed and hauled to the pit for backfill.

The two key constraints that will drive a project to incur the additional cost for centrifuges are:

- water availability – there needs to be sufficient process water available for the wet disposal method; and
- footprint – there needs to be sufficient off-path land available for the construction of the TSF. Further, the longer the material stored in a TSF takes to dewater, the larger the footprint that is required for tailings management. This has a knock-on effect on the rate at which rehabilitation can occur.

In the case of the Fingerboards Project, both water availability and footprint are key considerations and warrant the additional costs associated with centrifuges. This may not hold true for other projects, where centrifuges may have been evaluated but not adopted.

Further testwork has been undertaken on the fine tailings from the Project area, which provides a very high degree of confidence that the centrifuges will achieve the expected cake densities and water recovery percentages. A copy of this testwork is provided in Exhibit 1.

[The Proponent should provide:]

C4. The quantity of flocculant proposed to be used in the centrifuge process and how this chemical will be stored and managed to protect the surrounding environment.

Question C4

The flocculant used in the centrifuge process will be an anionic polyacrylamide, known as **PAM.** There are a number of similar products available – copies of the Safety Data Sheet for two of the possible candidates are provided in Appendix 2.

PAM flocculants are commonly used to treat drinking and wastewater – for example, both South Gippsland Water and East Gippsland Water refer to the use of anionic PAMs (such as polymer LT27) to treat drinking water in their annual drinking water quality reports for 2018/2019 and 2019/2020.

The flocculant will be used at a dosing rate of approximately 370 g/tonne of dry solids reporting to the centrifuge. This translates to a nominal (average or usual) dose rate of around 118 kg of flocculant every hour as the centrifuge units nominally receive around 321 tph of solids, noting that the percentage of fines tailings is variable due to natural variations in the deposit geology.

The preferred method of receiving flocculant powder is by container truck. From the container, the powder will be pneumatically transferred to an adjacent silo (expected volume of 50m^3), which will house the dry flocculant powder and provide an ongoing supply for at least one month.

The process for loading flocculant into the flocculant plant from the silo will be as follows:

1. The flocculant powder silo will be designed to dehumidify the contents. An exciter will be used to extract the powder from the silo into a small, heated hopper.
2. Air blowers will then convey the powder pneumatically through pipes to a wetting head.
3. The entire plant will be enclosed to avoid losses of flocculant powder.
4. The flocculant dry powder will be mixed with high-pressure spray water at the wetting head, and the mixture will be retained in a stirred tank.
5. After the flocculant has been wetted, it will be transferred to an adjacent tank awaiting dosing to the centrifuge units.

As an alternative, flocculant could also be received in 1-tonne bulk bags of dry flocculant powder, delivered via truck. A small shed on a concrete base would be provided to ensure the bags are stored in a lockable and dry environment. The process of mixing the flocculant would be the same, except that instead of points 1 and 2 above, the following process would be used to handle the flocculant.

1. A fresh bag of flocculant powder will be collected from the shed with a forklift.
2. The forklift will then place the bag into the bag load bay of the flocculant plant. From here, the flocculant will be managed through an automated system that extracts the flocculant powder into a small hopper and uses air blowers to convey the powder through pipes to a wetting head pneumatically.

The entire flocculant plant will be housed inside a concrete sump with approximately 500mm high bund walls to capture any spillage. The sump will be designed to accommodate the whole volume of neat flocculant in the unlikely event of a tank rupture. The sump is also equipped with sump pumps, which will reclaim any spilled flocculant.

Standard industry spill measures will also be available. Typically, spilled flocculant is mixed with sand and allowed to dry out. The dry flocculant and sand mixture is then separated onto a small stockpile on a concrete bund. It can be slowly added to the centrifuges or allowed to degrade to ammonia, carbon dioxide and water until only the sand remains.

[The Proponent should provide:]

C5. Information on the chemical composition and soil structure of the solid cake material following treatment with flocculant which demonstrates it is appropriate for overburden use, reseeding and vegetation growth.

Question C5

PAM flocculants are based on the acrylamide monomer, which typically makes up between 100 and 500ppm of the bulk polymer.

As well as being used to treat drinking and wastewater, PAM flocculants are used in agriculture to condition soil to facilitate water infiltration and binding, and to combat erosion to protect nearby waterways from silt entrainment. Broadleaf® and Swell-Gel® are examples of commonly available PAMs for public use in horticulture, gardening and forestry.

PAM works by bonding with suspended particles – like a temporary glue - allowing them to flocculate (form a larger matrix of particles) and settle out. During the centrifuge process, it temporarily binds the fine particles in the fine tailings slurry together, which allows them to settle out as larger particles. This then frees the water used in the slurry - known as **centrate** - to be recycled back to the primary process.

As discussed in response to question C4 above, PAM will be used at a very low dosing rate in the centrifuges – approximately 370 g per tonne of dry solids. The majority of the PAM used will be absorbed into the centrifuge cake. Any PAM retained in the centrate will return to the process water circuit where it will have opportunity to absorb into fines particles in the thickener. However, because flocculants like PAM degrade very quickly when transferred mechanically in oxygenated water, they are not typically observed in process water.

The centrifuge cake will be primarily composed of fine quartz and clays, which are naturally occurring. This will make up 70% of the mass. The remaining 30% of the mass is water, which is retained in the cake. Initially, the concentration of PAM in the centrifuge cake will be around 333 ppm. In the mining void, the centrifuge cake will be placed as backfill, along with overburden, on top of the coarse tailings. In total, the centrifuge cake will represent only 7% - 8% of the total overburden backfill volume. After backfilling, the concentration of PAM is diluted to 13.6mg/kg. PAM will then continue to degrade until it is nearly undetectable after 48 hours and will eventually degrade completely.

[The Proponent should provide:]

C6. Information on the likely impacts on waterways and streams from the introduction of flocculant into the Project area.

Question C6

Refer to the memorandum provided by Tony McAlister dated 12 March 2021, included in Appendix 3.

[The Proponent should provide:]

C7. Updated water balance which considers the use of centrifuges including updated estimates of surface water and ground water demand.

Question C7

Refer to the supplementary witness statement of Jarrah Muller dated 8 February 2021, and in particular the information set out in Appendix A of that supplementary witness statement.

[The Proponent should provide:]

C8. Power requirements and power availability for operation of the centrifuges.

Question C8

Two centrifuge buildings are proposed, each one serving an active mining area and MUP. The estimated average power demand for both centrifuge buildings is 2,133 MW for a total consumption of 17,000MWh per year.

Initially, the power demand for the Project will be 8,000kW/6,400kW (Maximum/Average) for a total average consumption of 54,000MWh per annum. At peak production, this will increase to 15,000kW/12,100kW (Maximum/Average) for a total consumption of 104,300MWh per annum.

AusNet Services has advised Kalbar that based on preliminary investigations, it is likely that the power demand for the Project can be met by the existing 66kV network supplied from the MFA-BDSS1 66kV line. Kalbar has engaged AusNet Services to conduct a feasibility study to determine the scope and cost of works required to connect the Project to the existing 66kV network, including any necessary upgrade works.

[The Proponent should provide:]

C9. Further detail on the size of the cake stockpile (e.g. average/maximum) and how the cake stockpile will be managed to address any environmental risks e.g. run-off/surface water impacts of the stockpile during a high rainfall event / flooding or other expected environmental issues.

Question C9

Centrifuge cake will only be trucked to the mine void for backfilling between 07:00 h and 18:00 h Mondays to Fridays, and between 07:00 h and 13:00 h on Saturdays. Outside these times, the centrifuge cake will accumulate on the cake stockpiles.

The cake stockpiles are designed to store a maximum volume of around 3,600m³ (6,000 tons) at each of the two centrifuge plants. The centrifuge cake will be hauled at a rate of approximately 680tph using dump trucks. A front-end loader will reclaim material from the cake stockpiles and load the dump trucks.

There will be two areas of bunding associated with each of the centrifuge buildings. The first bund will be around each centrifuge building, the second around each of the wider cake stockpile areas. The concrete floor of each centrifuge building will be sloped towards a central pump building sump that returns centrate to the process water dam. The bund around each centrifuge building will also ensure that all rainfall water on the building and equipment is captured and does not become runoff. It will also capture any spills in the event of accidental release of flocculant or slurry. The cake stockpile areas will be elevated higher than the plant sump level and each bund around them will be graded towards a clay lined drainage sump. If the drainage sump is filled during very high rainfall periods, above its design capacity, it will overflow and drain via gravity pipe to the building sump, from where the water is returned to the process water dam. This ensures that all rainfall and accidental water discharges inside the centrifuge areas are captured and not released to the environment.

[The Proponent should provide:]

C10. Clarification around the supplementary noise evidence (Tabled Document 124) suggesting front end loaders (FEL) may be working on the cake stockpile 24/7. Is this correct or will FELs only be used for truck loading during the day?

Question C10

This is not correct. Front-end loaders and cake haul from the cake stockpile to the mine void will only occur during the “day” period and will not operate during “evening” and “night” periods. The cake stockpiles have been sized to take this into account.

[The Proponent should provide:]

C11. An assessment of the landscape/visual impacts of the proposed centrifuge buildings.

Question C11

The response to this question is being prepared and will be provided as soon as possible.

Appendix 1

Fingerboards Mineral Sands Project Inquiry and Advisory Committee
Direction 59(c) of 29 January 2021 - Impacts of the use of centrifuges on EES study areas

Study area	Impact	Cross-reference
Biodiversity	• Inclusion of centrifuges will slightly reduce the water requirement assessed in the EES from 3 GL/year to around 2.9 GL/year, which will result in a slight reduction in potential impact to aquatic environments, including the Mitchell River. This is a neutral or slightly positive change. • Elimination of the temporary TSF will reduce truck haul distances within the Project area during the first years of mining. This reduction will potentially reduce potential impacts to ecological values associated with vehicular collision (fauna road mortality), noise and dust. This is a positive change. • Otherwise, the centrifuges are not anticipated to alter the results of the ecological impact assessment.	Refer to section 1.2 of the supplementary witness statement of Aaron Organ dated 8 February 2021.
Groundwater	• Inclusion of centrifuges will slightly reduce the water requirement assessed in the EES from 3 GL/year to around 2.9 GL/year, which will result in a slight reduction to the amount of borefield make up water required. This is a neutral or slightly positive change. • Centrifuges improve the reliability of the water balance given they involve a controlled, mechanical process that is not affected by weather, evaporation rates or slurry tailings deposition methods. This is not a change to the environment effects per se, but enhances confidence in the estimated water required from surface and groundwater resources, and the associated impacts of water extraction and water use. • Centrifuges would process a proportion of the sand tailings stream (due to a large cut off particle size), reducing the slurry volume directed to the sand stackers, which discharges directly into the pit voids. This reduces the amount of seepage from coarse sandy tailings to the water table from 1.7 GL/year to 1.15 GL/year, a reduction of 32%. This would result in a significant reduction in the modelled groundwater mounding presented in the EES. This is a positive change.	Refer to paragraphs 2.1 and 2.2 of the supplementary witness statement of Hugh Middlemis dated 5 February 2021. Refer to section 4 of the supplementary witness statement of Joel Georgiou dated 7 February 2021. Refer to section 5.2 of the supplementary witness statement of John Sweeney dated 8 February 2021.

Study area	Impact	Cross-reference
	• Elimination of the TSF eliminates the potential for seepage from the TSF to: o contribute to raised water groundwater levels; and o negatively impact groundwater quality. This is a positive change. • Elimination of the TSF also eliminates potential for TSF seepage impacting on any spring fed dam located within the same catchment as the TSF. This is a positive change. • Flocculant used in the centrifuges will be used sparingly and the majority of it will adhere to the fine tailings cake, not the process water. The flocculant to be used is polyacrylamide (**PAM**), which degrades to form nitrogen, ammonia, carbon dioxide and water. It is not considered harmful to aquatic organisms and does not cause long-term adverse effects in the environment. Further work is recommended during detailed design to determine the concentrations and flux of total nitrogen and ammonia that might be generated if residual PAM degrades in the mine void and seeps into groundwater. The initial assessment is that potential impacts of these compounds on groundwater is likely to be very low and therefore, this is expected to be a neutral change.	
Surface water	• Centrifuges significantly improve water efficiency and results in a slight reduction in the amount of water required for the project. This is a slightly positive change. • The elimination of the temporary TSF will eliminate the risk of dam failure and contamination in downstream waterways. This is a positive change. • The elimination of the temporary and in-pit TSFs allow for quicker rehabilitation time, both of which reduce the overall area of disturbance at any given time. With the smaller disturbance footprint, and the highly controlled nature and quality of centrate produced by the centrifuges, the overall water quality management regime at the site will be easier to control, test and operate. This is a positive change. • Additional use of flocculant may change the pH of the centrate and/or introduce other sources or compounds of additional concern into the centrate	Refer to section 3.3 and page 10 of Appendix A of the supplementary witness statement of Jarrah Muller dated 8 February 2021. Refer to section 2 of the supplementary witness statement of Tony McAlister dated 8 February 2021. Refer to section 2 of the supplementary witness statement of James Weidmann dated 7 February 2021. Refer to section 5.2 of the supplementary witness statement of John Sweeney dated 8 February 2021.

Study area	Impact	Cross-reference
	(e.g. dissolved aluminum), depending on the flocculant used. However, these concerns are readily manageable, especially given the localised and controlled manner by which centrate will be produced. With management, this is a neutral change. • The use of centrifuges in combination with flocculant is likely to reduce the concentration of metals in the returned process water following a single pass through the processing circuit. The effects of the improved water efficiency and closed loop system are likely to cause increased concentration of solutes over time. During detailed design, further investigation will be undertaken to predict long term average process water quality for total and dissolved metals, as well as other water quality parameters such as total dissolved solids, nutrients and other solutes that may concentrate over time. This may require management, but is not expected to have any impact on surface water. • Fine tailings cake from the centrifuges may accumulate in a temporary stockpile of up to 3,600m^3 before being hauled to the mine void for disposal. The stockpile presents a water quality hazard if run off does not report to the water management dams – this should be required as part of the detailed design of the Project. With management, this is a neutral change. • The inclusion of centrifuges will affect elements of the hydraulic assessment, but not the overall outcomes or recommendations. In particular: o The hydraulic modelling included the TSFs in the design surfaces. Elimination of the TSFs reduces the storage available for rain capture. However, this is unlikely to adversely affect flooding given the elimination of the TSFs also reduces the disturbance footprint at any point in time. o A reduction in the pre-mining disturbance footprint allows existing landforms and catchment boundaries to be more readily maintained, which is a key to flood mitigation. o Water extracted from fine tailings via the centrifuges will be returned to the process water dam. Centrifuges will not impact the operation of the water management dams which, when drawn down, provide freeboard and act as a buffer to attenuate flood impacts.	Refer to section 2 of the supplementary witness statement of Michael Cheetham dated 8 February 2021.

Study area	Impact	Cross-reference
	This is a neutral change. • Centrifuges reduce the Project water requirements due to reduced water losses to tails. This will result in lower utilization of the freshwater dam and higher volumes of water stored in the freshwater dam for longer periods. If the freshwater dam is full, it will not be possible to operate the DAF plant to treat mine contact water as it will not be able to be stored in the fresh water dam. This increases the probability of the dams spilling and filling. Mine year 8 has the highest probability of spill, with 3.4% spill probability from dams in the Mitchell River catchment, 0.9% in the Perry River catchment. Over the life of the mine, the average annual probability of a spill in the Mitchell River catchment is around 1.4%, and around 0.5% in the Perry River catchment. With management, this is a neutral change.	
Air quality	• Broadly, modelling of dust emission rates with centrifuges included in the Project, shows little change to the EES modelling. By using centrifuges, dust emissions from overburden haulage and vehicle exhaust emissions are reduced due to shorter haulage distances. However, the additional haulage of cake from the centrifuges to the mining void is a new dust source, which increases dust associated with tailings management. o In year 5 operations, use of centrifuges reduces the total estimated emission rate of TSP and PM10 but the total emission rate of PM2.5 increases by 1%. o In year 8 operations, use of centrifuges increases the total estimated emission rate of TSP by 1% and PM10 by 2%, with no change to the emission rate of PM2.5. o In year 12 operations, use of centrifuges reduces the total estimated emission rate of TSP and PM10, with no change to the emission rate of PM2.5. On balance, this is a neutral change, with slight positive and slight negative changes, depending on the mine year. • Dust dispersion modelling indicates that standard and additional mitigation measures are required to achieve air quality criteria for 24hr average	Refer to section 4 of the supplementary witness statement of Simon Welchman dated 9 February 2021.

Study area	Impact	Cross-reference
	concentrations of PM10 at all receptors with or without centrifuges. However, in the centrifuge scenario, there will be fewer exceedances using just standard mitigation than in the EES scenario. This is a slightly positive change. • Modelling indicates that by adopting specified mitigation measures, the Project using centrifuges would comply with the SEPP AAQ environmental quality objectives for PM10. This is a neutral change.	
Greenhouse gas (**GHG**)	• Inclusion of centrifuges would use approximately 10,194 MWh of electricity per year in total, which will have associated GHG emissions of approximately 10,400 tCO_{2-e} per year. This would represent a 15% increase in GHG emissions if no other changes to the Project were made. • However, using centrifuges means that amphirols are no longer required to dewater fine tailings, which eliminates their associated GHG emissions. Also, given the reduced haul distances, GHG emissions associated with diesel fuel use are reduced. While a complete GHG inventory for the Project with centrifuges has not yet been prepared, it is expected that total GHG emissions with centrifuges will not be significantly different from the estimates in the EES and will therefore be a neutral to slightly negative change.	Refer to section 4.5 of the supplementary witness statement of Simon Welchman dated 9 February 2021.
Noise and vibration	• Centrifuges eliminate the need to construct the temporary TSF and the in-pit TSFs, and the need for amphirol plant, which are the primary noise sources associated with the TSF. The predicted noise levels for the centrifuge based option are below the recommended levels in EPA Publication 1411 *Noise from Industry in Regional Victoria* for the day, evening and night periods. These levels are generally comparable to the TSF based option, with increases of up to 2dB (typically 1dB), and reductions of up to 4dB (typically 1dB), depending on the receptor. On balance, this is a neutral change, with slight positive and slight negative changes, depending on the receptor and the mine year.	Refer to page 3 of the supplementary witness statement of Christophe Delaire dated 8 February 2021.
Radiation	No impact.	Refer to section 3.4 of the supplementary witness statement of Darren Billingsley dated 8 February 2021.

Study area	Impact	Cross-reference
Roads, traffic and transport	• Elimination of the temporary TSF reduces internal haul distances during the first years of mining as trucks hauling overburden will no longer need to travel around the TSF. This is a positive change. • Impacts from a roads, traffic and transport perspective on the public transport are expected to be minor and do not require additional mitigation measures. o The construction of the centrifuge buildings will result in few additional construction vehicle movements – less than 5 return trips per day over a 2-3 month period. This is expected to be a combination of light and heavy vehicles and is unlikely to require over-dimensional loads. o During operations, use of the centrifuges may require some additional internal hauling activities – likely to require 3 additional operations staff which will generate 3 additional light vehicle return trips per day. This is a neutral or slightly negative change.	Refer to TN01 and section 4 of the supplementary witness statement of Paul Carter dated 8 February 2021.
Land use and planning	No impact.	Refer to section 2 of the supplementary witness statement of John Glossop dated 8 February 2021.
Landscape and visual	To be confirmed.	Additional photomontages are being prepared by Urbis and will be provided as soon as possible.
Agriculture and horticulture	Inclusion of centrifuges means the ratio of jobs created per ML of water used by the Project improves. Otherwise, no impact.	Refer to the supplementary witness statement of Doris Blaesing dated 8 February 2021.
Cultural heritage	No impact – the centrifuges will be located within the same Project footprint as the TSF option and impacts on cultural heritage will be managed in accordance with the approved cultural heritage management plan.	See Figure 8 in TN 01 and TN 008.
Socioeconomic	Many submitters raise concerns about the temporary TSF. Inclusion of the centrifuges removes the need for the TSF and any risk associated with it, which in turn is expected to allay some concerns of submitters. While some submitters may also be concerned about the use of centrifuges, the impacts of the centrifuge will typically be neutral or less than the TSF.	See for example, section 2.19 of Tabled Document 107.

Study area	Impact	Cross-reference
Human health	No impact.	Refer to section 3 of the supplementary witness statement of Karen Teague dated 8 February 2021.
Rehabilitation and closure	• Elimination of the TSFs will eliminate the delay required for each TSF to be filled and dried, which allows for continuous backfilling of voids and earlier commencement of rehabilitation. This is a positive change • Earlier commencement of rehabilitation may reduce the area of land disturbed at any one time and the amount of topsoil required to be stockpiled during the first years of mining. • Earlier commencement of revegetation will reduce post closure monitoring duration. This is not a change to the environment effects per se, but it is a positive change for the Project. • The dry fine tailings from the centrifuge will be placed in mine voids, and are unlikely to be used in manufacturing subsoils for rehabilitation. Nevertheless, if this was proposed then a procedure will need to be developed for breaking any dried lumps of fine tailings to a finer particle size so they can be mixed with sand tailings. It is likely that the mixing of fine dry tailings of a suitable particle size (probably in the order of <5mm) with sand tailings could be mixed thoroughly and evenly. This is a neutral change.	Refer to section 2 of the supplementary witness statement of Michael Cheetham dated 8 February 2021. Refer to paragraphs 9-13 of the supplementary witness statement of Robert Loch dated 6 February 2021.

We create chemistry

Safety data sheet

1. Identification

Product identifier

Magnafloc® 2025

Relevant identified uses of the substance or mixture and uses advised against

Relevant identified uses: flocculation agent

Details of the supplier of the safety data sheet

Company:
BASF SE
67056 Ludwigshafen
GERMANY
Global Mining Solutions

Telephone: +49 621 60-52555
E-mail address: Productinformation.Performance-Chemicals@basf.com

Emergency telephone number

International emergency number:
Telephone: +49 180 2273-112

2. Hazards Identification

Classification of the substance or mixture

According to UN GHS criteria

No need for classification according to GHS criteria for this product.

Label elements

Globally Harmonized System (GHS)

The product does not require a hazard warning label in accordance with GHS criteria.

Other hazards

According to UN GHS criteria

Very slippery when wet.

This type of product has a tendency to create dust if roughly handled. The product does not burn readily but as with many organic powders, flammable dust clouds may be formed in air. The product is under certain conditions capable of dust explosion.

3. Composition/Information on Ingredients

Substances

Not applicable

Mixtures

Chemical nature

polyacrylamide, anionic

4. First-Aid Measures

Description of first aid measures

Remove contaminated clothing.

If inhaled:
If difficulties occur after dust has been inhaled, remove to fresh air and seek medical attention.

On skin contact:
Wash thoroughly with soap and water.

On contact with eyes:
Wash affected eyes for at least 15 minutes under running water with eyelids held open.

On ingestion:
Rinse mouth and then drink plenty of water. Check breathing and pulse. Place victim in the recovery position, cover and keep warm. Loosen tight clothing such as a collar, tie, belt or waistband. Seek medical attention. Never induce vomiting or give anything by mouth if the victim is unconscious or having convulsions.

Most important symptoms and effects, both acute and delayed

Symptoms: The most important known symptoms and effects are described in the labelling (see section 2) and/or in section 11., Further important symptoms and effects are so far not known.

Hazards: No hazard is expected under intended use and appropriate handling.

Indication of any immediate medical attention and special treatment needed

Treatment: Treat according to symptoms (decontamination, vital functions), no known specific antidote.

5. Fire-Fighting Measures

Extinguishing media

Suitable extinguishing media: dry powder, foam

Unsuitable extinguishing media for safety reasons:
water jet

Additional information:
If water is used, restrict pedestrian and vehicular traffic in areas where slip hazard may exist.

Special hazards arising from the substance or mixture

carbon oxides, nitrogen oxides
The substances/groups of substances mentioned can be released in case of fire. Very slippery when wet.

Advice for fire-fighters

Special protective equipment:
Wear a self-contained breathing apparatus.

Further information:
The degree of risk is governed by the burning substance and the fire conditions. Contaminated extinguishing water must be disposed of in accordance with official regulations.

6. Accidental Release Measures

Avoid dispersal of dust in the air (i.e., clearing dust surfaces with compressed air). Avoid the formation and build-up of dust - danger of dust explosion. Dust in sufficient concentration can result in an explosive mixture in air. Handle to minimize dusting and eliminate open flame and other sources of ignition. Forms slippery surfaces with water.

Personal precautions, protective equipment and emergency procedures

Use personal protective clothing.

Environmental precautions

Do not discharge into drains/surface waters/groundwater.

Methods and material for containment and cleaning up

For small amounts: Pick up with suitable appliance and dispose of.
For large amounts: Contain with dust binding material and dispose of.
Avoid raising dust.

Reference to other sections

Information regarding exposure controls/personal protection and disposal considerations can be found in section 8 and 13.

7. Handling and Storage

Precautions for safe handling

Breathing must be protected when large quantities are decanted without local exhaust ventilation. Handle in accordance with good industrial hygiene and safety practice. Forms slippery surfaces with water.

Protection against fire and explosion:
Avoid dust formation. Dust in sufficient concentration can result in an explosive mixture in air. Handle to minimize dusting and eliminate open flame and other sources of ignition. Dry powders can build static electricity charges when subjected to the friction of transfer and mixing operations. Provide adequate precautions, such as electrical grounding and bonding, or inert atmospheres.

Conditions for safe storage, including any incompatibilities

Further information on storage conditions: Store in unopened original containers in a cool and dry place. Avoid wet, damp or humid conditions, temperature extremes and ignition sources.

Storage stability:
Avoid extreme heat.

Specific end use(s)

For the relevant identified use(s) listed in Section 1 the advice mentioned in this section 7 is to be observed.

8. Exposure Controls/Personal Protection

Exposure controls

Personal protective equipment

Respiratory protection:
Suitable respiratory protection for lower concentrations or short-term effect: Particle filter with medium efficiency for solid and liquid particles (e.g. EN 143 or 149, Type P2 or FFP2)

Hand protection:
Chemical resistant protective gloves (EN 374)

Suitable materials also with prolonged, direct contact (Recommended: Protective index 6, corresponding > 480 minutes of permeation time according to EN 374):
e.g. nitrile rubber (0.4 mm), chloroprene rubber (0.5 mm), polyvinylchloride (0.7 mm) and other
Supplementary note: The specifications are based on tests, literature data and information of glove manufacturers or are derived from similar substances by analogy. Due to many conditions (e.g. temperature) it must be considered, that the practical usage of a chemical-protective glove in practice may be much shorter than the permeation time determined through testing. Manufacturer's directions for use should be observed because of great diversity of types.

Eye protection:
Safety glasses with side-shields (frame goggles) (e.g. EN 166)

Body protection:
light protective clothing

General safety and hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Ensure adequate ventilation. Wearing of closed work clothing is recommended. No eating, drinking, smoking or tobacco use at the place of work.

9. Physical and Chemical Properties

Information on basic physical and chemical properties

Form:	powder
Colour:	off-white
Odour:	odourless
Odour threshold:	No applicable information available.
pH value:	6 - 8 (10 g/l) The product has not been tested. The statement has been derived from substances/products of a similar structure or composition.
Melting point:	The substance / product decomposes therefore not determined.
Boiling point:	not applicable
Flash point:	not applicable
Evaporation rate:	The product is a non-volatile solid.
Flammability:	not flammable
Vapour pressure:	The product has not been tested.
Solubility in water:	Forms a viscous solution.

Partitioning coefficient n-octanol/water (log Kow):
Study scientifically not justified.
Self ignition: not self-igniting

Viscosity, dynamic:
not applicable, the product is a solid
Explosion hazard: not explosive
Fire promoting properties: not fire-propagating

Other information

Self heating ability: It is not a substance capable of spontaneous heating.

Bulk density: approx. 750 kg/m3

Other Information:
If necessary, information on other physical and chemical parameters is indicated in this section.

10. Stability and Reactivity

Reactivity
No hazardous reactions if stored and handled as prescribed/indicated.

Corrosion to metals: No corrosive effect on metal.

Chemical stability
The product is stable if stored and handled as prescribed/indicated.

Possibility of hazardous reactions
The product is not a dust explosion risk as supplied; however the build-up of fine dust can lead to a risk of dust explosions.

Conditions to avoid
Avoid extreme temperatures. Avoid humidity.

Incompatible materials

Substances to avoid:
strong acids, strong bases, strong oxidizing agents

Hazardous decomposition products

Hazardous decomposition products:
No hazardous decomposition products if stored and handled as prescribed/indicated.

11. Toxicological Information

Information on toxicological effects

Acute toxicity

Experimental/calculated data:
LD50 rat (oral): > 5.000 mg/kg (OECD Guideline 401)

Irritation

Experimental/calculated data:
Skin corrosion/irritation rabbit: non-irritant (OECD Guideline 404)

Serious eye damage/irritation rabbit: non-irritant

Respiratory/Skin sensitization

Assessment of sensitization:
Based on the ingredients, there is no suspicion of a skin-sensitizing potential.

Germ cell mutagenicity

Assessment of mutagenicity:
Based on the ingredients, there is no suspicion of a mutagenic effect.

Carcinogenicity

Assessment of carcinogenicity:
The whole of the information assessable provides no indication of a carcinogenic effect.

Reproductive toxicity

Assessment of reproduction toxicity:
Based on the ingredients, there is no suspicion of a toxic effect on reproduction.

Developmental toxicity

Assessment of teratogenicity:
Based on the ingredients, there is no suspicion of a teratogenic effect.

Repeated dose toxicity and Specific target organ toxicity (repeated exposure)

Assessment of repeated dose toxicity:
Based on our experience and the information available, no adverse health effects are expected if handled as recommended with suitable precautions for designated uses. The product has not been tested. The statement has been derived from the properties of the individual components.

Aspiration hazard

No aspiration hazard expected.

Other relevant toxicity information

The product has not been tested. The statements on toxicology have been derived from products of a similar structure and composition.

12. Ecological Information

Toxicity

Toxicity to fish:
LC50 (96 h) > 100 mg/l, Oncorhynchus mykiss (static)
(under static conditions in the presence of 10 mg/L humic acid)

Aquatic invertebrates:
LC50 (48 h) > 100 mg/l, Daphnia magna

Persistence and degradability

Assessment biodegradation and elimination (H2O):
Not readily biodegradable (by OECD criteria).

Bioaccumulative potential

Assessment bioaccumulation potential:
Based on its structural properties, the polymer is not biologically available. Accumulation in organisms is not to be expected.

Mobility in soil

Information on: Anionic polyacrylamide
Assessment transport between environmental compartments: Adsorption in soil: Adsorption to solid soil phase is expected.

Results of PBT and vPvB assessment

According to Annex XIII of Regulation (EC) No.1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH): The product does not contain a substance fulfilling the PBT (persistent/bioaccumulative/toxic) criteria or the vPvB (very persistent/very bioaccumulative) criteria.

Other adverse effects

The product does not contain substances that are listed in Annex I of Regulation (EC) 2037/2000 on substances that deplete the ozone layer.

Additional information

Other ecotoxicological advice:
The product has not been tested. The statements on ecotoxicology have been derived from products of a similar structure and composition.

13. Disposal Considerations

Waste treatment methods

Must be disposed of or incinerated in accordance with local regulations.

Contaminated packaging:
Packs that cannot be cleaned should be disposed of in the same manner as the contents.
Uncontaminated packaging can be re-used.

14. Transport Information

Land transport

ADR

	Not classified as a dangerous good under transport regulations
UN number:	Not applicable
UN proper shipping name:	Not applicable
Transport hazard class(es):	Not applicable
Packing group:	Not applicable
Environmental hazards:	Not applicable
Special precautions for user	None known

RID

	Not classified as a dangerous good under transport regulations
UN number:	Not applicable
UN proper shipping name:	Not applicable
Transport hazard class(es):	Not applicable
Packing group:	Not applicable
Environmental hazards:	Not applicable
Special precautions for user	None known

Inland waterway transport

ADN

Not classified as a dangerous good under transport regulations

UN number: Not applicable

UN proper shipping name: Not applicable
Transport hazard class(es): Not applicable
Packing group: Not applicable
Environmental hazards: Not applicable

Special precautions for user: None known

Transport in inland waterway vessel
Not evaluated

Sea transport

IMDG

Not classified as a dangerous good under transport regulations
UN number: Not applicable
UN proper shipping name: Not applicable
Transport hazard class(es): Not applicable
Packing group: Not applicable
Environmental hazards: Not applicable
Special precautions for user: None known

Air transport

IATA/ICAO

Not classified as a dangerous good under transport regulations
UN number: Not applicable
UN proper shipping name: Not applicable
Transport hazard class(es): Not applicable
Packing group: Not applicable
Environmental hazards: Not applicable
Special precautions for user: None known

UN number

See corresponding entries for “UN number” for the respective regulations in the tables above.

UN proper shipping name

See corresponding entries for “UN proper shipping name” for the respective regulations in the tables above.

Transport hazard class(es)

See corresponding entries for “Transport hazard class(es)” for the respective regulations in the tables above.

Packing group

See corresponding entries for “Packing group” for the respective regulations in the tables above.

Environmental hazards

See corresponding entries for “Environmental hazards” for the respective regulations in the tables above.

Special precautions for user

See corresponding entries for “Special precautions for user” for the respective regulations in the tables above.

Transport in bulk according to Annex II of MARPOL and the IBC Code

Regulation:	Not evaluated
Shipment approved:	Not evaluated
Pollution name:	Not evaluated
Pollution category:	Not evaluated
Ship Type:	Not evaluated

15. Regulatory Information

Safety, health and environmental regulations/legislation specific for the substance or mixture

Not applicable

16. Other Information

Assessment of the hazard classes according to UN GHS criteria (most recent version)

The data contained in this safety data sheet are based on our current knowledge and experience and describe the product only with regard to safety requirements. This safety data sheet is neither a Certificate of Analysis (CoA) nor technical data sheet and shall not be mistaken for a specification agreement. Identified uses in this safety data sheet do neither represent an agreement on the corresponding contractual quality of the substance/mixture nor a contractually designated use. It is the responsibility of the recipient of the product to ensure any proprietary rights and existing laws and legislation are observed.

Vertical lines in the left hand margin indicate an amendment from the previous version.

SAFETY DATA SHEET

PRODUCT

OPTIMER® 83384

EMERGENCY TELEPHONE NUMBER(S)
1800 205 506

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME :	**OPTIMER® 83384**
APPLICATION :	ANIONIC FLOCCULANT
COMPANY IDENTIFICATION :	Nalco Australia Pty Ltd 2 Anderson Street Botany N.S.W. 2019 Australia A.B.N. 41 000 424 788 TEL: +61 2 9316 3000 FAX: +61 2 9666 5292
EMERGENCY TELEPHONE NUMBER(S) :	1800 205 506
Date issued :	11.06.2009
Version Number :	1.3

2. HAZARDS IDENTIFICATION

HAZARD CLASSIFICATION :

Not classified as hazardous according to the Australian Safety & Compensation Council (ASCC). This product is not classified as a dangerous good according to national or international regulations.

SAFETY PHRASES
S22 - Do not breathe dust.
S24/25 - Avoid contact with skin and eyes.
S37/39 - Wear suitable gloves and eye/face protection.

3. COMPOSITION/INFORMATION ON INGREDIENTS

CHEMICAL NAME	CAS NO	% (w/w)
Ingredients determined not to be hazardous		100

4. FIRST AID MEASURES

EYE CONTACT :
Brush off excess powder. Immediately flush eye with water for at least 15 minutes while holding eyelids open. If symptoms develop, seek medical advice.

SKIN CONTACT :
Brush off excess powder. Remove contaminated clothing. Wash off affected area immediately with plenty of water. If symptoms develop, seek medical advice.

INGESTION :
Get medical attention. Do not induce vomiting without medical advice. If conscious, washout mouth and give water to drink. If reflexive vomiting occurs, rinse mouth and repeat administration of water.

INHALATION :
Remove to fresh air, treat symptomatically. If symptoms develop, seek medical advice.

NOTE TO PHYSICIAN :
Based on the individual reactions of the patient, the physician's judgement should be used to control symptoms and clinical condition.

5. FIRE FIGHTING MEASURES

FLASH POINT : Not flammable

EXTINGUISHING MEDIA :
Foam, Carbon dioxide, Dry powder, Other extinguishing agent suitable for Class B fires, For large fires, use water spray or fog, thoroughly drenching the burning material.

Water mist may be used to cool closed containers.

UNSUITABLE EXTINGUISHING MEDIA :
Do not use water unless flooding amounts are available.

FIRE AND EXPLOSION HAZARD :
May evolve oxides of carbon (COx) under fire conditions. May evolve oxides of nitrogen (NOx) under fire conditions. May evolve ammonia under fire conditions. May form explosive dust-air mixtures. Handling operations may generate combustible dust in the finely divided and suspended state. To reduce the potential for dust explosions and/or fire, do not permit dust to accumulate. Empty product containers may contain product residue. Do not pressurize, cut, heat, weld, or expose containers to flame or other sources of ignition.

SPECIAL PROTECTIVE EQUIPMENT FOR FIRE FIGHTING :
In case of fire, wear a full face positive-pressure self contained breathing apparatus and protective suit.

SENSITIVITY TO STATIC DISCHARGE :
Dusts in sufficient concentration may be ignitable by static discharge.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS :
Restrict access to area as appropriate until clean-up operations are complete. Use personal protective equipment recommended in Section 8 (Exposure Controls/Personal Protection). Stop or reduce any leaks if it is safe to do so. Ventilate spill area if possible. Remove sources of ignition.

METHODS FOR CLEANING UP :
Remove as much as possible with broom, scoop or vacuum, as the addition of water causes slippery floor conditions. Reclaim into recovery or salvage drums. Clean contaminated surfaces with water or aqueous cleaning agents. Contact an approved waste hauler for disposal of contaminated recovered material. Dispose of material in compliance with regulations indicated in Section 13 (Disposal Considerations).

ENVIRONMENTAL PRECAUTIONS :
This product is toxic to fish. It should not be directly discharged into lakes, ponds, streams, waterways or public water supplies.

7. HANDLING AND STORAGE

HANDLING :
Do not take internally. Ensure all containers are labeled. Avoid eye and skin contact. Avoid generating dusts. Empty product containers may contain product residue. Do not pressurize, cut, heat, weld, or expose containers to flame or other sources of ignition. Do not use, store, spill or pour near heat, sparks or open flame.

STORAGE CONDITIONS :
Store separately from oxidizers. Keep in dry place. Store away from heat and sources of ignition. Connections must be grounded to avoid electrical charges.

SUITABLE CONSTRUCTION MATERIAL :
Compatibility with Plastic Materials can vary; we therefore recommend that compatibility is tested prior to use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS
The following component(s) have been assigned an exposure standard by ASCC (Australia) and/or other Agencies:

Country/Source	Substance(s)	Category:	ppm	mg/m3
	Inhalable (Total Dust) Nuisance Particulates (Inhalable particles.)	ACGIH/TWA		10
	Inhalable (Total Dust) Nuisance Particulates (Respirable particles.)	ACGIH/TWA		3
	Inhalable (Total Dust) Nuisance Particulates (Respirable fraction.)	OSHA Z1/PEL		5
	Inhalable (Total Dust) Nuisance Particulates (Total dust.)	OSHA Z1/PEL		15
	Inhalable (Total Dust) Nuisance Particulates (Respirable fraction.)	Z3/TWA		
	Inhalable (Total Dust) Nuisance Particulates (Total dust.)	Z3/TWA		
	Inhalable (Total Dust) Nuisance Particulates (Respirable fraction.)	Z3/TWA		5
	Inhalable (Total Dust) Nuisance Particulates (Total dust.)	Z3/TWA		15
	Respirable Nuisance Particulates (Inhalable particles.)	ACGIH/TWA		10
	Respirable Nuisance Particulates (Respirable particles.)	ACGIH/TWA		3
	Respirable Nuisance Particulates (Respirable fraction.)	OSHA Z1/PEL		5
	Respirable Nuisance Particulates (Total dust.)	OSHA Z1/PEL		15
	Respirable Nuisance Particulates (Respirable fraction.)	Z3/TWA		
	Respirable Nuisance Particulates (Total dust.)	Z3/TWA		
	Respirable Nuisance Particulates (Respirable fraction.)	Z3/TWA		5
	Respirable Nuisance Particulates (Total dust.)	Z3/TWA		15

* A skin notation refers to the potential significant contribution to overall exposure by the cutaneous route, including mucous membranes and the eyes.

ENGINEERING MEASURES :
General ventilation is recommended. Local exhaust ventilation may be necessary when dusts or mists are generated.

PERSONAL PROTECTION

GENERAL ADVICE :
The use and choice of personal protection equipment is related to the hazard of the product, the workplace and the way the product is handled. In general, we recommend as a minimum precaution

that safety glasses with

side-shields and workclothes protecting arms, legs and body be used. In addition any person visiting an area where this product is handled should at least wear safety glasses with side-shields.

RESPIRATORY PROTECTION :
Respiratory protection is not normally needed. If significant mists, vapours or aerosols are generated an approved respirator is recommended, selected and used in accordance with AS/NZS 1715 and AS/NZS 1716. A dust, mist, fume cartridge may be used. If respiratory protection is required, institute a complete respiratory protection program including selection, fit testing, training, maintenance and inspection.

HAND PROTECTION :
Nitrile gloves PVC gloves Neoprene gloves Rubber gloves Butyl gloves Cloth gloves

SKIN PROTECTION :
Wear standard protective clothing.

EYE PROTECTION :
Wear safety glasses with side-shields.

HYGIENE RECOMMENDATIONS :
Use good work and personal hygiene practices to avoid exposure. Consider the provision in the work area of a safety shower and eyewash. Always wash thoroughly after handling chemicals. When handling this product never eat, drink or smoke.

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE	Powder
APPEARANCE	White
ODOR	Slight
pH (1 %)	5.5 - 7.5
VAPOR PRESSURE	No data available.
VAPOR DENSITY	No data available.
SPECIFIC GRAVITY	No data available.
DENSITY	No data available.
BULK DENSITY	0.7262 kg/m3
SOLUBILITY IN WATER	Complete
MELTING POINT	No data available.
BOILING POINT	No data available.
FLASH POINT	Not flammable
LOWER EXPLOSION LIMIT	No data available.
UPPER EXPLOSION LIMIT	No data available.
AUTOIGNITION TEMPERATURE	No data available.

Note: These physical properties are typical values for this product and are subject to change.

10. STABILITY AND REACTIVITY

STABILITY :
Stable under normal conditions.

CONDITIONS TO AVOID :
Moisture Heat and sources of ignition including static discharges. Avoid generating dusts.

INCOMPATIBLE MATERIALS :
Contact with strong oxidizers (e.g. chlorine, peroxides, chromates, nitric acid, perchlorate, concentrated oxygen, permanganate) may generate heat, fires, explosions and/or toxic vapors.

HAZARDOUS DECOMPOSITION PRODUCTS :
Under fire conditions: Oxides of carbon, Oxides of nitrogen
ammonia

HAZARDOUS REACTIONS :
Hazardous polymerization will not occur.

11. TOXICOLOGICAL INFORMATION

OVERVIEW OF HEALTH HAZARDS

ACUTE HAZARDS - EYE CONTACT
May cause irritation with prolonged contact.

ACUTE HAZARDS - SKIN CONTACT
May cause irritation with prolonged contact.

ACUTE HAZARDS - INGESTION

Not a likely route of exposure. No adverse effects expected.

ACUTE HAZARDS - INHALATION
Repeated or prolonged exposure may irritate the respiratory tract.

CHRONIC HAZARDS :

No adverse effects expected other than those mentioned above.

SUMMARY OF TOXICITY INFORMATION

ACUTE TOXICITY DATA :
The following results are for the product.

ACUTE ORAL TOXICITY :
Species: Rat

LD50: > 2,000 mg/kg

Test Descriptor: Product

PRIMARY SKIN IRRITATION :
Species: Rabbit

Draize Score: /8.0 Test Descriptor:

Result: Essentially non-irritating

Remarks: Not irritating

PRIMARY EYE IRRITATION :
Remarks: Not irritating

SENSITIZATION :
This product is not expected to be a sensitizer.

CARCINOGENICITY :
None of the substances in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) or the American Conference of Governmental Industrial Hygienists (ACGIH).

For additional information on the hazard of the preparation, please consult section 2 and 12. HUMAN HAZARD CHARACTERIZATION
Based on our hazard characterization, the potential human hazard is: Low

12. ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL EFFECTS :

The following results are for the product.

ACUTE FISH RESULTS :

Species	Exposure	LC50	Test Descriptor
Zebra Danio	96 hrs	> 318 mg/l	Product

ACUTE INVERTEBRATE RESULTS :

Species	Exposure	LC50	EC50	Test Descriptor
Daphnia magna	48 hrs		> 212 mg/l	Product
Ceriodaphnia dubia	48 hrs	369 mg/l		

AQUATIC PLANT RESULTS :

Species	Exposure	EC50/LC50	NOEC	Test Descriptor

Green Algae (Chlorella vulgaris)	72 hrs	> 1,000 mg/l (EC50)		

AQUATIC MICROORGANISM RESULTS :

Species	Exposure	EC50/LC50	Test Descriptor
Pseudomonas putida	18 hrs	> 400 mg/l (EC50)	

CHRONIC INVERTEBRATE RESULTS :

Species	Test Type	EC25 / IC25	End Point	Test Descriptor
Ceriodaphnia dubia		2.4 mg/l		Product

MOBILITY AND BIOACCUMULATION POTENTIAL :

The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM, provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models.

If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air	Water	Soil/Sediment
<5%	5 - 10%	70 - 90%

The portion in water is expected to be soluble or dispersible.

This preparation or material is not expected to bioaccumulate.

PERSISTENCY AND DEGRADATION :

Chemical Oxygen Demand (COD) : 257,000 mg/l

The organic portion of this preparation is expected to be poorly biodegradable.

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION
Based on our hazard characterization, the potential environmental hazard is: Moderate

13. DISPOSAL CONSIDERATIONS

Dispose of wastes in an approved incinerator or waste treatment/disposal site, in accordance with all applicable regulations. Do not dispose of wastes in local sewer or with normal garbage.

SPECIAL PRECAUTIONS FOR LANDFILL OR INCINERATION :

No additional special precautions have been identified.

14. TRANSPORT INFORMATION

The information in this section is for reference only and should not take the place of a shipping paper (bill of lading) specific to an order. Please note that the proper Shipping Name / Hazard Class may vary by packaging, properties, and mode of transportation. Typical Proper Shipping Names for this product are as follows.

LAND TRANSPORT
Proper Shipping Name : PRODUCT IS NOT REGULATED DURING

TRANSPORTATION

AIR TRANSPORT (ICAO/IATA)
Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

MARINE TRANSPORT (IMDG/IMO)
Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

15. REGULATORY INFORMATION

AUSTRALIA :

NICNAS
All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

SUSDP SCHEDULE : Not Listed

INTERNATIONAL CHEMICAL CONTROL LAWS

UNITED STATES :
The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

CANADA :
The substance(s) in this preparation are included in or exempted from the Domestic Substance List (DSL).

EUROPE
The substance(s) in this preparation are included in or exempted from the EINECS or ELINCS inventories

JAPAN
All substances in this product comply with the Law Regulating the Manufacture and Importation Of Chemical Substances and are listed on the Existing and New Chemical Substances list (ENCS).

CHINA
All substances in this product comply with the Provisions on the Environmental Administration of New Chemical Substances and are listed on the Inventory of Existing Chemical Substances China (IECSC).

KOREA
All substances in this product comply with the Toxic Chemical Control Law (TCCL) and are listed on the Existing Chemicals List (ECL)

NEW ZEALAND
All substances in this product comply with the Hazardous Substances and New Organisms (HSNO) Act 1996,and are listed on or are exempt from the New Zealand Inventory of Chemicals.

PHILIPPINES
All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

16. OTHER INFORMATION

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the

recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

REFERENCES

Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, OH., (Ariel Insight CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPS CD-ROM Version), Micromedex, Inc., Englewood, CO.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPS CD-ROM Version), Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Title 29 Code of Federal Regulations, Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA), (Ariel Insight CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH, (TOMES CPS CD-ROM Version), Micromedex, Inc., Englewood, CO.

Ariel Insight (An integrated guide to industrial chemicals covered under major regulatory and advisory programs), North American Module, Western European Module, Chemical Inventories Module and the Generics Module (Ariel Insight CD-ROM Version), Ariel Research Corp., Bethesda, MD.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPS CD-ROM Version), Micromedex, Inc., Englewood, CO.

REVISED INFORMATION: Significant changes to regulatory or health information for this revision is indicated by a bar in the left-hand margin of the SDS.

Prepared By: Nalco Asia Pacific, Safety, Health and Environment (SHE) Specialist, (02) 9316 3162

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

MEMORANDUM

To Kalbar Operations Pty Ltd
From Tony McAlister, Water Technology
Date 12 March 2021
Subject Response to IAC question C6

1 BACKGROUND

This memorandum was prepared in response to IAC Question C6 concerning 'Information on the likely impacts on waterways and streams from the introduction of flocculants into the Project area'.

In relation to the above query, I note that Kalbar has confirmed the following in late January 2021:

- The flocculant anionic polyacrylamide (referred to as PAM) will be used for the project in:
  - The dissolved air flotation (DAF) plant;
  - The thickener; and
  - Centrifuges.
- In addition to the PAM, PAC (poly-alumina chloride) will be used as a coagulant in the DAF units only.

My initial responses to the above matters were provided in my Expert Witness Statement (February 2021) and my Supplementary Expert Witness Statement (February 2021). These are summarised below.

1.1 Use of flocculants

Following the above confirmation from Kalbar, I briefly discussed flocculants in my Expert Witness Statement (February 2021) and noted that further investigations are required to understand potential water quality impacts. In my Expert Witness Statement, I noted the concerns raised with flocculant products potentially being used in association with site operations. I also acknowledged the importance of being careful in selecting flocculants. In my statement, I provided the following commentary in regard to this matter:

- The comment that I provided regarding the use of flocculants within site operations to enhance operation and performance of the water management operations relates to the fact that this may change the pH of waters being managed and/or introduce other sources or compounds of potential concern into these waters (e.g., dissolved aluminium), depending upon the flocculant used. Further investigations by the proponent to clarify and address these matters to my satisfaction were recommended.
- With advice having been provided to me by other consultants working on the Fingerboards project while I was preparing my witness statement, I noted further that *'The type of flocculant used is an anionic polyacrylamide which is commonly referred to as PAM'.*

I made the following observations to help understand potential impacts on the environment. These are as follows:

- The bulk of the PAM will adhere to solids particles and will follow the particles. This is important as very little flocculant will remain in the water.

- Ultraviolet light degrades PAM to base compounds, and eventually, it degrades to non-detectable concentrations by forming nitrogen, ammonia, carbon dioxide and water.
- The entrainment of any flocculant in process water that is used for dust suppression will be extremely low, but more importantly, any flocculant that is present in dust suppression water will break down completely.
- The flocculant plant itself will be bunded to ensure that any spillages are contained specifically to avoid the environmental release of a higher concentration of PAM solution.
- Flocculant that is retained in the process water is locked into a recycle circuit. Some process water is present in the final products and by-products, but the bulk is recovered. High concentrations of flocculant in process water are counterproductive as they interfere with the process and result in financial losses that are both unwanted. For this reason, flocculant use is minimised to levels that will allow the process to work.
- PAM is commonly used in the agriculture, domestic wastewater treatment and mining industry. In agriculture, it is sprayed explicitly on the ground to counter erosion and to reduce sediment in catchments due to water runoff.
- Several studies have been performed in recent years to investigate the impact of PAM on the environment (land and waterways) – see below.
  - Polyacrylamide degradation and its implications in environmental systems - https://www.nature.com/articles/s41545-018-0016
  - Overview of the Effects of Residual Flocculants on Aquatic Receiving Environments - http://www.aucklandcity.govt.nz/council/documents/technicalpublications/TP226%20Overview%20o f%20the%20effects%20of%20residual%20flocculants%20on%20aquatic%20receiving%20environments.pdf
  - Polyacrylamides in Irrigated Agriculture https://www.five-elements.com.au/resources/Polyacrylamide%20in%20Irrigated%20Agriculture.pdf

1.2 Inclusion of Centrifuges

Since preparation of the EES, Kalbar has decided to include centrifuges as a component of their project operations. I was provided with a technical note dated 18/1/2021 detailing the rationale behind, and method of, implementation of centrifuges for water recovery and tailings management. I indicated that I am supportive of the decision to include centrifuges from the perspective of reducing any potential for water quality impacts on the Mitchell and Perry Rivers and Gippsland Lakes associated with the project. The following is a summary of excerpts from my Supplementary Expert Witness Statement.

My comments/justifications in support of incorporating centrifuges are outlined below:

- With the adoption of the centrifuges, there will no longer be a need for fine tailings storage facilities. This will significantly reduce the overall degree of site works at any one time associated with the project.
- Mine site operation with the adoption of centrifuges will see the mine voids effectively continuously backfilled, meaning that the disturbed mining area at any one time will be far smaller, and rehabilitation works can occur much sooner after mining works are completed in any particular portion of the site.
- The residual water/centrate resulting from the operation of the centrifuge will be able to be readily redirected for use elsewhere within site operations.
- With the smaller site disturbance footprint and the highly controlled nature and quality of the centrate, the overall water quality management regime within the site will be easier to control, test and operate; and
- Any potential 'secondary' local or regional water resource or water quality impacts associated with changes to the local groundwater regime will also reduce significantly as there will be far less potential

interaction between the water that would have been present within the fine tailings storage facilities for months at a time and the local groundwater table.

The only comment or caveat that I placed in regard to the above opinion relates to the use of additional flocculant within site operations to enhance operation and performance of the centrifuges. I indicated that the use of additional flocculant may change the pH of the centrate and/or introduce other sources or compounds of potential concern into the centrate (e.g., dissolved aluminium), depending upon the flocculant used. These concerns were highlighted as they were, with careful consideration (see more discussion on this below), readily manageable, especially so given the localised and controlled manner by which the centrate will be produced. Further investigations by the proponent to clarify and address these matters to my satisfaction were recommended. Commentary in regard to the general use of flocculants on site were provided in my earlier Expert Witness Statement (summarised in Section 1.1).

To provide further context in regard to the use of flocculants on the site, I noted the following:

- An adaptive/automatic management strategy can be implemented within the Kalbar site operations in the unlikely event that the regular site water quality monitoring works that are proposed detect unacceptable pH levels in site waters. This could, for example, include the addition of real time inline pH measurements on the centrate stream from the centrifuge plant. This would then ensure that the pH is corrected with the addition of lime, if and when such an event occurs. Such systems are automatic and do not require direct human monitoring to detect pH variances and are widely used in applications of this nature worldwide.
- Flocculants are widely used all around the world for water and wastewater treatment, sediment and erosion control and a range of other applications. They are not 'new' and there is significant knowledge and expertise available to ensure that they are applied in a safe, logical and appropriate manner.

2 REVIEW

Subsequent to the above, I have been asked to provide further advice to address the IAC Question C6. The following documents were provided to me in late February/early March 2021 in regard to this matter:

- Revised water balance following inclusion of the centrifuges (Jarrah Muller's supplementary witness statement);
- MSD information for the likely flocculant candidates (BASF); and
- Quantities of flocculant that will be used and information about how they will be managed (provided by Stefan Wolmarans, Wave International).

I have reviewed the above documents, together with relevant literature associated with the use of PAM in the project site. The following sections aim to provide an assessment of my findings to better inform potential impacts on waterways and streams from the introduction of flocculants into the project.

2.1 Literature review

2.1.1 ANZG (2018) guidelines

According to the ANZG 2018 guidelines for water quality in aquatic ecosystems, several groups of polymers are polyacrylamides, which can be classed as polyelectrolyte flocculants, otherwise called organic polymeric flocculants (OPFs). ANZG 2018 guidelines (the guidelines) recognise that there are several uses for OPFs such as:

- Providing a cost-effective means to improve the recovery of mineral ores and remove suspended material from wastewater; and

- Wastewater treatment at levels between 10 and 100 mg/L and for sludge conditioning at much higher levels.

I note that that despite the long-term (~30 years) use of OPFs, there is little public and peer-reviewed data on the toxicity of OPFs. The guidelines also identify the fact that one of the major difficulties in controlling flocculant releases in waterways is that it is difficult to analyse for flocculant levels in water. Therefore, there is insufficient data to develop guideline trigger values for OPFs, particularly given the range of polymer types.

The guidelines do note that there have been reports of unreacted polyelectrolyte flocculants causing fish kills in treated mining effluent in NSW. However, it is important to understand that the guidelines only provide a generalised reference of polyacrylamides under OPFs, which does not take into consideration the specific nature of anionic polyacrylamide. Toxicity varies with charge type and flocculant chemistry, and in general, cationic (not anionic) flocculants have been found to be most toxic to fish, but this varies for crustaceans. The guidelines also reference outcomes of a study by Lamberton[1] (1995) (not peer-reviewed, therefore cannot be used to derive guidelines) which showed acute effects to select fish species occurring mainly from cationic OPFs.

I have identified relevant peer-reviewed studies specific to anionic polyacrylamide in relation to aquatic toxicity which are presented in Section 2.1.2.

2.1.2 Impacts on aquatic species

Anionic polyacrylamide (PAM) is commonly added to agricultural irrigation water to substantially reduce soil erosion. A study funded by the California State Water Resources Control Board (Weston et al., 2009[2]) evaluated five PAM formulations, including two oil-based products, one water-based product, one granular product and one tablet product, for acute and/or chronic toxicity to five aquatic species commonly used for freshwater toxicity testing. The PAM concentrations used for erosion control are typically in the range of 1 to 10 mg/L. When applied as an oil-based product, acute toxicity at concentrations less than the 10 mg/L was seen in four of the five species. Diminished toxicity remained after passage of the irrigation water across an agricultural field, indicating a potential impact to nearby surface waters. However, results from the non-oil-based products indicated minimal toxicity associated with PAM, even at concentrations 10 times those used in agriculture when applied in the granular form, as a tablet, or in a water-based liquid. The study suggested that other agents in the oil-based products, such as surfactants or emulsifiers, rather than the PAM itself, contributed to the toxicity.

Therefore, strictly from the standpoint of aquatic toxicity, the use of the solid form and water-based PAM products is preferable to oil-based products. The latter show evidence of acute and chronic toxicity to aquatic life at environmentally realistic concentrations due to non-PAM ingredients in their formulation, and passage of the water across a site reduces, but does not eliminate, toxicity.

The use of solid and water-based forms of PAM appear to provide the environmental quality benefits such as reduced sediment transport to surface waters and reduced offsite movement of nutrients, pesticides, and microorganisms, with minimal toxicity concerns associated with use of the products themselves. Studies by Entry et al. (2002)[3] showed that water-soluble anionic polyacrylamide (PAM) was a highly effective erosion-preventing and infiltration-enhancing polymer. Water flowing from PAM treated irrigation troughs also showed

[1] Lamberton, C. J., (1995). Acute toxicity and management of polyelectrolyte flocculants in Australian aquatic ecosystems. University of Technology, Sydney.
[2] Weston, D. P. et al., (2009), Toxicity of anionic polyacrylamide formulations when used for erosion control in agriculture. Journal of Environmental Quality 38.1 (2009): 238-247.
[3] Entry, J. A., et. al., (2002). Polyacrylamide preparations for protection of water quality threatened by agricultural runoff contaminants. Environmental Pollution, 120(2), 191-200.

large reductions in sediment, nutrients and pesticides, thus showing great potential as an effective wastewater treatment.

Based on the above, careful consideration is recommended in selecting an appropriate PAM formulation when the potential exists for entry of tailwater to nearby surface waters.

2.1.3 Material Safety Data Sheet (MSDS) information

MSDS for two flocculant candidates were provided to me.

Option1: Below is the MSDS for Magnafloc ® 2025 (Supplier BASF SE, Germany). Based on the information provided in the MSDS, the following should be considered with respect to ecological impacts:

- Ingredients: Polyacrylamide, anionic.
- Toxicity to fish: LC50[4] (exposure 96 h) > 100 mg/L, Oncorhynchus mykiss[5] (static) (under static conditions in the presence of 10 mg/L humic acid).
- Aquatic invertebrates: LC50 (exposure 48 h) > 100 mg/L, Daphnia magna[6].
- Persistence and degradability: Not readily biodegradable (by OECD criteria).
- Bio-accumulative potential: Based on its structural properties, the polymer is not biologically available.
  Accumulation in organisms is not expected.
- Mobility in soil: Adsorption to solid soil phase is expected.

Option 2: Below is the MSDS for Optimer® 83384, another anionic PAM, which is a very similar product to the Magnafloc® 2025. Based on the information provided in the MSDS, the following should be considered with respect to ecological impacts:

- Ingredients: Not Listed.
- Toxicity to fish: LC50 (exposure 96 h) > 318 mg/L, Zebra Danio[7].
- Aquatic invertebrates: EC50[8] (exposure 48 h) > 369 mg/L, Daphnia magna; LC50 (exposure 48 h) > 212 mg/l, Ceriodaphnia dubia.
- Persistence and degradability: The organic portion of this preparation is expected to be poorly biodegradable.
- Bio-accumulative potential and mobility: If released into the environment this material is expected to distribute to the air (<5%), water (5 – 10%) and soil/sediment (70 – 90%). The portion in water is expected to be soluble or dispersible. This preparation or material is not expected to bioaccumulate.
- Environmental hazard and exposure characterisation: The potential environmental hazard is listed as moderate.

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[4] LC stands for 'Lethal Concentration', which is the concentration of the chemical in air/water that kills 50% of the test animals during the observation period.
[5] Scientific name for Rainbow Trout fish species
[6] Scientific name for small plankton like crustaceans throughout the northern hemisphere
[7] Scientific name for a freshwater fish species
[8] In ecotoxicity, EC50 (median effective concentration) is the concentration of test substance which results in a 50 percent reduction in either algae growth or algae growth rate or Daphina immobilization

2.2 Proposed usage and management

Flocculant is planned to be used at 370 g/tonne of dry solids reporting to the centrifuge. This translates to a nominal (average or usual) dose rate of ~118 kg of flocculant every hour as the centrifuge units nominally receive ~321 tph (tonnes per hour) of solids. There are two options proposed for flocculant delivery, as follows:

Option 1: The flocculant powder is delivered by container truck. The powder is pneumatically transferred to a silo which will house dry flocculant powder and provide an ongoing supply for at least one month. Flocculant loading into the flocculant plant would occur as follows:

- The flocculant powder silo is designed to dehumidify contents. An exciter is used to extract the powder from the silo into a small, heated hopper.
- Air blowers would then convey the powder pneumatically through pipes to a wetting head.
- The entire plant will be enclosed to avoid losses of flocculant powder.
- The dry flocculant powder is mixed with high-pressure spray water at the wetting head, and the mixture is retained in a stirred tank.
- After the flocculant has been wetted, it is transferred to an adjacent tank awaiting dosing to the centrifuge units.

Option 2: Approximately five bags of flocculant would be kept in the shed near the flocculant plant. This is sufficient to maintain operations for ten days before refilling the stock. Flocculant loading into the flocculant plant would occur as follows:

- A fresh bag of flocculant powder would be collected from the shed with a forklift.
- The forklift would then place the bag into the bag load bay of the flocculant plant. From here, the flocculant is managed through an automated system that extracts flocculant powder into a small hopper and uses air blowers to convey the powder through pipes to a wetting head pneumatically.
- The entire plant would be enclosed to avoid losses of flocculant powder.
- The dry flocculant powder is mixed with high-pressure spray water at the wetting head, and the mixture is retained in a stirred tank.
- After the flocculant has been wetted, it is transferred to an adjacent tank awaiting dosing to the centrifuge units.

The entire flocculant plant will be housed inside a concrete sump with ~500mm high bund walls to capture any spillage. The sump will be designed to accommodate the whole volume of flocculant in the unlikely event of a tank rupture. The sump will also be equipped with sump pumps which will reclaim any spilled flocculant.

Standard industry spill measures are also available. Typically, flocculant is mixed with sand and allowed to dry out. The dry flocculant and sand mixture is then separated onto a small stockpile on a concrete bund. It can be slowly added to the centrifuges or allowed to degrade to ammonia, carbon dioxide and water until only the sand remains.

3 CONCLUSIONS

When I have further reviewed all of the information presented above, and that contained in my earlier advices, I remain of the opinion that there are no notable water quality and environmental risks to waterways and streams within or adjacent to the site associated with the introduction of flocculants to the project area.

My rationale for this opinion is as follows:

- Literature values and data show that the flocculants proposed to be used, and importantly the concentrations at which they will be used, are not likely to be of concern if applied in an appropriate and controlled manner (as will be the case). The flocculants that will be applied will be granular in nature, and not oil based (hence the findings of Weston et al., 2009 regarding toxicity impacts of oil based flocculants are not of concern);
- The flocculant materials and techniques proposed to be used are widely applied in various roles and facilities in Australia, and worldwide, with no adverse environmental impacts;
- The way in which the flocculants will be applied will be carefully controlled, with numerous barriers in place to ensure that any accidental spills or releases of flocculant (which in such highly concentrated situations could be of concern) will not occur, and if they do occur, can be adequately captured and managed;
- Flocculants will be primarily retained within/by the solid fractions passing through the centrifuges (noting that this is their **primary** purpose - that being to bring these solid fractions and particles together such that they are more efficiently captured by the centrifuge process) and little of this material will remain within the liquid component of the material passing through the centrifuge. These solid fractions will subsequently remain on-site, as the operation proceeds;
- Water use within the site will be carefully controlled and managed with excess water from the centrifuges (i.e., the centrate) being recycled through the process many times. Hence, any residual flocculant that may be present in such waters will, by necessity, have multiple opportunities to attach itself to the solid fractions passing through the centrifuges before at some stage leaving the operation; and
- All site operations will be overseen by rigorous internal and external water quality and environmental monitoring programs. These programs will ensure that if, for an unknown or unforeseen reason, any component of site operations (including the application of flocculants within the centrifuge system or elsewhere on site) is causing some change to the quality of surface or ground water within the site, that appropriate and immediate corrective actions can occur. It is recommended that these monitoring programs include appropriate automatic or real-time controls and triggers such that any unforeseen circumstances are identified and corrected at the earliest opportunity.