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Mr David Accadia

Golder Associates
P.O. Box 6079
Hawthorn West, Vic., 3122

Dear David

Re: Independent Review of the Rasp Mine Blackwood Pit Tailings Storage Facility Extension

At the request of Golder Associates, Bruce Brown Consulting was asked to carry out an independent technical review of the proposed Rasp Mine Blackwood Pit Tailings Storage Facility Extension. The documents provided for the review are as follows:

- Design Memorandum, Rasp Mine – Blackwood Pit TSF Raise Design – Tailings Deposition Strategy and Water Management Design.
- Design Memorandum, Rasp Mine – Embankment Slope Stability for the Blackwood Pit Tailings Storage Facility Extension.
- Blackwood Pit Tailings Storage Facility, Rasp Mine, Broken Hill, Preliminary Drawings Numbered 1 – 15 inclusive.

The extension of the Blackwood Pit TSF will be carried out by the construction of three perimeter embankments to provide adequate tailings storage to July 2022. This will be carried out in two stages, with the first stage being the construction of the northeast embankment Number 2 and the subsequent stage being the construction of embankments 1 and 3 on the north and south sides.

The embankment sections comprise compacted rockfill with a geomembrane liner placed on a sand bedding layer. An upstream toe drain is located below the liner to collect any leakage and discharge it to local drainages or the seepage collection pond.

Tailings are deposited from the southwest end of the pit. The tailings beach slopes to the northeast end of the pit at a slope of 1.5% where a supernatant/storm water pond forms. When there is water in the pond, a pump station will recycle the water for reuse in the processing

plant. Flood storage is provided for the 1 in 100 year AEP, 72 hour storm and spillways are provided to pass the peak flow from a critical PMP event.

Review comments on the preliminary design are as follows:

- The overall design presented by Golder is a robust, conservative design that meets the requirements of ANCOLD Guidelines on Tailings Dams, 2012".
- The design is backed by 4 years of operation of the facility that provides observational data for the design.
- The embankment slopes are 2.5H : 1V on the upstream and downstream faces. The upstream or inside slope may well be governed by the need to place the sand bedding layer and the geomembrane. The downstream or outside slope is very conservative from a stability perspective. With the assumed rockfill friction angle of 40^{o} the infinite slope, factor of safety is 2.1. The assumed rockfill friction angle is conservative for a good quality, compacted rockfill. Conservatively using Lepps "average" rockfill strength parameters (Lepps, ASCE Journal SM and F Journal, July, 1970) for the low confining pressures in the rockfill in the downstream shell zones, a friction angle of 47^{o} could safely be adopted. Using this, a downstream slope of 1.4H : 1V would result in an acceptable factor of safety of 1.5. With this slope design it may be possible to move the embankments outwards reducing the amount of construction of upstream toes over tailings. The flatter slope may be desirable for closure and rehabilitation.
- The stability of the upstream or inside slopes where the toe extends over tailings will likely be governed by the strength of the tailings especially if there is any potential for liquefaction of the tailings either due to seismic loading or, rapid loading causing static liquefaction. The strength of the tailings is assumed to be 35 kPa at the surface increasing by a nominal 0.3 kPa per metre with depth. It has been assumed that the tailings, with a dry density of 1.45 t/m^3, will not be liquefiable. Both of these assumptions need to be verified before finalizing the Stage 2 design.
- ANCOLD discourages the use of the pseudo-static method of determining seismic stability. The pseudo-static analysis should only be used to determine the yield peak ground acceleration for input into a screening simplified deformation analyses such as Newmark, Swaisgood, Pells and Fell, to determine the magnitude of the embankment deformation under seismic loading. If the deformations are acceptable then the potential for liquefaction needs to be assessed to determine the post earthquake flow slide stability. For the TSF, it is expected that the low embankments, comprising compacted rockfill, will not deform to any significant extent.
- It is noted that the rate of rise of the tailings deposit in the northeast end of the pit has been 70 metres in 4 years or approximately 18 metres per year. This is quite high and it is likely that the deposit in that area is under consolidated to some extent. It is noted that the rate of rise has reduced significantly as the pit has filled with the present rate of rise being 3.3 m/year. The Stage 1 - embankment 2 in this area is constructed entirely on bedrock so it does not rely on the strength of the tailings. The Stage 2 embankments 1 and 3 will be partially founded on tailings with lower rates of rise and should be fully consolidated. The strength assumptions for these tailings foundation will need to be confirmed prior to the final design of the Stage 2 embankments.

- The sand bedding layer for the geomembrane is quoted as being 1 metre thick in the memorandum but is shown as 500 mm thick on the drawings. I am informed that the drawings are correct with the true thickness of the bedding layer being 500mm.
- The consequence category for the TSF has been determined to be "High" (ANCOLD) and "Extreme" (NSW DSC). The category has been determined on the basis of a dam break analysis that determined that the population at risk is 60 with the potential loss of life being 54. The dam break analysis assumes that the tailings flowing from the dam will have a solids content of 51% by volume that is stated to be equivalent to the insitu deposit density of 1.45 t/m^3. The solids content by weight at this density is 74% solids. At this solids content, the rheology of the tailings would limit flow out of the dam to an almost negligible level. The main consideration for a dam break analysis would be if the failure were to occur after the design flood and the main release would be water and the tailings that would be consequently eroded. The dam break analysis appears to be very conservative. Having said this, the design criteria resulting from the high consequence category probably does not have a significant influence on the overall design and reducing the consequence category would not result in significant cost savings.
- The regulatory requirement for removal of floodwater from the facility is that it be removed in 7 days. The pump capacity given in the memorandum to achieve this is 248 l/s. This capacity would remove the estimated floodwater volume of 21.5 Ml in one day. A pump capacity of 38 l/s would achieve this in 7 days. It is understood that this will be amended in the report to the DSC. There is no indication as to where the floodwater would be pumped. If the water is to be pumped to natural drainages, has the water quality and regulatory requirements been considered.
- An emergency spillway is included in the design to pass the peak flow from the critical duration PMP event. It is understood that the spillway will be constructed for Stage 1 that will remain in place for Stage 2. It is unclear if the spillway sill elevation is appropriate for both stages. This will be confirmed in the final design report.
- The drain flows from the embankments discharge to natural drainages or a stormwater and seepage collection pond. There is no discussion regarding the water quality and regulatory limits on the release of water from the site. It is understood that this issue will be addressed in the report to DSC.

I trust this review meets your requirements and I would be pleased to discuss this with you, as you require.

Yours sincerely,

Bruce Brown PhD.

Director,

Bruce Brown Consulting Pty., Ltd.