Review of Water-Related Aspects of the Mt Todd Gold Project Draft Environmental Impact Statement

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1. Introduction

Scope of Assessment

The Northern Territory EPA requires the following:

1) a critical evaluation the adequacy of information included in the EIS (the draft EIS and the Supplement) for the Mount Todd Gold Project with respect to surface and groundwater risks associated with the proposed mine expansion and in the context of existing water management issues, including the adequacy of proposed management and mitigation options presented in the EIS; and
2) Assistance with the development of recommendations for inclusion in the final Assessment Report(the presentation of the findings of the assessment undertaken by the NT EPA) on the acceptability of predicted impacts, proposed management measures and proposed monitoring and mitigation programs outlined in the EIS.

The evaluation should focus specifically on the issues listed below.

- Whether all risks to surface and groundwater posed by activities related to the proposed expansion of the mine site, both at the site and in the receiving environment, have been identified.
- The effectiveness of proposed mitigation strategies in addressing these risks, with specific reference to the potential for long term water quality impacts on the final void and the potential for contamination of the Edith River.
- Whether the remediation strategies proposed for the various waste storages are consistent with current leading practices applicable to the climatic regime in the Mount Todd area.
- Whether the mitigation and remediation strategies proposed for the mine site meet with the following environmental objectives as set out in the EIS guidelines:
    - the receiving environment surface water quality will be protected both now and in the future, such that ecological health and land uses, and the health, welfare and amenity of people are maintained;
    - the proponent prevents, mitigates or manages acid and metalliferous drainage so that the off-site environment is not significantly impacted during mine operations; and
    - the proponent rehabilitates the site to achieve maximum, long-term protection of the environment from seepage of contaminants with minimal maintenance inputs, post-closure

Scope of Report

This report reviews the content of the draft EIS and provides comments and recommendations to address the requirements of the above scope. The second (and final) report will be produced following submission of the Supplement to the EIS by the proponent.

Reviewer's Focussing Statement

Mt Todd is a brownfields site with an existing substantial acid and metalliferous drainage (AMD) legacy management issue, with historical precedent for uncontrolled discharges of AMD (with associated fish kills) into the Edith River, a major tributary of the Daly River system. Geochemical characterisation indicates that waste to be produced over the life of the proposed expansion project will be very similar to that produced previously, with the final waste rock dump to contain over 30 times as much of this waste as is currently in place, and the two tailings storage facilities to contain an additional 160 Mt of potentially acid generating material. Very close attention will thus need to be paid to how this waste is proposed to be managed and contained during the operational life of the project, and most particularly as to how it is proposed to mitigate a potential long lived post decommissioning legacy.

The proponent's proposed risk management strategies for both operations and closure have been assessed against best practice principles. In this context the implications for ultimate closure, of construction methods used for mine waste storage and management facilities during operations, should be effectively addressed by the proponent from the start of the project and not deferred until later when the consequences may not be able to be effectively mitigated.

Key Areas of Project Risk

The Project, based on information in the EIS, is intended to have a life of around 19 years inclusive of construction, operations and closure. The key structural (or domain) elements of the proposed project which need to be addressed, in the context of both operational and post decommissioning/rehabilitation phases, from a water-related environmental risk perspective are listed below.

1. *Expansion and deepening of the existing Batman Pit from its current depth of 114m to approximately 588m and surface area of 40 hectares (ha) to approximately 137ha, with a flooded pit lake as the proposed closure condition.*
2. *Expansion of the existing waste rock dump (WRD) - from a height of 24m to approximately 350m (increase from 16 Mt to 510Mt of waste rock), and a footprint of 70ha to approximately 217ha.*
3. *Raisin of the existing tailings storage facility (TSF1) from 16m to approximately 34m to contain an additional 60Mt of tailings.*
4. *Construction of a new tailings storage facility (TSF2) approximately 300ha in area and up to 60m high to contain 100Mt of tailings.*
5. *Construction of a 500 m^3/h water treatment plant to treat acidic and metalliferous water on site during mine operational life to minimise possibility of discharges of untreated water to the Edith River.*
6. *Reprocessing or rehabilitation of the existing heap leach pad (HLP) and processing and / or reclamation of the existing low grade ore stockpile.*
7. *Use of up to three passive treatment wetlands to treat seepage and runoff from the TSFs and WRD post closure.*

Specific aspects that need to be assessed in the context of their adequacy for mitigating potential operational water quality issues are:

- handling and placement of potentially acidic and/or metaliferrous drainage material during construction of the waste rock dump;

- management and treatment of the various sources of water on site including the process and tailings circuit, and runoff and seepage from the pit, WRD and various stockpiles to minimise, to an acceptable level, the risk of uncontrolled discharges of contaminated water; and
- management of the existing low grade stockpile, scats stockpile and heap leach pad.

Key water-related issues that need to be assessed for the post decommissioning phase are:

- the reliability or otherwise of predictions of seepage water quantity and quality from the TSFs and WRD;
- the proposed method of construction and covering of the waste rock dump and the ability of this elevated structure to withstand extreme rainfall and other climate events over the long term, whilst minimising future water quality issues;
- the methods of construction for the tailings dams and the proposed final cover design;
- the water quality in the proposed pit lake and the final water level in that lake;
- the possibility of long term groundwater issues;
- the design and establishment of treatment wetlands to polish seepage and runoff post decommissioning of the site; and
- the ability of the closed out site to not have any future detrimental impacts on the biological amenity of the Edith River.

All of the above risks have essentially been identified in Chapter 5 – Risk Assessment - of the draft EIS. In this chapter the following statement is made (the section in bold underline has been highlighted by the reviewer). "Assessment of risk has been conducted through consideration of the circumstances around risks, **identifying necessary controls to address potential impacts and assuming effective implementation of planned and committed mitigation of potential impacts**."

It is further noted that "the critical controls to address effective management of many of the higher risk areas (associated with surface water, groundwater, and mine closure) are anticipated to include:

- reinstatement and construction of TSF under-drainage systems, TSF management plan development and implementation (including borehole installations and monitoring);
- tailings management plan and design according to Australian National Committee on Large Dams (ANCOLD) guidelines;
- surface water management (quantity and quality);
- compliance with approved WDL and MMP conditions; and
- comprehensive mine closure planning – development and implementation"

This report will examine the proposed risk controls in the context of current best practice and assess whether what has been proposed is likely to be adequate to minimise risk – assuming effective implementation by the proponent for this project. There are a number of ways that this could be done, but for the purposes of this report it is considered that the most effective way will be to firstly consider the primary sources and drivers (acid and metalliferous waste and climate), secondly the proposed constructed minesite infrastructure components (WRD, TSF, Pit, water treatment- active and passive) and how these are likely to interact with, and respond to, the sources and drivers during operational and closure periods, and thirdly the environmental receptors(including aspects of monitoring and water quality objectives) in the context of how effective the mitigation of water quality needs to be. A section on assessment of the groundwater hydrology component of the draft EIS concludes the review.

2. Sources and Drivers

Waste Rock and Tailings

The much more extensive geochemical testwork that has been done for this project confirms what has been found to be the case for the waste produced by most minesites in the Pine Creek Geosyncline – essentially no or very little neutralising capacity to offset the acid generating capacity of relatively low levels of sulfide contained in the mineralised waste. In summary the waste to be produced from the expansion of the Batman pit will have the same characteristics as that which already comprises the waste rock dump, with approximately 60-70 percent categorised as either net acid producing or uncertain.

Preliminary sulphur cutoff criteria have been proposed based on results from acid base accounting (ABA) and Net Acid Generation (NAG) pH, to assist with waste rock management and closure planning. This focus on acid generating potential of waste is the route that has typically been followed in most routine mine waste assessment programs. Unfortunately this method of classification typically fails to appropriately identify the level of risk that is posed by non-acid generating waste, in particular the category of drainage that is described as circum-neutral (pH between 6 and 8). Such drainage can contain elevated levels of salinity and metals such as cobalt, nickel, manganese, and the oxyanions arsenic, antimony, molybdenum and selenium. In this context waste characterisation should focus on the broader issue of potential solute load, which is the real issue, rather than just acidic drainage which is a subset.

For the above reason a lot more attention needs to be placed in the geochemical assessment for this project on assessing the solute generation potential of the waste that is currently classified as non-PAG. This is vitally important given the fundamental role that this material is envisaged to play in the outer cladding of the WRD and other structures, and to prevent the functional mis-classification of the environmental risk posed by a given waste type.

A strong indication as to the need for this broader assessment is provided by the following statement about the findings from the humidity cell tests: “Cells producing neutral pH leachate showed comparatively high levels of arsenic and antimony suggesting meteoric water contact could result in release of these constituents.”

One tool that can be used for the rapid screening of samples for their potential solute generation potential is the Net Acid Generation or NAG test. NAG testing determines the contact pH and acid generation potential of mine rock samples after complete sulphide mineral oxidation using 15% hydrogen peroxide. Samples with NAG pH levels below 4.5 are usually classified as acid generating while pH values above 6 are regarded as non-acid generating. In this context it is noted that NAG testing was initiated by Vista in 2011. Unfortunately it appears as though only the pH and acidity were measured, and sample types classified on this basis. If the leachate produced from the NAG tests had also been analysed then this would have provided far greater insight into the solute generation potential of the non-PAG materials.

Recommendation 1: The scope of the geochemical testwork that has been done must be expanded to include a more rigorous assessment of the potential environmental risk posed by non-PAG material given the key role that this material is proposed to play in providing the outer cladding for the mine landforms.

Climate (Rainfall Regime)

The northern monsoon tropics are characterised by distinct wet and dry seasons which provide substantial challenges for both operations and closure. In particular the wet season is characterised by periods of intense rainfall, the duration and intensity of which are highly variable. This variation provides a major challenge not only for operational water management, but most particularly for designing mine site waste management structures that will be sufficiently stable over the long term post closure. The latter is especially important in the current context given that these structures will be expected to sustainably encapsulate reactive sulfidic waste. The key concept here is that of the design lifetime of a structure. The design lifetime in the monsoonal tropics will be largely dictated by the time over which a structure can withstand the erosive forces of the seasonal rain, before it fails. A design lifetime of 200y is typically considered for mine landforms, with this period having precedence for closure planning in the Northern Territory.

In this context structures are generally designed to withstand an extreme event with a certain probability of occurrence. In the Mt Todd EIS a 1 in 100 year annual return interval (ARI) has been selected as the "design event" and this has been specified as the event that needs to be accommodated, for example, by the creek diversion channel and other structures on site. In particular the new TSF2 will encroach on the 100-year ARI design flood extent, with the design including diversion channels and levees along Horseshoe Creek and Stow Creek to protect the embankment from flooding and erosion, noting that the diversion channels are proposed to be designed for a 100-year ARI flood event.

The critical question is whether a 1in 100 ARI event is appropriate to use for both the operational period and beyond. Whilst substantial post-event repairs to structures may be able to be done whilst the site is operating, this will not be the case post closure. A recent analysis (Logsdon, 2013) has shown that in order to have a greater than 90% confidence in an extreme event not occurring in any one year for a proposed engineering design life of 200y, a 1 in 2500 y ARI event needs to be factored into the design process.

Recommendation 2: For those structures that will be required to endure and maintain their functional integrity for a long time post closure a structural lifetime should be specified and an ARI that is more appropriate to minimise risk over this lifetime be used as the basis for the design and performance assessment.

The climate regime is also the primary driver for the site operations water management plan and underpins the sizing of onsite water storages, the design capacity of the proposed water treatment plant, and the design of mine landforms and post closure cover systems. In this context it is noted that there appears to be substantial uncertainty in the water balance modelling that has been done for this project. The extracts quoted below have been excerpted from Appendix I of the draft EIS and from Appendix J of the Jan 2011 PFS document in which the water balance modelling is described:

EIS Appendix I – pi: *"It has been suggested that storm rainfall during the last two wet seasons has been in excess of a 100-year ARI and is therefore likely to exceed the design criteria of water management infrastructure on the site."*

EIS Appendix I – piii: "Some discrepancies exist between modelled and reported areas of development footprints for the Low Grade Ore Stockpiles, Batman Pit, to a lesser extent the Waste Rock Dump, and the proposed period of mine production. Underestimation of the development footprint of the pit will have a significant impact on expected inflow and this may affect assumptions regarding transfer rates to the WTP from the pit which may then impact transfers from other areas of the mine."

EIS Appendix I – p13: *"The projected heights of the TSFs as they are raised to accommodate the volume of tailings over the life span of the mine production phase were previously investigated by water balance models (HydroGeoLogica, December 2010). No description of the water balance models is known to exist and it is assumed that one model (Water Balance_12-08-10_BIG.xls, HydroGeoLogica 2010) represents TSF1 up to production year 7 and the second model (Water Balance_12-08-10_100MT.xls HydroGeoLogica 2010) represents TSF2 for production years 7 to 17. It is assumed that the TSF water balance models have been updated with the latest mine development information."*

EIS Appendix I – p6: *"The underestimation of pit area by the Goldsim model may result in an underestimate of the pit wall area and ponded water area whilst overestimating the area of catchment runoff. This will result in a significant underestimate of pit inflow due to the differences in unit runoff depth. Therefore a water balance on an expanded pit is likely to change the assumptions regarding required transfer rates to the WTP from the pit and possibly transfers from other areas of the mine*."

EIS Appendix I -p17: "*The lack of formal documentation regarding the source of model contents hampered a thorough validation of the models. Model assumptions regarding the balance of seepage inflows and outflows along with the source of information used to compile storage curves, tailings production and water use data have not been reviewed. Given the changes to mine development it is assumed that the reviewed spreadsheet models have been superseded and that the required data for input to the Goldsim water balance model relating to TSF reclaim water has been obtained from an alternative source."*

EIS Appendix I -p19: *"The following summary of water management performance during the production phase is extracted from the Goldsim Model - MtToddWB_Production_PFS_45K - Vista Gold Australia Pty Ltd, 2013 and is based on probabilistic output (100 x 12-year daily sequences). No assessment regarding the validity of the stochastic rainfall generation model has been made."*

EIS Appendix I: "Seepage occurs from the WRD, HLP and Low Grade Ore Stockpiles and is modelled in the water balance as a proportion of daily rainfall lagged by a specified number of days (Table 9). No description of the method to obtain these parameters by previous studies has been found."

PFS Appendix J – Jan 2011-p30: *"The recommended treatment capacity of the New WTP is based on results from mine-life water balance modelling discussed in Appendix I. The mine-life water balance is based on a limited annual precipitation range and did not consider the effects or probability of extreme precipitation events and annual precipitation on the water balance or the sizing of treatment systems."*

It should also be noted that "average" climate conditions were used to model the performance of the proposed store and release covers for the TSFs and other footprints, with no evaluation done of the effects of potential extreme events on cover performance. If this had been done it could have been found that that the 1m thick cover design was not sufficient and in this context it should be noted 1m was the only thickness that was modelled.

The above statements excerpted from the draft EIS and detailed supporting documentation reveal substantive uncertainty in the robustness and reliability of the water balance modelling that has been done for the EIS. In part this is because the scope of the project has been changed significantly over the recent past. It is absolutely essential, given the water quality management issues associated with this project, that an up-to-date water balance model is produced that factors in the occurrence of extreme events.

Recommendation 3: Up-to-date water balance modelling should be undertaken that addresses the current project scope and incorporates the probability of occurrence of extreme events. When this model is produced it should be subjected to peer review by an appropriately qualified independent expert.

Recommendation 4: The capacity of the proposed water management and treatment system should be reviewed to ensure that it is capable of accounting for the predictions from the updated water balance model.

Recommendation 5: Modelling of the performance of the proposed design for the store and release covers and GCL-based cover (for the WRD) should be updated to assess the effect of potential extreme rainfall event scenarios.

3. Minesite Infrastructure Components

Waste Rock Dump (WRD)

The proposed waste rock dump will increase the amount of waste rock stored from 16 Mt to 510 Mt. The physical consequence will be an increase in footprint from 70ha to 217ha (achieved in production Year 7) and an increase in height from 24m to approximately 350m. The construction will be staged in lifts of 30m. It is proposed to "encapsulate" the PAG material with a 10m thickness of non-PAG rock deposited along the inter-bench slopes and, for seepage control, to place a GCL layer (extending inwards for 52m) between each lift. The essentials of the plan design have been copied below in Fig 24.1 from the draft EIS. At closure it is currently proposed to cover the top surface of the WRD with a GCL-based cover.

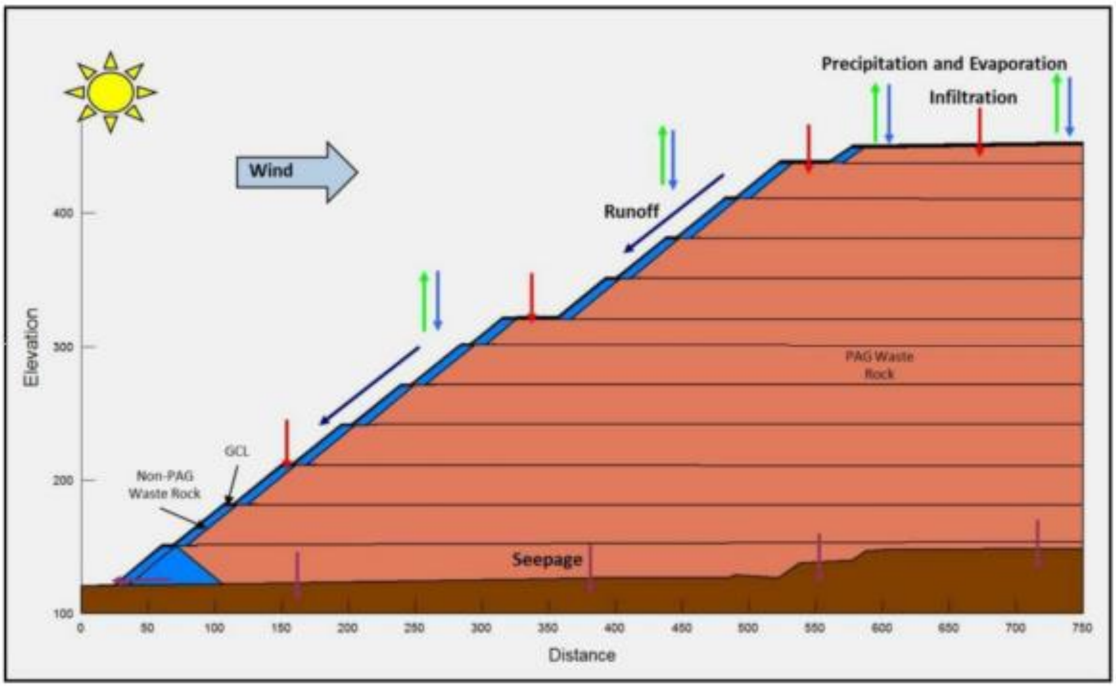

Figure 24-1 Waste Rock Dump Design

Comment in this report will be restricted to issues of potential water-related environmental risk associated with the proposed design, not economic or practical matters related to construction of such a large elevated structure.

The major issues that need to be addressed in the context of environment risk through operations and closure are: (1) the method of construction during the operational period and how that will mitigate potential for AMD generation, (2) the final cover design, (3) geotechnical stability over the long term, and (4) landform geomorphic (erosional) stability over the long term. All of these factors need to be appropriately addressed upfront given that once the structure is built it will not be possible to retrospectively address major performance shortfalls.

In summary, the only one of these four issues that has received more than superficial attention in the draft EIS is item 2, and that also requires more attention to detail. Each of these four topics is addressed in turn below.

(1) Construction of the WRD

The existing WRD will essentially be buried within the new WRD which will extend upgradient between RP1 and the Pit. In this context it should be noted that the WRD will be built over the alluvial channel of a former creek alignment. The existence of this lateral under-draining path is likely one of the pathways facilitating transport of ARD to RP1. Reducing this flow pathway should be addressed as part of the design for the proposed WRD.

It is now well known that the technique of end dumping for building up a waste rock dump increases the likelihood of AMD generation and transport, by virtue of the creation of preferred pathways for the transport of both oxygen and water. It is requested that the proponent provide information in the Supplement to the EIS about how it is planned to construct this dump and, in particular, how the wetting up of the dump and exposure to oxygen will be minimised during its construction. Related to this will be how the flow of water across and down the faces of the dump will be managed since this will substantively impact on the water management and treatment system during the operations period. Whilst the management of water flows has at least been partly explained for the final landform surface, this was not the case for the operational period.

Placement of a 10m layer on non-PAG rock along the front face of the bench has been proposed as the strategy to encapsulate the bulk PAG rock. However, it has not been explained if this cover will be placed in tandem with the construction of each bench lift or whether this will be placed at a later time. Best practice for AMD dump construction recommends that compaction be periodically carried out to limit infiltration during the construction phase, and that the surface should be sloped to maximise runoff and minimise surface ponding. Another (geochemical) control strategy is the installation between benches of a layer of neutralising material – eg limestone- that functions as a horizontal reactive barrier. These strategies would actively mitigate water quality risk during both the operational and through the post closure period for this proposed structure.

Recommendation 6: The proponent provide substantially more detail about the construction of the waste rock dump with emphasis on incorporating best practice strategies to mitigate as far as practicable the future AMD risk of this structure.

(2) Covering the WRD

It is proposed in the EIS that a GCL-based cover will be used for the surface of the WRD. This is a very significant change from the originally proposed store and release cover (Jan 2011 PFS). It is requested that the proponent provide the reason for this change since it will have a substantive bearing on how the cover will interact with both the physical and biological environment. In particular, it is likely that a store and release cover can better accommodate the effects of differential vertical consolidation, which is likely to be substantial through a 350m profile of uncompacted waste rock. The performance of a store and release cover relies on evaporation via the roots of vegetation. In contrast the performance of a GCL-based cover could be substantively compromised by root penetration. The proponent should provide evidence of the successful long term implementation of a GCL-based cover system in a similar climate regime and, as recommended above, undertake predictive performance modelling incorporating the effects of climate variability.

Recommendation 7: The proponent provide justification for the change from a store and release cover to a GCL-based cover since it will have a substantive bearing on how the cover will interact with both the physical and biological environment.

Recommendation 8: The proponent should provide evidence of the successful long term implementation of a GCL-based cover system in a similar climate regime and, as recommended above, undertake predictive performance modelling incorporating the effects of climate variability.

(3) Geotechnical Stability

The issue specifically refers to the impact of vertical consolidation and/or slope failures on the integrity of the structure. The possible effect of consolidation has already been referred to above for the final surface cover of the dump. This could also be an important issue for the effectiveness of the planned inter-bench GCL layer, which will depend on the maintenance of a slight (5 degree) downward slope to direct seepage to the outer dump face. Whilst the proposed design might look good in static 2D cross section, the potential for failure of this important control strategy should be assessed by consolidation modelling of the rock mass.

The second aspect of geotechnical stability relates to the possibility of failure at the toes of the benches. Indeed the use of a GCL layer to intercept and direct seepage along the inter-bench plain could substantively increase this risk. It is thus requested that a slope stability analysis be performed under saturated conditions (along the surface of the interbench GCL) to assess the factor of safety of the proposed design.

Recommendation 9: The proponent undertakes consolidation modelling to assess the structural viability of the proposed interbench GCL seepage interception layer, and the physical viability of the proposed GCL-based surface cover.

Recommendation 10: The proponent undertakes slope failure modelling to assess the effect of the proposed inter-bench GCL seepage interception layer on the long term stability of the structure.

(4) Landform Geomorphic Stability

The long term geomorphic stability of this landform has not been sufficiently addressed in the draft EIS or in any of the precedent material cited by the reviewer. Longevity against the erosive forces of intense rainfall events will perhaps be the most critical determinant of the structural lifetime of the proposed waste rock dump, especially the efficacy of the drainage system. There are many examples in the monsoonal tropics where drainage structures have failed within a short period of time after construction. For this reason the proponent should rigorously test the proposed design (including catchment and drainage structures) with a well-regarded and tested 3D event-based computer geomorphic model such as CAESAR. The SIBERIA model is often used for this purpose but it can only use yearly rainfall, rather than rainfall event time series data as input, and is thus not suited for testing of extreme events. It is noted that this modelling can also assist with the design evaluation of the drainage management system(s) that will need to be in place during construction of the dump.

Recommendation 11: The proponent should test the proposed design (including catchment and drainage structures) with a well-regarded and tested 3D event-based computer geomorphic model.

Tailings Storage Facilities (TSFs)

Apart from the WRD the TSFs will occupy the biggest legacy footprint on the site. These structures will contain fine-grained net acid producing material. There will be two TSFs. The first will be the existing TSF raised to accommodate an additional 60 Mt. The second will be purpose built to contain approximately 100 Mt of tailings from year 6 onwards. The existing dam (TSF1) will be raised in six stages to a level approximately 34m above ground level. A second dam (TSF2) will be constructed to the south east and will have a height of about 60m above ground level.

The key issues to consider for the TSFs are their design as it relates to operational, closure and post closure performance and stability. In contrast to the WRD, substantive detail has been provided about the TSFs, perhaps because the issue of dam wall stability figures so prominently in the risk assessment process for minesites as a result of historical failures. As for the WRD the key issues will be addressed in turn. In this case they will be (1) Structural stability, (2) design for operation and facilitation of closure, (3) covering for closure, (4) environmental performance, and (5) other closure options.

(1) Structural Stability

Unfortunately there was no substantive information provided about either the design detail or analysis of structural stability in the draft EIS. It is recommended that the proponent redress this deficiency in the supplement to the EIS. However, the required level of detail is present in the Water Management Update (Appendix K and attachments) dated Jan 2011. This reviewer is satisfied (with the following three caveats) that a sufficient level of analysis, including identification of residual risk factors, has been carried out at this time to support the proposed design. These caveats are as follows.

(1) Part of the toe of TSF2 may be encroached upon by greater than a 1 in 100y flood event as indicated above. This was not addressed as part of the stability analysis.
(2) The design criteria used for the TSF raise was based on the Canadian Dam Association (CDA) Dam Safety Guidelines (1999). It is recommended that a comparison be made with the latest Australian Dam Safety Guidelines in the Supplement to the EIS to provide assurance that these CDA guidelines provide a similar level of stability.
(3) Additional analysis will be needed for assessment of resistance to seismic events, especially in relation to the proposed upstream lift method of construction.

Recommendation 12: The issue of encroachment of flood events on the toe of TSF 2 needs to be addressed in the design of this structure and associated water diversion channels.

Recommendation 13: A comparison should be made in the Supplement to the EIS between the latest Australian Dam Safety Guidelines to provide assurance that these Canadian Dam Saftey guidelines (1999) provide a similar required level of assurance.

Recommendation 14: Additional analysis will be needed for assessment of resistance to seismic events, especially in relation to the proposed upstream lift method of construction.

(2) Design for Operation and Closure

TSF 1 and TSF 2 need to be considered separately in this context since TSF1 is an existing structure and TSF 2 will be newly built.

TSF 1

All of the presented evidence indicates that this structure was well designed and soundly built. In particular it possesses an extensive underdrainage system which is extremely beneficial for both operations and closure. Although this facility is not lined, the presence of the underdrainage system means that a substantial proportion of the vertical drainage can be captured and returned to process via the decant tower system. The underdrainage system also means that the tailings mass may consolidate more quickly through the operational period and thus facilitate capping and closure.

TSF 2

The design proposed for TSF 2 is best practice, and arguably leading practice. The twin liner system will prevent vertical seepage, whilst the overdrain and decant tower system will facilitate vertical drainage and enhance consolidation. If the overdrain was not present, the lined facility would act as an undrained bathtub with little opportunity for enhancing consolidation of the tailings and hence expeditious capping and closure.

(3) Covering for Closure

Placing a cover over thixotropic tailings will be a challenge as noted in the EIS. It is proposed that a 1m layer of non-PAG crushed rock will be spread out over the tailings to provide a stable platform for placement of the final cover. However, whether this will be practicable will depend entirely on the extent of prior consolidation that has occurred. As noted above the presence of an under blanket drainage system will favour more rapid consolidation. However, it cannot be assumed that sufficient consolidation will have occurred to permit the proposed strategy to proceed. Thus it is recommended that a contingency for placement of a geotextile load bearing layer and/or the installation of vertical wick drains be added to the closure cost estimates.

Additionally there will inevitably be substantial differential consolidation across the tailings surface, so this will need to be factored as an additional surcharge volume (and cost) required for the placement of a cover system. Consolidation modelling will be needed for this. At the level of the PFS, 1D modelling may suffice to develop this estimate. It should be noted that addition of the 1m rock layer surcharge will likely result in the vertical expression of pore water that could intrude upwards into the cover. This possibility should be factored into the risk assessment for closure of the TSFs, noting that it has a higher likelihood of occurring for the lined TSF2.

As already noted above, the current extent of modelling of the proposed store and release cover system is insufficient to provide a robust assessment of long term cover performance.

(4) Environmental Performance

The biggest potential environmental risk to be posed by the TSFs will likely be post closure, assuming that the water management and treatment system is operated appropriately during the operations period, and that there is no structural failure of the walls.

During operations the acid generating tails will be saturated, which will essentially prevent oxidation. However, following cessation of operations the phreatic head will fall in a vertically drained unlined system such as TSF1, allowing the entry of oxygen into the pore space and thus initiating oxidation. The placement of an effective cover system should minimise entry of water (transport vector) into the tails as well as increasing the diffusion path for oxygen. This is why the design of the cover system, including sufficient contingency for surface erosion through time, is so important, and why it has been noted that the current level of assessment of proposed cover performance is not adequate.

In addition, the issue of differential consolidation must be addressed in assessing cover design for such large TSFs since failure to do this could result in a depression developing in the middle of the structure, with consequent wet season ponding of water and vertical infiltration and transport of reaction products.

In the case of TSF 2 the liner system should at least for some considerable time minimise the downward leaching of solutes through the base of the TSF. However, ultimately these liners will fail, and the environmental performance of TSF2 will depend on the performance of the overlying cover system.

Recommendation 15: The performance of the proposed store and release cover should be assessed using dynamic (ie non-averaged) climate data, specifically addressing the issue of extended periods of high rainfall.

Recommendation 16: The issue of differential consolidation must be addressed in assessing cover design for such large TSFs since failure to do this could result in a depression developing in the middle of the structure and compromising the environmental performance.

(5) Other Closure Options

It appears to have been assumed in the draft EIS that closure of the tailings in place in the TSFs is the only possible option. In this context it should be noted that covering of the above-grade TSFs and ongoing management and monitoring is the single most costly item ($55M+) in the closure plan. Above grade facilities also constitute an indefinite term risk to the environment.

In pit tailings disposal is increasingly being regarded as best practice by the industry when all factors, economic, environment, and social are taken into account. Accordingly it is recommended that the proponent assess the feasibility and cost of relocating the tailings to the pit at the end of mine life. Given that this is proposed to be a pit lake this environment would provide the ideal water cover for the perpetual secure containment of this reactive material. It is possible that residual cyanide could be considered to be an issue in this context. However, cyanide rapidly degrades in the environment unlike metals.

Recommendation 17: The proponent should assess the feasibility and cost of relocating the tailings to the pit at the end of mine life.

Batman Pit

The existing Batman Pit will be deepened from its current depth of 114m to approximately 588m with the surface area expanding from 40 hectares (ha) to approximately 137ha. A flooded pit lake is the proposed closure condition.

Current Situation

Currently the pit is flooded with water and this water needs to be removed before the proposed project can start. The water was initially acidic and contained elevated concentrations of metals. It has been treated in situ by the addition of micronized calcium carbonate followed by lime to raise the pH to neutralise the acidity and remove metals. It is stated in the draft EIS that the regime for discharge of this water to the Edith River is not part of the EIS approval process and will be governed by the provisions of the current waste discharge licence (WDL 178-2) which has been approved for two years - at the end of which time the provisions of the WDL will be reviewed. This discharge licence was approved at the time when the pit was approaching maximum storage capacity and effective risk management for this legacy site required that compatability with the highest environmental value be balanced against the greater risk (and environmental consequence) of an uncontrolled release. The following is excerpted from the NTEPA FAQ sheet accompanying the discharge licence.

"*A minimum 80% protection level has been set to address the inherent environmental risks associated with the Mt Todd mine site and to enable all the management objectives identified to be met. It would be very difficult, if not impossible, to achieve all three objectives if the protection level was set higher. For example if the level was set at 95% Vista may not be able to discharge enough water to prevent uncontrolled discharges from the site. An 80% protection level is often applied as an intermediate target for water quality improvement and in this instance is considered an appropriate short term solution to the current situation at Mt Todd. Vista will be required to apply for a new Waste Discharge Licence for discharge at the expiry of the Waste Discharge Licence. Consideration of an appropriate level of protection will be made at that time, based on the situation at Mt Todd at the time, the concept of continual improvement and the objectives of stakeholders and the community.*"

This strategy is consistent with addressing a critical water management issue at a legacy site. However, it is not appropriate for an operating site with an active water management and treatment system as documented in the draft EIS. In this instance the default starting point for the setting of water quality objectives (WQOs) would be expected to be the 95% Ecosystem Protection Values contained in the Australian Water Quality Guidelines, AWQG (ARMCANZ 2000). This is a very important issue since the setting of these water quality objectives will flow through all elements of the water management and treatment system, and the regulatory compliance regime for the project. The proponent may subsequently choose to develop local water criteria using several possible options provided in the AWQG, and negotiate these with the regulator. The extensive toxicity testwork program, conducted for the onsite sources of water, including for a pilot treated sample of the pit water, and reported in the Vista Gold Australia Pty Ltd Discharge Plan January 2013 provides a very strong basis for developing such criteria

Operations Period

During the project operations period the pit will be expanded and water that accumulates will be pumped out and treated in the proposed HDS water treatment plant. The water that reports to the pit via wet season rainfall will contact the exposure of sulfide minerals on the pit walls, with a high probability of producing an acidic and metal rich leachate. This will need to be pumped out of the pit and treated in the water treatment plant, so that mining can progress. As noted above in the section on climate drivers there appears to be substantive uncertainty in the volume of water that will need to be pumped from the pit for treatment. Given the size of this pit water source and its likely poor quality, a higher level of confidence about the potential volumes from this source is required so that the water treatment plant has sufficient design capacity.

Recommendation 18: A higher level of confidence about the potential volumes of water produced from the pit is required so that the water treatment plant has sufficient design capacity.

Closure of Pit

The closure objective for the Batman Pit is a pit lake, which is intended to be formed by passive filling. Given the length of time this filling will take, coupled with current predictions that this pit will be a terminal sink for the inputs of water and associated solutes, and experiences with mine pits elsewhere in the Pine Creek Geosyncline, the quality of water contained in it will inevitably be very poor (acidic and metal rich).

The key questions to be answered to ensure the post closure risks are appropriately defined and managed are:

- what is the anticipated final fill level of the lake,
- will the final level be sufficiently low that there is negligible risk of overtopping and/or contaminating the near surface groundwater system,
- Is a poor quality pit lake acceptable to regulators and the community stakeholders, and
- are there any other alternatives.

The results of the water balance modelling presented in the draft EIS indicate that the lake will be a terminal sink, with a final level (15m AHD) about 120m below the lowest level (134m AHD) of the pit, achieved 300-500y after closure. If this is indeed likely to be the case then there will no risk of overtopping and negligible risk of contamination of near-surface groundwater.

However, the modelling that was reported in the main draft EIS document stated that groundwater inflows and outflows are negligible, and groundwater inflows were not included in the model, whereas recent work indicates that groundwater inflow could vary between a few litres per second and 31L/s over the operational phase of the mine. Further it is stated in Appendix I that discrepancies were noted to exist between modelled and reported areas of development footprints for the pit. In particular it is stated in Appendix I that "The underestimation of pit area by the Goldsim model may result in an underestimate of the pit wall area and ponded water area whilst overestimating the area of catchment runoff. This will result in a significant underestimate of pit inflow due to the differences in unit runoff depth. Therefore a water balance on an expanded pit is likely to change the assumptions regarding required transfer rates to the WTP from the pit and possibly transfers from other areas of the mine".

The apparently contradictory information about what has been included, or not included, in the water balance for the pit that appear in the main EIS chapters and the supporting Appendices do not inspire a high degree of confidence in the reliability of what has been presented. The proponent should ensure that this situation is redressed in the Supplement to the EIS, given the critical import of such predictions to the assessment of the veracity of the EIS. The final version of the model that is presented in the supplement should represent in full the critical drivers that apply to the development scenario for which approval is sought.

Recommendation 19: The final version of the pit closure water balance model that is presented in the supplement to the EIS should incorporate in full the critical drivers that apply to the actual development scenario for which approval is sought.

The issue of whether or not a pit containing poor quality water, which won't impact on declared beneficial uses of surface or groundwater, is acceptable as a final closure condition is a matter for resolution between the proponent and its community and regulatory stakeholders.

It would be beneficial if the proponent could demonstrate that it has genuinely considered and evaluated other options for the pit, rather than presenting the poor quality pit lake as the only alternative. For example, the pit could serve as a final repository for tailings (as discussed above), but this would still result in the ultimate formation of a pit lake. Rapid flooding of the pit (by catchment diversion), if this was hydrologically feasible, would likely produce a quality of water that was better in the shorter term, but which would subsequently deteriorate via wash in of leachate from the sulfidic wall rock.

Recommendation 20: The proponent should demonstrate that it has genuinely considered and evaluated other options for the pit, rather than presenting the poor quality pit lake as the only alternative.

Water Treatment – Active

Active water treatment, and the associated equalisation pond and pump and pipe transfer systems, will be the critical component that will enable the site to operate in zero discharge mode for all but the most extreme of rainfall event conditions. For this reason it is essential that the climate drivers for the water balance, including prolonged events, have been appropriately modelled. Otherwise the plant or pumping systems may be undersized to sufficiently mitigate the risk of uncontrolled discharge of treated water. The same comments that have been made several times above relating to potentially underestimating flow inputs also apply here.

Recommendation 21: The site water balance modelling on which the sizing of the WTP and associated infrastructure has been based should be rerun to ensure that the proposed operation has a high probability of being able to manage its water without the occurrence of an uncontrolled discharge of untreated water.

Currently it is proposed that during operations, water will be managed via a 500m /h WTP, with a standard and well proven treatment process based on lime precipitation conducted in a high-rate solids contact clarifier. Water will be treated for general on-site use and to meet discharge criteria for release to the Edith River or RWD when required. Treatment sludge will be sent to the TSF for disposal.

Other than flow rate, the other key input variable for water treatment is water quality. It is stated in Appendix I Water Management Update (Jan 2011) that existing and pre-production water quality estimates were based on average water quality data collected up to June 2006 and the prior 12 to 24 month period. It is reassuring to note that measured water quality data, rather than the predictions from the geochemical modelling (Appendix L), were used for this purpose since the geochemical modelling outputs (based on very limited humidity cell test work) appear to substantively underestimate likely dissolved metal concentrations.

It is implicit in the draft EIS that the site will endeavour to operate in zero discharge mode with treated output from the WTP going to the TSF, RWD or other site uses. However, it would be a substantive waste of resources if “high” quality treated water were to be degraded after this treatment, especially if it were treated to a level that would permit controlled discharge to the Edith River. In particular directing treated water to the TSF would not only degrade the treated product but it would also maintain the net inventory on site which is not desirable, especially during the wet season. Whist this reviewer understands the sensitivities surrounding discharges of water from this site, application of a 95% ecosystem protection criterion developed using the approach documented in the latest Vista Gold Discharge Plan (January 2013), and application of the associated dilution factor, should go a large way towards addressing this issue.

It is stated upfront in the EIS that the total project life will be 19 years, of which the final 4-5 years will be devoted to closure. However, upon reading the details of active water treatment requirements at the end of operations it is apparent that this may require 10 years or more before the proposed passive treatment systems will be able to cope with the volumes and nature of water requiring treatment. This aspect needs to be addressed by the proponent as it could substantively increase the length of active management of the site and thus the full project life.

Recommendation 22: The proponent should clarify the length of time likely to be needed for active water treatment post-decommissioning in the context of the total life of the project that has been provided in the EIS.

Water Treatment – Passive

It is proposed that up to three passive treatment systems will be phased in during the later stages of operations and into the closure period. Passive treatment systems can be attractive BUT there are some substantive limitations which the draft EIS has failed to address to provide reassurance that the proposed treatment wetlands will likely be viable, especially after the site is decommissioned. Firstly, from a biogeochemical and biological perspective, the current international “state of the art” for use of wetlands to treat minewaters indicates a good probability of intermediate term (ie 5-10y) success for surface flow wetlands treating water with starting pH values in excess of 6 – so called “circumneutral” minewaters. The drawdown seepage from the TSFs will be in that category so this is a positive for the use of surface flow wetlands proposed to treat this seepage.

However, the prognosis for the use of passive treatment systems for the sustainable treatment of high intensity (pH < 3.5) acid mine drainage over long periods of time is not good, based on experience over the last 2-3 decades in the United States where much of the development and testing of passive treatment technology for minewater has been done. The reason for this is that the sulfate-reducing systems on which these systems are based require periodic re-charging with large amounts of organic carbon, typically in combination with added limestone to raise the pH sufficiently so that the sulfate-reducing bacteria can survive. Subsurface or vertical flow systems are also prone to hydraulic clogging as a result of the precipitation of iron and aluminium hydroxides. In the United States the current regulatory view is that passive treatment systems are not being favourably considered for mine closure plans, for these very reasons.

The other major factor that must be considered is the availability of sufficient water to sustain the operational footprint area of a wetland. Given that evaporation substantially exceeds rainfall for all but a couple of months in the northern monsoonal tropics it is essential that a water balance be done to assess the practicality of sustaining a wetland through the long dry season. No evidence has been presented in the EIS to suggest that wetlands will be hydrologically viable. If a wetland dries out then not only will its biological assemblage be damaged but there is a high probability of re-oxidation of diagenetic sufides in the wetland bed, resulting in an acidic and metalliferous first flush the following dry season. Subsurface wetlands may be more potentially viable if located immediately downstream of a seepage source, noting the geochemical issues raised above.

In summary, a much more convincing case for the viability of wetlands as a sustainable post closure seepage treatment option needs to be presented, given the critical importance of this strategy for mitigating post closure water quality issues. At least the potential viability from a water balance perspective needs to be demonstrated, and preferably accompanied by an authoritative literature review that documents where this approach has been successfully applied over at least a 5-10y timeframe.

Recommendation 23: The proponent needs to provide a much more technically convincing case for the viability of passive treatment systems to mitigate post closure water quality issues.

4. Environmental Receptors (including Water Quality Objectives and Monitoring)

Water Quality Objectives

Under the *Water Act* 1992 of the Northern Territory, the declared beneficial use of surface water from the Edith River and its tributaries is the protection of aquatic ecosystems.

The critical question to be asked in this context is "have the environmental values and appropriate applicable water quality objectives (WQOs) been developed and defined in the EIS according to the framework defined in the Australian Water Quality Guidelines?" The reason for this is the ultimate performance targets for the management and mitigation of water quality risks for discharges from the site during operations and the closure period depends on the numeric values of the defined WQOs.

Given the prescribed environmental value of the Edith River, the default starting point should be a 95% ecosystem protection condition for environmental compliance (at SW4?) downstream of the site. However, the material contained in the draft EIS is equivocal about this aspect, refering instead to compliance with a putative waste discharge licence that will apply at the time, and almost implying that the approval condition (80% ecosystem protection) in the current WDL (WDL 178-2) will remain. The proponent should make use of the excellent work done in support of the current water discharge plan for Mt Todd to proactively develop a 95% ecosystem protection strategy to be presented in the supplement to the EIS.

Recommendation 24: The proponent clarify in the Supplement to the EIS which water quality objectives are intended to provide the basis for its water quality compliance regime during the operating life of the project

Recommendation 25: the proponent make use of the excellent (and peer reviewed) work done in support of the current (Jan 2013) water discharge plan for Mt Todd to proactively develop a 95% ecosystem protection strategy to be presented in the supplement to the EIS.

The following two sentences are reproduced from section 2.3.2, Mine-Life Water Treatment Assumptions, in Appendix I of the Jan 2011 Water Management Update. They are the cause of some concern for the reviewer given their potential implications for environmental protection, and the fact that arsenic and antimony have been detected in significant concentrations in leachates produced from the geochemical test work program (Appendix J EIS).

- "*Vista will obtain approval from the NT Government to permit effluent releases (that comply with the WDL and water quality-base effluent standards established for the Edith River as currently approved) from the Existing WTP and New WTP to Batman Creek.*
- *Numeric standards for sulfate, arsenic, and other oxyanion will not be applied by the NT Government to the WDL or water quality-based effluent standards for the Edith River."*

The proponent is requested to clarify if it is indeed intending to carry over the current approval conditions in WDL 178-2 and seek exemptions for sulfate, arsenic and other oxyanions in discharge standards applied to the Edith River. The reasons for doing this may be due to the inability of the WTP to meet the potential required environmental protection objectives for these chemical species, or it may apply solely to the proposed framework for discharge from the Batman Pit of the current in situ treated water. Whatever the reason this aspect needs to be specifically addressed in the context of the treated water being able to meet contemporary water quality guidelines.

Recommendation 26: The proponent should clarify why it may be seeking exemption for sulfate, arsenic and other oxyanions in discharge standards applied to the Edith River.

Proposed monitoring

The proposed locations for onsite monitoring of source terms and for baseline and compliance monitoring in the Edith River are considered appropriate. However, continuous monitoring of flow, EC and pH should be implemented at key locations, and the time series data presented in the water management reports or equivalent required by the regulator. Continuous monitoring at key locations is current best practice. The technology for continuous monitoring for these parameters is now well developed and robust, and there are an increasing number of instances where this technology has been successfully implemented on sites in the NT. Continuous monitoring has proved its worth from both site operational water management and regulatory reporting perspectives.

Arsenic and antimony should be included in the default water quality analysis suite given the findings from the geochemical test work. In this context it should be noted that they are not currently included in the schedule of parameters to be measured when discharges are occurring (Table 6 Appendix J).

Recommendation 27: The proponent commit to implementing continuous measurements of flow, pH, and EC at key monitoring locations.

Recommendation 28: Arsenic and antimony should be included in the standard water quality analysis suite

It is noted that biological monitoring (macroinvertebrates) will be conducted as part of the water quality monitoring program. However, one of the issues with this methodology is that the surveys are often done well after a discharge occurs, and hence the system has had a chance to substantively recover (via recruitment from upstream) from the impact of an acute discharge. The macroinvertebrate methodology is better suited to detecting longer duration chronic impacts. It is suggested that the proponent consider implementing a form of in situ biological monitoring so that time series of upstream-downstream difference data can be produced. The in situ deployment of aquatic snails as done by the Supervising Scientist at the Ranger Mine is an example of such a leading practice implementation of in situ biological monitoring.

Recommendation 29: The proponent consider implementing a form of in situ biological monitoring so that time series of upstream-downstream difference biological response data can be produced.

5. Groundwater Hydrogeology

This reviewer concludes that a sufficient level of modelling has been done to provide confidence that interaction between water in the pit post closure and the surrounding groundwater will not be significant from a contamination perspective and that the ultimate cone of depression is unlikely to significantly impact on flows in the Edith River.

However, as is apparent from several other legacy locations in the Top End of the Northern Territory, it is the shallow groundwater originating from underneath mine landforms that typically contributes the majority of contaminant load to surface water that exits the site. Particularly pertinent in this context is the following excerpt from the EIS: "The weathering profile is hydro-geologically significant in the project area. Based on examination of numerous boring logs, the top 3m of material is generally completely weathered, very highly fractured, or unconsolidated. Alluvium often extends somewhat deeper than 3m below streambeds. Weathering of the bedrock is generally observed down to approximately 25 to 30m below land surface."

This aspect of shallow seepage reporting to surface drainage lines has not been sufficiently addressed in the groundwater hydrology part of the EIS. In particular the statement is made under groundwater management measures that "the WRD extension will be constructed such that it does not result in significant change to the local groundwater regime." How this was to be achieved in practice was not explained.

Whilst it may have been considered that the majority of near surface seepage will be effectively intercepted by the proposed passive treatment systems such cannot be assumed to be the case.

Recommendation 30: The proponent should specifically address potential disseminated fugitive near-surface seepage (especially in relation to post closure risk mitigation) in the supplement to the EIS.

6. Concluding Summary

It is noted that as far as operational water management is concerned this is proposed to be an essentially zero discharge site. Provided that the water management and treatment system is appropriately sized (see strong caveat about water balance modelling below) it is likely that the water aspects of this site could be managed appropriately during the operational lifetime of the project.

However, given the history of this site, the most pressing issue to address is whether the proposed operation can be successfully closed out such that it will present low ongoing risk of detrimental impact on the receiving environment. In this context a best practice approach mandates that potential closure risks be identified from the start, and that the design and construction of those landscape features that will remain in perpetuity (TSFs WRDs, pits) appropriately mitigate those risks for a period defined by the engineering design lifetime of these structures.

Significant gaps have been identified in the work that has been done to date to provide assurance that appropriate levels of post closure mitigation can be successfully implemented. Specific recommendations have been made through this report to address these gaps. In particular, the waste rock dump is considered by this reviewer to provide the biggest long term residual structural and geochemical risk on the site.

It is noted that the closure of the site will be critically dependent on sourcing sufficient, within an economically viable transport distance, low permeability material (LPM – clay) needed to build the covers over the WRD and the TSFs. Insufficient work has been done to define this resource, which is an Achilles Heel for the closure plan.

An overarching issue is that of the site water balance and the climate drivers that have been used to develop the operations and closure water balances. There remains a high residual level of uncertainty in the assumptions made, and indeed the inputs that have been included, in this modelling. This is a critical area that will need to be redressed in the supplement to the EIS.

A related issue is the assumption that a 1 in 100 year event provides adequate basis for long term assurance of structural integrity in an extremely variable tropical monsoonal environment. This reviewer has challenged this assumption and requests that the proponent provide a more substantive assessment of the factors that will impact on the design lifetime of the mine landforms, and of the performance of the proposed closure cover systems.

Consideration should be given to the fate of the tailings at the end of the project life. It has been proposed that the tailings remain in place. The option of transferring the tailings back into the pit should be assessed, especially given that the pit will flood through time, given the substantial above grade legacy that this mass of acid generating material represents. The cost of doing this should be compared with the cost to cover, maintain and monitor the TSFs in situ post closure.

It is noted that there is still some uncertainty over the water quality objectives that will govern the assessment of the environmental performance of this project. This issue should be resolved in the supplement to the EIS, noting that the excellent work that was done to support the development of the current water management plan for the site provides the basis for doing this.

7. References

Logsdon, MJ (2013) What does “perpetual” management and treatment mean? Toward a framework for determining an appropriate period-of-performance for management of reactive sulfide-bearing mine wastes. In Proceedings International Mine Water Association Conference 2013, (eds Brown A, Wolkdersdorfer C, Figueroa L), Golden, Colorado, August 5-8 2013, pp 53-58.