Public Submissions

to the Draft Environmental Impact Statement (EIS)

McArthur River Mining Pty Ltd

Overburden Management Project

2018

Contents:

Environment Centre NT
protecting nature | living sustainably | creating a climate for change

Attention: Rod Johnson

Northern Territory Environment Protection Agency

Darwin NT 0800

Mode of delivery: By email *eia.ntepa@nt.gov.au*

17th May 2017

RE: Draft ENVIRONMENTAL IMPACT STATEMENT – McARTHUR RIVER MINE (MRM): Overburden Management Project

Whilst the Environment Centre NT (ECNT) appreciates the opportunity to provide comment on the proposal to manage the MRM Overburden and the MRM closure plan, we are deeply concerned that this EIS offers a bad value proposition.

By this we assert that the site status is now far worse than what previous authorisations have ever contemplated. Over the life of this mine the NT Government have failed to prosecute multiple breaches, which we fear may ultimately leave future generations of Territorians with the liability of a significant and unexpected impact into perpetuity.

We are hopeful that this assessment represents an opportunity to ensure that the operator meets the full liability of mine rehabilitation. At the same time we are asked to contemplate taking on the inevitable risk that comes from extended operations and an increased volume of waste to be managed.

It is therefore imperative that this process sets new standards for both the operator, whose rehabilitation requirements must be adequately scoped; and the regulator, whose capacity and commitment to comprehensively monitor performance and enforce requirements - including prosecuting breaches of authorisation - needs revival and reinforcement.

We would also like to add, that even with the extension to the date of comment ECNT has been given, we have not had the capacity to read and assess the full EIS due to the inadequate time given relative to the volume and complexity of the material provided. We believe this is detrimental to the protection of the environment and wellbeing of the stakeholders impacted by this project.

We are available to discuss any of the issues raised in this submission. Shar Molloy can be contacted on 0488 112 350 or 8901 7783.

Yours sincerely

Shar Molloy
Director
Environment Centre NT

Justin Tutty
Management Committee
Environment Centre NT

Notes re Appendices:

Various scientific reports directly related to this EIS have been included in our appendices and have been relied on to address the complex technical issues related to this EIS. Whilst the reports are addressed to the Environmental Defenders Officer (EDO), ECNT worked in collaboration with the EDO to obtain these assessments. Full permission from the EDO has been given to ECNT to reference and include these reports in our submission.

McArthur River Mine – Terms of Reference – General Information (Appendix A)

As part of the Final Terms of Reference under section 2.1 (Appendix A) Glencore have been requested to provide a history of the development of the McArthur River Mine to date, including disclosure of the context and nature of prior approvals. Whilst some aspects have been minimally addressed across chapters 1,2 and 3, the disclosure by Glencore does not adequately meet the terms of reference request regarding 2.1 General Information.

ECNT have participated fully in formal processes around environmental assessment of McArthur River Mine, and can offer further detail.

Certain features of decision making around the original mine deserve exposition. Barrister Tony Young (now a Federal Circuit Court Judge) wrote in Land Rights News, January 2015, that:

> *In early 1993 the Northern Land Council, acting on behalf of the Yanyuwa traditional owners of the McArthur River mouth and the Pellew Islands and the Gurdanji traditional owners of the mine site, wrote to the NT and Commonwealth governments seeking to be heard on aspects of the proposal, particularly social impacts on the Aboriginal people at Borroloola and environmental impacts on the McArthur River.*

The letter was ignored.

Judge Young tells that:

> *The Yanyuwa .. asked for continuing and public environmental monitoring of the impact of the mine on the McArthur River. The Northern Territory government and Mount Isa Mines refused to consider this.*

By Glencore's account, the expansion from underground to open-cut mining sounds straightforward:

> *An EIS was lodged as part of the formal assessment process to the NT, based on the guidelines issued in 2003. This was followed by the submission of an EIS Supplement (December 2005), Public Environmental Report (July 2006) and Mining Management Plan (September 2006).*

But this description leaps over the significant fact that the PER was prepared only because the initial EIA was unsuccessful.

In February 2006, then Environment Minister Marion Scrymgour announced that the open cut plan would not be endorsed by her department:

> *"The proposal does not ... meet the test of sustainability - the EPA's assessment provides a compelling argument for caution. ... I have therefore advised Xstrata that their EIS did not convince me that the uncertainties associated with mine expansion could be managed."*

In leading to this recommendation, the Environmental Assessment Report (AR51, NRETAS) noted, alongside concerns regarding realignment of the river:

> *There is potential environmental risk of mining operations and its components (including the tailings storage facility, the overburden emplacement facility and flood protection bund) posed by its location within the primary channel of a major tropical river. This includes the long term management of materials (sediments and contaminants), and their potential impact on ground and surface waters (and subsequent impact on local ecology) both during and post mining operations.*

When, after reviewing a subsequent Public Environment Report, the Minister advised that the expansion would not be explicitly denied a second time, Environment Minister Marion Scrymgour nonetheless noted:

> *significant and long term risks of contaminants entering the river and ground water—the proposed tailings facility would not be accepted in Queensland and Victoria;*

All parties must by now be wondering if the standards of those states should have been applied.

Traditional Owners, with support of the Northern Land Council, challenged this approval in 2007. Work on the expansion was ordered to stop when the Supreme Court ruled in favour of the Owners, and declared the approval invalid. NT Government controversially recalled a midnight session of parliament to change the Ratification Act and retrospectively approve the expansion.

The fiercely contested and highly controversial nature of the approval of the first stage of expansion to open cut at McArthur River is highly relevant context. It is significant that the initial rejection of the first stage of expansion has been omitted from the proponent's version of events in subsequent applications. Tis EIS specifically calls upon the proponent to provide this context.

While not rejecting the project a second time, the NT Government acknowledged significant public concern over the project. Minister for Mines and Energy Chris Natt said the appointment of an independent monitor was a condition of the project being approved.

It is significant, then, to note that the subsequent 2012 Phase 3 application ignored, and even explicitly rejected, relevant information and advice on risks and alternatives from that same independent body. ECNT participated fully in the formal processes around the Phase 3 assessment, echoing a number of recommendations of the Independent Monitor, which are only now being considered. It is dismaying to find that decisions that should have been agreed during the previous assessment were ignored at the cost of significant unnecessary environmental harm, and are only now being considered, conditional upon the miner being rewarded with a further extension of operations.

We have included in the Appendix of our submission the report of Associate Professor Gavin M. Mudd[1] who also adds detail regarding the 'History of the Project', particularly information regarding classification of the overburden material. Accurate data regarding the characteristics of the waste rock mined each year, where it has been placed and how it has been managed is vital data that is missing from the proponent's submission and is necessary to inform this assessment.

As Mudd writes

> *Documenting this history is not merely a simple recount of the MRM project, it is fundamental to establish why acid mine drainage risks have been so poorly recognised previously, leading to the major issues of smoke plumes from the PAF waste rock and concerns over seepage impacts on groundwater and surface water resources and eventually the need for this current EIS. Without such detailed history – and the data to go with it – it limits confidence in the current EIS and its associated assessment of PAF waste rock and AMD risks.*

We support Gavin Mudd's recommendation:

> **The EIS Response Document must include a complete historical data set of all mining activity to date at MRM. The key aspects must include an annual data set of ore mined and milled, ore grades, concentrates produced, tailings generated and waste rock mined. In addition, a careful account should be provided of where all waste rock has been placed to date – including the estimated PAF and NAF quantities for each area of waste rock management.**

[1] Assoc. Prof. Gavin M. Mudd, May 2017, *McArthur River Mine Overburden Management Project – Draft Environmental Impact Statement.* P.1 – P.3

Chapter 3 – Project Description and Justification

TSF and Tailings reprocessing

DME, in their response to the 2016 IM report, acknowledged:

> *"The most significant risk from current operations relates to the operation of the TSF"*

ECNT welcomes the recognition that the tailings should not be simply capped at the end of mine life, but must be reprocessed and returned to the open cut pit. This was a recommendation we made in the previous (2012) assessment. Our recommendation was made as a matter of urgency, not just for the long term management of tailings post-mining, but in response to the poor performance of the TSF cell 1.

ECNT and Gavin Mudd in his comments of this EIS[2], raise concerns that there is little evidence provided to show that reprocessing the tailings is technically and economically viable. The complex issue technical issues of reprocessing tailings is not adequately addressed with only a two page review. ECNT is concerned that if MRM determines that reprocessing the tailings is not a viable financial option, it will not fully rehabilitate the site, including returning the tailings to the open cut pit. Thus it is imperative that the EIS Response address the following recommendations (Adopted from Gavin Mudd):

- **Provide a clear case for the technical and economic viability of tailings reprocessing, especially how this may improve long-term environmental outcomes for the MRM site after the completion of all activities and rehabilitation.**

- **Include detailed costings for the various rehabilitation scenarios, especially the case where tailings are simply transferred from the current dam to the former pit.**

- **Include a future scenario where the tailings are simply transferred from the storage dams to the former open pit mine.**

Mine Wastes

We support Gavin Mudd's[3] recommendation to clarify the difference between low capacity (LC) and high capacity (HC) in a language that can be easily understood, including the difference it makes to mining activities and rehabilitation.

> **The EIS Response Document is to provide a better and clearer explanation of the distinction of mine wastes as 'high' or 'low' capacity. This includes detailing the importance of this classification and the impact of not easily being able to segregate this material in daily mining activities according to this classification.**

[2] Ibid, p. 3-4
[3] Ibid 4-5

McArthur River ecosystem – including mine pit lake and river flow through

Whilst the level of technical information in this current EIS is mostly thorough, the proponents plan to create a mine pit lake and redivert the McArthur River to its original path through the mine pit lake is of utmost concern. Community feedback and scientific opinion confirms these concerns.

ECNT met with numerous Borroloola residents from the 13th to the 15th April in town locations and on various outstations. Whether community members thought the mine should be closed immediately or whether the members thought the mine should continue operations, every single person was alarmed and did not approve of the McArthur River mine being reverted to flow through the mine pit lake containing the tailings and waste rock materials.

Scientific expert opinion confirms the intuitive assessment of the local Borroloola residents. Dr Garcia[4] in her assessment of the current MRM EIS states that "the possible negative consequences to the McArthur River food web and those that rely on the food web by re-establishing the original path through the pit lake could be catastrophic and long-lasting such as the potential local extinction of an already threatened species Pristis pristis". She also expresses concern about introducing a deep pit lake into the channel of McArthur River which is not typical of a river ecosystem and thus the unanticipated negative consequences to the overall health of the ecosystem. Dr Garcia notes that in the proponents own limnology report states that there will be "periods of more intense mixing that bring the sediment release material into the surface waters" (Appendix V 2.3)

Dr Vietz[5] also reiterated that his greatest concern of the EIS proposal is the passing of water flow through the mine pit lake which potentially contains acid sulfate soils. He adds that "redirection of the McArthur River through the mine tailings could impact on bedload sediment transport conveyance from the McArthur River upstream of the mine pit lake to downstream of the mine pit lake" and that this effect has not been investigated in the current EIS. He suggests that to avoid the risks associated with the McArthur River being diverted back through the mine pit lake that an obvious alternative is to not connect the pit mine lake and adequately size the existing diversion channel.

It is of concern that the proponent favours a configuration that will eventually permit exchange of pit lake water to the river. The latest report from the MRM Independent

[4] Dr Erica Garcia, May 9th 2017, A limnological assessment of McArthur River Mine Overburden Management Project Environmental Impact Statement pages 1-2

[5] Dr Geoff Vietz, April 2017, McArthur River Mine Overburden Management Project, Expert Opinion pages 2-3

Monitor[6] reflects on closure planning, and warns of the possibility of ultimate pit lake acidification. We believe that addressing this concern by redirecting the McArthur River through the mine pit lake will not meet the closure objective of leaving the site in a condition that is safe and secure for humans and animals. We note the identified risk in this current EIS for the potential entry of the (relatively large) Largetooth Sawfish into the lake which "could result in mortality of this threatened species if the environment present is unsuitable." There appears to be a deliberate plan to manage ongoing contamination hazard at the decommissioned pit by transporting pollutants to sea - contrary to conditions of the mineral leases.

Given the concerns of Dr's Garcia and Vietz, the MRM Independent Monitor and community concerns we make the following recommendation:

> **Reject the plan to redirect the McArthur River through a mine pit lake and reconsider complete backfill scenario as detailed below.**

Chapter 4 – Decommissioning, Rehabilitation and Closure

Noting the proposed configuration seems designed to send contaminants offsite, we are concerned that the stated closure objectives in regards to water seem limited to beyond the lease boundary for the first century and then only within the McArthur River thereafter. As well as representing valid targets, on-site ground water monitoring will be a fundamental tool for understanding balance of the system as a whole, and transport of contaminants around and off the site.

> **Recommendation: closure objectives should also include quantitative targets for on-site surface and groundwater**

On the little available information regarding so-called 'legacy regions', these would appear to be sacrificed zones, that will require ongoing maintenance of fencing and signage.

> **Recommendation: provide more detail regarding legacy regions**

The draft identifies plans to revegetate "with native woodland and pasture species". This could be interpreted as non-native pasture species which are often weedy, and consequently incompatible for disturbed regions. All non-native plants must be seen as weeds and extinguished from the site. Cattle can graze healthily upon native grasses but exotic ones have impacts on biodiversity that are untenable. Experience with slower than

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[6] *Independent Monitor ENVIRONMENTAL PERFORMANCE ANNUAL REPORT 2015*, McArthur River Mine, August 2016 Accessed from https://dpir.nt.gov.au/__data/assets/pdf_file/0008/384983/independent-monitor-environmental-performance-ar2015.PDF

anticipated success at revegetating the diversion channels from the first stage expansion should inform the approach to revegetation.

Recommendation: clarify stated revegetation plans

The mine pit lake configuration and timeline need further risk assessment for the likelihood of poor wet seasons. This and other features need to be risk-assessed in the context of anticipated variability due to global climate change.

Recommendation: contingency planning for pit lake management in event of dry wet seasons

Experience on other NT rehabilitation projects suggests weed management needs to be concerted and cannot simply be completed in a few years.

Recommendation: appropriate planning for sustained weed management operations

There is a potential that adverse environmental effects may take some time to bioaccumulate and so caution is warranted when reassessing the need to continue monitoring of fauna.

Recommendation: appropriate planning for sustained fauna monitoring

Chapter 5 – Project Alternatives

In this section, we are told (5.5.2.1.2)

> *"The sequencing and scheduling of mining activities has been refined via mine optimisation modelling"*

Noting that environmental performance since the 2012 approval has been far worse than predicted, ECNT recommend that it is time to concentrate on optimising for rehabilitation outcomes rather than mining outcomes.

ECNT welcome the proposal to remove, rather than terra-form, the TSF. In our comments to the previous assessment in 2012, ECNT recommended depositing tailings to the void for closure. We welcome this late recognition of this requirement, but suggest this conclusion could have been reached sooner, without the implication that this preferable configuration should be made dependent upon a further extension to the life of mine.

We applaud contingency planning around early closure. But there is a lack of contingency planning for possible risks during continued mining. While it is not our wished for outcome, to fully inform assessment of the option of extended operations, Glencore should discuss contingency plans for the possible catastrophic failure of the TSF.

DME, in their response to the 2016 IM report, acknowledged:

> "*The most significant risk from current operations relates to the operation of the TSF"*

ECNT welcome recognition that tailings should not be simply capped, but must be returned to the mine pit. This was a recommendation we made in the previous (2012) assessment. Our recommendation was made as a matter of urgency, not just for the long term management of tailings post-mining, but in response to the poor performance of the TSF cell 1.

> **Recommendation: The proponent should fully describe the benefits of immediate processing of tailings and deposition to the mine pit.**

<u>Project vs no project</u>

Despite the statement's claim, the 'no project' scenario should not be interpreted as "*early closure*". This EIS process is in response to a Notice of Intent to *extend* the life of operations, yet again. Glencore's claim that successful rehabilitation is reliant on yet another expansion is alarming. Why did the most recent approval, and subsequent regulation, not ensure that rehabilitation can be achieved within the current context? How might Territorians find any faith that this fundamental objective will be met this time, if it has been ignored to date?

It is particularly jarring that Glencore claim:

> *"The closure of the NOEF is to be managed, in part, by the development of the future NOEF ... Early closure would limit the opportunities for implementation of these proposals."*

ECNT warned in 2012, in response to the draft statement for the last expansion, that further studies to confirm characterisation of the overburden material should be completed before any approval was granted. We identified this as:

> *"fundamental data that should be informing the assessment process - particularly given that less stringent management requirements are being set for NAF material."*

Our recommendation was based on expert advice given to the operator by the (former) Independent Monitor, who cautioned that a much higher proportion of overburden was potentially acid forming, rather than benign. The Independent Monitor identified that some material, while generating a neutral leachate, gave high sulfate and metals, warning that:

> *"the acidity from metal sulfide oxidation precedes the dissolution of the neutralising carbonate. There is also the potential for bypassing of the neutralising mineralogy."*

It is disturbing that Glencore now argue that a further extension of operations must be approved in order for them to adequately address the serious impacts of their wilful miscalculation.

Glencore's assessment of the impacts of a no-go option demand scrutiny and tolerate little doubt. The claim is made that their operation is:

> *"managed and regulated within a well-developed regulatory system, providing stringent controls on environmental and socio-economic performance"*

ECNT strenuously reject this claim, and cite the numerous unprosecuted (but nonetheless documented) breaches of their environmental requirements.

Glencore warn that if this deposit is not fully exploited, other mines would fill the market need, that "*potentially located in a less regulated environment*". We question how much less regulation Glencore might imagine than a sustained refusal to prosecute recurring breaches of the terms of their authorisation. The suggestion that "*this may lead to less favourable environmental outcomes*" is dismal.

The proponent claims DPIR would prioritise access and non-contamination of the remaining resource over prompt rehabilitation, if the new project were not to proceed.

It is true that, given the deteriorating state of infrastructure that has proven inadequate to manage the wastes now loaded, a so-called 'long-term care and maintenance' holding pattern would guarantee ramping environmental harm to surrounding land and water.

ECNT are interested in testing whether DPIR maintain policy that is consistent with the proponent's claim :

> *"It is unlikely, considering Government positions on resource stewardship, that substantial quantities of fill would be placed in the open cut final void with a significant resource remaining within the deposit."*

If indeed such a policy exists, it is imperative that we revisit it promptly, to avoid being blackmailed in this way by a rogue operator ever again. It would be preferable for the resources industry to understand that a future NT Government will weigh more heavily concerns of environmental stewardship than those of comprehensive exploitation of a resource.

ECNT contend that inadequate consideration has been granted this option

> **Recommendation: the proponent should demonstrate a full appraisal of the benefits of ceasing mining operations at McArthur River.**

Discussion of small scale vs large scale underground mining (5.5.2.1.1) underscores the fact that this project has enjoyed - and seeks to continue – a relationship with regulators that rewards staggered applications with piecemeal approvals. What is now described as 'early closure' was, in previous applications, a proposed expansion. Despite clear provision in the EPBC referral process for identifying proposals that would better be understood as a component of a larger action, this proponent has successfully gamed NT and Federal assessment processes to gain successive approvals for a staged development which now presents a far more significant environmental hazard and legacy than initial assessments ever considered. It is highly unlikely that any new mining hopeful who presented plans for a comparable operation, requiring active management for a thousand years, would ever move beyond an initial draft.

ECNT have previously described in a number of forums the risks of piecemeal assessment; that significant harms which may fall through the cracks between each approval, and that cumulative impacts of successive approvals may not get the scrutiny their combined impact should demand. In this project, we see a further flaw of piecemeal assessment: that one inadequately scoped and enforced authorisation can then be perversely presented as justification for a giving the operator more years.

Alternative 7 – Complete Backfill of Final Void

ECNT see value in keeping the final landforms as low as possible, given that

> *"the most prominent habitat feature within the MRM leases is the large sandstone plateau, the Bukalara Range,(which) stands 30 m to 100 m above the surrounding plains"* [9.3.1.1]

ECNT are interested in further exploration of those options (7 and 8) that would backfill overburden to the pit. While it is apparent that handling of the overburden material would present environmental management challenges during decommissioning works, these options appear to offer a number of long term environmental benefits that have not been thoroughly considered in this EIS.

In reviewing the option of complete backfill provided in this EIS, Gavin Mudd[7] highlights the inadequacies of figure 5.10 and the lack of consideration given to the safe emplacement of tailings and PAF wastes into lower section of the mine pit. Critical information regarding historical waste placement, characteristics and volumes is missing from this EIS to enable possible engineering approaches to mitigate leaching risks from wastes in the upper zones. This alternative has not been adequately considered including providing detailed

[7] Assoc. Prof. Gavin M. Mudd, May 2017, *McArthur River Mine Overburden Management Project – Draft Environmental Impact Statement.* page 5.

hydrological assessments, acknowledgment that risks can be mitigated and fails to make a strong case that this option should be rejected.

Gavin Mudd further highlights the distorted and bias comparison in reference to Table 5.4, he states the table "appears to be somewhat subjective, is heavily focussed on financial aspects – with 8 of the 12 key aspects relating to financial costs (i.e. constructability, financial cost, maintenance ease). This effectively biases the outcome towards avoiding a higher cost approach that delivers better environmental and social outcomes, which is where the primary focus should be". We lament that Glencore is very quick to say that this option will render the project uneconomic and unviable. As Mudd[8] points out the NT Rum Jungle Mine first rejected the proposal to backfill waste rock on cost grounds. Now after failure of the above ground rehabilitation works, the project is committed to back fill at the expense of this NT community. Does rejecting this alternative option at this point effectively transfer the cost of safe and secure rehabilitation to future generations? The public have little detail to go on regarding the costs of rehabilitation, and the miner's capacity and willingness to meet those costs in the short or long term.

We adopted Mudd's recommendation:

The EIS Response Document must include a realistic complete backfill scenario which ensures all PAF material is sequenced as deep as possible in the former pit. As part of the process, the broader Borroloola community must be engaged meaningfully in ascertaining their preferences for complete pit backfill – with a multi-criteria analysis or approach which properly allows for their social and environmental preferences to be included as equalweight to financial or economic considerations (i.e. cost alone should not dominate rejection of the complete backfill scenario).

The following scientific opinions add weight to our concerns for this project as it has been presented by Glencore. We urge you to read the reports that we have submitted in their entirety as our summaries are unable to do them justice.

Chapter 8 - Water Resources, ground and surface (inc Appendix T & N)

Upon reading the comments from Abbas El-Zein[9] we support his serious concerns regarding 'both the approach taken to protect water from contaminants and the quality of predictions from the numerical modelling of groundwater contamination by heavy metals'.

[8] Ibid, page 6.

[9] Abbas El-Zein, *Environmental Impact Statement on the Expansion of the McArthur River Mine,* May 2017

His first concern is that the project assessment appears to rely on sorption as the primary means by which heavy metals are prevented from polluting surface waters downstream without consideration of competition, non-linearity and pH sensitivity. The evidence provided in the EIS may not be a "scientifically valid assessment of the extent of attenuation of heavy metal contamination as sorption needs to be determined for the specific geology of the MacArthur River region while considering competition between contaminants for sorption sites, non-linear sorption conditions, sensitivity to soil pH and desorption"[10]

He goes on to say "judging by the EIS, the reliance on sorption for protection of surface waters downstream of the mine has not been adequately supported by the evidence provided in the EIS and carries therefore significant risks. If sorption has been overestimated, the actual concentrations of heavy metals may be orders of magnitude larger than those predicted in the EIS and may travel manyfold further than estimated in that document". This needs to be addressed in the EIS response document.

El-Zein[11] also asserts that detailed designs of the base lining for the NOEF need to be provided. "Absence or inadequate design of this feature would be against best practice and may lead to contamination at the receptors"

El-Zein's[12] assessment also address concerns related to low confidence in contaminant transport model provided and asserts that "more detailed information about the contaminant transport model is required for a proper assessment of the risk to receptor". This is a significant issue as "the numerical model is the single most important piece of evidence on which the EIS bases its argument that the mine's activities, as planned, can be conducted while achieving the environmental standards required. Therefore, significant weaknesses in the model raise serious concerns about the future risks to water quality".

Lastly El-Zein questions whether molecular diffusion needs to be considered given that "the EIS stated aim to provide protection for ground and surface water for up to 100 years and then and up to 1000 years, and given that many parts of the geology around, and downstream from, the site have low to very low hydraulic conductivities". This is significant because "if diffusion turns out to be significant in parts of the geology, concentration of contaminants at the source may be higher than what is predicted by the EIS report and the contamination plume would travel further than what is shown in Figures 154 to 162".

Recommendation: The EIS Response Document needs to respond to all of Professor El-Zeins concerns and refer to his detailed comments on the EIS for further understanding of the important issues he raises.

[10] Ibid, page 3.
[11] Ibid page 4.
[12] Ibid page 5.

We also support the following recommendations from Gavin Mudd concerning water resources[13]

The discrepancy in using SILO versus onsite climate data should be explicitly justified, as there appears to be a potentially significant inconsistency in annual rainfall values – these are critical in ensuring the accuracy of all hydrological models used for the EIS.

The EIS Response Document must outline methods to identify the extent of groundwater contamination across the MRM site and propose plans for its remediation before or during rehabilitation and site closure to ensure that environmental and cultural values are maintained The groundwater monitoring plan should include bores downstream of the diversion channel (e.g. on the far right of Figure 8-53).

The EIS Response Document must include proposals to distinguish possible mine-related impacts on the surface water quality of the McArthur River. Such methods must allow the neutral identification of the source from the MRM site, and provide scope for warning before the impacts are severe.

Again we urge you to seek further understanding directly from his comments.

Appendix N – Geotechnical Assessment
Information detailed here is provided by Professor David Airey[14] in his comments for the Draft EIS

Airey states that "a thorough analysis of the NOEF stability is presented using appropriate methodology. However, any analysis is only as good as the input parameters and this is where I have some concerns". In the case where no original data has been provided in the EIS "it is thus impossible to assess the methodology used to perform the tests or the methods of interpretation. In my experience, based on reviewing test reports, simply performing Australian standard tests does not guarantee the quality of the data. They need to be carefully reviewed by experienced geotechnical engineers who have a thorough understanding of soil mechanics". His biggest concern relates to "Figure 13 in Appendix N. This shows a plot of peak friction angle against "cohesion". The first and most critical issue with this is that most clays do not have any true cohesion". He goes on to say 'the reason why this is critical is that the stability of the steeper part of the slope of the NOEF relies on the "apparent" cohesion (c'). It can be shown by a simple infinite slope analysis with a failure plane running along the CCL layer that the factor of safety increase from 1 to 1.5 is due to the apparent cohesion. If the cohesion is assumed to be zero the factor of safety will be one, that is the CCL will be on the verge of failure, and this would represent an

[13] Assoc. Prof. Gavin M. Mudd, May 2017, *McArthur River Mine Overburden Management Project – Draft Environmental Impact Statement.* page 7-8.

[14] Professor David Airy, *Report on the Draft EIS of the Overburden Management Project*, May 2017

unacceptable risk on any critical slope. To understand the basis for the “apparent” cohesion more information is required”.

Professor Airey continues to raise concerns regarding friction angles, cohesion, pore pressures and water retention curves. This is admittedly beyond our technical understanding but we are clear that he raises very valid concerns that need to be fully addressed in the EIS response.

> **Recommendation: The EIS Response Document needs to respond to all of Professor Airey’s concerns and refer to his detailed comments on the EIS for further understanding of the important issues he raises.**

Chapter 12 - Social Economic Environment

Perhaps the most significant economic benefit from this project to the NT comes from employment. The employment figures as displayed in Appendix Z may be misunderstood by the presentation of totals. Unlike revenue, employment does not accrue; if and when we enable jobs for the second stage of the project, we no longer have the jobs from the previous stage.

Section 6.2.2 of Appendix Z claims that NT royalties are directly related to production levels: this has not been the evidence over most of the life of the mine. The NT has no control over what profit Glencore pays royalties on, irrespective of the volume of production.

While the short term and immediate economic benefit of extended operation are well described, neither the Economic Impact Assessment nor the chapter on socio economic environment adequately address the nature of transition to a post-mining economy. ECNT welcome the recognition of Gurdanji ambitions for ongoing employment in the closure and monitoring phases of the project through a Gurdanji Rangers Unit. It is likely that various actions from the community benefit fund will contribute to building the local economy as operations at the mine scale down, but insufficient detail is provided. We are not well equipped to evaluate the economic benefit post-mining of the various project alternatives.

> **Recommendation: describe in more detail how the economic benefit from extended operations can contribute to a smooth transition to a post-mining economy.**

Final comments - Long term monitoring
We support and adopt Associate Professor Gavin Mudd's[15] recommendations regarding long term monitoring and his request for detail financials for project funding for one thousand years. This is required to give confidence and certainty that it will not be the tax-payers left to fund a safe and secure rehabilitation. Guarantees need to be given that the present and future generations of the Borroloola community will not be left living in a perpetually poisoned environment.

The EIS Response Document must present a detailed approach for assessing surface water quality and how to identify potential mine related impacts.

The EIS Response Document must present a detailed financial approach for ensuring that funding for the next one thousand years will be secured by the MRM project and not left to tax-payers to fund.

Appendices:
The following reports have been emailed with our submission and form a part of our Appendices (in order of appearance in our submission)

Assoc. Prof. Gavin M. Mudd, May 2017, *McArthur River Mine Overburden Management Project – Draft Environmental Impact Statement*

Dr Erica Garcia, May 9th 2017, A limnological assessment of McArthur River Mine Overburden Management Project Environmental Impact Statement

Dr Geoff Vietz, April 2017, McArthur River Mine Overburden Management Project, Expert Opinion

Abbas El-Zein, *Environmental Impact Statement on the Expansion of the McArthur River Mine,* May 2017

Professor David Airy, *Report on the Draft EIS of the Overburden Management Project*, May 2017

[15] Assoc. Prof. Gavin M. Mudd, May 2017, *McArthur River Mine Overburden Management Project – Draft Environmental Impact Statement.* page 8.

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Dear Mr Johnson

DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR THE MCARTHUR RIVER MINE – OVERBURDEN MANAGEMENT PROJECT

We thank you for the opportunity to submit comments to the Draft Environmental Impact Statement for the McArthur River Mine – Overburden Management Project (the "Project"). Officers of the Northern Land Council (NLC) have examined the document and have prepared a submission, which is attached.

The NLC advocates that further research be undertaken to ensure that all risks associated with the Project are captured in the EIS and provide maximum protection to the environment of the region. The NLC submission draws attention to the following issues that are considered to be of particular significance to local Aboriginal people and the NLC:

- Proposed management of reactive waste material and spontaneous combustion;
- Stakeholder consultation;
- Competence of both the mine operator and regulator; and
- General comments about deficiencies relating to the EIA process in the Northern Territory

These issues and other concerns are further described in the NLC's submission. Should you have any queries regarding our comments, please do not hesitate to contact Rhonda Yates on 8920 5241 or via email sarmar@nlc.org.au.

Yours sincerely

Joe Morrison
CHIEF EXECUTIVE OFFICER

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Draft Environmental Impact Statement for the McArthur River Mine Overburden Management Project

Northern Land Council Submission to the

Northern Territory Environment Protection Authority

17 May 2017

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<u>ATTACHMENTS</u>

1. Cultural Heritage, Socio-Economic Environment and Consultation Processes
2. Issues Related to Spontaneous Combustion

1 Introduction

The Draft Environmental Impact Statement for the McArthur River Mine Overburden Management Project (the EIS) is an extraordinary document about a singular development with a remarkable history: the world's largest zinc/lead extraction and processing operation as overseen by Australia's weakest political jurisdiction.

On the one hand, the EIS seeks “closure” by setting targets for ending mining operations and constructing a new post-mining landscape. On the other, by formally proposing a 1000-year timeline for observing and intervening in that landscape's evolution, this proposal shows that there will be no end to the uncertainty created for the Aboriginal owners and other users of the mid-to lower McArthur River catchment and its adjoining seas.

The Northern Land Council (**NLC**) provides support to the Top End (Default PBC/CLA) Aboriginal Corporation, which is the registered native title body corporate in respect of native title determination over the area of land covering McArthur River Station, on which the mine is located (**Native Title Determination**). The *Aboriginal Land Rights (Northern Territory) Act 1976* also requires the NLC to *“assist Aboriginals in the taking of measures likely to assist in the protection of sacred sites on land (whether or not Aboriginal land) in the area of the Land Council”*.

Mineral leases granted under the *McArthur River Project Agreement Ratification Act 1992 (NT)* expire in January 2018, but the relevant Minister is required to renew them for a further 25 years, ending in 2043. On expiry of the leases then, or somewhat later when the mining stops (which is currently proposed for 2048), the native title rights over the site will have full effect. Native title holders will have rights to, for example, conduct cultural activities, take and use the natural waters and other natural resources. The condition of the land and its resources - hence the on-site and wider effects of the mine - are of critical interest to native title holders and other Aboriginal land owners and residents in the region.

The NLC is obliged to do all it can to ensure that those rights and interests are not compromised. The focus of this submission is therefore on those aspects of the proposal that are considered most likely to affect the long term interests of the native title holders and other Aboriginal people. These encompass present and future operations and approaches to closure.

2 Understanding of the proposal

The proposal under consideration differs from operations already approved after previous EIS in that it incorporates:

- extending the commercial operational life of the mine to 2047;
- re-designing the principal overburden dump to a smaller footprint but taller profile with consequently steeper slopes, enabled in part by placing some overburden in worked out sections of the open pit late in mine life;
- new processes for categorising and handling waste rock, including highly reactive material;
- when extraction of ore from the pit is nearly complete, reprocessing tailings to extract additional saleable product (lead-zinc concentrate): running from about 2037 to 2047;

- placement of reprocessed tailings in the pit, and decommissioning and rehabilitation of the tailings storage area when all tailings have been removed (about 2045-2048);
- completion of construction of a single waste rock dump encompassing the existing northern overburden emplacement facility (NOEF), its covers and associated drainage and monitoring systems prior to mine closure (progressively from 2018-2031);
- active filling of the open cut pit with water to minimise length of exposure of reactive material (2048-2052);
- reconnecting the natural McArthur River channel with the pit (first downstream and then upstream) if pit water quality permits, so that the river flows again but through the open pit "lake" (tentatively 2062 for downstream and 2072 upstream connection);
- new rehabilitation objectives for the site and its offsite impacts; and
- processes and timelines for monitoring and responding to performance in meeting those objectives, including:
  - a period (of "adaptive management" of the site during which adjustments and structures and processes might be made to improve performance (from 2047 for about 70 years);
  - another longer period of "proactive monitoring" to check whether performance meets targets (from about 2120 to 2200); and
  - a subsequent "reactive monitoring" phase that would continue indefinitely during which the site would be checked when there was reason to anticipate disturbance (i.e. extreme weather, earthquake, etc.) that might compromise structures (from 2200 nominally to 3037).

Because methods of extraction and processing and total volume of ore mined and rate of mining do not differ greatly from existing approvals, the EIS does not cover mining, processing or haulage operations.

3 Approach to analysis and commentary

As noted above, our concerns relate primarily to issues with the most direct and enduring impact on Aboriginal connections to lands and capacity to safely use waters and other resources for customary, recreational and commercial purposes. We have therefore focused on understanding the implications of proposals for waste rock handling and tailings disposal, which have the potential to contaminate surface and groundwaters over the very long term and use of the open cut pit on completion of ore extraction, which will become a permanent and problematic feature of the landscape. We also offer some additional comments on less central but still significant matters of concern.

The comments and recommendations specific to the Project will therefore emphasise:

(1) treatment of Aboriginal and other local interests in setting objectives, especially in regard to post-mining (rehabilitation) targets;

(2) difficulties with the existing overburden emplacement facilities (OEF), especially the new NOEF;

(3) design of the NOEF, including its incorporation of the existing structure;

(4) proposals for in-pit disposal of reactive overburden and tailings; and

(5) use of the open cut pit and its connection to the river-scape.

We will also offer comment on issues raised by this Project and its history, but which also have wider relevance, including:

(6) weaknesses in the Environmental Impact Assessment (EIA) process and the regulator's capacity to set meaningful conditions;

(7) capability and commitment of both operator and regulator to manage the process and ensure conditions are met; and

(8) transfer of risks and costs to landholders, residents, resource users and other members of the general public.

Where references are made to particular statements cited from the EIS, page numbers are prefixed by chapter or appendix identifier (e.g. 3-10 and A-10 refer to page 10 of Chapter 3 and Appendix A respectively). Other references are provided in full in the endnotes.

4 Consideration of issues

The comments are based on input from Aboriginal people with connections to the affected region, and NLC staff. And although we have chosen to use the themes outlined above to present our submission, some additional matters of concern are raised in recommendations.

Due to the large amount of information provided in the EIS, its highly technical nature, its presentation, and the limited time given to respond, we expect to seek and receive additional input as awareness of the proposal grows and relevant people have more time to consider its implications. More matters may be raised with the NTEPA and government as the process unfolds.

4.1 Aboriginal interests and environmental objectives

This EIS is unusual in setting very long term closure objectives (page 3-41). The form and content of those objectives and the way they were arrived at says a good deal about the proponent's view of Aboriginal landowners, their communities and their place in the Territory.

The core goals set out by the proponent are to leave the post-mining landscape "safe and secure" in the short term (100 years) and "safe" for the long term (1000 years). In going beyond these vague terms, emphasis is placed on geotechnical, erosional and geochemical stability and on monitoring these features at the mine site.

Stability is an obvious requirement for safe and usable landscapes but it is remarkable that this term should be used to describe a situation that will require active intervention in perpetuity. For example, maintaining geochemical stability on site will require the regular removal of contaminated sediments and water from various sumps, trenches and natural drainage lines for disposal into the pit or directly into the river. Achieving local stability in the ways proposed under the EIS will, as raised later in this submission, create risks of destabilising areas outside the mine site and will themselves be unstable because they are dependent on undisclosed governance and financial arrangements.

Security can be defined as freedom from danger or threat. It is an essential pre-requisite for people to maintain customary and other relationships with land and waters. They must be free

to use animal and plant resources without fear that they have been adversely changed. From this perspective, priorities for the region's Aboriginal people, including native title holders and sacred site custodians might be expected to place special emphasis on the health of the region's natural resources and the integrity of sites of significance in their cultural and landscape settings. However, there is no way of determining from the EIS what relevant Aboriginal people actually think, because the consultation process and the manner in which it is reported are flawed.

These problems are set out in detail in Attachment 1, and can be summarised as:

- In the NLC's opinion inappropriate identification of people with the authority and knowledge to speak for relevant country on matters affecting its management and condition;
- many individuals identified as traditional owners who, in the NLC's opinion, are not traditional owners of the area within the mineral leases;
- failure by the proponent to identify, in NLC's opinion, the correct people as traditional owners people of the area covered by the mineral leases, including areas on which the expanded NOEF is to be sited;
- no information by the proponent on how it identifies "custodians";
- failure to engage with relevant organisations, including the NLC, who have the statutory roles and knowledge, to identify the correct people;
- despite recognition of the risks involved in consulting the wrong people, failure to manage the process to avoid these risks, risks which also include subsequent conflict;
- failure to observe leading practice for consultation and public participation in the assessment, despite readily accessible expertise and industry and other guidance on these issues[i,ii];
- failure to satisfy the requirements of the EIS' terms of reference relating to objectivity; and
- no evidence that key environmental and other risks from operations and closure objectives and the proposed management of these risks were properly communicated to the correct people in an objective manner and that people had the opportunity to seek independent advice.;

For these reasons, the NLC is not satisfied that the correct people, particularly custodians, have been identified and consulted or that consultations were conducted properly. In our view, consultations need to be undertaken with the relevant custodians, not just by the representatives of the proponent, where such consultations are unlikely to be on arm's length terms, but rather with custodians being afforded the opportunity to obtain independent advice which is especially important in light of the long-term impact of the proposal.

4.2 Retention of the existing NOEF

The existing NOEF was poorly constructed in a manner which apparently did not accord with conditions of approval for Phase 3 (page 3-110). There appears to have been no effort to construct a continuous, uniformly impermeable base using benign materials (suitable clays) available on site. Although the existing facility appears to be naturally underlain by alluvial clay over much of its area, it is also intersected by stream channels (page 3-175 and elsewhere) filled with highly permeable alluvium (sands and gravels; page 6-73), creating a

number of competent pathways for seepage entry to groundwaters. This problem is exacerbated by construction at or below 2013/14 groundwater levels[1] (the level at which the new NOEF will be built). Modelling suggests that groundwater will be at or higher than these levels at least one year in 12 (page 3-115), posing a significant risk to the integrity of the base.

Compounding these fundamental errors, the emplaced overburden was not well segregated and salinity-generating and acid-forming materials were mixed with benign materials in many parts of the structure (page 3-109). Some highly reactive material was placed outside the cell intended to accommodate potentially-acid forming (PAF(RE)) overburden. Reactions continue at significant rates in a number of locations, evidenced by "hotspots" revealed in drilling programs (page H.52 and elsewhere).

Given the state of the existing NOEF, oxidation products from both the PAF cell and improperly-placed material may currently be entering groundwaters in substantial quantities. Even if encapsulation is successful in slowing reactions, the vadose zone will likely intersect improperly placed non-benign (and often oxidised) materials with some frequency to exacerbate contamination of seepage, including mobilisation of metals. If the material is not removed to permit construction of a functional low permeability base, then seepage rate targets set for other parts of the (expanded) overburden facility cannot be met and groundwater and surface water pollution will be greater than would otherwise be achievable: and these problems will continue indefinitely.

MRM has categorically rejected the option to replace or reconfigure the existing NOEF (page 3-104). Indeed the company has implied that a requirement to do so may put at risk the continuation of mining (page 7-27), community benefits (page 7-18) and quality of rehabilitation (pages 7-29, 7-30).

Nonetheless, it is the NLC's considered view that the flaws in the existing NOEF will not be sufficiently ameliorated by incorporation in a larger structure, because problems with the base are not addressed. In our view there could be no clearer obligation than to correct past mistakes. Yet the response presented is to cover it up and require local people to accept the consequences.

4.3 Design of new Overburden Emplacement Facilities

Having completed important work on materials classification to better segregate and store problematic overburden, MRM proposes an improved design of new parts of the main waste rock dump, the NOEF, including a constructed low permeability base, cells for reactive material divided by low permeability advection layers, a halo of relatively benign material, and a low permeability cover over upper surface and sides to limit both infiltration of water and movement of gases (pages 3-110 to 3-120). Steps are also proposed to improve operational performance in selectively handling and placing overburden within facilities (pages 6-67 and 6-68).

The design also differs in storing more material on a smaller footprint, requiring a much taller structure with steeper sides. In addition to concerns about the decision to incorporate an existing flawed structure in the existing NOEF, the revised design also raises a number of additional issues for Aboriginal interests.

1 Appendix H (NOEF Historical Construction and Drilling Report) does not give elevation relative to groundwaters, but it appears reasonable to assume that the new NOEF would be built no lower than the existing level.

4.3.1 Height

At the request of custodians of the nearby Barramundi Dreaming sacred site, the NOEF height is presently restricted to 80 metres. At 140 metres, the redesigned structure will be 60 metres higher than the previous design. MRM stated that that they have obtained the written consent of relevant traditional owners (page 12-43). However, as noted in Section 4.1, there is a lack of information about the process which MRM adopts to identify the custodians. There is also no information as to the consultation process involved with the custodians and whether the custodians were afforded the opportunity to obtain independent advice about the agreement as any advice provided by MRM about the impact of the agreement would not be independent and objective.

4.3.2 Stability and durability

There are also serious concerns about the physical stability of such a structure that is apparently expected to remain in place for at least 1000 years.

Sides will be trilinear concave, being steepest at the top (1v:2.5h) and shallowest at the foot (1v:4.5h). The EIS acknowledges that construction at these angles with available mine machinery will be challenging (page 3-131), especially given the importance of flawless continuity of impermeable covers extending down the sides to the base. Irrespective of the quality of construction, erosion and slippage is inevitable. The EIS also acknowledges that regular repairs will be essential (e.g. J-67 to J-71), which will be especially challenging after cessation of mining given the likely absence of appropriate machinery. Stability may also be compromised if oxidation of reactive components of the core continue, including the risk of spontaneous combustion that would lead to slumping. Risks are increased by the decision to retain the existing NOEF in its present “contaminated” form.

It therefore appears questionable to apply the **minimum** Factor of Safety for tailings dams (page 3-151) in an environment where: parts of the base will be regularly exposed to groundwater over somewhat heterogeneous natural sediments (particularly in the case of the existing NOEF: see Section 4.2 above); extreme rainfall events are common and recurring erosion is therefore inevitable; and exposure of the base to external flooding from the McArthur River, Surprise Creek and Barney Creek is likely during the period covered by the EIS (noting that flood protection measures are designed to cope with 1 in 100 year events - page U-250 and elsewhere).

It is relevant that in documents prepared for the Phase 3 EIS[iii], stability benefits of shallower slopes were emphasised, with 1:4 slopes regarded as providing an adequate Factor of Safety. It was noted that rock that may initially be relatively stable at the angle of repose may need cutting back to a 1:4 slope to enable erosion protection if it became more friable with weathering.

The NLC has serious concerns about risks of catastrophic and/or progressive failure of the proposed structure. Obviously, well-designed facilities for safe handling and storage of reactive overburden will be required throughout mine life and the proposed siting of the bulk of the overburden may be reasonable during operations. However, we consider that a decision to leave a large and inherently unstable waste rock dump on an active floodplain transfers too much risk and ongoing liability to local Aboriginal people and the Territory public in general. The manner in which necessary levels of expensive repair and other intervention could be guaranteed indefinitely is unclear and is likely to remain uncertain. Local resources are already stretched in coping with other mining legacies[iv,v,vi].

4.3.3 Cover and advection barriers

In options for NOEF design and construction, bituminous geomembrane was identified as a functionally superior alternative to compacted clay liners to both limit advection (oxygen reaching reactive material) and percolation of water (contributing to some reactions and mobilising oxidation products). In presenting results of a multi-criteria analysis for NOEF cover design, it is shown that the membrane scores best of all options considered, if it is assumed that it remains functional over the very long term. Initial costs would be offset by relative simplicity of repair (page U-65).

Its use was, however, rejected on the grounds that "further investigation and validation of installation methods, as-built performance, and longevity will be required before this alternative could be considered for large scale operational use" (page 3-130). Doubts about long term durability appear to have been decisive.

Given the risks of recurring failure of alluvium-based covers due to erosion and the other factors outlined above, capacity to make rapid repairs effective over timeframes relevant to the length of mine operations (prior to closure), appears to us an important advantage. As noted above we do not regard a "permanent" OEF on the floodplain as a serious option, irrespective of cover design. But given the problems experienced with overburden management to date, we would argue that improved capacity to rapidly and effectively limit oxygen and water entry to overburden facilities is essential, and the role of such membranes should be re-considered for this purpose.

4.3.4 Seepage

The effectiveness of compacted clay layers in limiting movement of gases depends strongly on their moisture content. The NOEF design emphasises a balance between sufficient percolation to maintain performance of advection barriers while avoiding excessive mobilisation of pollutants and their entry to groundwaters (S-83). This approach requires acceptance of ongoing interventions to capture and remove "toe" seepage through drainage layers built into the OEF and to intercept deeper seepage through trenches and vertical or horizontal bores (e.g. page 15-18). Barney Creek and Surprise Creeks become permanent drains for handling polluted groundwater expressed at the surface. Polluted waters will mostly be disposed of in the mine pit or flushed down the McArthur River at time of high flow, as permitted in the mine's Waste Discharge Licence (e.g. page 8-3).

We consider that every plausible measure should be taken to limit the total loads of pollutants entering the McArthur River, and argue that the proposed NOEF design unreasonably increases these loads. Much reliance is placed on the capacity of soils to neutralise acid products and bind metals before they reach the river, but information is not presented on how long this capacity can reasonably be expected to be maintained nor the extent to which competent pathways to both shallow and deeper groundwaters will emerge to evade neutralisation and absorption. We suggest re-examination of the potential for the levels of oxidation products that ultimately find their way into the McArthur River to be significantly reduced by use of bituminous membranes in life of mine waste rock dumps. The EIS notes that tightening of discharge criteria may compromise the ability to relinquish the site (page 4-12).

Irrespective of the trigger values for contaminants at the key monitoring point at SW11, there remains considerable uncertainty about their ultimate fates and the risks of accumulation in parts of the river and its catchment. Dumping contaminants in the river during high flow obviously dilutes them, but it also means that they will be delivered to the floodplain where

they may accumulate in depressions that lose water primarily by evaporation. Even within streams, slackwater areas tend to accumulate more metals[vii]. There appears to be no consideration of this important issue.

Related concerns about unremediated pollution of deeper groundwaters are covered in Sections 4.4 and 4.5 below.

4.3.5 Spontaneous combustion

Work done to improve classification, recognition and segregation of highly reactive overburden will help reduce the risk of spontaneous combustion of sulphide-rich materials. Risks remain in the existing flawed NOEF (page 3-109), which is not to be reconfigured despite showing hotspots where oxidation rates continue to be high.

Additional risks will arise during construction and operation of new overburden arrangements, wherever they are located. For example, it is not clear whether the proposed 10 cm separating layer of compact alluvium (page 3-104) will isolate PAF layers enough to inhibit sustained and spreading reactions. Will reactions beginning in one layer - say as a result of exposure to moisture in un-seasonal rain events or unusually high humidity during handling - facilitate oxidation in others through heating and related convective and diffusive movement of gases through the layers of reactive material and the thin bands of benign material separating them? All alluvium to be used in PAF cell construction should be rigorously tested for suitability.

Thermal monitoring of the NOEF may allow MRM to identify areas where combustion events are occurring, but it will not be useful as a predictive management tool unless the temperature at which combustion commences is known. The EIS does not appear to present any direct evidence that its thermal imaging systems will be capable of detecting change early enough permit intervention before substantial SO_2 has been generated and is detectable by gas monitoring systems.

4.3.6 Dust

All overburden placement options, irrespective of levels of rehandling, raise serious issues in management of dust that led to elevated metal levels in sediment and fish in Barney Creek (page 1-21 and elsewhere). The Independent Monitor noted failures to report exceedances of soil and sediment criteria at a number of sites during 2015[xiii].

The principle treatment for dust suppression is watering (e.g. page 7-30), which is clearly inappropriate when handling non-benign waste rock which is most likely to produce bio-available metals. Problems are likely to be significant in all OEF areas. Ongoing and intensive mitigation measures such as sediment traps will be essential to avoid similar risks in all drainage lines within reach of dust plumes, but will not retrieve all metals deposited, which may accumulate in poorly drained depressions in the landscape.

The NLC views the entry of lead and other toxic metals to food chains as a most serious threat to the health of Aboriginal people who regularly consume animals at higher trophic levels that may accumulate metals at dangerous levels. These include goannas, turtles, file snakes and birds that consume small fish and that may move from the site of contamination. None of these have been examined for elevated lead or other relevant metals. It is essential that monitoring of lead in tissues extend beyond the obvious species like barramundi (pages W-16 to W-19) or plants that probably pose much lower risks.

4.4 Placement of tailings and/or overburden in open pit

The major change between the Phase 3 EIS and the overburden project is to dispose of mine waste, including some overburden, tailings and polluted ground- and surface waters into the mine pit, which would be filled with water.

4.4.1 Tailings

MRM intends to change arrangements for long-term management of tailings. When all accessible ore has been processed, tailing reprocessing to extract additional concentrate will begin (in 2037), with reprocessed waste going into the open pit (page 5-17). The Tailings Storage Facility will be decommissioned and rehabilitated, reducing or at least relocating one major long term source of contamination of ground and surface waters. Existing tailings will be moved to the mill for reprocessing as a slurry and waste pumped to the pit in the same form. In general, the NLC views this as a positive concept, but there remain some significant questions about the relative benefits and (environmental) costs of the methods proposed in the EIS to use the pit to store tailings or overburden or various combinations of both; and about the related condition of pit waters in the short to long term.

4.4.2 Overburden

Some highly reactive overburden extracted late in mine life is also to end up in the pit. Initially it will be stored in temporary PAF cells in the Eastern OEF, which is protected from flooding by placement within the mine pit levy (page 5-16). Seepage will be directed to the open cut.

However, the option to return all overburden to the pit has been rejected. The EIS describes this option (Alternative 7) as placement of "overburden inside the mine levee wall where the perception is it will have a lower risk of impact on the external environment" (page 5-29 to 5-32). It is argued that:

> not all overburden can be accommodated below the natural surface level in the final void, due to the material swell factor in the order of 25-35%. Excess overburden would need to be placed in a specially constructed facility about 20 m in height constructed over the back-filled open cut final void, extending from the WOEF to the mine levee wall. Priority would be placed on returning potentially reactive overburden to the final void meaning that majority of the tailings will remain in a surface storage facility so as not to consume final void capacity for the replaced overburden.

Many reasons are given for this option being untenable (page 5-31), including:

- The existing and expanded NOEF core, encapsulated for up to 20 years, would be re-exposed, increasing oxidation rates and risking release of additional contaminants.
- The original contaminant load, plus the increased load, placed into the final void and overlying OEF and would require ongoing management. Oxidation products will include soluble contaminants with potential for bioaccumulation.
- Large scale water treatment would be required during the backfilling process to remove these contaminants from the water.
- Despite water treatment and barrier layers, oxidation products may have connections to the external receiving environment.

- Rainfall and surface water runoff accumulating inside the mine levee would not have an escape pathway. This water would either have to be pumped back out over the mine levee wall or left to infiltrate (e.g. via palaeochannels under the mine levee wall). Pumping would be required for the foreseeable future, while infiltration increased risk of the water becoming contaminated and entering the downstream environment.
- The mine levee would require perpetual maintenance.
- Undertaking another mining activity (NOEF back into open cut) will have impacts (e.g. dust and fuel consumption (with greenhouse gas emissions).
- Re-exposure of overburden material risks spontaneous combustion generating sulphur dioxide, posing a health and safety risk.
- This option presents the greatest cost ... rendering the project uneconomic and unviable. No further operations would occur, with consequent cessation of employment and community investment projects, services, taxes and royalties.
- Tailings would remain in a capped facility in the present location.

A related option is to put the worst of the reactive overburden in the pit and to retain a smaller, lower profile waste rock facility north of the existing one, containing a significant amount of non-benign overburden (Alternative 8 pages 5-32 to 5-34). The highly reactive overburden placed in the pit would be topped with a layer of overburden with high neutralising capacity mixed with tailings to form a relatively impermeable layer. This would in turn be capped with a layer of compacted clay over which a layer of benign alluvium and rock would be placed. This layer would be at a depth about 16 m below the natural surface, ensuring that only benign materials would be in the alluvium stratum where most groundwater movements occur.

This option raises many of the same difficulties associated with the full return of overburden, as well as more complex overburden handling arrangements on a substantially larger footprint, including areas north of the present NOEF. The EIS also rates this option as commercially non-viable, and requiring that mining halt.

It is impossible for the external reviewer of this material to make judgements about the merits of these competing arguments and the proponent's selection of the preferred option, because none of the environmental costs of any of the options are quantified in ways that permit meaningful comparison, and claims about financial cost are not supported by any information at all. These difficulties are compounded by the fact that the bond available to repair existing damage and the conditions under which it can be accessed are unknown.

The discussion of options presented in the EIS is therefore most useful in revealing, beyond any reasonable doubt, the deep intractability of the severe environmental problems already created, which are likely to grow in scale with continued mining. All options are plagued by great uncertainty: and all require ongoing maintenance of artificial and potentially fragile structures and rigorous and expensive monitoring of their condition and contaminant products for a very long, but ultimately uncertain period of time. There is no unambiguously favourable response to the dismayingly difficult situation the operator and the regulator have created for the region's people and the Territory more broadly. We return to this issue in recommendations.

4.5 An open cut lake

The proposal to place tailings and some overburden in the pit and then fill it with water is presented as the best way to isolate these materials long term. Immersion is argued to bring oxidative reactions to a halt through persistent anoxia at depth (the tailing surface will be about 150 m below the lake surface) maintained by thermal stratification that will also inhibit mixing of contaminants of concern into the upper water column. Immersion will inhibit oxidation of acid forming materials in the pit wall to reduce acid and metalloid discharge from that source.

However, we consider that there is considerable uncertainty about the level of mixing that will actually occur[viii], especially if the lake is reconnected to the McArthur River (page V-21). We also understand that other chemical reactions can contribute to mobilisation of metals under aqueous low oxygen conditions, sometimes driven by micro-organisms that derive energy from metabolism of sulphides[ix]. This uncertainty is acknowledged in "a contingency to isolate the mine pit lake from the McArthur River in the event that water quality is compromised by unanticipated chemical reactions ..." (page AB.21). But if sites of such reactions are close to groundwater flows, then as well as increased contamination of pit water, transport from the lake and expression in external surface waters may occur.

The EIS notes the existence of large "unknown" deeper groundwater connections between the underground mine workings and other parts of the landscape. Contamination reaching deeper groundwaters may also be expressed at the surface in upwellings - as the EIS suggests occur with some naturally saline waters (e.g. T-64) - or prevent productive and safe use of deeper groundwaters in the future. The EIS does not explicitly address issues associated with deeper groundwater contamination, emphasising interception of near surface groundwaters in natural drainage lines or interception trenches (e.g. 3-159, 164). The conditions under which deeper dewatering may be considered necessary and deployed through vertical and horizontal wells to extract contaminants of concern is not specified (e.g. pages, 3- T-51). Experience with interception wells at the TSF suggested they were ineffective and their use was discontinued (page T-50). Interception wells do not appear to be proposed in association with the NOEF, but they are mentioned as an option for the southern OEF (3-98).

Suggestions that the lake will, in a reasonable time, achieve water standards that permit reconnection to the river and allow discharge of near-surface waters under high flow conditions - and so help maintain pit water quality - are premature. And to set up the McArthur River as a permanent receiver of unspecifiable contaminant loads from multiple sources also appears to us to be unacceptable. It is irresponsible and potentially misleading to have informed the traditional owners that they may be able to use the pit waters (page Y.6) for any purpose in the reasonably foreseeable future.

In regard to catastrophic failure, the EIS offers assurances that pit walls will be stable over the very long term so that risks of collapse, and consequent re-mobilisation of sediments and a pulse of highly contaminated water entering the McArthur River are low. Similar types of risks may arise from failure of levees controlling water entry and outflow from or to the McArthur River. In our view any risk of such an outcome, for which there appears no plausible remediation, is too high.

Given these and many other related risks, we consider that alternatives to a lake must be more seriously examined.

4.6 Socio-economic and cultural issues

The analysis of socio-economic impacts is inadequate, partly because it was informed by a grossly inadequate consultation process (Section 4.1 above).

There is no treatment of impacts on the customary economy of the region, which may be substantial if there is no confidence in the health of food taken from it. Management, monitoring and reporting of mine biophysical impacts must be designed and delivered to build and support that confidence.

The incomes claimed and their contribution to GSP and GNP are impressive (e.g. Table 12-16), but it has been established repeatedly in many settings that trickle back to the regions feeling the effects of such developments rarely allows locals to enjoy the benefits[x].

The employment of a small number of local people and targets to increase Indigenous employment are obviously welcome (page 12-14). However, numbers are tiny as a proportion of the total workforce and likely to remain so, for reasons that are often outside of the control of the mine and difficult to overcome in a small remote community, such as uncertainty about ability or interest in working in such an environment and limited local availability of specialised skills. However, we consider that much more could be done to support local opportunity that would endure beyond life of the mine. One very effective approach to this would be to develop with local groups mechanisms to offset partially the long term residual impacts of the mine, which will be very substantial whatever choices are made about waste rock and tailings storage. In addition other environmental services might be purchased from Indigenous providers, including management of fire and weeds in and around the site to protect sites under rehabilitation.

In regard to tangible heritage, the archaeological material provided is reasonable in respect of the limited sites it documents, specifically those in the direct footprint of the proposal. Other impacts like dust and effects of blasting on rock art may extend beyond the active site. For example, Haglund[xi] found art and camp site complexes of archaeological significance within the mineral leases, along Emu Creek and close to its junction with the McArthur River. There is no discussion of impacts and risks to these complexes. Other potentially relevant surveys were conducted in 1992, 2002 and 2005 by Hollingworth, Huonbrook and Begnaze consultancies respectively.

4.7 "Residual" risk, adaptive management and offsets

The EIS' preferred approach to a large array of potentially severe environmental risks is to diminish their significance individually, or where plausible impacts are clearly unacceptable and undeniable, invoke unspecified future acts of adaptive management.

The NLC accepts that skilled and committed application of adaptive management theory and practice can be a most valuable approach to problem-solving[xii]. However, crude trial and error of the sort that appears to have affected aspects of the site's management in the past provides no base for adaptive management, especially when the errors resulting from flawed practice are treated by mine management as unchangeable, despite having undeniable potential to cause long-running impact. Adaptive management requires both commitment and capacity to withdraw the actions causing unwelcome change when required. Where actions cannot be withdrawn or reversed, but can have irreversible consequences, the only adaptation available is to learn to live with those consequences. This appears to be what the proponent requires of the people of the region and the Territory more generally.

Despite many perpetual impacts, not least the acceptance of ongoing uncertainty whatever the decision about in-pit disposal, there is no apparent interest by MRM in offsetting detriment of any sort at any level. This stance is facilitated by the Northern Territory's abandonment of environmental offsets, which in all other jurisdictions are treated as a critical component of the mitigation hierarchy.

The most likely result of present policy is that environmental outcomes in the Northern Territory will be inferior to those in other jurisdictions. Unless government requires developers to apply superior on-site management practices of a type, quality and cost not required in other jurisdictions, the Territory will not get the same biophysical outcomes achieved elsewhere through high quality offsets. There is certainly no evidence that regulators have set a higher bar for acceptable residual detriment, or that if they did, they would be capable of securing observance. There is also no evidence that MRM will itself pursue higher standards.

4.8 Weakness in the assessment process

As already noted, none of the specific environmental objectives, standards or closure conditions are seriously influenced by Aboriginal views and values. Moreover, mainstream and fundamental concerns that were clearly anticipated and documented in, for example, the 2006 assessment report by the agency equivalent of the NTEPA and recurring reports from the Independent Monitor, also appear to have failed to influence the current approach in any meaningful way. This raises fundamental questions about the capacity of the Territory's assessment and regulatory frameworks to deal with such large-scale projects and their effectively irreversible impacts on landscapes and lives.

The present EIS exemplifies the difficulties faced by affected parties seeking to protect their own interests or those of others to whom they have obligations. A huge volume of apparently competent and comprehensive technical analysis is presented, but embedded in an assessment of risk that muddles issues like corporate reputation with major biophysical impacts. Numerous biophysical risks are packaged in different ways and presented as probabilities varying by orders of magnitude. There is no attempt to present a coherent view of "aggregate" biophysical risk to permit meaningful assessment of the various alternatives or the real benefit to those who are expected to accept that risk. Critical parts of the risk equation, such as the financial and cumulative aspects, are available only as unsupported assertions.

We accept that analysis and presentation of aggregate risk and environmental and related costs is a difficult task, but consider it essential in cases such as this: if the assessment process is to be more than an elaborate but ultimately meaningless ritual. In the short time available for response to such complicated proposals, it would be unreasonable to suggest that private individuals, groups or organisations with legitimate interests might construct their own frameworks to assess aggregate risk that would permit them to present closely reasoned and convincing counter-arguments to those advanced by a development proponent.

We suggest that the empirical evidence of the damaging legacies of past decisions shows that such analysis is also beyond the reach of Northern Territory Government agencies and their regulatory tools as they are currently constituted.

4.9 Capability and commitment

We have noted acknowledgements in the EIS supporting documents that critical parts of the operation that contributed to the need for the present assessment failed to follow design intent

or approvals. These failings were not corrected at the time by the government regulator, and are now treated by the proponent as irreversible on financial grounds. Other departures from good practice and adverse outcomes have been revealed by the Independent Monitor[xiii] who, for example, demonstrated that lead was entering food chains and has documented recurring failures to complete sampling and report incidents of exceedance of criteria. This role is extraordinarily valuable and obviously essential for this development, but insufficient for such major projects where actions can have major irreversible effects.

In our view, the Northern Territory Government places too much reliance on such *post hoc* mechanisms and not enough on direct oversight at critical points in project development. This may be largely due to resourcing constraints[xvi] but, whatever the explanation, the issue certainly needs addressing. As noted above, when effective responses are ruled out of bounds, invocations of adaptive management by proponents or assessors (page Y-18) distort that body of theory and practice. No, or ineffective, response to all-but irreversible error is not adaptive management.

We are also concerned that regulators and other government agencies are exposed to conflicts of interest. The Department of Primary Industries and Resources (DPIR), for example, promotes investment in local mining developments[xiv]. In records of consultations associated with this EIS, MRM reports laudatory comments from government personnel about progress made and criticism of others who raise concerns (pages Y-10, Y-19). However, it would obviously be much better for all participants if significant improvements in process, practice and outcomes were less often required following conspicuous problems and government personnel refrained from impugning the legitimacy of criticism.

Promoting sustainable development is an important role, but separating that role from statutory obligations must be rigorous, so that conflicts are demonstrably avoided.

4.10 Public exposure to risks and costs

The Terms of Reference for the EIS framed by the NTEPA include the statement that:

> the Project may create an ongoing environmental, social and/or economic legacy if operations are required to cease ahead of schedule due to unforeseen circumstances, prior to the planned closure and rehabilitation of the site.

Necessary pre-conditions for such a risk in respect of biophysical environmental issues are:

- the bond held by the regulator is inadequate;
- patterns of development involve no increase in scale and impact of operations through time; and
- activity scheduled later in the life of the project includes measures to reduce the costs of rehabilitation at closure.

That is, the statement is relevant only if the regulator failed to secure an adequate bond that was accessible whenever needed and matched to the development trajectory and peak remediation needs.

We consider that a particular obligation of the regulator is to ensure that bonds are capable of meeting costs of rehabilitation that may arise at any and all stages of development. Otherwise the public is coerced to accept the risks and costs of corporate or project failure or poor proponent performance, however originating, and to tolerate or even to facilitate continuation of poorly-managed and environmentally destructive operations, because this is the most

accessible means of avoiding liability in the short term. The Territory is at risk of entrenching as standard practice a dependence on continued mining to manage impacts that should not have been permitted in the first place[iv,v].

Under this model - enabled by lax enforcement of environmental conditions and inadequate bonds - the worse the environmental performance early in a project, the greater the leverage accrued by a proponent to set future conditions. Policy appears to be moving in the wrong direction to avert such perverse outcomes, with the 2013 decision to reduce the size of bonds in "exchange" for a rehabilitation levy[xv] obviously increasing the risks of under-provision by trading off present convenience against major future costs.

Neither MRM nor the regulator is prepared to reveal the size of the financial bond for the McArthur River Mine. However, this sort of statement from the NTEPA and related hints in the EIS - about risks of adopting more costly alternatives and ceasing mining prematurely - imply that neither the assessment authority nor the proponent believe that the bond would be adequate if mining stopped now.

This places Aboriginal and other local interests in an intolerable position: either to accept approaches to further development that they regard as flawed, or accept other unspecified (because hidden) risks of inadequate remediation. It is essential that environmental assessors and the wider public have full details of the remediation funds held and the conditions under which they can be accessed: so that relative costs and benefits of continuing or discontinuing operations can be weighed.

Given the quality of operations and regulator's performance at this site and elsewhere, it is clearly untenable to leave such matters to undisclosed arrangements between the regulator and the proponent.

5 Conclusions

The EIS is clearly deficient in its present form. The proponent's apparent reading of the levels of environmental harm and risk tolerable to the local, regional and other Northern Territory communities do not accord with the NLC's understandings. The project could not be allowed to proceed on the basis set out.

Risks are greatly exacerbated by the weak levels of commitment and capability displayed by Northern Territory regulators. The NTEPA has recognised and documented some of these issues[iv,v,xvi].

Despite the embarrassing history of continuous environmental management failings at this site, the EIS presents no evidence of fundamental shifts in quality of commitment or capability to deliver on commitments. This is, in our view, evidence that the system for representing and protecting the environmental interests of Northern Territory residents is not taken seriously. Urgent action is required to restore balance and integrity, and the capacity to achieve equity of access to benefits and fair sharing of costs of development across society.

6 Recommendations

Given that we regard this project as an exemplar of deep systemic problems, our recommendations run from specific project issues and requirements for additional information, through to proposals for review of law and process.

In general it is apparent to the reader that a proper assessment and consideration of aggregate (total) risk in relation to the management of overburden at the mine site has not been presented by the proponent as part of this EIS. The conclusions reached throughout the EIS are not always supported by empirical evidence or otherwise sufficiently justified. To rectify these and the specific deficiencies raised below, the regulator should insist that further work be undertaken and the findings presented to the public for all stakeholders to consider. The publicly available information should include full disclosure of projected long term costs.

It is the NLC's view that if all highly reactive material, and the bulk of the remaining reactive material, were reinterred back into the pit at below groundwater levels with a suitable impermeable cover and other engineered solutions that include dealing with the tailings, that superior environmental outcomes would be achieved in comparison to the alternative scenarios. That said further research is required to draw any definitive conclusions about the long term feasibility of all scenarios being considered. In this regard the proponent should be required to undertake further investigations and to present the results and underpinning assumptions, including the financial, to allow stakeholders to have a full and proper understanding of the project and its likely impacts. The final design should be one that achieves the best possible environmental outcomes.

6.1 Engagement of Aboriginal Interests

1) The approach to consultation as presented in the EIS does not satisfy the requirements of the Terms of Reference (TOR). The process is required to:

    - engage with the relevant statutory organisations, in particular the NLC, via established and transparent processes, to consult with native title holders on matters that will have long term impacts on their native title rights and interests;
    - show how key risks were appropriately described to local Aboriginal stakeholders, and their views sought on all of those risks;
    - identify which stakeholders are required to accept residual risk, and show that these people were effectively and objectively consulted;
    - demonstrate that information about alternative scenarios and risks associated with mine closure were comprehensively identified and issues arising addressed; and
    - show how Aboriginal values and interests were taken into account in project design and consideration of alternatives.

2) If the proponent is unable to provide such evidence of fully informed consultations with the correct people, the NTEPA should require engagement of suitably qualified specialists to ascertain and report stakeholder views on the alternatives and risks.

3) Advice is required on whether signatories to the agreement about the height of the proposed NOEF relative to the relevant sacred site were offered opportunity to seek independent legal and technical advice on the impact that the signing of this agreement may have.

6.2 Social and cultural impacts

4) The EIS provides no meaningful assessment of social and cultural impacts on Aboriginal people. The proponent should be required to engage a suitably qualified expert to research

and report on the potential social and cultural impacts of the proposal. The NLC is able to provide information relevant to this matter on request.

5) The current status of, and potential impacts to archaeological sites in the area, particularly documented sites located along Emu Creek and including sites outside the mining leases, should be further investigated.

6.3 Mine operations and closure

6) Proposals for mine operations and closure should be reconsidered to include:

- reconfiguration of the existing NOEF as soon as possible to reduce seepage and oxidation problems, as a condition of further mining;
- in-pit storage of tailings and reactive overburden, with optimal design determined independently[2];
- use of bituminous liners or similar impervious materials to improve isolation of reactive waste during temporary storage (pending in-pit disposal) be re-examined;
- extend monitoring of lead in tissues to include all species taken for consumption by Aboriginal and other local people; and
- rigorous testing of all alluvium to be used in PAF cell construction.

7) More and better information is required on:

- total loads of persistent contaminants, especially metals, and their ultimate long term distribution and concentrations in all potential receiving environments should be seriously examined, irrespective of concentration at release into the McArthur River;
- management of dust in and around all over-burden storage facilities given that the apparently preferred method of watering cannot be used;
- direct evidence that thermal imaging systems (will be capable of detecting change early enough permit intervention before substantial SO_2 has been generated and is detectable by gas monitoring systems;
- risks and risk treatments regarding contamination of deeper groundwaters that cannot be intercepted at the surface by proposed measures;
- criteria for determining whether interception bores are required and configuration of interception arrangements;
- options for limiting groundwater exchanges with the pit at all depths, whether flooded or not and whether used for tailings or overburden storage or not;
- the potential for ongoing reactions involving sulphides in the pit even under low oxygen conditions;
- where excessive cost is asserted as a reason for rejecting use of obviously superior methods to reduce serious environmental harm, then full disclosure of the costs are required;
- given assertions that mining will cease if conditions for improved environmental management increase costs, information on the size of the bond available for immediate remediation should be made publically available; and
- statements of aggregate risk that provide insights to the probability and impacts of one or more serious failures of mitigation measures over specified time periods.

2 The Supervising Scientist, Department of Environment, may be able to assist given recent experience with the Ranger Uranium Mine in Kakadu National Park.

6.4 Improved assessment and regulatory process

8) The seriousness of the present situation should be communicated to government with a view to urgently correcting the management difficulties with this project, but also going further to examine statutory and other change to drive better assessment outcomes and develop suitable management processes, including:

- informed public participation, especially proper engagement with Aboriginal people; and
- reconsideration of agency structures and policies that generate apparent conflicts of interest in dual roles to promote developments and then set conditions for and oversee their operations; and
- systemic improvements in the handling of major development projects in the Northern Territory, including improved and transparent arrangements for handling rehabilitation bonds; and
- restoration of robust systems for environmental offsets; and
- obligatory public release and unfettered access to all monitoring and reporting data gathered as a condition of approvals.

9) To help inform review of law, practice and administrative arrangements, this project should also be subject to a comprehensive independent review covering all relevant operational and regulatory decisions and influences on performance.

7 References

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xv Northern Territory Government (2013) Mining Management Amendment Bill: Levy on Mining Rehabilitation Securities. Northern Territory Government, Darwin. 2 pp.

xvi NTEPA (2014) Recommendations on the Environmental Assessment and Regulation of Mine Sites. March 2014. *Northern Territory Environment Protection Authority, Darwin.* 10 pp.

ATTACHMENT 1 – CULTURAL HERITAGE, SOCIO-ECONOMIC ENVIROMENT AND CONSULTATION PROCESSES

The principal shortcomings related to chapters 11 and 12 of the EIS are summarised as follows:

- inappropriate application of anthropological concepts and terminologies, which have implications for the project that are detailed below;
- application of stakeholder engagement methodologies which do not align with the requirements of the TOR provided by NT EPA, or comply with leading practice standards;
- inadequate consideration of the impacts to cultural heritage; and
- inadequate assessment of the cultural and social impacts of the proposal.

It is the NLC's opinion that the additional works listed below are required to be completed in order to comprehensively describe the potential impacts of the proposal in respect of chapters 11 and 12 of the EIS. The proponent is urged to:

(1) engage with the relevant statutory organisations, in particular the NLC, via established and transparent processes, in order to consult with native title holders on matters that impact on their impact native title rights and interests;
(2) engage independent specialists to undertake a consultative process which properly ascertains and considers stakeholders' views on the alternative scenarios and risks addressed in the TOR provided by the NT EPA;
(3) conduct further research and report on the potential impacts to cultural heritage sites located off the mineral leases, and
(4) engage suitably qualified independent professionals to conduct further research and produce reports on the cultural and social impacts of the proposal to inform the final EIS.

Inappropriate application of anthropological terms and concepts

As a basis for consultations with local Aboriginal stakeholders, the proponent and authors of relevant sections of the EIS attempt to group stakeholders according to their interests; particularly whether or not they are a "traditional owner" (see Appendix 8 of Appendix Y). This is problematic because there is no definition provided to inform the reader of how the proponent and authors identify a traditional owner. For example, is the person identified as a traditional owner of the area within the mineral leases, the area directly affected by the enlargement of the waste rock dump; or of another area somewhere else? This raises further questions, for example, on what basis is someone identified as a traditional owner? Are they a traditional owner of their father's country, or is the title of traditional owner inherited by some other means? Describing a person as a traditional owner has limited utility, unless some rationale is provided to enable the reader to critically analyse such rationale. It is difficult to rely on the indigenous stakeholder data provided in the EIS because no information is provided to define the term or inform the reader how a person becomes identified in the EIS.

The estate groups identified to hold native title rights and areas in the McArthur River Station have been set out in the Native Title Determination. Therefore, it would be appropriate and less problematic in stakeholder analysis to consider which stakeholders hold native title rights and interests in affected lands and waters rather than presenting information about traditional ownership. Chapter 12 p.12 states that "*A comprehensive cultural heritage assessment was*

undertaken as part of the project, which aimed to identify native title holders ...", however the assessment process and its outcomes of this assessment are not described anywhere in the EIS.

The attempt to apply anthropological terminologies in the EIS is problematic, and the problems that arise from this are further compounded by the fact that such terms are wrongly, and inconsistently applied. Critical discrepancies in the data on traditional owners provided in the EIS include:

- Of those listed as traditional owners in Appendix 8 of Appendix Y, a substantial proportion of people listed are not, in NLC's opinion, traditional owners of the area within the mineral leases directly affected by the enlargement of the waste rock dump;
- there are a number of people listed in Appendix 8 of Appendix Y, who, in NLC's opinion, are traditional owners of lands directly affected by the enlargement of the waste rock dump but who are not listed as traditional owners; and
- the graph on page 29 of appendix Y reflects these errors.

How it is decided that a person is a "senior man" as described on page 29 of Appendix Y is not described. At times the EIS applies the term "custodian", in respect of people with particular responsibilities for sacred sites, but again there is no relevant definition provided, or explanation of how or why the term is applied by the authors to particular persons. As a result consultations by the proponent with site custodians on issues related to sacred site protection are of questionable value given the lack of information about the consultation process and the process involved with identification of custodians.

Failure to engage appropriately with relevant organisations on the above

Because identification of and consultation with native title holders is among its core statutory functions, the NLC:

i) employs anthropologists with expertise in the field;
ii) manages large quantities of relevant anthropological data, and
iii) drives well established processes by which these tasks are administered.

The NLC is able, on request, to provide advice in relation to these matters. There has been no request from the proponent that the NLC provide information in respect of native title holders or traditional owners of affected areas.

The proponent directly consults people they consider to be traditional owners or custodians of sacred sites, without engaging with the organisations who normally manage such consultations. In the case of sacred sites it appears (from information provided in the EIS) that Authority Certificates were requested from the Aboriginal Areas Protection Authority (AAPA) *after* the proponent directly sought to negotiate an agreement with people whom the proponent considered to be sacred site custodians. No rationale is provided for this approach. It raises the question as to why the proponent did not seek advice from the NLC, or engage in AAPA's established Authority Certificate application processes prior to seeking agreement from these custodians. The risk that this strategy may result in the proponent consulting the wrong people is identified on p.46 of Chapter 12. The proposed mitigation measures applied to this risk by the proponent are flawed as described in the preceding section. The risk of causing or exacerbating conflicts within the community are not identified by the proponent, but are of relevance in respect of this project.

ATTACHMENT 1 – CULTURAL HERITAGE, SOCIO-ECONOMIC ENVIROMENT AND CONSULTATION PROCESSES

It is of note that in Appendix 7 to Appendix Y, the NLC is described as having a cultural interest rather than a governance interest. It appears that the proponent has failed to recognise the statutory functions of the NLC. Page 10 of Appendix Y locates NLC in the "Keep Satisfied" grouping of stakeholders along with other non-regulatory government agencies. As NLC has not been involved in the consultation process by MRM with the local Aboriginal people, the NLC is unable to be satisfied that the relevant custodians and native title holders have been consulted both recently in regard to this EIS and historically in relation to the MRM project in general.

Project-specific implications

The definition of custodians and traditional Aboriginal owners is a particularly sensitive point because, on the basis of information provided in the EIS (particularly the Stakeholder Consultation Report), it appears, in NLC's opinion, that custodians of a sacred site significantly impacted by the proposal, were not consulted. Therefore the agreement negotiated between the proponent and the custodians of this sacred site[3] with regard to the proposed NOEF, is highly problematic. The NLC is of the view this agreement may have been executed without all relevant custodians having been consulted. Because the agreement has been negotiated and executed without the involvement of the NLC, it is not possible to provide any further comment on this issue.

The NLC requests that the proponent provide the following information in the final EIS:

- evidence that risks were appropriately described to stakeholders, and their views sought;
- identify which stakeholders are required to accept residual risk, and provide evidence that these people were effectively and objectively consulted; and
- Mine closure is particularly relevant to indigenous people who hold native title rights to the area covered by the mine and these rights endure through generations and will come into full effect upon the expiry of the mineral leases covered by the mine. The NLC requests evidence to demonstrate that information about alternative scenarios and risks associated with mine closure:
    - were comprehensively identified and addressed;
    - were effectively communicated (i.e. to a non-specialist audience of which many do not speak English as their first language); and
    - were objectively presented.

Should the proponent be unable to provide such evidence, the NLC recommends that suitably qualified and independent specialists be engaged to undertake consultations which ascertain and describe stakeholders' views on the alternatives and risks as presented in the NT EPA's TOR.

In respect of point 2 above, I refer the proponent to industry leading practice, operating principles for Respecting Indigenous Peoples and Traditional knowledge:

> ***"Safeguard against exploitation:*** *Build in safeguards to protect indigenous communities that are vulnerable to unfair exploitation, e.g., because of inexperience …"*
> (Croal et al 2012)

3 This agreement is referred to in the EIS, but has not been provided to, viewed by, or discussed with the NLC.

ATTACHMENT 1 – CULTURAL HERITAGE, SOCIO-ECONOMIC ENVIROMENT AND CONSULTATION PROCESSES

Chapter 12 p.46 refers to a database kept by the mine which is said to record stakeholders and their relationship with the mine. The indigenous stakeholder data provided in the EIS includes significant error and raises concerns about the integrity of the proponent's dataset, and the methodologies on which the proponent's data was collected. Given the errors presented in the EIS, the NLC questions whether or not a qualified anthropologist was engaged by MRM to oversee stakeholder engagement. The NLC is also concerned that stakeholders recorded in this database may not have provided their consent to have their personal information either held by the company or made public via the EIS process.

Objectivity in the consultative process

Given the history of community concerns in relation to this project, it is advised that the proponent make more effort to maintain high levels of independence and objectivity in the stakeholder consultation team; i.e. to build a team that can best ascertain the views of stakeholders without appearing to have a commercial or economic interest in promoting the project. The EIS consultation team of 6 people comprised 4 MRM staff (Y-15).

There is little material to facilitate qualitative analysis of any consultations that occurred. The table provided at Appendix 2 to Appendix Y ("*Stakeholder Consultation Register*") provides a table listing who was consulted and when. However there does not appear to be a clear description of the specific questions and issues raised by the consulting team or any information describing stakeholder engagement methodologies. For example techniques that may be employed in community meetings to facilitate effective engagement with a broad range of participants, or alternative techniques applied to assist in group decision making.

Industry leading practice on public participation (PP) requires that stakeholder engagement processes be:

> ***"Credible and rigorous*** *– PP should adhere to established ethics, professional behaviour and moral obligations. Facilitation of PP by a neutral facilitator in its formal or traditional sense improves impartiality of the process as well as justice and equity in the right to information. It also increases the confidence of the public to express their opinions and also to reduce tensions, the risk of conflicts among participants, and opportunities for corruption. In a formal context, the adoption of a code of ethics is encouraged."*
> (Andre et al, 2006)

The TOR provided by the NT EPA (TOR-20) reflects these standards in the requirement for objectivity during discussion of the risks and impacts associated with the proposal. However, there is no evidence that such objectivity was featured in these stakeholder consultations. The communication tools provided as appendices to Appendix Y heavily promote the benefits of the proposal, for example in economy, employment and consultative effort.

The NLC requests that the proponent provide the following information in the final EIS:

- evidence that risks were appropriately described to stakeholders, and their views sought;
- identify which stakeholders are required to accept residual risk, and provide evidence that these people were effectively and objectively consulted; and

- Mine closure is particularly relevant to indigenous people who hold native title rights to the area covered by the mine and these rights endure through generations and will come into full effect upon the expiry of the mineral leases covered by the mine. The NLC requests evidence to demonstrate that information about alternative scenarios and risks associated with mine closure:
    - were comprehensively identified and addressed;
    - were effectively communicated (i.e. to a non-specialist audience of which many do not speak English as their first language); and
    - were objectively presented.

Should the proponent be unable to provide such evidence, the NLC recommends that suitably qualified and independent specialists be engaged to undertake consultations which ascertain and describe stakeholders' views on the alternatives and risks as presented in the NT EPA's TOR.

Social, Cultural and Economic impact assessment

The archaeological material provided in the reports may be reasonable in respect of the limited number of sites it documents. However these sites appear to be restricted to those located within the direct footprint of the proposal. Impacts on cultural heritage sites may include off-site impacts for example as a result of dust or blasting on rock art.

Haglund (1975) found art and camp site complexes of archaeological significance within the MLs, along Emu creek and close to its junction with the McArthur River. There is no discussion of impacts and risks to these complexes. Other potentially relevant surveys were conducted in 1992, 2002, and 2005 by Hollingsworth, Huonbrook, and Begnaze consulting agencies respectively.

The NLC recommends further investigations be conducted into the current status of, and potential impacts to archaeological sites in the area, particularly those documented sites located along Emu Creek.

Chapter 11 Cultural Heritage is of relevance to this issue; it is noteworthy that:

- P.1 identifies legislation relevant to cultural heritage but does not include the *Native Title Act*.

- P.4 section 11.3.2 lists site complexes and historical archaeological surveys and notes the Haglund study but does not list the Emu Creek complexes Haglund documented.

- P.23 describes consultations with the custodians of a sacred site but does not explain what custodianship means in this context.

Chapter 12 Socio Economic Environment is inadequate: while an economic impact assessment is presented at appendix Z there is minimal analysis of social impacts. There appears to be no analysis in the EIS of potential cultural impacts as undertaken by a suitably qualified expert. The impact of the proposal on locally specific indigenous economies (for example, on subsistence economies, the injection of monies from agreements into distributive kinship economies) appears not to have been considered in the EIS.

ATTACHMENT 1 – CULTURAL HERITAGE, SOCIO-ECONOMIC ENVIROMENT AND CONSULTATION PROCESSES

The NLC recommends that a suitably qualified expert be engaged to research and report on the potential social and cultural impacts of the proposal.

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ATTACHMENT 2 – ISSUES RELATED TO SPONTANEOUS COMBUSTION

Spontaneous Combustion at the McArthur River Mine

This part of the NLC's submission considers only the process of spontaneous combustion of mined, waste and processed materials. It seeks to assess how well MRM understands spontaneous combustion and how spontaneous combustion will be managed during operations and following closure of the mine.

Outcomes below are based upon assessment of Sections 3, 4, 6, 7, 13 and 15 and associated Appendices H – R inclusive, S, AD and AF.

1. Spontaneous Combustion and AMD

Spontaneous combustion may occur when sulphide and carbon rich rocks oxidise in the presence of water and the atmosphere. This process is common in the coal industry and it is from the coal industry where most of the advances in management have been drawn. However, spontaneous combustion may also occur where ore deposits containing fine-grained, disseminated pyrite (FeS_2) and carbonaceous materials are exposed to the air (Landers and Usher, 2015). In their EIS, MRM have identified three stratigraphic units (black bituminous shale, upper pyritic shale and lower pyritic shale) that have greatest propensity to spontaneously combust (p4 Appendix AF).

Spontaneous combustion is characterised by high temperatures and release of gases, especially H_2S and SO_2. These gases may be released directly to the atmosphere or may dissolve in water, releasing acidified contaminants, often referred to as acid mine drainage (AMD). AMD can also occur through breakdown of potentially acid forming materials (PAF), without the assistance of acidic gases released by spontaneous combustion. Numerous chemical reactions may occur, four of which are identified below:

$$2FeS_2 + 7O_{2\,(aq)} + 2H_2O \rightarrow 2Fe^{2+} + 4SO_4^{2-} + 4H^+ \qquad (1)$$

$$4FeS_2 + 11O_{2\,(aq)} \rightarrow 2Fe_2O_3 + 8SO_{2\,(g)} \qquad (2)$$

$$2FeS_2 + 5O_{2\,(aq)} + 2H_2O \rightarrow Fe_2O_3 + 4SO_{2\,(g)} + H_{2\,(g)} \qquad (3)$$

$$4FeS_2 + 12O_{2\,(aq)} \rightarrow 4FeSO_4 + 4SO_2 \rightarrow 2Fe_2O_3 + 4SO_2 + O_2 \qquad (4)$$

Hydrogen sulphide (H_2S) and elemental sulphur (S) may be produced deep within the rock dump, where there is insufficient oxygen available for combustion. Following reaction 1, the sulphate (SO_4^{2-}) and hydrogen (H^+) ions may combine to create sulphuric acid (H_2SO_4), which reacts with surrounding material to generate AMD. The quantity and rate of localised acid generation from the spontaneous combustion of iron sulphides will depend on how much of the SO_2 is released to the atmosphere, and how much combines with water to form H_2SO_4 within the waste rock.

Although O_2 is needed to oxidise pyrite, it is the amount of water vapour in the atmosphere that is critical to spontaneous combustion. Oxidation of pyrite and spontaneous combustion increases rapidly once the atmosphere's water vapour content exceeds 20% and may be further enhanced if pyrite is present as fine particles (Pahlman and Reimers, 1986). This suggests that significant problems may occur in hot, humid environments and that and assessment and management of risks should focus on manual handling and isolating materials from the atmosphere to reduce instances of spontaneous combustion and related AMD.

ATTACHMENT 2 – ISSUES RELATED TO SPONTANEOUS COMBUSTION

2. MRM's assessment of risk

The principal risks related to spontaneous combustion and AMD considered by MRM are consistent with the processes outlined above. They include:

- increased geochemical load on pit water (through AMD);
- release of SO_2 from the NOEF;
- release of AMD contaminants from the NOEF during new construction work;
- release of SO_2 from spontaneous combustion of tailings; and
- release of SO_2 from spontaneous combustion during partial backfilling of the pit.

3. Management of spontaneous combustion during operations

There appears to be little consideration given in the EIS to how management of existing material on the NOEF is to be improved. Prior to this EIS, PAF material was categorised mainly according to its acidity and AMD generating capability, which appears to have allowed some highly reactive materials to have become distributed throughout the NOEF. If this is the case, sporadic episodes of spontaneous combustion may continue to occur until the NOEF is provided a stable, impermeable cover. This may need to be re-assessed as the project progresses and contingencies put into place until such a cover is established.

The main principles to be applied to future management of reactive PAF material are construction of dedicated cells in which it is to be contained, low lift construction and compaction, dry season mining and covering during the wet season (p6-63 & p 6-64). The more important actions proposed by MRM are:

- MRM has reclassified its material in an effort to improve identification and segregation of materials that are likely to spontaneously combust (p6-22).

  Reclassification of material is no longer based on pH, but considers the materials' geochemistry (and especially the sulphur content) when describing materials considered to be reactive and with acid-forming potential. Reclassification is a positive move because in this case, it increases the volume of material that is identified as not environmentally benign and requiring management.

- MRM plans to undertake early detection of reactive materials during mining and daily monitoring of the NOEF for AMD, thermal energy, SO_2 and visual signs of reaction (p15-26) to help manage spontaneous combustion.

  Early detection of potentially reactive material during the mining phase is one of the key proactive measures to reduce spontaneous combustion events by segregating and correctly placing material in the NOEF. Thermal monitoring of the NOEF would allow MRM to identify areas where spontaneous combustion events are occurring, but would not be useful as a predictive management tool unless it can clearly identify a temperature at which combustion commences. The EIS does not appear to present any direct evidence that the thermal imaging system it proposes to use is capable of this degree of definition for material at the MRM mine site.

  Similarly, measurements of SO_2 (and other toxic gases) and heat plumes serve as useful indicators that combustion events are occurring or have occurred, but they are unsuitable as predictive or preventive tools. The environmental management plan provided does not

provide advice on how to manage SO_2 once it is released. MRM's main aim is to prevent formation of SO_2 by encapsulating the bulk of the PAF in an above-ground facility. Encapsulation should include all material existing within the NOEF – which should be considered to be reactive by virtue of it not having previously been segregated according to the newly proposed classifications and its known propensity to spontaneously combust.

Maintenance of the above-ground facility thus becomes critical and its suitability beyond life of mine must be questioned because it may or may not have long-term resistance to erosion and weathering in the tropical environment. If integrity of the facility cannot be maintained once the mine has closed and MRM has departed the risk of further and possibly larger spontaneous combustion events (created by the concentration of combustible materials into confined spaces) will increase over time. Under these circumstances, MRM will not achieve its ambitious performance indicator that "major spontaneous combustion events must not occur on the NOEF during the operational phase, and no spontaneous combustion must occur following closure" (p15-25).

MRM's measures for the management of AMD are generally reactive and focus on monitoring and capture of contaminated water. Ideally, all waste rock materials should be returned to the pit void and isolated from the air at the end of mining if spontaneous combustion and AMD is to be avoided.

- Reactive PAF materials will be mined primarily during the dry season, and then placed into dedicated cells in the core of the NOEF, where they will be compacted. A layer of 100mm of compacted alluvial sheeting will be placed on top of every 2m of reactive PAF material within each cell. Temporary covers consisting of alluvial and non-acid forming material will be in place prior to each wet season (p15-25, p3-104).

  Better segregation of reactive material as proposed by MRM should result in a reduced risk of spontaneous combustion; however the effectiveness of the 100mm alluvial layer in dissipating the heat generated and isolating the atmosphere must be questioned. When materials spontaneously combust, temperatures in excess of 350^oC may be generated and create a self-sustaining process. The alluvial cover layers may not be of sufficient thickness or resistance to insulate other reactive PAF layers above or below and prevent spread of the reaction.

  If the alluvial layers are unable to effectively dissipate heat or isolate reactive PAF from the atmosphere, spontaneous combustion may continue to occur sporadically during placement in the cells, or deep within the NOEF once it has been buried. Materials proposed for use in construction of the alluvial layers should be tested and information regarding their ability to transmit heat, water and air when compacted should be provided so that risk of long-term failure can be assessed.

- MRM plans to flatten the batter slopes of the NOEF and install advection barriers to reduce the potential exposure of PAF material to the atmosphere. This will be supported by air and water quality monitoring and systems designed to capture highly contaminated water (BB31, p7-35).

  This statement is inconsistent with the project description and justification which indicates that in the future, the NOEF will be trilinear concave batter slopes increasing from 1V:4.5H to 1V:3.5H to 1V:2.5H at the top (p 3-110). The EIS does not appear to contain details of the current NOEF batter slope.

Advection barriers are designed to control air and/or water flow through the NOEF and if the model presented is correct, they should provide an additional layer of protection against spontaneous combustion or AMD generation deep inside the NOEF. However, the model has several shortcomings because it doesn't account for oxygen transport through the alluvium; it assumes the advective material is homogeneous; and does not consider changes in temperature, air pressure and saturation (Appendix I, Section 7.2). Materials proposed for use in construction of the advection barriers should be tested and information regarding their suitability under a range of climatic conditions should be assessed and provided.

- The exposure of tailings during re-mining may lead to generation of AMD and/or SO_2. MRM plans to manage tailings exposure by using a hydraulic process that includes irrigating and monitoring the surface of the TSF to minimise exposure (BB64, p7-36; BB45 p7-37, p3-177).

  MRM has proposed an option to mine and reprocess its tailings and place the residual material into the pit void at time of mine closure (Appendix R, p79). This is a positive step that should continue to be encouraged.

  The hydraulic recovery process proposed should maintain the tailings in a state, however drying of the tailings material may create the risk of dust or spontaneous combustion following oxidation of any residual sulphides. Tailings have been previously classified by MRM as PAF material, but have not been reclassified in the new EIS. Consequently, tailings management is unchanged and has not been considered in this EIS (p3-9).

  The EIS does not contain a detailed description of tailings geochemistry, but MRM has previously claimed that "geochemical testing indicates that the tailings have an inherent acid neutralising capacity (ANC), which reduces the risk of the tailings oxidising and generating acidic conditions" (URS 2008). This seems to contradict the statement that they are potentially acid forming. However, entrained pore water holds high concentrations of sulphate and, under present storage conditions or during transfer to the pit, this may be a more significant concern.

  If tailings are considered to be PAF material, the use of a hydraulic process to recover and transfer them to the pit void appears to be an appropriate means of managing the associated environmental risks.

- MRM plans to reduce the risk to workers during in-pit rehabilitation by engineering and management controls including monitoring and ventilation of the pit atmosphere and segregation of highly reactive materials until they are placed into the pit when operations cease (BB43, p7-36).

  The release of SO_2 in the pit is a safety concern for mine workers that the company will find difficult to manage. Early removal of materials from the pit is a practical means of reducing the probability of spontaneous combustion events once the material has been mined, but will not reduce the risk of combustion at the pit wall prior to or during mining. It is difficult to conceive how it will be possible to ventilate a large pit, should the SO_2 concentration become high across the pit. This part of the plan would be better understood if more detail on the controls proposed and records of SO_2 levels in the pit were provided in the EIS.

It is hoped that MRM will continue to research management of spontaneous combustion in overburden facilities and implement improvements as leading practices evolve.

4. Management of spontaneous combustion following mine closure

The key to MRM's future management of spontaneous combustion rests with identification, classification and management of waste materials. Most of the matters related to this have been discussed in section 3 of this assessment.

- MRM plans to place highly reactive material into the pit and rapidly cover the pit to reduce exposure to the atmosphere (BB43, p7-36).

  This should be implemented for all reactive and PAF materials, including those already existing in the NOEF.

- MRM plans to isolate pit waters in the void surrounded by a levee. Additional measures may include treatment of the water until it is of sufficient quality to allow flow through (BB58, p7-26).

  Isolation of contaminated water in the pit void should only be considered a temporary measure because the body of water may be largely unusable and the levee will ultimately erode and release some of it into the environment. Treatment of the water will be imperative if it does not meet certain environmental requirements.

- The post-mining overburden facility is being redesigned so that reactive waste is segregated in purpose-built PAF cells to minimise contact with oxygen and water (BB48, p7-34).

  The concept of segregating reactive waste is a positive, albeit expected move, although return to the pit void is preferred.

5. References

Landers M. and Usher B.H. (2015): Management of spontaneous combustion for metalliferous mines, 10th ICARD IMWA, April 20 – 25, Santiago, Chile.

Pahlman J.E. and Reimers G.W. (1986): Thermal gravimetric analysis of pyrite oxidation at low temperature, Report of investigation #9059, United States Department of the Interior, Bureau of Mines, Washington DC, USA.

URS (2008): McArthur River Mine Open Cut Project Public Environmental Report, Section 7 – Tailings Storage Facility, p7-21.

6. Concluding remarks

It is the NLC's opinion that:

- The chemistry of spontaneous combustion of waste rock materials and formation of AMD is more complex than has been discussed by MRM in its EIS;
- Analysis of the geochemical characteristics of waste rock is sufficiently comprehensive and has allowed an improved categorisation of reactive PAF materials;
- Future management practices to be put in place should be adequate for reducing the environmental and health risks of the range of gases and water soluble by-products (including those not specifically identified) that may be produced by spontaneous combustion of materials at MRM during its future operations;

ATTACHMENT 2 – ISSUES RELATED TO SPONTANEOUS COMBUSTION

- The effectiveness of alluvial layers in insulating pockets of reactive PAF within the NOEF may require further investigation;
- The existing NOEF contains reactive PAF material dispersed throughout, and this will require management consistent with the improved approach presented in the EIS if further episodes of spontaneous combustion are to be prevented;
- All management practices can be improved. MRM should continue to research spontaneous combustion and develop current leading practice so that improved long-term beneficial outcomes can be achieved;
- The overburden emplacement facilities are located on a floodplain and within a high rainfall, monsoonal part of the Northern Territory so long-term erosion, leading to eventual exposure of reactive PAF materials remains a serious concern; and
- A more permanent solution to limit exposure of reactive PAF materials and prevent AMD would involve re-internment in the pit void and covering it with an impermeable solid cover, maintaining it below the standing groundwater level or both.

McArthur River Mine
Overburden Management Project – Draft EIS

PUBLIC SUBMISSION FOR THE PURPOSES OF THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS PURSUANT TO THE NT & CTH ASSESSMENT BILATERAL

ENVIRONMENTAL ASSESSMENT ACT (NT)
***ENVIRONMENT PROTECTION & BIODIVERSITY CONSERVATION ACT* 1999 (Cth)**

Filed by:

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17 May 2017

SUBMISSIONS ON THE DRAFT EIS:

CLIENT GROUP:

The Environmental Defenders Office (NT) Inc (**the EDO**) has been instructed to act for the following people in the preparation of this submission and it is made on their behalf:

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Joy Priest

Together, "**the EDO's clients**"

GROUP SUBMISSION

This submission is made on behalf of the EDO's clients. Each of them has differing cultural rights and responsibilities for various areas of Country in the Gulf of Carpentaria. Activities occurring at the McArthur Rive Mine (**the Mine**) have the potential to impact offsite areas. Despite this potential, McArthur River Mining Pty Ltd's (**MRM**) consultation processes have extended only superficially to local stakeholders other than the traditional owners of the area on which the mine site is located.[1] Clearly, the Mine site's traditional owners are important stakeholders and the EDO's clients do not seek to undermine any statements made by them, or their authority to make such statements. However, the features of the Mine mean that the obligations for meaningful engagement (by both MRM and the Government) with all four clan groups should be a precondition to any approval of the OBMP.

EXPERT REPORTS

The EDO's clients have gone to great lengths to obtain expert reviews of various aspects of the Draft EIS. The following reports are attached to this submission and should be considered in their entirety.

- Attachment A: Review by Associate Professor Gavin Mudd – Environmental Engineering, RMIT University.
- Attachment B: Review by Professor David Airey – School of Civil Engineering, University of Sydney
- Attachment C: Review by Professor Abbas El-Zein – School of Civil Engineering, University of Sydney
- Attachment D: Review by Associate Professor Barry Noller, Centre for Mined Land Rehabilitation, University of Queensland.
- Attachment E: Review by Dr Geoff Vietz, Director of Streamology – Waterway Science and Management
- Attachment F: Review by Dr Erica Garcia, Research Institute for Environment and Livelihoods, Charles Darwin University.

[1] Consultation processes and their deficiency in terms of best practice is discussed below.

SUMMARY OF SUBMISSIONS:

The EDO's clients are deeply concerned about the impact of the McArthur River Mine on the environmental and cultural values of the Gulf; they are particularly concerned about impacts to the McArthur River down stream of the mine site. Because of these concerns the EDO's clients have engaged a variety of experts to review the Draft EIS.

General opposition to continued mining

The EDO's clients are generally opposed to the continued mining at McArthur River Mine because of the problems already created through bad decision-making, poor quality environmental assessments and mismanagement at the site. The EDO's clients view the risks as too great and the benefits too few to justify the approval of the OBMP thereby allowing continued mining at the site until 2037.

Recommendation 1: That the NTEPA recommend that the OBMP be refused approval. That the responsible NT Minister and Commonwealth Environment Minister refuse approval of the OBMP.

Despite this general opposition to the approval of the Overburden Management Project (**OBMP**) the EDO's clients make the following additional recommendations (which are outlined in greater detail below):

Public participation in the EIS process

Recommendation 2: In view of the absence of efforts to comply with cl 7.3 to date, that prior to providing public comments to MRM for the preparation of the supplementary EIS, the NTEPA make specific arrangements for Indigenous members of the Gulf to make comment on the OBMP should they wish to.

Recommendation 3: All submissions to the Draft EIS be made public – including (and particularly importantly) the review submission by ERIAS.

Recommendation 4: In light of the deficiencies in the process outlined above, the NTEPA and Commonwealth Minister should seek further information from local stakeholders, particularly in relation to matters of cultural significance and proposed closure planning and future land use.

Recommendation 5: To allow greater public scrutiny and transparency, as part of the EIS supplement, MRM should include all original data sets, rather than just summaries/extracts.

Project alternative – complete backfill

Recommendation 6: The EIS Response Document must include a realistic scenario which ensures all PAF material is sequenced as deep as possible in the former pit. As part of the process, the broader Borroloola community must engage meaningfully in ascertaining their preferences for complete backfill – with a multi-criteria analysis or approach which properly allows for their social and environmental preference to be included as equal weight to financial or economic considerations (i.e. cost alone should not dominate rejection of the complete backfill scenario).

Closure costs and security bond

Recommendation 7: The Supplementary should specifically address the issue that Glencore (MRM's parent company) is unlikely to bear liability for acts or failures of MRM. An approval should not be issued to MRM unless some mechanism is in place to ensure that its parent company Glencore is liable for rehabilitation costs. As an example, some form of parent company guarantee could be considered to avoid the problem of MRM default.

Recommendation 8: That no approval be issued without the community first being informed of and consulted about the NT Government's security bond for the site.

Recommendation 9: The EIS Response Document must include a clear case for the technical and economic viability of tailings reprocessing, especially how this may improve long-term environmental outcomes for the MRM site after the completion of all activities and rehabilitation.[2]

Recommendation 10: The EIS Response Document must include detailed costings for the various rehabilitation scenarios, especially the case where tailings are simply transferred from the current dam to the former pit. The detailed costings should form part of a comprehensive document outlining the financial feasibility of the project taking into account the costs associated with closure and post-closure activities. [3]

Project history and proponent environmental history

Recommendation 11: The EIS supplementary include a complete historical data set of all mining activity to date at MRM. The key aspects must include an annual data set of ore mined and milled, ore grades, concentrates produced, tailings generated and waste rock mined. In addition, a careful account should be provided of where all waste rock has been placed to date – including the estimated PAF and NAF quantities for each area of waste rock management.

The NOEF & SOEF

Recommendation 12: The Supplementary EIS should include the original data sets that underpin the test summaries for stability (including water retention curves) set out in the Draft EIS.

Recommendation 13: The Supplementary EIS should include tests performed for residual friction angles.

Recommendation 14: The Supplementary EIS should provide clear direction to decision makers about where long-term parameters are uncertain or based on assumptions which may prove incorrect.

Recommendation 15: The supplementary EIS should include a detailed description of the proceedings before the *Mines and Energy Review Panel* including the position of the Department of Mines and Energy vis-à-vis that of MRM which was ultimately accepted by the Panel.

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[2] Mudd (2017) Attachment A, p 4

[3] The requirement for feasibility inclusion closure to be fully set out at the ealiest opportunity represents best practice, see for example The World Bank Group, Oil, Gas and Mining Policy Division *Guidance Notes for the Implementation of Financial Surety for Mine Closure.*

Limnology and the flow through mine pit lake option

Recommendation 16: That MRM include in the supplementary to the EIS a new limnology report addressing the concerns raised by Garcia and Vietz. This should include an assessment of the limitations of the current limnology assessment with regards the risks of flow through and the need for increased thoroughness of investigations of fluvial geomorphology.

Additionally those reports should details the economic assessment of each option, the EDO's clients are concerned that this option has been chosen for its economic benefits (no necessity to maintain levee wall into perpetuity and the use of levee wall clean fill) rather than its environmental or touted stakeholder acceptance benefits.

Recommendation 17: That the OBMP preferred option be changed because of the concerns addressed about the river flow through and that appropriate stakeholder engagement be conducted to inform members of the community about the new preferred approach and why river flow through is, contrary to what was said previously, presents unacceptable risks.

Ground and surface water

Recommendation 18: The supplementary EIS must outline methods to identify the extend of groundwater contamination across the MRM site and propose plans for its remediation before or during rehabilitation and site closure to ensure that environmental and cultural values are maintained.

Recommendation 19: The groundwater-monitoring plan should be amended to include bores downstream of the diversion channel.

Recommendation 20: The supplementary EIS must include all of the raw data used by MRM to substantiate their claims that sorption will effectively prevent heavy metals from polluting surface waters downstream of the Mine. Additionally, the supplementary should address concerns raised about the sorption modelling.

Recommendation 21: The supplementary EIS must address the lack of information about base lining of the NOEF with a CCL, including through the provision of detailed designs of the base lining that will need to be provided.

Recommendation 22: The supplementary EIS should provide an honest assessment of the level of confidence MRM can have in relation to the contaminant transport models.

Recommendation 23: The supplementary address the potential for contaminants to be transported by molecular diffusion.

Recommendation 24: The discrepancy in using SILO vs onsite climate data should be justified in the supplementary.

Impacts to human health and downstream flora and fauna

Recommendation 25: Exposure Assessment and monitoring of local people who consume fish and other aquatic foods should be undertaking for lead and cadmium by an independent third party at the cost of MRM.[4]

[4] Noller (2017) Attachment D at p

Recommendation 26: a large experimental mesocosm facility needs to be set up with associated infrastructure that can be used to conduct simulate experiments and enable the exchange of tailings in water at depth and accumulations of metals over several lifetimes of short-lived aquatic species, including 10-20 years for turtle and crocodile via biopsy monitoring and biomarker techniques that do not result in mortality of the animal.

Stakeholder engagement

Recommendation 27: Visual aids in the form of photomontages should be provided to local stakeholders to give them a more accurate and realistic understanding of MRM's proposed higher NOEF option.

Recommendation 28: The supplementary draft EIS should specifically address issues which were left in a state of uncertainty following the stakeholder engagement process. Specifically, ambiguity around the pit lake and job opportunities for local people should be addressed.

Recommendation 29: Before considering whether approval is given to the OBMP, the Commonwealth Minister should require further information under s 132 about MRM's consultation with the local Indigenous clan groups about the potentially impacted MNES.[5]

Recommendation 30: Before any approval is given to the OBMP, the NTEPA and Commonwealth Environment Minister should satisfy themselves that any matters which are preconditions to the project proceeding have been entered into following the free, prior and informed consent of all relevant traditional owners.

[5] We note that the discretion of the Minister to seek further information is a broad one, see for example *Lansen v Minister for Environment and Heritage* [2008] FCAFC 189

RISKS OUTWEIGH THE BENEFITS: THE ARGUMENT FOR REFUSING THE OBMP APPLICATION OF THE PRECAUTIONARY PRINCIPLE

The principles of ecologically sustainable development (**ESD**) are foundation principles under the EPBC Act.[6] While not requirements of the NT environmental assessment legislation, the NTEPA is required to promote the principles of ESD.[7] There is great uncertainty with respect to this project. Uncertainty surrounds almost every aspect of the project including, for example, long term weather and climate projections, accuracy of models and the cost of the 100 year + closure period. Our expert reports demonstrate considerable differences of opinion between appropriately qualified independent experts and MRM's consultants.

Because of the above, a particularly cautious approach is warranted. In this case, given the enormity of the challenges which are presented by managing the site in its current form the best environmental outcome can be achieved by the cessation of mining from the expiry of the current MMP and the immediate commencement of site remediation. This would include the complete backfill of the current tailings and overburden into the pit void.

The phase of mining (previously approved under phase 3) proposed by the OBMP will see an additional 575 Mt of overburden placed on the Northern Overburden Emplacement Facility (NOEF) between 2018 and 2032.[8] This represents an almost 300% increase on the 195 Mt of material already in place on the NOEF.

We are, to some extent, dealing with a known quantity now. The site's current risks are known and – presumably – the current security bond can be utilised to offset (to a significant extend) the consequences associated with the problematic statement made by MRM in the Draft EIS at chapter 5, p 7:

> Early closure of the operation (the No Project scenario) would also present an unfavourable environmental outcome.
>
> This EIS presents detailed closure proposals for the open cut, NOEF and TSF. The success of these proposals relies on the full development of the operation. It is unlikely, considering Government positions on resource stewardship, that substantial quantities of fill would be placed in the open cut final void with a significant resource remaining within the deposit. This would preclude the preferred TSF solution of rehandling of tailings back into the open cut final void. It is more likely the site would have a prolonged period of care and maintenance waiting for management solutions or regulatory direction, which could delay the implementation of final closure works and hence increase the environmental risks during that period.

The sense one gets when reading that statement is that MRM is in essence trying to blackmail the government into approving the OBMP. This is unacceptable. Assuming the security bond is "significant" a large number of jobs can be created over the short-mid term through the commencement of rehabilitation on the site – a major project in and of itself.

Commencing rehabilitation following the expiry of the current MMP means that the environmental risks that present from the considerable uncertainties associated with the approval of the OBMP and continued mining for 20 years never eventuate. Unfortunately, the experience with this project and operator has been that continued mining results in additional problems; problems that may at some point in the future manifest in some catastrophic event or impact to the environment.

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[6] See s 3A *EPBC Act* 1999 (Cth)
[7] s 7 *Northern Territory Environment Protection Authority Act* (NT)
[8] See Draft EIS, table 3-26

The EDO's clients do not accept that the benefits of the project outweigh its potential risks. MRM, unsurprisingly, gives primacy to economic factors as demonstrated by the *'Project vs No Project'* section of the Draft EIS where it's stated that:

> *The main consequence of not proceeding with the Project would be that a globally significant base metals resource would not be developed to its full potential, with associated socio-economic benefits unrealised.*[9]

The EDO's clients do not believe that the economic benefits realised to date, or those proposed in the future are in any way sufficient to justify the impacts that have already occurred to date, that will occur in the future and those that may arise.

Particularly we note at this point the meagre number of jobs proposed for local people[10], who bear the majority of the risks. We also note the following problematic statement that:

> *It is assumed there is limited scope for increasing numbers of locals in skilled positions, so increases were mainly related to rehabilitation activities such as monitoring, planting, weeding and earthworks maintenance.*[11]

Recommendation 1: That the NTEPA recommend that the OBMP be refused approval. That the responsible NT Minister and Commonwealth Environment Minister refuse approval of the OBMP.

[9] See Draft EIS, Chapter 5, p 5-6
[10] 71 jobs over 100 years (Appendix 7, p 5)
[11] See Draft EIS, Appendix Z, p 4

PUBLIC PARTICIPATION IN THE EIS PROCESS

Public participation is acknowledged as a critical component of the environmental impact assessment processes, both at a Commonwealth and Northern Territory level.[12] At a Commonwealth level, the inclusion of public participation requirements in the *EPBC Act* seeks to ensure Australia's compliance with a number of international agreements to which it is a party.[13]

Aside from ensuring compliance with Australia's international obligations, public participation in EIA is included because of the recognised benefits it provides, namely:

- **Better decisions** will arise where decision makers are better informed both through the provision of local knowledge and the public examination of expert knowledge;
- **Greater legitimacy of decisions** where decision makers must taken into account the views of the public, allowing all community members an opportunity to influence an outcome; and
- **Proper conduct** for public decisions made within a democratic system.

To have efficacy, however, it is not the mere existence of public participation in the EIA process, which is important, but rather, its implementation. The EDO notes clause 7.3 of the *Bilateral Agreement under s 45 of the EPBC Act* between the Commonwealth of Australia and the Northern Territory. Clause 7.3 notes specifically that:

> *Indigenous people affected by a proposed action may have particular communication needs, and will make arrangements to ensure that affected Indigenous people have reasonable opportunity to comment on actions assessed under this Agreement.*

<u>*Awareness of the public comment period*</u>

Public awareness in Borroloola about the ability to make submissions on the Draft EIS is very low. That is a failure of the Northern Territory and Commonwealth Governments. Public notification of the kind required by the EA Act and the EPBC Act are insufficient and actively discourage public participation. We are unaware of any communication directly between members of the local community and the NT Government in relation to the Draft EIS. As far as we are aware the only consultations on the Draft EIS have been either by MRM, the Northern Land Council, the EDO and the Environment Centre NT. For a project of this magnitude - and with its potential impacts - it is a gross failure on behalf of both governments to have failed to consult the community and to inform them of their rights to participate in the EIA process.

We note that pursuant to s 8 of the *Northern Territory Environment Protection Authority Act* (NT), the NTEPA must in exercising its powers and functions must, encourage community involvement and engagement. It is difficult to see how the NTEPA has done so in this instance.

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[12] See for example, *Rio Declaration on Environment and Development*
[13]

Time period for public comment

The statutory time periods for public comment are far too short. Like the inadequacy of notification of the public comment period, the period itself actively discourages public participation. Unfortunately the effect of that is to deprive decision makers of potentially valuable information and, as a corollary, increases the risk on unacceptable impacts of a project. In this case, the EDO acknowledges that the initial timeframe was extended by MRM until 17 May. Despite this extension, the timeframe allowed severely stifled our ability to provide meaningful comment and meant we were unable to obtain experts to review all elements of the Draft EIS that we had hoped to.

Under the current framework MRM has been afforded the luxury of limitless time to prepare its submission (the TOR for the OBMP were provided to MRM in 2014), whereas the EDO's clients have had to make this submission under extreme time and resource pressure. It is a grave unfairness within the current system, which places the community at a great disadvantage vis-à-vis a proponent.

In light of the incredibly complex nature of this project, its controversial history and its contentious future, the comparatively small public comment window has greatly undermined the integrity and validity of the public consultation process.

It is important for the NTEPA in preparing its assessment report to recognise that the public contribution to this process is no less valuable that that of the proponent. To that end, we suggest that both the NT Ministers (environment and *responsible* minister in NT) and the Commonwealth Minister be provided with this submission in full, particularly as it contains significant expert analysis and review of the Proponent's material. We would also request that this submission be provided to ERIAS, the Independent Monitor, who we understand is providing the NT Government (and NTEPA) with an independent review of the Draft EIS.

Recommendation 2: In view of the absence of efforts to comply with cl 7.3 to date, that prior to providing public comments to MRM for the preparation of the supplementary EIS, the NTEPA make specific arrangements for Indigenous members of the Gulf to make comment on the OBMP should they wish to.

Recommendation 3: All submissions to the Draft EIS should be made public – including (and particularly importantly) the review submission by ERIAS.

Recommendation 4: In light of the deficiencies in the process outlined above, the NTEPA and Commonwealth Minister should seek further information from local stakeholders, particularly in relation to matters of cultural significance and proposed closure planning and future land use.

Lack of available data in the draft EIS

The issues arising from lack of data availability is dealt with more specifically in relation to the relevant sections set out below, however we note in this section that expert review of the Draft EIS was not only hampered by short timeframes but also by the absence of complete data sets.

We note both the comments of David Airey in his expert report (Attachment B):

> *The report presents summaries of tests performed by a range of reputable organisations, however, none of the original data has been provided. It is thus impossible to assess the methodology used to perform the tests or the methods of interpretation. In my experience,*

based on reviewing test reports, simply performing Australian standard tests does not guarantee the quality of the data. They need to be carefully reviewed by experienced geotechnical engineers who have a thorough understanding of soil mechanics.

…

However, it is not possible to assess the reliability of these water retention curves or their consistency with other data because only summary results are presented in Appendix N.

And Abbas El-Zein in his expert report (Attachment C):

In relation to points a and b, the EIS makes incomplete reference to two other reports, presumably providing more details on how sorption was measured. However, these reports were not provided by the consultant upon my request. Instead, a small extract (4 tables) was provided which doesn't include any discussion of the assumptions made during the measurements of K_d and seems to confirm that sorption was taken to be linear and non-competitive.

In light of the above, the Draft EIS fails to meet the requirements of s102(2)(b) of the EBPC Act, and as a consequence (unless addressed in the supplementary) the Minister will fail to ensure (as required by cl 5.04 of the *Regulations*) that the EIS addressed the matters set out in Schedule 4 of the *Environment Protection Biodiversity Conservation Regulations,* specifically:

Schedule 4(3) Relevant Impacts

(e) any technical data and other information used or needed to make a detailed assessment of the relevant impacts.

Recommendation 5: To allow greater public scrutiny and transparency, as part of the EIS supplement, MRM should include all original data sets, rather than just summaries/extracts.

LACK OF APPROPRIATE COMPLETE OPEN PIT BACKFILL SCENARIO

At various points during the Draft EIS, MRM refers to the objectives of the *Northern Territory Draft Guidelines for Mine Closure Plans* (the NT Draft MCP Guidelines).[14] The EDO made comment on these draft guidelines in 2016, but we understand they are not a public document at this time. A key feature of that document was to begin from a presumption that complete backfilling of final pit voids would be required by the NT Government. Despite this, MRM does not adequately make the case for dismissing a complete backfill of the pit. Mudd, comprehensively deals with both the case for complete backfill in *The McArthur River Project: The Environmental Case for Complete Pit Backfill*[15], and the deficiencies of the Draft EIS regarding complete backfill in his report (attachment A).[16] We don't propose to go over that ground as it can be read in the report of Mudd and its appendices. We do draw attention again the primacy MRM has given to economic interests over environmental ones:

> *This alternative would represent the greatest cost to McArthur River Mining, rendering the project uneconomic and unviable. Thus, no further operations would occur, with a consequent cessation in employment and associated community investment projects, services, taxes and royalties…*[17]
>
> Additionally, when questioned about complete backfill during stakeholder engagement by MLA Gerry Wood (who noted that Ranger Uranium Mine is undertaking complete backfill), MRM responded "*It is important to remember that they were required to do that from the start so it was factored into their economics. That is not the case at MRM.*[18]

The context here is critical. It is MRM's historic failures, which have led to the need for this EIS. It is difficult to accept MRM continually placing economic concerns over environmental ones. The entire OBMP would, presumably, not have been a factor when MRM considered the economics of this project. Increased costs are a consequence of MRM's failures and best options should not be discounted on cost grounds alone where they have the potential for better environmental outcomes.

Recommendation 6: (Adopted from Mudd) The EIS Response Document must include a realistic scenario which ensures all PAF material is sequenced as deep as possible in the former pit. As part of the process, the broader Borroloola community must engage meaningfully in ascertaining their preferences for complete backfill – with a multi-criteria analysis or approach which properly allows for their social and environmental preference to be included as equal weight to financial or economic considerations (i.e. cost alone should not dominate rejection of the complete backfill scenario).

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[14] See for example Draft EIS, Chapter 4 p 4-7
[15] See Mudd (2017) Appendix B
[16] Mudd (2017) p 5 – 6 & Mudd. G
[17] Draft EIS, Chapter 5, p 5-31
[18] See Draft EIS, Appendix Y, p 73

MECHANISMS TO COMPEL COMPLIANCE WITH OBMP LOM CLOSURE PLAN

Lack of mechanisms to fund closure

The EDO's clients are not confident that MRM will see their closure plan through if the OBMP is approved. This must be one of the primary considerations for the NTEPA in preparing their assessment report and for decision makers in considering whether to approve the project. The short-term economic benefits of the project are well defined, but the long terms risks and costs are not. Importantly, the Draft EIS closure plan does not provide an estimate of costs of rehabilitation.

Decision makers should accept that – save for the security bond – there is currently no funding mechanism or hook that will keep MRM on the site financing its closure plan for (potentially 1000+ years). It would be naïve and contrary to past experience to expect social conscience and social licence to keep MRM on the site for a period of up to 1000 years. Historical experience with the mining industry generally does not support a conclusion that MRM will stay and fulfil its closure obligations.[19] Therefore, decision makers should proceed on the basis that taxpayers will be liable for closure costs once the productive life of the mine is at an end.

Decision makers should be aware that the NT does not have chain of responsibility legislation of the kind found in QLD.[20]

Recommendation 7: The Supplementary should specifically address the issue that Glencore (MRM's parent company) is unlikely to bear liability for acts or failures of MRM. An approval should not be issued to MRM unless some mechanism is in place to ensure that its parent company Glencore is liable for rehabilitation costs. As an example, some form of parent company guarantee could be considered to avoid the problem of MRM default.

Security bond under the MMA

At various points throughout the Draft EIS, MRM makes positive statements about the sufficiency of its security bond provided pursuant to s 43 of the *Mining Management Act.*[21] The issue of the MRM security was raised during the consultation process with MRM noting that community members were concerned about the level of security held for the site.[22]

The EDO's clients take small comfort from MRM's assurances that the security bond is sufficient and would feel far better if MRM instead chose to be transparent about how much the Government holds. Nevertheless, it is difficult to see how the government could be holding a bond sufficient to cover the potentially 1000 years of rehabilitation and monitoring – indeed it is unclear how a bond of that nature could even be calculated. To exemplify the difficulty of that task, consider the ability to predict the costs of an excavator in the year 2000 in 1900. It would have been practically impossible. It is even less feasible to predict what costs might be 1000 years from now.

It is difficult to reconcile MRM's statements about economic viability – for example in relation to backfilling the void – and their commitment to stay on the site for potentially 1000 years, some 980 years post the end of commercial exploitation of the ore body.

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[19] See for example, Mineral Policy Institute (2016) *Ground Truths: Taking Responsibility for Australia's Mining Legacies*
[20] See *Environment Protection (Chain of Responsibility) Act* 2016 (QLD)
[21] See for example, Draft EIS Appendix Y, p 64
[22] See for example, Draft EIS Appendix Y, p 41 & 64

Further we note that Dr Mudd describes the long-term monitoring as "conceptual at best, especially given the lack of detailed water quality criteria against which to assess and judge potential impacts"[23].

While the EDO's clients support the extraction and placement of tailings in the pit after the completion of mining (whether that occurs in 2018 without approval of the OBMP or later if approved) we note the concerns raised by Professor Mudd in relation to the economic viability of tailings reprocessing.[24] These concerns raise additional alarm bells about MRM's capacity/ability/desire to "stay the course" if the OBMP is approved.

Recommendation 8: That no approval be issued without the community first being informed of and consulted about the NT Government's security bond for the site.

Recommendation 9: (Adopted from Mudd – Attachment A) The EIS Response Document must include a clear case for the technical and economic viability of tailings reprocessing, especially how this may improve long-term environmental outcomes for the MRM site after the completion of all activities and rehabilitation.[25]

Recommendation 10: (Adopted from Mudd – Attachment A) The EIS Response Document must include detailed costings for the various rehabilitation scenarios, especially the case where tailings are simply transferred from the current dam to the former pit. The detailed costings should form part of a comprehensive document outlining the financial feasibility of the project taking into account the costs associated with closure and post-closure activities. [26]

[23] Mudd (2017) Attachment A
[24] We note that MRM has said that closure plan is not conditional upon reprocessing – see Appendix Y
[25] Mudd (2017) Attachment A, p 4
[26] The requirement for feasibility inclusion closure to be fully set out at the ealiest opportunity represents best practice, see for example The World Bank Group, Oil, Gas and Mining Policy Division *Guidance Notes for the Implementation of Financial Surety for Mine Closure.*

OVERBURDEN CHEMISTRY / MATERIALS CHARACTERISASTION

The Draft EIS demonstrates a significant improvement in the categorisation of materials that form the overburden on the site. Various experts engaged by the EDO's clients have noted the generally high quality of the geochemical work, which has been undertaken by MRM. [27] Despite this we note that previous (recent) history shows that MRM's track record is poor with regard to the assessment of waste rock characterisation and acid mine drainage issues.

Noller does make note of uncertainties, particularly regarding the underestimating of acid generation risk on the site, however, his review was generally complimentary of the work done by MRM in the geochemical section of the Draft EIS. Despite this he concludes that good management of the overburden will be critical to ensure that water materials are not dispersed by water or air.[28]

Additionally, Noller notes that the systems and resources required to undertake monitoring over the post closure phases must be planned and allocated as part of the closure process.[29]

Poor detail of the Mine's history

Because of the above and specifically low levels of confidence in previous work done by MRM, issues were raised with the way the Draft EIS presents (or fails to present) information in relation to the site's history.[30] Particularly the Draft EIS almost completely ignores the history of failure by MRM that has necessitated this project. Professor Gavin Mudd, in his report (Attachment A) states the following:

> The lack of any meaningful presentation and discussion of the environmental history of MRM at the start of Chapter 3 effectively avoids the reasons why there needs to be an entire EIS on just managing overburden (or waste rock) at the site (I know of no other mine in Australia which has been required to produce an EIS for this aspect of mining alone) – and perhaps most critically avoids the reality that the project has consistently under-estimated the proportion of potentially acid-forming (PAF) mine wastes. A careful examination of this history also shows that (briefly summarised from Mudd, 2016):

Understanding the history of the site and the previous modus operandi of MRM is critical to the forming of an opinion about the current project and whether it should be approved and if so, subject to what conditions. Indeed it is a requirement for the Commonwealth Minister to consider *environmental history* of the proponent in deciding whether or not to approve the project.[31]

The current Draft EIS tends to gloss over the past and provides a misleading impression of the developments, which have led to this EIS process.

Recommendation 11: (Adopted from Mudd – Attachment A): The EIS supplementary include a complete historical data set of all mining activity to date at MRM. The key aspects must include an annual data set of ore mined and milled, ore grades, concentrates produced, tailings generated and waste rock mined. In addition, a careful account should be provided

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[27] See Mudd (2017) Attachment A & Noller (2017) attachment D
[28] Noller (2017) Attachment D, p 14
[29] Noller (2017) Attachment D, p 15
[30] We note that the Terms of Reference for the Draft EIS require '*History of the development of the McArthur River Mine to Date* and the *Environment Protection and Biodiversity Conservation Regulations, Schedule 4* requires that statements include details about the background of the action.
[31] See s 136(4) EPBC Act (Cth)

of where all waste rock has been placed to date – including the estimated PAF and NAF quantities for each area of waste rock management.

Poor explanation of 'Low Capacity' or 'High Capacity' Mine Wastes

We draw attention to the discussion of Dr Mudd, at 2.3 of his report where he discusses the deficiencies in the descriptions of high or low capacity waste. We particularly note the limited utility of this definition given the statement in the EIS (raised by Mudd) that: *In practice, the segregation of MS-NAF(LC) from MS-NAF(HC) in unlikely to be possible most of the time. Both material classes have similar geochemical properties and will require mitigation, so this has little effect on the architecture of the NOEF.*[32]

[32] Mudd (2017) Attachment A

NOEF STABILITY AND DESIGN

Our comments on the stability and design of the NOEF are drawn from the comments of Professor David Airey (Attachment B). Airey notes that "any analysis is only as good as the input parameters and this is where I have some concerns".

The Draft EIS presents summaries of tests performed but does not include original data. Unfortunately this has limited the ability for Professor Airey to meaningfully review the Draft EIS.

Professor Airey raises a primary concern with Figure 13 in Appendix N to the Draft EIS. His concern relates to a plot showing peak friction angle against "cohesion". Professor Airey notes "most clays do not have any true cohesion…the correct terminology should have been apparent cohesion".[33] This is a critical point because the stability of the NOEF will be reliant on the "apparent cohesion" caused by a combination of soil expansion and pore water suctions.

Professor Airey notes that:

> *The reason why this is critical is that the stability of the steeper part of the slope of the NOEF relies on the "apparent" cohesion. It can be shown by a simple infinite slope analysis with a failure plane running along the CCL layer that the factor of safety increase from 1 to 1.5 is due to the apparent cohesion. If the cohesion is assumed to be zero the factor of safety will be one, that is the CCL will be on the verge of failure, and this would represent an unacceptable risk on any critical slope.*[34]

Airey further notes that:[35]

- MRM do not appear to have performed tests on their assessment of residual friction angle.
- There is a risk that local sections of the high upper slopes of the NOEF could fail.
- MRM fails to acknowledge the inherent uncertainty of the long-term stability of the NOEF slopes. Airey states there is "considerable risk" attached to MRM's apparent assumption that base drainage will continue to function effectively until 3017.
- There is inconsistency between the water retention curves and assumed strength parametres.

Recommendation 12: The Supplementary EIS should include the original data sets that underpin the test summaries for stability (including water retention curves) set out in the Draft EIS.

Recommendation 13: The Supplementary EIS should include tests performed for residual friction angles.

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[33] Airey (2017), Attachment B
[34] Airey (2017) Attachment B
[35] Airey (2017) Attachment B

Recommendation 14: The Supplementary EIS should provide clear direction to decision makers about where long term parameters are uncertain or based on assumptions which may prove incorrect.

THE SOEF

The EDO has previously raised concerns with the government about the determination of the *Mines and Energy Review Panel* with respect to the Southern Overburden Emplacement Facility (SOEF). Those concerns remain.

We note the errors during 2016 where "63 truckloads of PAF" were placed incorrectly on the SOEF.[36]

Recommendation 15: The supplementary EIS should include a detailed description of the proceedings before the *Mines and Energy Review Panel* including the position of the Department of Mines and Energy vis-à-vis that of MRM which was ultimately accepted by the Panel.

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[36] See Draft EIS, Chapter 3 at p 3-94

LIMNOLOGY & FLOW THROUGH MINE PIT LAKE

MRM presents the '*flow through mine pit lake as secondary option'* as their preferred alternative. MRM states that this design will achieve a "higher level of stakeholder acceptance" than the isolated void originally proposed in Phase 3.[37] MRM have chosen to present this option as the preferred one because they see it as having the following key advantages:

- Mine pit lake water dilution is decreased (relative to Alternative 3), with periodic flushing of the mine pit lake by flood waters only;
- Mine pit lake water will be relatively stable, though not as stable as Alternative 3 in low flow years;
- Reduced sediment deposition in the mine pit lake as compared to Alternative 3;
- Engineered inlets on the upstream and downstream side of the mine pit lake can be constructed and maintained to function as intended;
- The bulk of the mine levee wall would not need to be functional after breaching;
- The excavated levee material could be used as a source of clean fill in rehabilitating other areas;
- Higher degree of acceptance to stakeholders;
- Self-sustaining; and
- Under low-flow conditions, evaporative loss from the mine pit lake does not limit downstream flows in the McArthur River.

The EDO's clients' express serious reservations about the flow through mine pit lake approach. To them, it is not an option that increases acceptability of the project. Indeed we question MRM's approach to stakeholder engagement around this issue generally (discussed in more detail below). The EDO's clients concerns about the flow through are backed up by the views of the scientific experts engaged by the EDO's clients.

Dr Erica Garcia (Attachment F) raises concerns about the "high potential" for tailings to move from storage into downstream parts of the river. Garcia references the discussion in the *Final Void Limnology Assessment Report* where it is conceded that constant low level mixing and periods of high mixing (of contaminants/sediments and surface water) will occur.

Dr Geoff Vietz (Attachment E) shares Garcia's concerns with the flow through of the mine pit lake. Noting variously that:

- *The redirection of the McArthur River through the mine tailings could impact on bedload sediment transport convenyance from the McArthur River upstream of the mine pit lake to downstream of the mine pit lake.*
- *Diverting flow through the pit is likely to lead to deposition of sediments and aggradation in the upper reaches of the diversion channel.*
- *Risk the channel could capture the river's entire flow at times, leading to erosion issues in the diversion channel.*

Furthermore, Garcia notes that the flow through mine pit lake option introduces a non-typical new habitat into the river ecosystem, which may present unknowable or unanticipated negative impacts on the system. It is unclear why these risks were not raises specifically and in detail with stakeholders during consultation.

Garcia concludes *"the possible negative consequences to the McArthur River food web and those that rely on the food web by re-establishing the original path through the pit lake could*

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[37] Draft EIS, Chapter 5 *Project Alternatives,* p 5-5

be catastrophic and long-lasting". Vietz notes that the risks associated with the flow through can be avoided by simply not doing it. In light of the above comments it is difficult to justify why this option is the preferred option.

Recommendation 16: That MRM include in the supplementary to the EIS a new limnology report addressing the concerns raised by Garcia and Vietz. This should include an assessment of the limitations of the current limnology assessment with regards the risks of flow through and the need for increased thoroughness of investigations of fluvial geomorphology.

Additionally those reports should details the economic assessment of each option, the EDO's clients are concerned that this option has been chosen for its economic benefits (no necessity to maintain levee wall into perpetuity and the use of levee wall clean fill) rather than its environmental or touted stakeholder acceptance benefits.

Recommendation 17: That the OBMP preferred option be changed because of the concerns addressed about the river flow through and that appropriate stakeholder engagement be conducted to inform members of the community about the new preferred approach and why river flow through is, contrary to what was said previously, presents unacceptable risks.

GROUND & SURFACE WATER

Our submissions in relation to ground and surface water are primarily based on the expert input of Professor Abbass El-Zein and Dr Gavin Mudd. Professor El-Zein raises "serious concerns" about the approach taken by MRM in the Draft EIS to ensure the protection of water (both surface and ground) from contaminants. Dr Mudd raises concerns about modelling, climate data, background levels and surface water quality.

In summary those concerns are:

- An difficulty in discerning background or baseline groundwater chemistry.
- Over-reliance on sorption without consideration of competition, non-linearity and pH sensitivity. This, according to Professor El-Zein is important because *"if sorption has been overestimated, the actual concentrations of heavy metals may be orders of magnitude larger than those predicted in the EIS and may travel manyfold further than estimated in the document".*[38]
- Paucity of information about base lining.
- Weaknesses in the contaminant transport numerical model. According to Professor El-Zein, *"confidence in predictions of the contaminant transport model, based on evidence provided in the EIS, must be considered low".* We note that particular issue is taken with MRM's consultant's statement that *"flow boundaries have been kept consistent i.e., the flow model and the contaminant transport models boundary conditions for the flows are identical".* According to Professor El-Zein this does not make "scientific sense". According to Professor El-Zein, the weaknesses in this numerical model raise serious concerns about the future risks to water quality.[39]
- Lack of consideration of molecular diffusion as a contaminant transport mechanism.
- Discrepancy between climate data source SILO and onsite data – particularly regards rainfall.

Our recommendations below are informed by the comments of Professor El-Zein and Dr Gavin Mudd. We note that additional information sought from MRM was not provided and this has hampered Professor El-Zein's ability to perform the review requested of him.

Recommendation 18: (Adopted from Mudd) The supplementary EIS must outline methods to identify the extend of groundwater contamination across the MRM site and propose plans for its remediation before or during rehabilitation and site closure to ensure that environmental and cultural values are maintained.

Recommendation 19: (Adopted from Mudd) The groundwater monitoring plan should include bores downstream of the diversion chanel.

Recommendation 20: The supplementary EIS must include all of the raw data used by MRM to substantiate their claims that sorption will effectively prevent heavy metals from polluting surface waters downstream of the Mine. Additionally, the supplementary should address concerns raised about:

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[38] El-Zein (2017), Attachment C, p 3
[39] El-Zein (2017), Attachment C, p 5

(a) the apparent absence of *non-linear* modelling of sorption for the Site in circumstances where sorption has been overestimated in similar conditions;

(b) competition for sorption sites given the presence of multiple contaminants at the Mine;

(b) the potential variations over time which may impact on the soil's capacity for sorption; and

(c) the lack of consideration of desorption.

Recommendation 21: The supplementary EIS must address the issues raised by Professor El-Zein with regards to lack of information about base lining of the NOEF with a CCL, including through the provision of detailed designs of the base lining that will need to be provided.

Recommendation 22: The supplementary EIS should provide an honest assessment of the level of confidence MRM can have in relation to the contaminant transport models. Specifically, the supplementary must enable the NTEPA and decision makers to be in a position to assess the risks associated with calibration issues, short time interval models for contaminant transport models, the lack of modelling of heavy metals present in soil and the lack of boundary conditions.

Recommendation 23: The supplementary address the potential for contaminants to be transported by molecular diffusion.

Recommendation 24: (Adopted from Mudd) The discrepancy in using SILO vs onsite climate data should be justified in the supplementary. The EDO notes historical issues with MRM's consideration of climate change impacts, raised by the Independent Monitor.[40]

PROTECTION OF HUMAN HEALTH & DOWNSTREAM FLORA AND FAUNA

It was beyond the scope of our expert review to determine whether adequate protection of human health and downstream flora and fauna impacts are provided for by the Draft EIS. However, our experts have made a number of recommendations in this regard. Particularly concerns were expressed about the way testing is occurring for offsite and downstream water quality, human health impacts and impacts to flora and fauna.

We particularly raise the following issues:

- Using guideline values is not a credible method for assessing the effects of contaminants on organisms. That is, it shouldn't be assumed that just because a contaminant doesn't exceed a guideline value for sediment or water that the contaminant is not having an effect on organisms. Noller notes: "*for aquatic species such as fish and invertebrates contaminants in the food chain may effect particular species in the food chain and not be detected by physico-chemical monitoring*"[41]
- There is no direct monitoring of the exposure of the local population for heavy metal intake.

In light of the above we make the following recommendations:

[40] See Mudd (2017) Attachment A, p 7 and Part 1 of the Independent Monitor Audit Report 2015
[41] Noller (2017) Attachment D at p 24

Recommendation 25: (Adopted from the report of Noller) Exposure Assessment and monitoring of local people who consume fish and other aquatic foods should be undertaking for lead and cadmium by an independent third party at the cost of MRM.[42]

Recommendation 26: (Adopted from the report of Noller) a large experimental mesocosm facility needs to be set up with associated infrastructure that can be used to conduct simulate experiments and enable the exchange of tailings in water at depth and accumulations of metals over several lifetimes of short-lived aquatic species, including 10-20 years for turtle and crocodile via biopsy monitoring and biomarker techniques that do not result in mortality of the animal.

MRM'S CONSULTATION ON THE OBMP & SOCIAL MATTERS MORE GENERALLY

When making an approval decision, the Minister (or delegate) must consider social matters.[43]

The Draft EIS does not provide adequate information for the Minister to assess the social impacts of the OBMP and the Mine more generally. In considering whether to grant approval the Minister's ability to consider social matters is very broad, as is the weight he might place upon those matters. In this case, the Mine's potential to adversely impact the social fabric of the community is clear. It is evident from the clear divergence of opinions about the Mine and about its future.

Because of the mine's potential impacts on not only the site but the surrounding areas and downstream mean that the future of the Mine should be decided in consultation with all four clan groups. The Draft EIS should directly address issues of community divisions and social cohesion and what strategies they have in place to directly involve all clan groups in decision-making. This has not occurred.

The EDO's clients make the following points in relation to consultation undertaking in relation to the OBMP:

- The stakeholder consultations with all four clan groups cannot be considered best practice and fail to meet the standards required under Australia's international obligations for extractive industry projects working in regions populated by Indigenous people. To the extent that the Draft EIS is relied upon by a government-decision maker, additional consultation will be required to meet Australia's international obligations.[44]

- There are a number of flaws in the consultation process undertaken by MRM. Firstly, the framework under which the consultation too place is unclear and appears not to properly distinguish between consultation with communities generally and the level of consultation required to meet the test of free, prior and informed consent of Indigenous communities.[45] Among the requirements for effective consultation

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[42] Noller (2017) Attachment D at p
[43] s 136(1)(b) *EPBC Act* 1999 (Cth)
[44] The obligations of the Australian state to ensure effective consultation with Aboriginal people originates in international law from, inter alia, the *Declaration on the Rights of Indigenous Peoples* (DRIP). The Australian Government on 3 April 2009 announced its support for the DRIP. See the following relevant articles, 18, 19, 25, 27, 29 and 32.
[45] We note that MRM claims its policy and approach aligns with the International Council of Mining and Metals' 'Position statement on indigenous peoples and mining' (May 2013), which sets out its members' approaches to engaging with indigenous peoples, and to free, prior and informed consent.[45]

developed through international standards is the requirement to include Aboriginal people in the development of consultation processes themselves. It does not appear this was done in this case.

- The consultation plan does not demonstrate that MRM has adequately addressed power imbalances between it and the local community through the provision of resources including, financial assistance, interpreters, independent legal representation and independent technical assistance.[46]

- While traditional owners were questions regarding the particular land on which the mine is located, it does not appear from the stakeholder engagement report that members of all four clan groups were asked about nationally significant environmental matters, or culturally significant matters. Rather it appears it has been assumed that mainstream legal frameworks (in the form of EIA legislation) sufficiently identifies and deals with those risks.

- The EIS identified that "employment and training opportunities" presented during consultation sessions form part of the "significant support" for the project.[47] However, there were contradictory statements made regarding the likelihood of employment, and the nature of any employment. The EIS reports an employment target of 20%, however these jobs appear to be limited in skill levels and may not reflect a genuine transition for many to skilled jobs. For example, the Economic Impacts Assessment Report contained in Appendix Z (page 4) assumes there will be limited scope for employing locals and skilled positions and presupposes that increases in employment will be mainly related to rehabilitation activities such as monitoring, planting, weeding and earthworks maintenance." This is reiterated in Chapter 12 (pages 12–33) which states that during Stage Three (decommissioning and rehabilitation): "there will not be the same demand for skilled construction workers. During this period McArthur River mining has plan for approximately 11 positions to be held by local indigenous residents".

  Firstly, it is not clear what the basis is for the assumption that local Aboriginal residents should be limited to unskilled positions in circumstances where the plan is presupposing a commitment of the company to the mine for a number of years. For instance, MRM would be in a position to offer scholarships to local indigenous students who wish to take up environmental science, mechanical engineering, or management degrees and could complete their degrees well within time for the decommissioning efforts. Secondly, a number of comments by stakeholders during the consultation (as recorded in the stakeholder consultative report) suggest a potentially exaggerated understanding, or belief, in the number of jobs that will likely arise from the Project. It is difficult to read the comments in the stakeholder report

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According to that statement, one of the indicia of free, prior and informed consent is that "*indigenous peoples can give or withhold consent to a project, through a process that strives to be consistent with their traditional decision-making processes while respecting internationally recognised human rights and is based on good faith negotiation*".[45] Members of the Council also commit to implementing 10 principles arising from that position statement, including relevantly, principle 3, to "respect human rights and the interests, cultures, customs and values of employees and others affected by our activities (International Council on Mining & Metals, *Position Statement on Indigenous Peoples and Mining* (2013) p.3

[46] Given the highly technical nature of the project, it is appropriate that the four clan groups be provided with resourcing to access independent experts to review the methodologies and conclusions contained in the Draft EIS.

[47] Draft EIS, Appendix Y, p 42.

about an increase in local jobs and focus on local workers as consistent proposed. Given the often general and vague language used in the report, in our view it is likely that community members demonstrating commitment to the project because of its potential to add jobs may be operating under a misapprehension as to how many jobs are likely to be added. Additionally, the report contains a series of aspirational statements rather than actual commitments around employment and training.[48]

- The plan to run the river back through the pit lake was poorly explained and it appears from the stake holder engagement report that significant confusion remains within the community about this aspect of the Draft EIS. During consultations, stakeholders suggested that the lake might be used for such things as agriculture and recreation and were told that would be explored further. However, elsewhere in the Draft EIS it is confirmed that there would not be access to the pit lake, or that it could be used as a water sources. There is not evidence to suggest that this was ever clarified with stakeholders.

Recommendation 27: Visual aids in the form of photomontages should be provided to local stakeholders to give them a more accurate and realistic understanding of MRM's proposed higher NOEF option.

Recommendation 28: The supplementary draft EIS should specifically address issues which were left in a state of uncertainty following the stakeholder engagement process. Specifically, ambiguity around the pit lake and job opportunities for local people should be addressed.

Recommendation 29: Before considering whether approval is given to the OBMP, the Commonwealth Minister should require further information under s 132 about MRM's consultation with the local Indigenous clan groups about the potentially impacted MNES.[49]

The Agreement in relation to the height of the waste rock dump

This is not a matter that specifically concerns the EDO's clients. However, the EDO's clients - in taking issue with MRM's consultation processes more broadly - feel compelled to raise the questionable legitimacy of the purported agreement with traditional owners in relation to the raising of the height of the waste rock dump.

As discussed above, there is a significant power imbalance that exists between the local community and MRM (owned by multinational Glencore). Because of this it is incumbent upon MRM to ensure that stakeholders understand their rights and achieve free, prior and informed consent. This should be achieved by allowing sufficient time for consideration, by providing local stakeholders with independent legal representation and ensuring that interpreters are provided where necessary. As noted above, this is important in general consultation but it is even more critical when making agreements with traditional owners and members of local stakeholder groups.

It is far from clear whether MRM followed those processes and if they have not it raises real questions as to the legitimacy of MRM's agreement and indeed whether the agreement can be regarded an *unconscionable contact*.

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[48] Draft EIS, Appendix Y, p 42

[49] We note that the discretion of the Minister to seek further information is a broad one, see for example *Lansen v Minister for Environment and Heritage* [2008] FCAFC 189

Recommendation 30: Before any approval is given to the OBMP, the NTEPA and Commonwealth Environment Minister should satisfy themselves that any matters which are preconditions to the project proceeding have been entered into following the free, prior and informed consent of all relevant traditional owners.

David Morris
Principal Lawyer
Environmental Defenders Office NT
17 May 2017

McArthur River Mine Overburden Management Project – Draft Environmental Impact Statement

Comments by Assoc. Prof. Gavin M. Mudd
Environmental Engineering, RMIT University

May 2017

1. Background

I have been engaged by the Environment Defenders Office Northern Territory (EDONT) to provide independent expert comments on certain sections of the current Draft Environmental Impact Statement (EIS) concerning the Overburden Management Project for the McArthur River mine (MRM). Specifically, I have been asked to review Chapters 3 (Project Description) and 8 (Water Resources). In addition, I have also reviewed Chapters 4 (Decommissioning, Rehabilitation and Closure), 5 (Project Alternatives) and 6 (Materials Characterisation) to provide additional context and details for the primary chapters I comment on.

As per the Code of Conduct for Expert Reports, my comments are my own and based on my extensive experience, knowledge and unique insights into the environmental impacts and risks of mining. A short-form of my curriculum vitae (CV) is appended to this report (Appendix A).

In 2016 I was the sole author of a major research report on the McArthur River mine (Mudd, 2016), which argued the case for complete pit backfill as a rehabilitation strategy after mining as I believe this should reduce acid mine drainage (AMD) risks in the long term. I append this report to these comments (Appendix B), as this report is crucial for the context of my comments.

2. Comments on Chapter 3 – Project Description

Overall, the chapter is extensive and presents a wide array of necessary information concerning current operations and the proposed future operations at MRM as required by the EIS. There are, however, some gaps still remaining – addressing these would help in understanding the history and current status of the MRM project and its future trajectory. My comments focus on these gaps and justify why they must be addressed in the EIS Response.

2.1 History of the Project

A requirement in the Terms of Reference for the Draft EIS is the *'History of the development of the McArthur River Mine to date'* (page 3, Appendix A, EIS), although there is only a single sentence describing the history of the mine (first sentence, section 3.1). There is a very brief review of the basic history in earlier in the EIS in Section 1.2, but this is a simple timeline and fails to note the major environmental issues associated with the project.

The lack of any meaningful presentation and discussion of the environmental history of MRM at the start of Chapter 3 effectively avoids the reasons why there needs to be an entire EIS on just managing overburden (or waste rock) at the site (I know of no other mine in Australia which has been required to produce an EIS for this aspect of mining alone) – and perhaps most critically avoids the reality that the project has consistently under-estimated the proportion of potentially acid-forming (PAF) mine wastes. A careful examination of this history also shows that (briefly summarised from Mudd, 2016):

- **1992 EIS:** as the project was to be an underground mine, minimal waste rock was expected (especially as this would be managed almost entirely underground) although the PAF nature of some waste rock was recognised;
- **2005 EIS:** the project converted to open pit mine, and only 11% of 183 million tonnes (Mt) of waste rock would be PAF (i.e. 89% would be non-acid forming or NAF);
- **2012 EIS:** the project proposed a major increase in scale, expanding cumulative waste rock to 657.3 Mt although there is no proportional split given between expected PAF and NAF waste rock – instead, the EIS proposes that the management of PAF by isolation within NAF will be sufficient and best practice.

The current EIS claims that:

> *"Prior to 2014, potentially acid forming (PAF) material was estimated to comprise approximately 35% of the total overburden material to be excavated during the life of the mine. The remaining 65% of overburden was classified as non-acid forming (NAF), and therefore considered to be environmentally benign material." (page 3-1)*

Yet this value of 35% PAF waste rock was not presented in any of the previous EIS's – nor is there any acknowledgement that the Independent Monitor's (aka MRIM) reports on environmental monitoring and management at MRM suggest that the proportion of PAF waste rock was 91%, leaving NAF at just 9% (ERIAS, 2015). A criticism also raised by ERIAS (2015) and Mudd (2016) is the lack of reporting of waste rock data mined each year, where it is placed and how it has been managed. It is a significant failure in both regulation and transparency that the MRIM still cannot access such data to inform their assessments.

The quote above in the EIS also suggests that a changed identification regime was implemented sometime in 2014 but there are no details provided nor any justification as to why this was done (especially so soon after the 2012 expansion EIS).

In Chapter 6 (Materials Characterisation), it was stated that around 2012 that PAF-based testing of drill core samples showed that PAF was ~30% of the samples compared to just 15% of the geological model of the mine and that there was a need to recognise saline and neutral mine drainage as being of potential environmental concern (page 6-21). Based on cumulative totals of mine waste by classification (Table 6-10), the proportions of all forms of PAF (RE, HW, HC) are 26.0 + 5.1 + 197.6 Mt / 594.1 Mt = 38.5%, MS-NAF (HC+LC) are 136.0 + 140.7 Mt / 594.1 Mt = 46.6%, while alluvium and LS-NAF comprise the remaining 14.9%. Therefore, the combination of reactive PAF and NAF wastes is 38.5 + 46.6% or some 85.1% – a recognition of the severe extent of reactive wastes being mined from the MRM open pit and much closer to the estimate of the MRIM of 91%.

Documenting this history is not merely a simple recount of the MRM project, it is fundamental to establish why acid mine drainage risks have been so poorly recognised previously, leading to the major issues of smoke plumes from the PAF waste rock and concerns over seepage impacts on groundwater and surface water resources and eventually the need for this current EIS. Without such detailed history – and the data to go with it – it limits confidence in the current EIS and its associated assessment of PAF waste rock and AMD risks.

Recommendation 1: The EIS Response Document must include a complete historical data set of all mining activity to date at MRM. The key aspects must include an annual data set of ore mined and milled, ore grades, concentrates produced, tailings generated and waste rock mined. In addition, a careful account should be provided of where all waste rock has been placed to date – including the estimated PAF and NAF quantities for each area of waste rock management.

2.2 Tailings Reprocessing

Whilst it is good to see the EIS proposing to extract and reprocess the tailings and discharge them to the former open pit after the completion of mining, there is virtually no evidence provided that this will be successful. In other words, there is no clear case given for the technical success of tailings reprocessing – and in my experience, this requires very careful assessment for a variety of reasons I explain below.

In Australia, there is very little experience in reprocessing base metal tailings, with the only known examples being a modest extent at the former mines at Woodlawn (1978 to 1998, New South Wales) and Hellyer (1985 to 1999, Tasmania). During the latter years of operations at Woodlawn, tailings were mixed with fresh ore but the project proved difficult and uneconomic (about 1.8 Mt of tailings were treated). The Woodlawn tailings are currently reported as a mineral resource by current site owner Heron Resources Ltd (see Rankin, 2015). At Hellyer, after mine closure, the tailings were investigated and after modification of the Hellyer mill, reprocessing began in late 2006 but metallurgical problems and the global crash in metals prices led to the project being shelved in mid-2009 (about 1.9 Mt of the ~10.9 Mt of tailings were treated).

The common issues faced by reprocessing base metal tailings include recovery rates, grinding, weathering of the tailings, refractory mineralogy and economics (e.g. Mudd et al, 2017). At Hellyer, for example, galena (lead sulphide) had chemically weathered in the tailings dam to a lead oxide, meaning it could not be recovered by the conventional flotation process used in the mill. The recovery rate of zinc at Hellyer was also very low, being about 16%, which was probably related to the refractory nature of the residual zinc in the tailings. The large Century zinc mine closed in late 2015 in western Queensland, and despite significant efforts to re-develop the site to reprocess tailings mixed with low grade ore, this has not proceeded (probably a function of both economic market conditions as well as technical risks).

The McArthur River deposit lay dormant and undeveloped as a mine precisely due to its fine-grained mineralogy making it a difficult ore to process and extract saleable concentrates from. The long-term recovery rate for zinc is about 75% (data updated Mudd, 2009 and Mudd et al, 2017), and, based on a concentrate grade of 45% Zn (Rossberg & Pafumi, 2015), this means that by the end of 2015 the quantity of tailings would be approximately 30 Mt with probable grades of ~3.7% Pb, ~3.6% Zn and ~33 g/t Ag (this is my estimate only, based on production data, and not JORC-code compliant). This compares favourably with numerous global mineral resources of lead-zinc (see Mudd et al, 2017) but the complex technical issues which would be faced by reprocessing tailings at MRM remain poorly addressed. On pages 3-176 to 3-178, a very brief review of tailings reprocessing is given, making it sound almost identical to current ore processing – yet recovery rates of only 20% for zinc and 7% for lead are expected as well as the throughput being close to double that of the current processing capacity, meaning it is very different to current operations.

As such, although it is simple in concept to see a large tonnage of tailings with low grades of lead, zinc and silver and combine this with the cheap nature of extraction (compared to the higher cost of open pit mining and associated waste rock etc.), in reality the metals left in tailings were commonly not extracted during primary ore processing due to their refractory nature. This means that all base metal tailings reprocessing projects need very careful study and assessment to demonstrate their technical and economic viability.

Recommendation 2: The EIS Response Document must include a clear case for the technical and economic viability of tailings reprocessing, especially how this may improve long-term environmental outcomes for the MRM site after the completion of all activities and rehabilitation. This is also in line with normal industry practice for the reporting of ore reserves and mineral resources (e.g. JORC) – that is, tailings cannot reported as a potentially economic resource until such studies have been completed.

A benefit of reprocessing tailings is the additional revenue this can generate for a project – which could be useful in offsetting the costs of site rehabilitation. Given the risky nature of tailings reprocessing projects, however, the funding of rehabilitation should not be reliant on such revenue to ensure the MRM site is fully rehabilitated.

Recommendation 3: The EIS Response Document must include detailed costings for the various rehabilitation scenarios, especially the case where tailings are simply transferred from the current dam to the former pit.

It is clearly a realistic possibility that reprocessing tailings may remain unviable, even by the year 2038 (unless there are considerable improvements in processing technology by then and/or market conditions have led to much higher prices to offset potentially high costs).

Recommendation 4: The EIS Response Document must include a future scenario where the tailings are simply transferred from the storage dams to the former open pit mine.

2.3 Poor Explanation of 'Low Capacity' or 'High Capacity' Mine Wastes

In general, the level of detail for the geochemical evaluation of mine wastes at MRM now appears to be excellent and is linked in detail with daily mine activities and longer term plans and designs. This is a major step forward from previous EIS studies.

In discussing the geochemistry of various mine wastes coming from the MRM open pit, there are four dominant types now recognised – being split as metalliferous saline non-acid forming or potentially acid forming combined with 'high capacity', 'low capacity' or 'reactive'. In this chapter (i.e. Project Description), however, there is ***NO*** explanation or description whatsoever of what high or low capacity means. In the Materials Characterisation section (Chapter 6), there is also minimal discussion of what this distinction means – although there is detailed discussion of the geochemical characteristics of the various classifications, they do not make the need to distinguish 'high' versus 'low' clear in simple or non-technical language. In other words, it is highly complex language and fails to present a clear, direct and readily understood explanation of the mine wastes' classifications and why this is important. Furthermore, the EIS states (page 6-62):

"In practice, the segregation of MS-NAF(LC) from MS-NAF(HC) is unlikely to be possible most of the time. Both material classes have similar geochemical properties and will require mitigation, so this has little effect on the architecture of the NOEF."

Although it is stated that the main need for identifying high versus low capacity mine wastes is to estimate the proportion of low buffering capacity wastes, this remains poorly justified if in fact it is impossible in reality to use for mine management and daily activities.

Recommendation 5: A better and clearer explanation of the distinction of mine wastes as 'high' or 'low' capacity needs to be given, especially since it appears effectively impractical to implement in daily mining activities.

2.4 Lack of Appropriate Complete Open Pit Backfill Scenario

The EIS's preferred option is to emplace reprocessed tailings into the bottom of the pit, with very minor emplacement of some waste rock in the final years of open pit mining into mined out areas of the pit – but not to remove the waste rock from their respective facilities and completely backfill the pit. Complete pit backfill is discussed as 'Alternative 7' in the Closure Alternatives section of Chapter 5 (i.e. section 5.5.2.2.2.7, pages 5-28 to 5-31), but it fails to make a thorough case.

There is no groundwater table marked in Figure 5-10 – this is critical as this shows the zone below which oxidation would be effectively minimised due to the lack of oxygen. This is also important for highlighting any mine wastes above this line, as these wastes would be subjected to ongoing oxidation and weathering. Although this is correctly acknowledged in Alternative 7, Figure 5-10 also seems to suggest that most mine wastes would be emplaced in the former pit before tailings reprocessing – yet tailings would be discharged from 2038 into the former pit.

It is also shown in Figure 5-10 that most of the PAF wastes would be emplaced in the bottom two-thirds of the pit, with other MS-NAF wastes above – including some PAF wastes. There is no sense whatsoever in leaving highly reactive PAF wastes in the near surface of any pit backfill scenario – the EIS must articulate a careful design and planning strategy to ensure that all PAF wastes would be below a re-established groundwater table. It seems that Alternative 7 is simply fashioned to avoid having to triple handle such wastes which may be near the base of the current NOEF – yet the lack of data on mining to date and where such historical mine wastes are being managed limits insights into such critical issues.

Whilst there is a clear recognition of the leaching risks from wastes in the upper zones which would remain unsaturated (the vadose zone), there is no detailed hydrological assessment of this scenario – such as quantifying potential recharge rates, possible groundwater mounding in the former pit and connections to the McArthur River channel. Furthermore, there is minimal recognition that such risks can be mitigated with detailed engineering approaches, such as the low permeability barriers which are even shown in Figure 5-10.

In addition, the comparison of Alternative Closure Scenarios (Table 5-4), which appears to be somewhat subjective, is heavily focussed on financial aspects – with 8 of the 12 key aspects relating to financial costs (i.e. constructability, financial cost, maintenance ease). This effectively biases the outcome towards avoiding a higher cost approach that delivers better environmental and social outcomes, which is where the primary focus should be. There is a need also to facilitate such a comparison by those in the broader Borroloola community – as

they will live with the consequences of whatever final rehabilitation option is adopted for the MRM site.

For comparison, the second rehabilitation project for the former Rum Jungle uranium mine, about 100 km south of Darwin, is now proposing waste rock backfill to former pits – this option was rejected in the first rehabilitation project in the 1980s on cost grounds. The rehabilitation works didn't even last a decade before significant deterioration was observed in engineering performance – whilst this is in part due to a than less complete understanding of AMD and soil cover designs to limit sulphide oxidation in waste rock at this time, another major factor was poor construction where the covers were not built to the required design (see summary in Mudd & Patterson, 2010). The fact that the second rehabilitation project is now committed to complete backfill – despite this still being the more expensive but an option the local community (especially indigenous interests) strongly prefer – shows the inherent risks of leaving sulphidic mine wastes above ground and the need to engage community meaningfully.

Given the weaknesses identified above, the Alternative Closure Scenario 7 fails to make a strong case to reject complete pit backfill as a viable long-term outcome for the MRM site.

> **Recommendation 5: The EIS Response Document must include a realistic complete backfill scenario which ensures all PAF material is sequenced as deep as possible in the former pit. As part of the process, the broader Borroloola community must be engaged meaningfully in ascertaining their preferences for complete pit backfill – with a multi-criteria analysis or approach which properly allows for their social and environmental preferences to be included as equal weight to financial or economic considerations (i.e. cost alone should not dominate rejection of the complete backfill scenario).**

3. Comments on Chapter 8 – Water Resources

Overall, the chapter is reasonably extensive but is heavily reliant on a wide range of numerical hydrology models which are linked together to address water resources risks and impacts (e.g. GoldSim, DumpSim, ELCOM, TUFLOW, MODFLOW, TOUGH2, etc). There also appears to be minimal use of onsite monitoring data of climate and water resources, which remains a large weakness in validating the various models – this is quite surprising given the large scale of the MRM site and extent of monitoring which would be conducted as per statutory requirements. Detailed and specific comments are given below.

3.1 Climate Data

The dominant data source used for climate data (rainfall, temperature) was the estimated series called 'SILO' (from the Queensland Government – although it is stated that previous assessments have shown SILO data to correlate well with onsite data, this should be presented in the EIS for rigour and completeness. A simple comparison shows the annual rainfall to be ~713 mm/year from SILO (page 8-9) compared to 801.3 mm/year[1] from onsite (Table 1-1, page 1-16), with evaporation rates closer at 2,739 and 2,732 mm/year, respectively. This difference in rainfall needs to be addressed as it represents a significant increase in water inputs to the site and region.

[1] It should be noted that the mean monthly rainfall data given in Table 1-1 only adds up to 792 mm – not 801.3 mm as shown (presumably the 801.3 mm is the average of mean annual rainfall instead).

Recommendation 6: The discrepancy in using SILO versus onsite climate data should be explicitly justified, as there appears to be a potentially significant inconsistency in annual rainfall values – these are critical in ensuring the accuracy of all hydrological models used for the EIS.

3.2 Groundwater Chemistry and Contamination

A detailed analysis of groundwater chemistry is given in Section 3.8 of Appendix T to the EIS. This section is actually very thorough and uses extensive time-series graphs, chemical plots and maps of concentrations to show the current impacts on groundwater, especially the shallow water table.

A major weakness, however, is that it is very difficult to discern what can be considered background or baseline groundwater chemistry for the MRM region. This is critical as it helps to clearly define any groundwater that is impacted. For example, based on Figure 38 (Appendix T), it would appear that a background sulphate concentration could be considered as less than 50 mg/L – but this needs to be assessed in connection with sulphides present in host rocks and associated aquifers. Based on a visual examination of Figure 38, it would appear that baseline concentrations of sulphate might vary up to 250 mg/L.

Furthermore, whilst there is some recognition of groundwater contamination, there is no recognition of the almost definite need to remediate groundwater as part of mine rehabilitation and site closure. Given the issues already identified and acknowledged concerning current groundwater impacts in the EIS (e.g. see Appendix T), a bigger and longer-life mine will undoubtedly increase the groundwater contamination risks and this will have to be addressed during site rehabilitation and closure.

Recommendation 7: The EIS Response Document must outline methods to identify the extent of groundwater contamination across the MRM site and propose plans for its remediation before or during rehabilitation and site closure to ensure that environmental and cultural values are maintained.

For groundwater monitoring, there appears to be no bores downstream of the diversion channel. Such a bore would be useful in understanding any ongoing risks from seepage from the diversion channel. This is similar to surface water monitoring also.

Recommendation 8: The groundwater monitoring plan should include bores downstream of the diversion channel (e.g. on the far right of Figure 8-53).

3.3 Surface Water Quality

The detailed appendix on surface water impacts is extensive, and a considerable advance on previous EIS's for the MRM site. However, there is virtually no information presented in the main EIS document itself on surface water quality – this is a huge, substantial weakness. The EIS states that "… comprehensive surface water and groundwater quality monitoring program within and in the vicinity of the mine site has been underway for over 20 years" (page 8-27) – yet no detailed chemical data is presented at all in the EIS and is instead left to Appendix U. For a project such as this, it is absolutely imperative to provide data on pH, electrical conductivity, turbidity, alkalinity, salts and heavy metals in the main EIS chapter itself. Such data can be used to understand averages and ranges of concentrations and inform guideline values (or levels) for monitoring and potential impact assessment.

Furthermore, the presentation and discussion of surface water quality in Appendix U (pages 57 to 60) still fails to propose a reasonable method or approach to differentiating a mine-related signature of impact on the McArthur River. That is, possible methods include isotopic fingerprinting (e.g. using lead isotopes to distinguish MRM-related lead versus other sources in the catchment), an upstream-downstream concentration difference (e.g. can a higher concentration downstream signify a mine-related contaminant source?).

Recommendation 9: The EIS Response Document must include proposals to distinguish possible mine-related impacts on the surface water quality of the McArthur River. Such methods must allow the neutral identification of the source from the MRM site, and provide scope for warning before the impacts are severe.

3.4 Long-Term Monitoring

Whilst it is welcome to see a recognition of the need for long-term environmental monitoring up to one thousand years into the future (e.g. Figure 8-57) – this is perhaps conceptual at best, especially given the lack of detailed water quality criteria against which to assess and judge potential impacts (as noted above). Furthermore, there is no funding mechanism presented which can finance such monitoring – leaving one to infer that it would be tax-payers paying for this for the thousand years.

Recommendation 10: The EIS Response Document must present a detailed approach for assessing surface water quality and how to identify potential mine-related impacts.

Recommendation 11: The EIS Response Document must present a detailed financial approach for ensuring that funding for the next one thousand years will be secured by the MRM project and left to tax-payers to fund.

4. References

ERIAS, 2015, *Independent Monitor - Environmental Performance Annual Report 2014 - McArthur River Mine*. Prepared by ERIAS Group Pty Ltd (ERIAS) for the NT Minister of Mines & Energy and the NT Dept. of Mines & Energy, Melbourne, VIC, October 2014, 674 pages.

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Rossberg, F & Pafumi, J, 2013, *McArthur River Mine*. In "Australasian Mining and Metallurgical Operating Practices - The Sir Maurice Mawby Memorial Volume: Third Edition", W J Rankin (Ed.), Australasian Institute of Mining & Metallurgy (AusIMM), Melbourne, Australia, Monograph 28, pages 1661-1682.

Appendix A:

Short Form CV – Assoc. Prof. Gavin M. Mudd

Assoc. Prof. Gavin M. Mudd

Curriculum Vitae: May 2017

Current Position	***Associate Professor – Environmental Engineering*** School of Engineering, *RMIT University*, Melbourne, VIC, Australia Ph +61-3-9925-3209 – Mobile +61-419-117-494 Email: Gavin.Mudd@rmit.edu.au

Qualifications

Doctorate (PhD) — *Victoria University*, Melbourne, Australia (awarded Oct. 2001)
B. Env. Eng. (Hons) — *RMIT University*, Melbourne, Australia (awarded May 1995)

Current and Previous Appointments

- January 2017 to present – **Associate Professor in Environmental Engineering**, *School of Engineering*, *RMIT University*, including a wide range of teaching, research and administration.
- May 2003 to January 2017 – **Assistant Lecturer / Lecturer / Senior Lecturer / Course Director in Environmental Engineering**, *Dept. of Civil Eng*, *Monash University*, including a wide range of teaching, research and administration.
- November 2009 to February 2010 – **Visiting Fellow**, Institute of Environmental Studies, University of New South Wales, Sydney
- July to October 2009 – **Visiting Fellow**, Dept of Civil & Environmental Eng, University of Auckland, New Zealand
- Approximately 20 months **consulting experience** - contaminated sites, environmental assessment, groundwater, solute transport and unsaturated flow modelling, laboratory testing of mine wastes, liaison with government and industry organisations, working with and for Aboriginal people.
- July 2000 to April 2002 - **Research Fellow in Mine Waste Hydrology**, *Dept. of Civil Eng*, *University of Queensland*.
- March to July 1998 (Semester One) - **Lecturer in Earth Sciences/Geomechanics**, Victoria Uni.
- March 1995 to June 2000 - **PhD Research** - groundwater impacts and management of coal ash disposal.

Research Interests & Performance (as of 19 March 2017)

- **H-index: Scopus** – **<u>21</u>**; 1,311 total citations from 74 documents/papers.
- **H-index: Google Scholar** – **<u>30</u>**; 2,813 total citations from 184 documents/papers.
- **Edited Books** – **<u>1</u>** edited conference proceedings (SSEE 2009 Conf., Melbourne, Australia, Nov. 2009).
- **Book & Encyclopaedia Chapters** – **<u>20</u>** edited book and encyclopaedia chapters, several under review or in active preparation.
- **Journals** – **<u>71</u>** journal papers published, several more under review or in active preparation.
- **Major Research Reports and Handbooks** – **<u>29</u>** research and technical reports and contributions to industry, government and community handbooks.
- **Conference Papers – Peer Reviewed** – **<u>56</u>** peer-reviewed conference papers and/or presentations.
- **Sustainable Mining** – environmental impacts, geochemistry, leachability & management of mine wastes, acid mine drainage, sustainable resource management; commodities include uranium, gold, nickel, copper, lead-zinc-silver, platinum group elements, iron ore, cobalt, rare earth elements, critical and specialty metals (such as indium, rhenium, molybdenum), lithium, coal, oil and gas.
- **Industrial Ecology** – life cycle assessments, environmental impact assessment, material flow analyses.
- **Hydrogeology & Groundwater Resources** – groundwater management & sustainability, groundwater impacts from mining, geochemistry, flow and solute transport modelling, vadose (unsaturated) zone issues.

Selected Recent Publications

1. **Mudd, G M**, 2017, *Criticality Assessments*. In "Routledge Handbook of the Resource Nexus", Editors R Bleischwitz, Hoff, H, Spataru, C, van der Voet, E and van Deveer, S, Routledge, In Press.
2. Weng, Z & **Mudd, G M**, 2017, *Global Rare Earth Supply, Life Cycle Assessment and Wind Energy*. In "Wind Energy", Editor T Letcher, Elsevier, In Press.
3. Northey, S A, **Mudd, G M**, Werner, T T, Haque, N, Jowitt, S M, Weng, Z & Yellishetty, M, 2017, *The Exposure of Global Base Metal Resources to Water Criticality, Scarcity and Climate Change*. **Global Environmental Change**, Accepted subject to revision.
4. **Mudd, G M**, Jowitt, S M & Werner, T T, 2017, *The World's Lead-Zinc Mineral Resources: Scarcity, Data, Issues and Opportunities*. **Ore Geology Reviews**, 80, pp 1160-1190.
5. Werner, T T, Jowitt, S M & **Mudd, G M**, 2017, *The World's By-Product and Critical Metal Resources Part III: A Global Assessment of Indium*. **Ore Geology Reviews**, In Press (doi:10.1016/j.oregeorev.2017.01.015).
6. Werner, T T, Jowitt, S M & **Mudd, G M**, 2017, *The World's By-Product and Critical Metal Resources Part II: A Method for Quantifying the Resources of Rarely Reported Metals*. **Ore Geology Reviews**, 80, pp 658-675.
7. **Mudd, G M**, Jowitt, S M & Werner, T T, 2016, *The World's By-Product and Critical Metal Resources Part I: Uncertainties, Current Reporting Practices, Implications and Grounds for Optimism*. **Ore Geology Reviews**, In Press.
8. **Mudd, G M** & Jowitt, S M, 2016, *From Mineral Resources to Sustainable Mining: The Key Trends to Unlock the Holy Grail?* Proc. "Geometallurgy 2016", Australasian Institute of Mining and Metallurgy, Perth, QLD, June 2016, ***Keynote Paper and Presentation***, In Press.
9. **Mudd, G M**, 2016, *The Mineral Resources-Energy Technologies Nexus: An Optimistic Assessment*. **Energy & Resources**, 27 (3), pp 177-182.
10. Weng, Z, Haque, N, **Mudd, G M** & Jowitt, S M, 2016, *Assessing the Energy Requirements and Global Warming Potential of the Production of Rare Earth Elements*. **Journal of Cleaner Production**, 139, pp 1282-1297.
11. **Mudd, G M**, Jowitt, S M, Werner, T T & Weng, Z, 2016, *Critical Metals for 21st Century Energy Technologies: Assessing Global Resources and Grounds for Optimism*. Pres. "EcoBalance 2016: Responsible Value Chains for Sustainability", Kyoto, Japan, October 2016.
12. Weng, Z, Jowitt, S M, **Mudd, G M** & Haque, N, 2015, *A Detailed Assessment of Global Rare Earth Resources: Opportunities and Challenges*. **Economic Geology**, 110 (8), pp 1925-1952.
13. **Mudd, G M**, Weng, Z, Jowitt, S M, Turnbull, I D & Graedel, T E, 2013, *Quantifying the Recoverable Resources of By-Product Metals: The Case of Cobalt*. **Ore Geology Reviews**, 55, pp 87-98.
14. **Mudd, G M**, 2012, *Key Trends in the Resource Sustainability of Platinum Group Elements*. **Ore Geology Reviews**, 46 (1), pp 106-117.
15. Prior, T, Giurco, D, **Mudd, G M** & Behrisch, J, 2012, *Resource Depletion, Peak Minerals and the Implications for Sustainable Resource Management*. **Global Environmental Change**, 22 (3), pp 577-587.
16. van der Voet, E, Salminen, R, Eckelman, M, Norgate, T, **Mudd, G M**, Hischier, R, Spijker, J, Vijver, M, Selinus, O, Posthuma, L, de Zwart, D, van de Meent, D, Reuter, M, Tikana, L, Valdivia, S, Wäger, P, Hauschild, M & de Koning, A, 2013, *Environmental Challenges of Anthropogenic Metals Flows and Cycles*. Working Group Metals, **UNEP International Resources Panel**, April 2013, 234 p.

Research Awards

- **Mann Redmayne Award for best paper published in Applied Earth Sciences (2015)**, Joint Australasian Institute of Metallurgy (AusIMM) and Institute of Materials, Minerals and Mining (IoM3) journal
- **Most-cited paper in Resources Policy (2009-2013) by Elsevier in 2014 (for my 2010 paper in Res. Pol.)**

Major Research Grants & Involvement (Recent and Current)

- **CSIRO Wealth From Waste Cluster** – joint CSIRO-university initiative, led by Institute for Sustainable Futures at University of Technology Sydney (UTS), the project is exploring the concept of material flows from mineral resources to products through to recycling and related issues. Monash University was a major cluster partner, along with Yale University, University of Queensland and Swinburne University. *(Project completed, 2013-2016)*
- **CSIRO Minerals Futures Cluster** – joint CSIRO-university initiative, led by Institute for Sustainable Futures at UTS, with my involvement through Monash helping to explore the concept of 'peak minerals' and related environmental issues in the mining industry. *(Project completed, 2009-2012)*
- **Institute for Sustainable Water Resources (ISWR)** – aquifer storage & recovery (ASR) and groundwater geochemistry in alluvial aquifers of Melbourne. *(Project completed, 2004-2008)*
- **Facility for Advancing Water Biofiltration (FAWB)** – urban water biofilters. *(Project completed, 2007-2009)*
- **eWater CRC** – groundwater-surface water interaction project. *(Involvement completed, 2006-2009)*

Teaching Awards

- **Department of Civil Engineering's Award for Excellence in Teaching (2012)**, Monash University
- **Faculty of Engineering Dean's Award for Excellence in Teaching (2012)**, Monash University
- **Vice Chancellor's Citation for Outstanding Contribution to Student Learning (2011)**, Monash University

Post-Graduate Research Supervision

- **4 PhD students and 3 Masters** completed as principal supervisor, **4 PhD students** completed as co-supervisor
- Presently 1 PhD student as principal supervisor and 1 PhD student as co-supervisor.

Teaching Interests

- Environmental Impact Assessment (EIA), Environmental Risk Management, Groundwater Management, Natural Resources Management.
- Sustainable Engineering and Industrial Ecology (especially as applied to mining and resources and tools such as life cycle assessment, material flow analysis).

Undergraduate Teaching

- **Environmental Engineering** – Environmental Engineering (ENE1621) Environmental Impact Assessment & Management Systems (ENE3608), Environmental Risk Assessment (ENE4607), Research Projects (ENE4603/4).
- **Guest Lectures** – Geography, Environmental Science, Civil Engineering, Mining Engineering.
- **Previously Taught** – Groundwater & Environmental Geoengineering (CIV3248, 2004 to 2011), Energy & the Environment (ENE3048, 2007, ongoing minor role).

University Administration

- **Course Director – Environmental Engineering** (BEnvEng, BEnvEng/BSci, BEnvEng/BArts, BEnvEng/BComm)
- **University** – Environmental Sustainability Stakeholder Committee
- **Faculty of Engineering – Academic Progress Committee (APC)**

External Committees

- **Present** (September 2009 to present) – **Alligator Rivers Region Technical Committee (ARRTC)**, environment representative, national committee overseeing research on environmental aspects of uranium mining in the Alligator Rivers Region of the Northern Territory. ARRTC is a statutory committee of the Australian Government and membership is government-appointed based on relevant scientific expertise.
- **Prior** (Nov 2006 to Nov 2010) – **Society for Sustainability and Environmental Engineering (SSEE; Victorian Branch)** – Victorian committee of national society, part of Engineers Australia (SSEE is now the Sustainable Engineering Society or SEng).
- **Prior** (May 2004 to Dec 2006) – **Great Artesian Basin Co-ordinating Committee (GABCC)** – national inter-governmental committee for oversight of groundwater management of the GAB. The GABCC is a statutory committee of the Australian Government and membership is government-appointed based on relevant expertise.

External Consulting & Community Engagement

- **General Mining** – as requested, providing technical advice on environmental issues and mining (e.g. gold mining in WA, Indonesia, New Zealand and Papua New Guinea; copper heap leaching; mineral sands mining; existing and proposed coal mining; coal seam gas; mining legacies and lack of mine rehabilitation, etc.).
- **Uranium Mining** – pro-active role in providing detailed technical review and advice on uranium mining issues in the Kakadu National Park world heritage area (Ranger, Jabiluka), and globally (e.g. Malawi, USA, Canada).
- **Mineral Policy Institute (MPi)** – Chair of the Board (2010-present). MPi is the only Australian non-government organisation dedicated to research and advocacy on the environmental and social issues around the mining industry. MPi's work includes projects in Papua New Guinea, Malawi, Australia, New Caledonia and others, covering issues such as deep sea mining, mine waste management, corporate governance and accountability, community empowerment and development, mining legacies, and related aspects of modern mining.
- **Groundwater** – technical advice on groundwater chemistry and impacts from mining or other sites (e.g. coal seam gas), groundwater resources and management.
- **Environmental Impact Assessment** – providing technical advice on EIA processes, critiquing EIS's, links to environmental management systems and environmental regulation.

- **Community Seminars** – I have always maintained a strong community engagement, presenting regularly at community seminars, workshops and conferences, with a major focus in recent years being the groundwater and environmental issues involved with unconventional gas developments (e.g. 2013 I gave ~25 community talks).

Professional Memberships

Current:
- Australasian Institute of Mining and Metallurgy (**AusIMM**)
- Sustainable Engineering Society (**SEng**, part of *Engineers Australia*)
- Society of Economic Geologists (**SEG**)

Former:
- International Society for Industrial Ecology (**ISIE**)
- International Association of Hydrogeologists (**IAH**)
- Australian Mining History Association (**AMHA**)

Appendix B: Backfill Report on McArthur River

THE MCARTHUR RIVER PROJECT:

THE ENVIRONMENTAL CASE FOR COMPLETE PIT BACKFILL

Dr Gavin M. Mudd

mineral policy institute

This report is dedicated to the Gurdanji, Mara, Garawa and Yanyuwa Peoples and their continuing struggle to protect country from invasive mining.

ACKNOWLEDGEMENTS

Research: Gavin Mudd, Charles Roche and Lauren Mellor

We recognise and pay tribute to the communities, researchers and mining professionals who have long understood the need for mining legacies reform in Australia.

This project was made possible by the generous contribution of artwork sales by the community of Borroloola.

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Gavin is a senior lecturer and course director in Environmental Engineering at Monash University and chair of the Mineral Policy Institute. Dr Mudd has been involved in the environmental aspects of mining for over 15 years—including extensive experience in groundwater and surface water impacts, mine waste management, mine rehabilitation, energy and carbon intensity assessments, sustainability reporting and applying sustainable development principles to the mining industry.

ABOUT THE MINERAL POLICY INSTITUTE

The Mineral Policy Institute [MPI] is an international civil society organisation with a volunteer board representing members from across the world. Operating from Australia we focus on assisting communities affected by specific mining projects and on achieving industry reform through improvements to policy, law and practice.

With a strong emphasis on free prior and informed consent, MPI undertakes a supportive and background role to assist mining affected communities. Our aim, and our role is to support communities to more effectively protect their rights and respond to mining issues that impact on them.

While mining disproportionately impacts the developing world, however, the decisions that govern these projects are made and need to be influenced in the developed world. MPI has the expertise, the experience and the networks to assist communities and to access the many mining companies based in Australia [also US, UK, South Africa and Canada] and their investors from around world.

We are guided by a vision of a just and sustainable mineral cycle where human rights are protected, impacts dramatically reduced and mineral/fuel efficiency and reuse is paramount. While we believe that minerals/fuel are central to the quality of human life today, the benefits of the current minerals systems are greatly skewed to a relatively small global elite. MPI plays a key role in addressing this paradox… to increase the equitable distribution of the benefits while decreasing the social injustices and environmental impacts of the mineral/fuel system.

As an industry watchdog, we rely on community funding to ensure our independence from industry. Seeking to improve and influence an industry that plans in decades, we require funding to progress and achieve long-term strategic goals and to assist communities who are impacted by mining today, tomorrow and in the future.

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The McArthur River lead–zinc–silver (Pb–Zn–Ag) mining project is located in the central eastern region of the Northern Territory (NT) of Australia, home to the Gurdanji, Mara, Garawa and Yanyuwa Peoples. Discovered in the late 1950's and mined since the mid-1990's the deposit remains one of the world's largest mineral resources of Pb–Zn–Ag (Mudd *et al*, 2016). The McArthur River, from which the mine takes its name, is seasonal, changing from a chain of ponds in the dry to a tropical torrent in the wet season on its 300km journey to the Gulf of Carpentaria.

In terms of Australian and world Pb–Zn mining, the project is technically difficult and has had a challenging history—on many fronts. The initial challenges faced by McArthur River were predominantly technical in nature with the very fine-grained ore being difficult to treat with the standard ore processing (or milling) technology of the time, resulting in the project laying dormant until the early 1990's when improvements in technology finally allowed development (see Mudd, 2007; Mudd *et al*, 2016). The deposit lies mostly under the McArthur River itself, which forced the use of underground mining initially until the technical challenges and poor economics of this approach necessitated the switch to larger scale open cut mining and diversion of the project's namesake river in the mid-2000's—but with considerable controversy and protracted litigation by the indigenous community (e.g Howey, 2010; Young, 2015). In recent years, major concerns have been raised over acid mine drainage, waste rock, tailings and water management—especially plumes of smoke originating from the waste rock—and the implications for the longer term future of the project area.

The mines controversial history cannot be read in isolation; rather it is represents a continuation of a history of neglect and suppression of the Aboriginal people from Borroloola, which is only exceeded by the trauma of the many massacres by settlers and government agents (Roberts, 2005). The early years of exploration, the impact of the first mining proposal and the response from local communities to mining was well captured by the film 'Two Laws'[1]. In it we hear not just of the clash of laws, but a clash of value systems, with the traditional owners fighting to control their own land and future. During the late 1970's to early 1990's, this struggle for indigenous land rights was opposed by the joint efforts of the NT Government and MIM, who were later supported by a Federal Government in the 1990's keen to fast track the mine to mollify the mining industry and international investors after the Mabo decision and the establishment of native title (Young, 2015).

Long before the community resorted to legal challenges (discussed later) to the mine, they had been raising strong objections to it, particularly in relation to the protection of sacred sites and potential environmental impacts, especially to the McArthur River. Young writes of the ***"…aboriginal traditional owners being subject to governmental pressure, obstruction and chicanery at almost every turn"*** (2015 p.15). This is not to say that opposition to the mine was universal, far from it, but concern over the environment was strong and at the heart of all concerned, whether in favour of the mine proceeding or not. Concern about and opposition to the mine has continued, with spikes of resistance occurring in relation to the river diversion, the 'burning waste dump', potential contamination of the river, fish and grazing cows, pollution issues at the Bing Bong Port and the inaccessibility of cultural sites on the mining lease.

While not the focus of this report, the cultural, social and environmental history of the region and the actual and potential impacts from McArthur River mine is a dominant factor in the region. Denied of control, the local communities continue to bare the brunt of the negative impacts, while government and industry collude to deny and downplay impacts.

This report is a review of the current state of technical issues at the McArthur River project, including the site history, environmental impact assessment (EIA) history, waste rock, tailings and water management and associated acid mine drainage issues. It examines the technical arguments for and against complete backfill of waste and tailings into the eventual final void, thereby achieving environmental outcomes that are aligned with community expectations for mine site closure and rehabilitation. It is unfortunate that so much of the information about the McArthur River project remains uncertain or unpublished, limiting transparency and independent analysis—especially since elsewhere the Australian mining industry is adopting greater openness in reporting and access to data (e.g. Newcrest Mining and Cadia).

The report provides a unique and independent assessment of the issues and risks which need to be considered in detail and possible future outcomes for the McArthur River project, especially long-term environmental outcomes relating to mine wastes.

1 A 1981 documentary by the Borroloola Aboriginal Community with Carolyn Strachan & Alessandro Cavadini.

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BRIEF HISTORY AND STATISTICS OF THE MCARTHUR RIVER PROJECT

The occurrence of Pb–Zn mineralisation had been noted since the 1890s near the Borroloola region of the central eastern side of the NT, but it was not until the mid-1950's that modern mineral exploration began to explore the southern end of the geological McArthur Basin in this area—with geologists working for Mt Isa Mines Ltd ('MIM') discovering the Pb–Zn mineralisation at the "Here's Your Chance" (HYC) ore body in late 1955 (Logan *et al*, 1990). Initial MIM studies of the HYC deposit showed that it contained extremely fine-grained mineralisation, with good Zn grades—but technology of the time could not process the ore to recover the Pb–Zn efficiently. Despite ongoing exploration and a major feasibility study in the late 1970's, the giant size of the deposit could not overcome the basic technical issues, these reduced economic viability and the project remained stalled. By the early 1990's, however, new developments in fine grinding technology, especially the new IsaMill grinding technology (Fountain, 2002; Rossberg & Pafumi, 2013), allowed a bulk concentrate to be extracted from the ore—although this was only able to be sold to a limited number of smelters around the world (namely those using Imperial Smelting Furnace technology). In the early 1990's, MIM underwent an environmental impact assessment (EIA) process for the project, gaining approvals and development began in 1994 with site commissioning in May 1995—by late 1995 the McArthur River project was in full-scale commercial production and processing at a rate of about 1.6 million tonnes per year (Mt/year). The project was developed as a joint venture with MIM holding 70% and a Japanese consortium of Nippon, Mitsui and Marubeni holding 30%.

In its initial two years of operations (the 1995/96 to 1996/97 financial years) the McArthur River project made a significant financial loss, forcing MIM to examine ways to make the site profitable in the prevailing economic environment (MIM, var.-a). This was compounded by underground mining being more difficult than originally envisaged, with poor ore recovery from stopes, ore dilution and difficult ground conditions causing concerns about stability and rockfalls (Stewart & Gwynne, 1998). Investments in various mine productivity initiatives (to address the issues just noted), saw profitability achieved in the 1997/98 financial year and by 1998/99 "problems encountered with the start up of McArthur River Mine's (MRM) performance have now been overcome" (p. 21, 1999 Edition, (MIM, var.-a). Financial statements reported this turnaround with the financial year 2000 showing an "exceptional result" of $23.4 million profit from $183.9 million of sales—almost double that of Mount Isa's profits of $12.0 million from $412.2 million of revenue (p. 16–17, 2000 Edition, (MIM, var.-a). By 2002 McArthur River was again making losses, but this was overshadowed in mid-2003 by the takeover of MIM by new global mining company Xstrata plc[2]. Around the same time, nearly half of the world's Imperial Smelters had closed (5 out of 12), meaning higher costs for the McArthur River project and again placing the project in a difficult financial position (e.g. 2003 Edition, (Xstrata, var.-a). Various proposals were considered to return the project to profitability, including an onsite Zn refinery with a 350 MW power station and converting to a large open cut scale (4.8 Mt/year) (Rossberg & Pafumi, 2013; Warner, 1998). Despite little public justification, the final option chosen in 2005 was to convert from the underground to an open cut operation, requiring a 6 km long diversion of the McArthur River itself (since the orebody goes underneath the project's namesake river) as well as slightly expanding milling capacity (to 1.8 Mt/year) with improved processing technology. Xstrata also bought the remaining 30% in September 2005 to take full control of the McArthur River project.

An EIA process was undertaken for the proposed open cut project to obtain all relevant NT and Commonwealth approvals, with the main environmental impact statement (EIS) released in August 2005 (URS, 2005). The proposal raised significant controversy, especially relating to indigenous heritage and environmental risks—although a pilot or 'test' pit had already been approved in July 2005 by the NT Department of Primary Industries, Fisheries and Mines (NTDPIFM) prior to the release of the EIS and public consultation phase of the EIA process. In February 2006 the NT Environmental Protection Agency (NTEPA) recommended rejection of the project. Despite this and to avoid MIM reducing their workforce and potentially closing the mine, special approval was given by NTDPIFM to expand the test pit in April 2006. At the same time another EIA process was begun to assess the open cut expansion project again—this time through a public environment report (PER—a "mini" or reduced scope EIS) released in July 2006 (URS, 2006). The NTDPIFM and NT Government approved the PER in October 2006, closely followed by relevant Commonwealth EIA approvals. The underground mine was permanently closed in April 2016.

Significant opposition to the project and approval process resulted in the Borroloola region Traditional Owners initiating legal proceedings, firstly in the NT Supreme Court in December 2006, then with additional

2 Xstrata plc was a UK-listed company with mainly Swiss origins and South African assets but with a major stake owned by natural resources trading company Glencore International AG.

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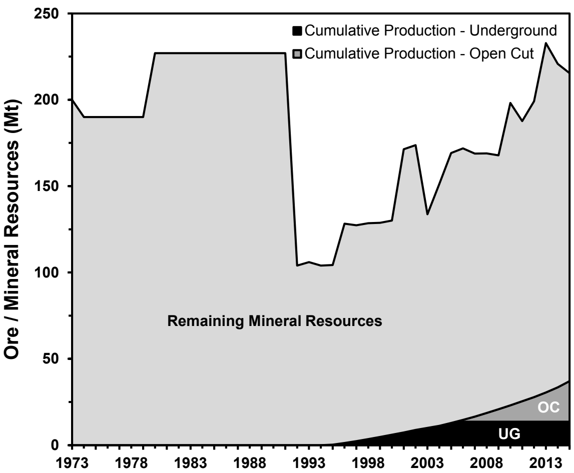
proceedings in the Commonwealth Federal Court in February 2007. On 30 April 2007, the community won the case in the NT Supreme Court and the approval of open cut expansion was ruled invalid. This ruling was strongly criticised by the then NT Chief Minister, Clare Martin, who announced on 2 May 2007 the Labor Government would pass legislation to over-ride the court's decision—this was completed amidst intense political controversy on 4 May 2007, just five days after the Supreme Court's decision. This lead to a historic point in NT politics with three indigenous members (Malarndirri (Barbara) McCarthy, Alison Anderson and Karl Hampton) crossing the floor to vote against the bill whilst the Environment Minister, Marion Scrymgour, and the Shadow Minister for Mines, Fay Miller were both absent from the chamber when the vote was taken (Howey, 2010; Young, 2015).

The Federal Court process included an injunction sought to prevent the diversion of the McArthur River, this was rejected on the 13 May 2008, with the final decision one month later also finding against the communities' case on 13 June 2008 (Howey, 2010). This decision was appealed by community representatives and won on 17 December 2008, stopping work on the open cut—although the McArthur River itself had already been diverted for the 2008/09 wet season (and the mill kept running on stockpiled ore). This forced Xstrata to quickly resubmit documentation for a new determination in mid-January 2009, which was given conditional approval by the new Labor Minister for the Environment, Peter Garrett, on the 20 January 2009 and included a 10 day public consultation period—by 20 February 2009 the project had been approved (again). Work resumed in the open cut and operations settled into a normal routine.

A unique outcome of the two 2005–2006 EIA processes and subsequent political manoeuvring was a number of conditions, including ***"… a substantial environmental bond, a properly researched and managed program for revegetating the river, proper management of contaminants from the mine site and tailings facility well beyond the projected life of the mine, the establishment of a mine funded monitoring and regulatory agency and a legal agreement or legislation to provide social benefits for the Gulf community"*** (Young, 2015 p.4). This resulted in the mine funding an 'independent monitor' to take and test samples and publicly report on the environmental impacts of the project, with the process managed by the NT Government. A consultant was to be appointed through a tender process and was expected to provide neutral, objective testing and analysis of the McArthur River project—an extremely rare requirement for mining projects across Australia.

The mine sought additional environmental approvals in March 2011 to expand the production rate (up to ~5.5 Mt/year), undertaking another EIA process and releasing a major EIS in February 2012 (URS, 2012)—with the NT Government approving this latest expansion of McArthur River in June 2013. A unique aspect of this expansion was the inclusion of a new processing circuit to allow the production of a separate Zn concentrate along with the normal bulk Pb–Zn concentrate—made possible by recent advances in milling technology.

By the end of 2015, the project has processed about 37.1 million tonnes (Mt) of ore, at grades of 5.0% Pb, 11.8% Zn and about 50 g/t Ag, to produce about 0.75 Mt Pb, 3.3 Mt Zn and 885 t Ag (i.e. 28 million ounces Ag) (data updated from (Mudd, 2009b). Unfortunately, Xstrata–



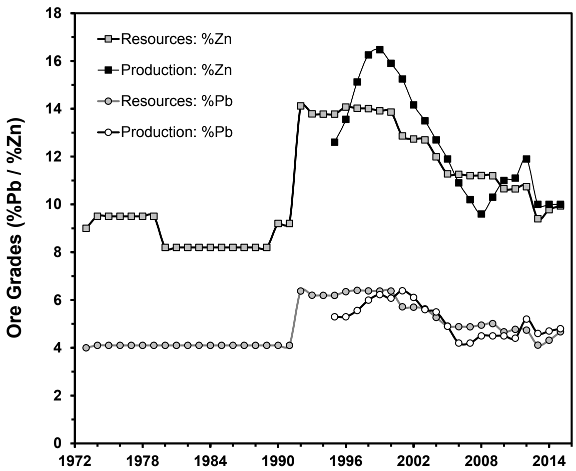


Figure 1: Historical mining data for the McArthur River project: (left) remaining mineral resources and ore milled by underground or open cut; (right) Pb–Zn ore grades for remaining mineral resources and ore milled (data sourced from (Glencore, var.-a, b, c; MIM, var.-b; Mudd, 2009b; Xstrata, var.-b, c)

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Glencore did not report the extent of ore mined from underground mining versus open cut mining during the transition from 2005 to 2009, nor has there been any reporting of the extent of waste rock mined during the project (see (Glencore, var.-a, c; Xstrata, var.-a, c, d, e)[3]. As of December 2015, the project still has a remaining mineral resource of 178.3 Mt at 4.7% Pb, 9.9% Zn and 48 g/t Ag, containing about 8.3 Mt Pb, 17.7 Mt Zn and 8,504 t Ag (or 273 million ounces Ag) (Glencore, var.-b)—showing that the project, at ~5.5 Mt/year, still has the potential to be mined for at least another thirty years.

Based on the 2005 EIS (Table 4.2, p. 4–4) and the 2012 EIS (Table 4–6 & 4–7, p. 4–17/18), it is possible to estimate the extent of waste rock mined at McArthur River based on the 'strip' ratios—simply the waste rock divided by ore mined. Depending on the stage of the open cut, the strip ratios vary from 2.8 to 6.4 over the period 2006 to 2029 and average about 5.6 (Phase 3 value). The approximate waste rock mined per year from the open cut is given in Figure 2 (there is no waste rock from underground mining since this is disposed of in former underground mine voids; see section 7.1 (URS, 2005)—a cumulative total of ~173.6 Mt of waste rock.

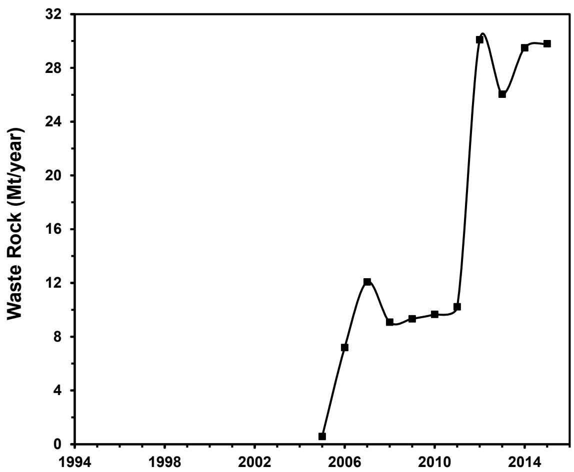

Figure 2: Estimated annual waste rock mined at the McArthur River open cut (data calculated from production data above and strip ratios from Table 4.2, (URS, 2005)

Through the Independent Monitor a variety of major environmental issues and risks have become apparent (see EES, 2009, 2010, 2011, 2012; ERIAS, 2014, 2015)—such as tailings seepage into surface waters and groundwater, acid mine drainage (or AMD; explained in more detail later), as well as the potential for heavy metals to be accumulating in biodiversity near the mine. In early 2015, these concerns were amplified by the fact that the northern waste rock dump appeared to be 'on fire' due to the large plumes of smoke emanating from the dump. This is closely related to AMD, since the geochemical reactions occurring to form AMD also generate significant excess heat. It is well known in the mining industry that unrehabilitated waste rock dumps undergoing the generation of AMD can reach internal temperatures of 60–80° C (e.g. Blowes *et al*, 2014)—meaning that the waste rock dumps at McArthur River are 'cooking' the rocks and causing smoke. Whilst it is relatively rare in mining that AMD processes lead to this outcome, it is an issue that has long been recognised given the pervasiveness of AMD problems across the mining industry. For example, the elevated temperatures caused by AMD in organic-rich shales at iron ore mines in the Pilbara was causing uncontrolled and early detonation of explosives—leading to different mine planning and major changes in mine waste management of such materials (see Porterfield *et al*, 2003).

Although the McArthur River site put substantial work into the reduction and prevention of the smoke generation, further reports of smoke emanating from the site emerged in early August 2016[4] but this time from the relatively new southern waste rock dump (not shown in Figure 3).

The public health consequences and obvious environmental implications of such significant AMD risks led to a new EIA process being initiated in June 2015, although the EIS has yet to be publicly released.

Recent aerial views of the project area are shown in Figures 3 and 4.

There is therefore a clear need to examine possible long-term scenarios for the McArthur River project, and especially the short-term management of waste rock but critically the suitability of leaving such reactive mine wastes above ground in perpetuity—i.e. forever.

3 Although subsequent Xstrata sustainability reports aggregate their Australian zinc operations for one report, the total waste rock reported therein is across all Mt Isa sites as well as McArthur River and no specific data for McArthur River is provided (except tailings) (see Xstrata, var.-d). It is most unfortunate that since the takeover of Xstrata by Glencore (~2012) that no more sustainability reports have been published.

4 Sara Everingham, "Waste rock could be burning again at McArthur River Mine." Australian Broadcasting Corporation (ABC), 5 August 2016, www.abc.net.au/news/2016-08-05/waste-rock-could-be-burning-again-at-mcarthur-river-mine/7696024

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Figure 3: Recent aerial perspective view of the McArthur River project area (supplied by Borroloola community)

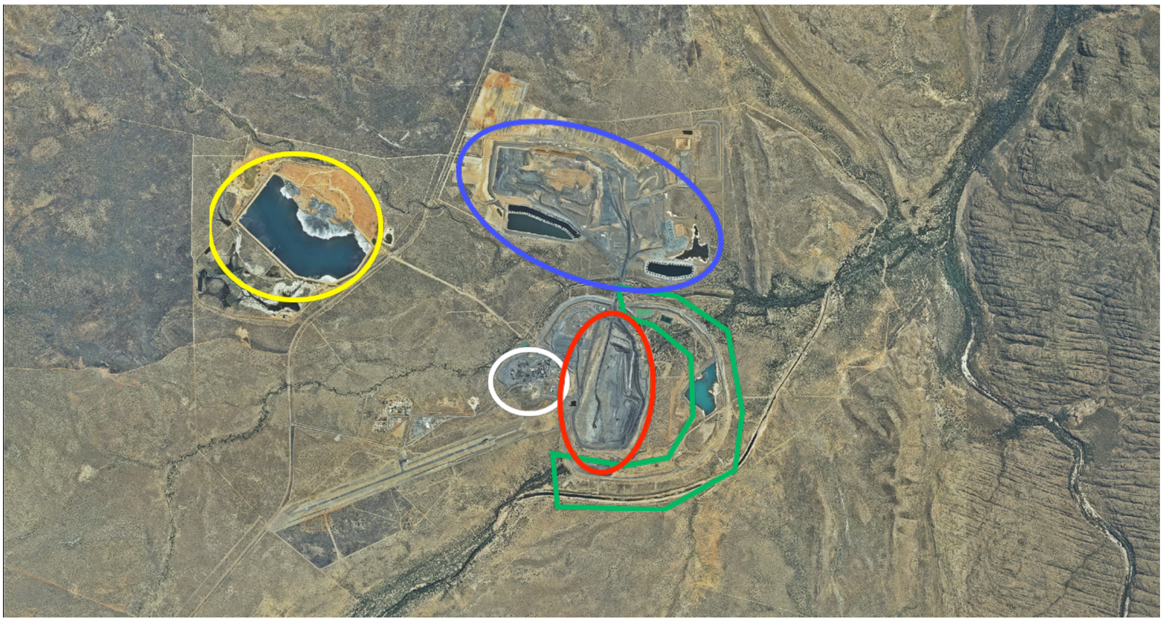

Figure 4: Aerial view of the McArthur River project area, showing the open cut (red oval), northern waste rock dump (blue oval), tailings dam (yellow oval), process plant (white oval), McArthur River diversion and bund wall (green outline) (adapted from Figure 1.2, (ERIAS, 2015)

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ACID MINE DRAINAGE: A BRIEF OVERVIEW

BACKGROUND

> ***"... when the ores are washed, the water which has been used poisons the brooks and streams, and either destroys the fish or drives them away."* (Agricola, 1556)**

This famous quote from Georgius Agricola of Saxony in eastern Germany, initially a medical doctor, later a scholar of mining[5] and widely recognised as one of the founders of the modern mining industry, is stark recognition of acid and metalliferous drainage—more commonly known as acid mine drainage or 'AMD'. In other words, AMD has long been acknowledged as a major environmental (and social) problem—the principal difference between Agricola's era and now is the massive global scale of mine wastes and associated AMD issues (amongst many others, such as erosion, groundwater, ecosystem re-establishment, visual amenity, social impacts, etc.).

In mining, both tailings and waste rock can present major AMD risks. Due to growing metal demands and declining ore grades, and especially the rapid expansion of open cut mining, the mass of mine waste produced annually by the global mining industry is of the order of several tens of billion tonnes (or more) and growing rapidly every year (e.g. Franks, 2015; Mudd & Boger, 2013; Spitz & Trudinger, 2008). This mass of mine waste presents major challenges to assess and manage to prevent unacceptable environmental and human health impacts, especially as regulatory requirements and community expectations continue to improve. Typically, waste rock is placed in large heaps or dumps, while tailings are deposited using a slurry pipeline into valley fill or ring dyke structures commonly called tailings dams or tailings storage facilities (or TSFs). Either approach presents various risks, depending on complex factors (especially climate and geographic issues), with some examples of TSF disasters include Mufulira (1970, copper), Bafokeng (1974, platinum), Los Frailes (1998, zinc), Baia Mare (2000, gold), Kolontár (2010, red mud), Mount Polley (2014, copper–gold) or most recently Samarco (2015, iron ore)—all having major environmental impacts and/or loss of life. A widely cited quote, attributed to the US Environmental Protection Agency from 1987, states:

> ***"problems related to mining waste may be rated as second only to global warming and stratospheric ozone depletion in terms of ecological risk. The release to the environment of mining waste can result in profound, generally irreversible destruction of ecosystems"***
>
> (Note: the primary US EPA source/report for this quote is unknown; it is cited by (EEB, 2000)

In a similar vein, the industry-funded International Network for Acid Prevention ('INAP') states as the first line on their website that "acid drainage is one of the most serious and potentially enduring environmental problems for the mining industry" (see front page of www.inap.com.au[6]).

A perhaps ironic curiosity of global mining history is the name-sake mine which the British Rio Tinto company operated in the Tinto region of southern Spain from the 1870s to the 1950s—a region renowned for lead and copper mining from Roman times—yet the very name 'Rio Tinto' effectively means tainted river or red river in Spanish. This is, ironically, recognition of the ongoing impacts of AMD for more than a millennia—Rio Tinto even made use of the AMD in large piles of ore to leach the copper out cheaply for great profit, a process now called heap leaching. Hence it cannot be claimed that AMD was never understood, it's just that the often severe environmental impacts from AMD were explicitly ignored. Despite the common belief that AMD is a relatively 'recent' problem in mining, it is indeed an ancient problem—the difference being the global scale, reach and a stronger environmental ethic in more recent decades. Given the vast scale of accumulated mine wastes globally, AMD is a significant and growing global problem.

A BRIEF OVERVIEW OF AMD

At its simplest, the biogeochemical[7] processes which lead to AMD are the exposure of various iron sulfide minerals in mine wastes to oxygen and water, typically due to the mining and exposure of iron sulfides to the surface environment—allowing the sulfide to convert to sulfuric acid and the iron to an iron oxy-hydroxide (or just iron hydroxide), with the overall process called sulfide oxidation. The most common iron sulfide minerals involved in AMD are pyrite (FeS_2) and pyrrhotite ($Fe_{1-x}S$), although others may also be involved (eg. arsenopyrite, chalcopyrite). Although there are many possible stages in the formation of AMD, including the action of microorganisms (e.g. Blowes *et al*, 2014; Dold, 2014), the overall biogeochemical process can be explained by the following simplified equation (e.g. Lottermoser, 2010; Taylor & Pape, 2007; Verburg, 2011):

5 Agricola, noting the high incidence of disease in his patients who worked in mining, became more interested in the basics of mining and changed career to focus on mining and metals.

6 Last accessed 12 August 2016.

7 Biogeochemical is simply the combination of biological, geological and chemical processes.

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chemical equation:

$4\,FeS_{2(s)} + 15\,O_2 + 14\,H_2O \rightarrow 4Fe(OH)_{3(s)} + 8\,H_2SO_4$ + energy

(or in words):

pyrite + oxygen + water → iron oxy-hydroxides + sulfuric acid + heat

In other words, for every bit of pyrite (or similar sulfide) it takes a significant amount of water and oxygen to produce iron oxy-hydroxides (a solid rust-like precipitate), sulfuric acid and energy in the form of significant heat. The acid in turns dissolves a range of heavy metals and salts, creating a drainage chemistry which is invariably very toxic to aquatic ecosystems—as already observed by Agricola centuries ago (and others before him). Visual examples of AMD sources and impacts on streams are shown in Figure 5.

Figure 5: Examples of acid mine drainage from around Australia: (top to bottom, left to right) AMD affected stream, former Sunny Corner Pb-Ag mine, NSW (14 July 2013); AMD affected urban drain, Zeehan Pb-Ag mining field, TAS (13 February 2014); AMD in seepage drain from the rehabilitated tailings dams of the former Captain's Flat Pb-Zn-Ag-Cu-Au mine, NSW (3 July 2015); Dee River, ~10 km downstream of the former Mt Morgan gold-copper mine, QLD, nearby public warning sign (inset; 25 Sept. 2012); AMD-affected retention ponds from the former Tabletop gold mine, QLD (25 June 2011); AMD-affected groundwater entering open cut, former Redbank Cu mine, NT (26 June 2011)

(all photographs by the author, except bottom right by Jessie Boylan/MPi)

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In reality, the biogeochemistry of AMD is highly complex, and depends on a wide variety of factors such as mineralogy, grain or particle size, climate (especially hydrology and temperature), mine waste geochemistry and management, moisture behaviour in mine wastes, microbiology and sometimes trace element substitution (see Blowes *et al*, 2014; Dold, 2014).

The characteristics and nature of AMD problems at any mine site can vary considerably, though there are a number of common observations:

- *Time lag (delay)*—an initial lag period before AMD issues become noticeable is quite common, especially in arid zones, related to the time taken for pH to decline below 3 and oxidation accelerate due to the action of microorganisms;

- *Longevity*—once begun, AMD can continue to leach from mine wastes for decades or even up to millennia (as in the Tinto region of southern Spain). Some researchers have begun to argue the case for perpetual management of the potential long term impacts of AMD (e.g. Kempton *et al*, 2010);

- *Heavy and trace metals*—these are often site-specific and closely related to the ore being processed and associated mine wastes. For example, arsenic is commonly found in copper, nickel or gold ores, while selenium is common for coal, copper is widely present in AMD leachates, while other metals such as zinc, aluminium, lead or nickel are highly variable.

Another common scenario is near-neutral drainage, where there is significant oxidation occurring but the drainage passes through alkaline materials (e.g. dolomite) and this buffers the pH towards neutral. The leachate often contains high salinity but the dissolved metals will vary depending on their pH-redox controls. This is the reason why the most recent Australian guide (Taylor & Pape, 2007) uses the term 'acid and metalliferous drainage', since there are numerous cases whereby drainage is not strongly acidic but remains highly toxic to aquatic ecosystems.

INDUSTRY APPROACHES TO IDENTIFICATION AND MANAGEMENT OF REACTIVE SULFIDIC WASTES

Since the rise of environmental assessment processes and more stringent regulation in the 1970s, the mining industry has gradually increased their focus on how to identify and manage AMD risks, especially during initial assessment and approvals processes but also during operational practices. Over the past 20 years in particular there have been a range of guidance handbooks and reports prepared (e.g. INAP, 2010; Johnston & Murray, 1997; Parker & Robertson, 1999; Taylor & Pape, 2007), all outlining common approaches to identifying the extent of possible AMD risks and how to manage mine wastes during mining, site closure and rehabilitation to ideally prevent, or, at the very least, minimise long-term environmental risks to levels acceptable to regulators and local communities. In addition, there have been important academic contributions in monographs, conference and journal papers, textbooks and the like (e.g. (Blowes et al, 2003; Dold, 2014; Lottermoser, 2010; Nordstrom & Alpers, 1999; Spitz & Trudinger, 2008; Verburg, 2011)—amongst an increasingly wide array of literature now available on AMD.

- *Identification*—a comprehensive range of tests are available to assess the potential for AMD from mine wastes. Rock samples can be tested for their mineralogical content, such as sulfides or alkali minerals, and these accounted for in terms of the extent of acid potential versus alkali neutralising capacity (i.e. acid plus alkali gives a salt plus water)—this is known as acid-base accounting and leads to the 'net acid production potential' (NAPP), where a positive value indicates acidic potential and negative suggests acid neutralisation. Samples can also be subjected to leaching in a laboratory, and where a chemical is used to accelerate the potential AMD process (e.g. hydrogen peroxide), this is referred to as a 'net acid generation' (NAG) test. Tests of individual samples are known as 'static' tests. Another approach is to subject a reasonable mass of rock (or mine wastes) to water and surface conditions, such as large columns or humidity cells which can mimic the field conditions of a mine site, these are known as kinetic tests and can be conducted in the laboratory or the field. Tests involving large samples being tested over time are known as 'dynamic' or 'kinetic' tests. The use of geochemical models can also be a useful approach in assessing potential AMD risks. Overall, it is important to understand the strengths and weaknesses of all approaches, as AMD biogeochemistry is invariably complex and not always easy to predict with accuracy—hence a large program involving static and kinetic tests in combination with geochemical modelling is considered good practice.

- *Mine Planning & Operations*—Assuming mine wastes are correctly identified for their AMD potential, a mine can plan their operation to sequentially mine in a way which allows direct management of mine

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wastes and associated AMD risks. Most commonly, this involves the segregation of AMD wastes and their emplacement inside non-AMD producing wastes, as shown in Figure 6. Importantly, it is critical to constantly sample and test mine wastes throughout a projects' life. Finally, it is important to ensure that a comprehensive water management plan is in place which links AMD potential to seepage pathways, surface or mine water runoff ponds and the site water balance, as there may be a need to treat waters to ensure relevant environmental objectives and regulatory requirements are met.

- *Rehabilitation*—to limit AMD in the first place, engineering approaches typically aim to limit the availability of water, oxygen or both to underlying mine wastes. In wet climates, due to the low solubility of oxygen in water, an engineered water cover may be realistic, such as leaving permanent wetlands or ponds over reactive mine wastes. In dry climates, it may be possible to aim for engineered soil covers which shed water away from the underlying mine waste through surface runoff and limit the infiltration of water. In climates in between these extremes, careful consideration needs to the rehabilitation design of covers for waste rock dumps and tailings dams, to limit the intermittency of water and oxygen influxes to mine wastes, as this can be an ideal way to maximise AMD.

MCARTHUR RIVER AND MANAGEMENT OF REACTIVE SULFIDIC WASTES

By the end of 2015, the McArthur River project had generated approximately (~) 27.5 Mt of tailings and ~173.6 Mt of waste rock—although exact tailings and waste rock data has never been published or made available by the site (despite repeated requests to the company and NT regulator by or on behalf of the Borroloola and NT communities). Although the McArthur River project appears to manage its mine waste in a manner consistent with current industry practice (as per previous sub-sections)—that is, waste rock is placed in engineered dumps while tailings are pumped as a slurry for disposal in an engineered storage dam (or TSF)—there appears to have been something gone seriously wrong with the identification of AMD potential given the emergence of smoke plumes from the waste rock dumps and increasing concerns raised by the Independent Monitor of AMD issues and related water quality problems in mine water management. This is further discussed later in this report.

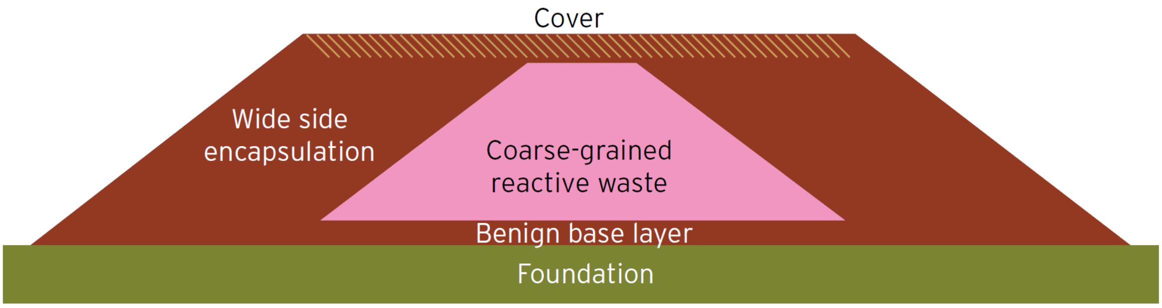

Figure 6: Conceptual plan for emplacing potential AMD (reactive) wastes inside non-acid forming mine wastes (Taylor & Pape, 2007)

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As noted above, the McArthur River project has gone through four major EIA processes in its ~25 years of developments to date. This section briefly notes the key risks and predicted outcomes from the various EIA processes—but focuses only on issues related to mine wastes (tailings and waste rock) and associated AMD risks and final site rehabilitation.

1992 EIS

Although the original 1992 EIS was not available for this report, the EIA Assessment Report was (CCNT, 1992). Key findings and issues identified include:

- *Waste Rock Management*—although the recognition of AMD risks was clear and the proposed method of encapsulating acid-producing rocks within alkaline rocks (such as dolomite) was accepted due to the greater abundance of dolomite compared to acid-generating wastes, it was also recognised that there was a lack of sufficient quantitative data to assess long-term risks. Finally, as the mine was underground, the extent of waste rock was very small and was expected to be emplaced back in the underground workings as the mine progressed and voids became available for such disposal—thereby minimising this major environmental risk.

- *Tailings Management*—the tailings were to be discharged as a slurry into a storage facility (or 'tailings dam') and, due to the very high evaporation rate of the region, would dry and form a stable structure—although there was uncertainty given the lack of experience with this approach. The tailings were recognised as potentially acid-forming, but there was uncertainty over the speed of the potential acid formation. Finally, although the tailings were expected to produce a dry, stable mass which limits the potential for seepage (due to the lack of water to seep), the uncertainty regarding tailings water management—especially whether the tailings would indeed dry out—meant that seepage risks from the tailings dam remained of significant concern.

- *Rehabilitation*—the plans for eventual site rehabilitation were "… not well documented, in particular those for the waste rock dump and the tailings impoundment" (CCNT, 1992 p.19). Although five options were presented, they effectively lacked technical detail matched to local site conditions—meaning significant future work was required.

2005 EIS

The management of tailings and waste rock was discussed in detail in Section 7 and mine rehabilitation in Section 20 of (URS, 2005), with key findings and issues including:

- *Waste Rock Management*—based on detailed geochemical studies in 2002, waste rock was classified (Table 7.1) as non-acid forming (NAF) or potentially acid-forming (PAF), with the dominant rock types being Upper Pyritic Shale (47% PAF), Lower Pyritic Shale–Bituminous Shale (13% PAF), Lower Dolomitic Shale (not PAF), W-Fold Shale (not PAF) and Teena Dolomite (not PAF). Based on the final open cut mine plan and some 183 Mt of waste rock, **it was expected that only 11% would be PAF whilst 89% was NAF** (Table 7.2). As outlined

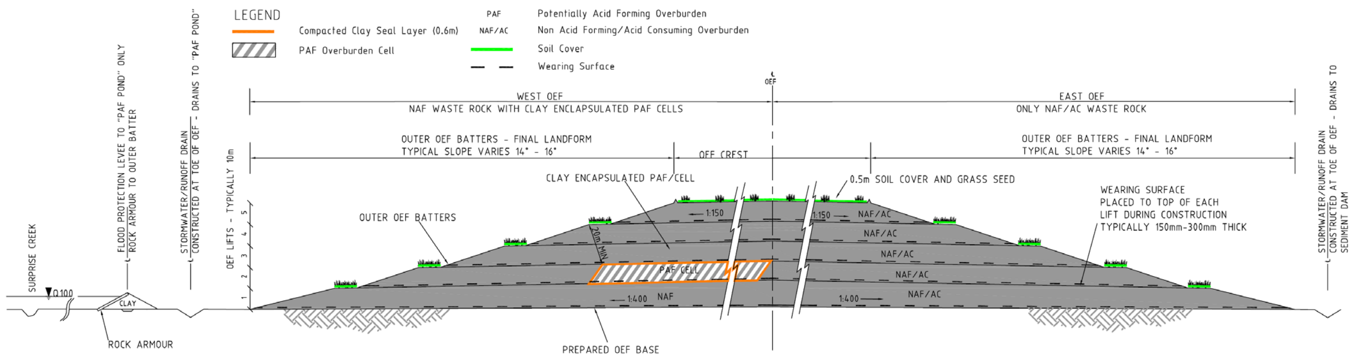

Figure 7: Schematic of encapsulating potentially acid forming (PAF) waste rock within non-acid forming (NAF) waste inside the 'overburden emplacement facility' (OEF) (adapted from (URS, 2005)

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previously (sub-section 4.2), approaches proposed by the project included detailed geochemical testing ahead of mining to identify waste rock as NAF or PAF, encapsulation of PAF wastes within NAF wastes, careful engineering of base liners beneath waste rock dumps, seepage collection and water management systems. The waste rock dump was proposed to the north of the pit, and was named the 'overburden emplacement facility (OEF). A schematic is shown in Figure 7. There is no discussion of previous management practices versus actual outcomes.

- *Tailings Management*—tailings would continue to be slurried to and deposited in the tailings dam to the west of the mill and mine, and extended into the area used for evaporation and water management. There is considerable discussion of tailings dam design, associated water management practices (especially water quality), seepage models and the fact that seepage was first observed in Surprise Creek from the tailings dam in June 1997 (i.e. about 2 years after operations began), and discussion of the closure and rehabilitation of the first cell of the tailings dam (the main dam associated with underground operations). Although there is detailed discussion of seepage issues from the tailings dam, due mainly to areas of permeable sandy/gravelly lenses, there is no explicit discussion of how the tailings have dried (or not as the case appears to be). Similar to waste rock, there is no detailed discussion of previous management practices versus actual outcomes (except perhaps that seepage was somewhat unexpectedly found to occur).

- *Rehabilitation*—various aspects of site closure and rehabilitation were discussed and adopted, including site infrastructure (roads, mill, power station, accommodation camp), waste rock dumps (OEF) and tailings dam cells. In essence, site infrastructure would be removed and/or isolated while mine wastes would be rehabilitated by placing engineered soil covers to limit infiltration, seepage and long-term AMD risks and all areas would be revegetated. A range of qualitative criteria commitments are presented, with post-mining land use, after consultation with stakeholders, expected to be low intensity cattle grazing. Curiously, there is no mention at all in Section 20 of any rehabilitation of the ~6km diversion channel of the McArthur River and long-term risks of flooding to the site, especially any risks of flooding the open cut—implying that this was not considered important to assess.

2006 PER

The management of tailings and waste rock were discussed to varying levels of detail in Sections 2, 3, 6 and 7 (URS, 2006), whilst mine rehabilitation was not assessed at all, with key findings and issues including:

- *Waste Rock Management*—Section 6.2.1 notes briefly that all overburden (mine waste) materials have been tested and classified as either NAF or PAF, with "11% of the total overburden could be PAF" (p. 6–2) and will be managed accordingly (i.e. as per the previous EIS and industry practice for AMD as reviewed in section 3.3 of this report). Results are also presented of further kinetic testing (Table 6.1) being undertaken to further study AMD risks from overburden materials. The potential for in-pit disposal of waste rock was recognised as beneficial (section 3.4.2) but argued as impractical during operations given the design of the open cut (i.e. limited opportunity due to the ongoing nature of mining in all areas of the pit).

- *Tailings Management*—similar to the 2005 EIS, tailings would continue to be slurried to the TSF, with extensive design aspects used to limit seepage rates, such as compacted clay, geopolymers and the use of groundwater bores to pump seepage back to the TSF. The seepage problems of the main TSF (or cell 1) are acknowledged, and it is proposed to close and rehabilitate this section of the TSF. The need to manage water within the TSF to limit sulfide oxidation is also acknowledged. Finally, a detailed rehabilitation plan for the TSF is presented and discussed, mainly placing an engineered soil cover system over the TSF to isolate the tailings and achieve a stable landform for the long-term.

2012 EIS

The management of tailings and waste rock and mine rehabilitation were discussed in detail in Sections 3 and 5 of (URS, 2012), with key findings and issues including:

- *Waste Rock Management*—there is a recognition of PAF mine wastes, and that these need to be isolated and that such wastes are currently successfully isolated within clay lined cells surrounded by NAF materials (sub-section 3.4.10). In this section, it is explicitly acknowledged that engineered soil cover systems are far from ideal in isolating PAF wastes in perpetuity, as the approach adopted at

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McArthur River would **"… eliminate the long-term cover failure risks associated with traditional PAF OEF design: cover erosion, surface runoff ingress, localised cover failure through deep rooted trees, burrowing animals and uprooting of trees in storm events"** (URS, 2012 p. 3–14). The additional waste rock expected to be mined under the Phase 3 expansion totalled 525.8 Mt, adding to the 131.5 Mt already allowed for from the 2005/06 EIA processes for Phase 2 (or the original open cur approvals) (Table 4–6. (URS, 2012).

- *Tailings Management*—expansion of TSF scale but largely a continuation of current practice with no significant changes from the 2005 EIS.
- *Rehabilitation*—although various options for the final open cut were considered (e.g. redirecting the flows temporarily or permanently from the diversion channel to the pit), the preferred option was to allow the open cut to fill naturally with no link the diverted McArthur River. It was acknowledged that this scenario would lead to declining water quality (i.e. brackish to saline water) in the pit over decades to a century. A variety of design criteria or principles were presented for the TSF and OEF's (e.g. slope angles, 20 m of NAF wastes surrounding PAF wastes by the end of OEF construction, landform stability, revegetation, etc.), although there was minimal detail of AMD risks in the main EIS volume—with the technical detail left to specific appendices (e.g. E1–E2).

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INDEPENDENT MONITOR REPORTS

The process of appointing an 'independent monitor' (IM) to take samples and assess the environmental impacts of a mining project is very rare in Australia—with the only other prominent example of such close environmental scrutiny being the Ranger uranium mine (in the Kakadu region of the Northern Territory; e.g. Ferguson & Mudd, 2011; Mudd, 2008). Since it's beginning, the IM of the McArthur River project (or 'MRIM') has been able to assess the extent to which the mine is meeting its environmental requirements and provide an independent perspective on its impacts.

Although there are several substantial reports now published by the MRIM (EES, 2009, 2010, 2011, 2012; ERIAS, 2014, 2015), this report will focus on the most recent report as the basis for the current state of affairs for the McArthur River mine and its environmental risks and issues.

Overall, the MRIM has shown consistently that despite many environmental management requirements being met, major gaps remained and that these risks were escalating. By the 2014 period of reporting by the MRIM (ERIAS, 2015), the increasing AMD risks were identified as the ***"most significant environmental issue at McArthur River mine" (p. ES-1) and that "management of overburden remains the single largest issue which has implications for both the short- and long-term environmental performance of the site"*** (p. ES-2). Importantly, specific issues or concerns identified by the MRIM include:

- Potential AMD risks in the southern OEF facility;
- The lack of reported waste rock data, especially the balance of PAF and NAF materials, with the MRIM's best estimate being that only 9% was NAF (in stark contrast to the 2005 EIS estimate of 89% of waste rock being NAF, as noted earlier)—**or, in reality, meaning that some 91% of waste rock was PAF waste**;
- Quality control issues in the construction of the OEF facilities and the clay liners used to isolate PAF wastes—including testing and inspection regimes;
- TSF management, including incident management, inspection processes, and flooding capacity of Cell 1 (the main TSF area used for the first decade or so before the open cut expansion);
- Escape of heavy metals into the environment around the Barney Creek haul road bridge via sediment, dust and/or surface runoff;
- The complex and sometimes lengthy time required by the primary NT regulator, the Department of Mines & Energy (NTDME), to assess and approve critical operational documents—especially the Mining Management Plan (MMP) as required by NT mining legislation—this was ending in confusion between approved activities from the 2012 Phase 3 EIS and those intended for the expected overburden management EIS due to be completed and released soon.

As a contrasting example, the Cadia Valley operations of Newcrest Mining Ltd report annually their waste rock but also the split between NAF and PAF, as shown in Figure 8. A good feature of NSW mine regulation is that companies are required to make annual environmental monitoring and management reports publicly available on their own mine-specific websites—and NSW remains the only state in Australia to require this. This allows greater transparency on the results from monitoring and potential mine-related impacts, but also shows that parts of the mining industry recognise the need to address AMD risks publicly as part of such statutory requirements to address public concerns.

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13.1 WASTE ROCK AND TAILINGS MANAGEMENT

13.1.1 Material Characterisation

Cadia Hill waste rock is classified into three different waste types depending on its mineralisation and sulphur content. The three classifications are Blue, Green and Pink representing Non Acid Forming (NAF) Waste, Mineralised Waste and Potentially Acid Forming (PAF) waste respectively. Waste type is colour coded to simplify the day-to-day Load and Haul operations (Figure 13-1). This classification scheme is the same as has been reported in previous AEMRs.

Waste rock is sampled and classified on the basis of the sulphur (S) content. A 0.5% sulfur cut-off grade is used. Classification is based upon the estimated grade of each modelled block (1 block is 12.5m x 12.5 m x 15m (bench height). The sulphur grade for each block is estimated by spatial modelling of the waste material, using a statistical process known as ordinary kriging. Ordinary kriging uses a weighted assay estimate based on a graph known as the geostatistical semi-variogram. All blocks with an estimated sulphur grade above 0.5% S are classified as PAF. Additionally, where there is a demonstrable geological cause, e.g. a “g-fault” is identified, material with a lower sulphur cut-off may be classified PAF.

13.1.2 Waste Rock Emplacement

13.1.2.1 Cadia Hill Gold Mine

Approximately 13.65 Mt of in-situ material was mined from Cadia Hill pit during the reporting year. This amount consisted of approximately 11.9 Mt of ore, 1.44Mt of low grade material (yellow) and 281Kt of waste rock. Most waste mined was placed in the South Waste Rock Dump; consisting of 0.155 Mt of mineralised waste (Green), 3Kt of PAF waste (Pink) and 0.123Mt of NAF waste (Blue) Approximately 1.22Mt of ore was reclaimed from stockpiled for feeding through the primary crusher.

Figure 8: Waste rock section of the 2010/11 environmental monitoring and management report for the Cadia Valley operations of Newcrest Mining Ltd in NSW (combined from pages 140–141, Newcrest, 2012) (note: the Cadia Hill pit was close to care and maintenance during this time, with earlier years showing greater volumes of waste rock mined and classified)

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THE CASE FOR COMPLETE PIT BACKFILL

The very nature of sulfide oxidation in mine wastes (i.e. AMD) at modern mines means that the environmental and related risks need to be considered very differently to historic approaches—due to the long time frame over which AMD can continue (up to millennia), the increasingly large to massive scale of wastes involved, and the challenges in ensuring the integrity of site rehabilitation long into the future. This means that new approaches to minimising long-term environmental risks need to be implemented—and for large volumes of sulfidic mine wastes from modern mining, arguably the best approach is to place such wastes back into the former open cut, also known as pit backfill.

In general, it is very rare in the global mining industry to undertake complete backfill of mine wastes into a former open cut after the completion of mining—with the best examples being the former Flambeau copper mine (a small project in Wisconsin, USA, operating over 1993–97) and the currently operating Ranger uranium project, NT. There are also examples where a former open cut is used for the deposition of tailings (rather than expand an existing or build a new TSF), such as the former Nabarlek uranium mine, NT, some gold mines in the Tanami region, NT, and other gold mines in Western Australia (e.g. Fortnum) and Queensland (e.g. Kidston). Invariably, all of these examples were justified on cost and environmental grounds, and not directly due to long-term AMD risks. A unique case study where partial pit backfill was justified on AMD grounds was the former Woodcutters Pb–Zn–Ag mine, near Batchelor, NT, whereby sulfidic mine wastes were backfilled into the former open cut as part of site rehabilitation to minimise long-term AMD risks—this is summarised in more detail below.

The McArthur River site, given the major and ongoing AMD risks it is managing, also presents a strong example for the use of complete pit backfill. The principal technical arguments include:

- Sulfidic waste is below ground level and erosion of engineered soil covers is avoided;
- Sulfidic waste is below the water table, and given the low solubility of oxygen in water and the time it takes for oxygen to diffuse through the thick cover of mine wastes, this almost eliminates the availability of oxygen to drive the biogeochemical process of sulfide oxidation and AMD;
- Deep-rooted trees cannot penetrate through and compromise any engineered soil covers, since thick roots provide open pathways for the infiltration of water;
- Sulfidic waste is well below the zone where interaction with the above ecosystem would be important, such as tree roots and burrowing animals;

Some issues of pit backfill include potential groundwater quality impacts (especially if AMD is already occurring in mine wastes and there is migration of solutes from the mine wastes into the surrounding groundwater), major costs involved, and the expansion of volume in rock when it is blasted and mined—meaning that waste rock may occupy a greater volume than the original pre-mined rock and some sulfidic wastes may still sit above the post-mining groundwater table and be subject to oxidation and AMD risks.

Overall, it is important to consider all impacts and risks and contrast above ground rehabilitation of mine wastes with the costs and benefits of pit backfill, even if only partial.

There remains a dearth of studies which document such outcomes in modern mining—although there remain abundant case studies showing the ongoing pollution risks of leaving sulfidic mine wastes above ground in perpetuity (e.g. former mines such as Rum Jungle, Mount Lyell, Redbank, Mount Morgan, Captain's Flat, Teutonic Bore, Brukunga, amongst many others).

WOODCUTTERS CASE STUDY

The former Woodcutters Pb–Zn–Ag mine, about 100 km south of Darwin, operated from 1985 to 1999 and was a modest scale project involving open cut and underground mining. A total of 4.72 Mt of ore was processed, at grades of ~6.0% Pb, ~12.9% Zn and ~80 g/t Ag, and although no data is reported on the extent of ore mined by open cut or underground mining nor any associated waste rock data, it is estimated that only ~0.27 Mt was mined by open cut (Mudd, 2009b). The site had gone through various owners, mainly junior miners, until Australia's major gold miner Normandy Mining became site owner in the late 1990's—only to have America's Newmont Mining Corporation take over Normandy in early 2002, leaving Newmont to complete rehabilitation of the Woodcutters site (despite never operating the mine). The rehabilitation works are outlined by Taylor and Pape (2007) and Dowd (2005) and briefly summarised here.

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In 2000, Normandy commissioned detailed groundwater–surface water modelling studies to assess five scenarios for site rehabilitation from AMD risks, with the study showing that there was a clear need to relocate sulfide-rich tailings into the former open cut and backfill to a similar topography prior to mining as well as build engineered soil covers over the waste rock dumps to limit surface infiltration and AMD generation. Despite having no strict legal requirement to undertake such works for site rehabilitation, Newmont committed to this approach and all works were completed by 2004.

Curiously, although estimates of site rehabilitation in the 1980s were a mere $0.5 million, the final cost of all works by 2004 was ~$40 million. Aerial views of the site before and after rehabilitation are shown in Figure 9.

Figure 9: Aerial views of the former Woodcutters Pb–Zn–Ag mine, NT—(top) prior to rehabilitation in 1998 (Taylor & Pape, 2007); (bottom) recent site view 17 May 2016 (GE, 2016) (note: north is pointing to the right)

MCARTHUR RIVER

At present, the expected approach for eventual closure and rehabilitation of the McArthur River site is to leave tailings and waste rock above ground after engineered cover systems have been constructed and allow the former open cut to flood whilst leaving the diversion channel in place (e.g. 2012 EIS, as briefly noted previously). This is shown conceptually in Figure 10, including the main arrows for water flows. As explicitly acknowledged in the 2012 EIS (as highlighted previously), the site recognises that the use of engineered soil covers alone is insufficient to ensure protection into the long term—due to erosion of soil covers, burrowing animals and tree roots which can act to compromise the integrity of the cover and allow the ingress of water and oxygen into the underlying sulfidic wastes.

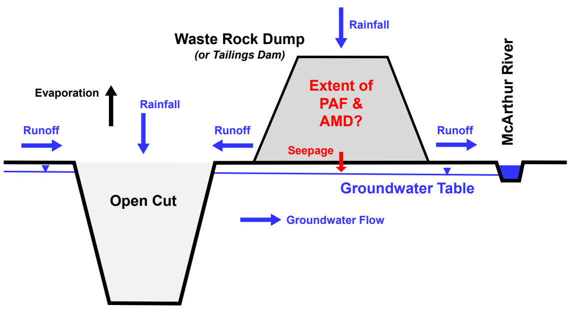

Figure 10: Conceptual representation of the McArthur River site after the end of mining

In all figures PAF wastes explicitly include both waste rock and tailings.

The current evidence at the site, however, is showing highly reactive wastes and that the vast majority of the waste rock is now (or probably should be) classified as PAF, as shown by the MRIM's assessments—meaning there remains deep concerns about the life-of-mine material balance to continue to isolate such PAF wastes within NAF wastes in the manner proposed in 2012 EIS.

As noted in the AMD overview, the primary approaches to preventing (at best) or (more realistically) minimising AMD generation involve isolation in water to reduce oxygen exposure, encapsulating wastes within acid-neutralising or NAF materials, or the use of engineered soil covers to limit water and/or oxygen ingress to the underlying sulfidic wastes.

However, given the current understanding of the material balance at McArthur River—i.e. some 91% is PAF wastes—there is clearly going to be a very large amount of PAF material above ground at the end of mining. Although the current expectation is that the

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waste rock dumps and tailings dams will be covered and rehabilitated as they are (i.e. above ground), this is without doubt unsustainable unless there is acceptance of active management of the site in perpetuity. In other words, the site would need constant monitoring and maintenance to manage AMD risks and ensure protection of the McArthur River itself and the ecosystems and communities that depend on it. From Figure 10, this means that all runoff would need to be tested and managed according to the extent of AMD it contains, including booth surface water runoff and any seepage to groundwater also.

An alternative approach is to relocate all PAF materials to the open cut after mining ceases, and then place NAF material over the top, as shown below in Figure 11. This figure, somewhat optimistically, assumes that the life-of-mine waste balance suggests that there is much greater NAF than PAF wastes—and with the PAF material buried deeper in the pit, this would ensure that these sulfidic wastes are below the re-established groundwater table and therefore minimal oxygen is present to drive AMD generation. Although there may still be risks of impacts on the surrounding groundwater quality, this would, conceptually at the very least, appear to be considerably lower than the Figure 10 scenario of leaving PAF wastes above ground and subject to erosion, infiltration and—in the end—extreme AMD risks for the long-term (probably many decades or longer).

The more realistic scenario, however, is that the PAF materials will be significantly greater in volume than NAF materials that they reach towards the top of the pit and potentially even remain above the re-established groundwater table after mining, as shown in Figure 12. The vast majority of the PAF wastes would be below the water table and present minimal AMD risk, a small quantity would remain above the water table and exposed to fluctuating infiltration and oxygen ingress given the wet–dry tropical climate of the region—leading to some AMD generation, which would seep into the deeper wastes within the pit and create potential to flow downgradient into the surrounding groundwater system. In reality, this is a very complex situation to assess, and given the paucity of data publicly available at present, it remains uncertain as to how realistic this scenario is for the life-of-mine plan for the McArthur River project. There may be technical or engineering options available to address such risks, such as grout curtains around the pit to limit outwards flow, reactive permeable walls made of say finely crushed limestone or other acid-neutralising materials, red mud from bauxite refining, or other approaches often used in contaminated site and AMD remediation projects (there is a wide array of literature on such methods, but this is beyond the scope available for this report).

A recent study of the Tallering Peak iron ore and Nifty copper mines, both in Western Australia, modelled the hydrology and water quality issues of leaving open cuts to form 'pit lakes' versus partial or complete backfilling of waste rock—showing that there can be some risks to groundwater quality from backfilling, and suggesting that pit lakes would therefore be preferable—but it failed to include a model assessing the option of leaving waste rock dumps above ground and the long-term risks to groundwater from AMD generation (see (McCullough *et al*, 2013). Although the Woodcutters site is a positive example of mine rehabilitation which included open cut backfill, there appears to be virtually no reports or papers on the outcomes of this approach, especially with respect to downgradient groundwater systems (the primary concern used to justify backfilling tailings into the former open cut during rehabilitation).

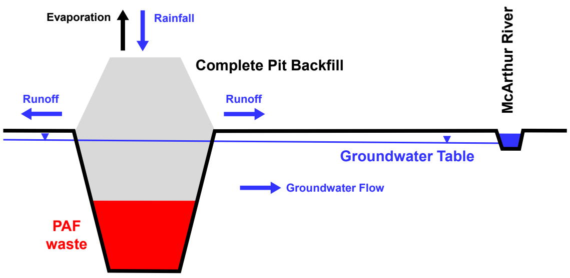

Figure 11: Conceptual representation of the McArthur River site after the end of mining assuming PAF wastes are smaller in volume than NAF wastes and PAF wastes are buried deep in the former open cut

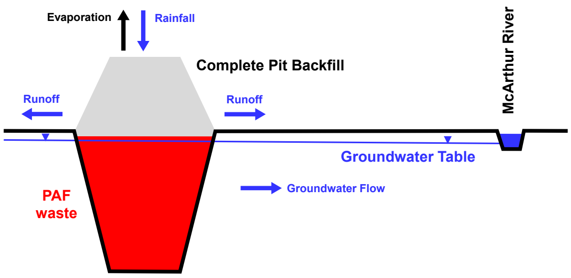

Figure 12: Conceptual representation of the McArthur River site after the end of mining assuming PAF wastes are greater in volume than NAF wastes and PAF wastes are buried deep in the former open cut but still approach the ground surface

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A contrasting example is the former Rum Jungle uranium mine, just south of Darwin, which was a major source of AMD to the Finniss River (this paragraph is summarised from Mudd & Patterson, 2010 and more recently public knowledge of the Rum Jungle site). The mine operated from 1954 to 1971, and no rehabilitation was completed until massive public pressure in the mid-1970's forced the Australian Government to fund works in the mid-1980's at a cost of some $18.6 million (dollars of the day). The total mine wastes at Rum Jungle, including both tailings and waste rock, was about 14 Mt (but excluding the Rum Jungle Creek South mine, since no major AMD issues were present at this site). At the time, residual tailings were excavated from the flood plain and buried in the former open cut and engineered soil covers were used to cover the waste rock dumps and minimise AMD—but within a decade the covers were failing due to ineffective cover design (it allowed the clays to dry out and crack during the dry season, allowing major infiltration in the wet season) and major quality control issues during construction (the covers were not built to the design thickness in some places, further exacerbating the effects of the wet-dry climate and facilitating infiltration). In recent years, AMD has again risen to levels of major environmental concern, and the Australian Government has invested millions of dollars more into new rehabilitation studies—arriving at the need to backfill sulfidic waste rock into the former open cuts, which was rejected in the 1980's due to cost.

Across the Australian and even global mining industry, there are exceedingly few case studies which present detailed assessments of above ground versus backfilling of mine wastes and rehabilitation outcomes—which would almost definitely be related to the lack of regulatory requirements for partial or complete backfill after mining finishes.

At present, it is critical to understand and assess these contrasting end-of-mine scenarios—rehabilitating waste rock dumps and tailings dams above ground (aka Figure 10), or backfilling PAF wastes into the open cut and covering with NAF wastes (aka Figures 11 and 12)—to allow informed decision making on both short and long-term risks, especially AMD generation rates and likely impacts, with the expected costs and benefits of each scenario.

CONCEPTUAL COSTINGS

Given the lack of publicly reported data on current waste volumes at McArthur River, especially the NAF/PAF split, a detailed cost estimate of final rehabilitation including complete pit backfill is impossible. Furthermore, the current financial basis for estimating the size of the rehabilitation bond for the site remains confidential—although the bond was substantially increased in 2015 by the NT Government to reflect the increasing issues with the McArthur River mine. It is possible, however, to develop a coarse estimate of likely costs (based on current costs and not allowing for inflation over time).

The recent rehabilitation scenario study for Rum Jungle (Laurencont *et al*, 2013), although it did not present detailed cost estimates for the preferred strategy of backfilling all sulfidic wastes into the two open cuts, stated that the cost of designing the rehabilitation plan alone was some $11.3 million—quite the contrast to rehabilitation costs in 1986 of $18.6 million (which would be a 2013 value of some $44 million[8]). To understand the contrast with McArthur River, the Rum Jungle site involves the backfill of some 13.3 Mt of waste rock whilst there would be potentially some 700 Mt of waste rock and more than 100 Mt of tailings—suggesting that the design alone for McArthur River would be considerably more.

In open cut mining, the use of large haul trucks requires diesel fuel, and typically this ranges from 0.33 to 1.18 litres per tonne of rock mined (or L/t rock), and averages 0.68 L/t rock (Mudd, 2009a). Other values include 0.98 L/t rock[9] for the (formerly) proposed open cut expansion of Olympic Dam (BHPB, 2009), or 1.17 L/t rock[10] based on a detailed study of the energy and carbon costs of gold mining (Norgate & Haque, 2012). On this data, we could assume a value of say 1 L/t rock, and assuming a conservative value of say $1/L of diesel, this means the ~800 Mt of waste rock and tailings to relocate during rehabilitation would cost of the order of $800 million in diesel alone—but without the costs of trucks, maintenance, labour and related costs. Even if a lower diesel intensity is used, say 0.5 L/t rock, this clearly places the costs of diesel in the ballpark of hundreds of millions of dollars alone.

The final rehabilitation scenario of complete pit backfill would be dominated by the costs of mine waste relocation, with other costs including site personnel, environmental monitoring, other engineering works, water management, and allowance for a contingency to recognise the potential for cost over-runs (as per normal

8 Based on website: www.thomblake.com.au/secondary/hisdata/calculate.php

9 Estimated from 403 million litres (ML) of diesel to mine 410 Mt of rock per year (Tables 5.1, 5.2).

10 Based on 5.3 kg of diesel per tonne of ore mined (i.e. 5.3 kg/t ore), 3 tonnes of waste rock per tonne of ore and a density of diesel of 1.135 L/kg (from (OCE, 2016).

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engineering and financial practice). As highlighted by the Woodcutters site, rehabilitation often turns out to be much more expensive than initial expectations—but comprehensive studies documenting the true costs of rehabilitation across the modern mining industry (i.e. mines operated and rehabilitated since the 1980's) are completely lacking, especially comparing rehabilitation bonds held by government versus final actual costs. For McArthur River, there remains no public confirmation of the expected rehabilitation costs (which at present is above ground waste rock dumps and the tailings dam) versus the bond held by the NT Government, including the technical and financial basis for this—despite the bond being increased in 2015 after considerable pressure by the NT Government.

LONG-TERM MINING IN THE REGION

As noted previously, the McArthur River project currently reports a mineral resource of some 178.3 Mt—although the 2012 EIS allowed for the mining of some 117.5 Mt (as of 2012, minus production 2013 to 2015 of some 9.3 Mt)—suggesting that there is still an additional ~60 Mt possible to mine, or another 10–12 years worth. In addition, the recent announcement of the Teena Pb–Zn–Ag discovery, some 8 km west of the McArthur River site, shows a mineral resource of 58 Mt at similar grades. Overall, this means that there is an even greater long-term scale of mining possible for the McArthur River project and region than envisaged by current EIA approvals. Future assessments need to consider such possible scenarios in conjunction with current operations and plans, as the cumulative environmental (and social) risks grow as project scales expand.

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SUMMARY AND KEY RECOMMENDATIONS

The history of the McArthur River Pb–Zn–Ag project is one of under-estimating long-term environmental risks, with the poor prediction of the severity of acidic drainage from sulfidic mine wastes being the most fundamental failure to date. Despite three periods of detailed environmental impact assessment (1992, 2005–06, 2012), the problems at McArthur River have continued to escalate, dominated by acidic drainage issues—raising legitimate questions concerning the efficacy of current NT EIA processes to understand and assess risks presented by projects such as McArthur River. In order to improve public understanding and transparency around the variety of complex issues at the site, the following recommendations are made:

- Full details of waste rock mined, tailings produced and their composition (i.e. PAF versus NAF) should be reported annually, and these reports and datasets made publicly available—an account should also be provided on all mining to date, with future reports always including all historical data over time;
- Continuous water quality monitoring, such as pH, electrical conductivity (EC) and possibly sulfate (SO_4), should be implemented across the site, especially at key seepage or drainage sites from the waste rock dumps and tailings dam cells as well as upstream and downstream in the McArthur River and Barney and Surprise Creeks;
- All environmental monitoring data, held by both the McArthur River site and the NT Government, should be made publicly available, and as above, continue to be made available into the future;
- Full details concerning the current rehabilitation bond held by the NT Government (through the NTDME), including the technical and financial basis, with a particular focus on current criteria for rehabilitation and the life-of-mine plan;
- Similarly to the Ranger uranium mine, annual plans of rehabilitation should be prepared and part of regulatory requirements—but unlike Ranger, they should be made public to ensure transparency about the current rehabilitation bond, expected mining plans and the capacity to fund and achieve an acceptable rehabilitation outcome for the site;

To ensure that all issues are assessed and understood in a comprehensive manner, it is clear that current NT EIA processes are ineffective at addressing such complex sites as McArthur River—meaning a higher level of assessment is required. At present, the NT EIA process does not allow for a public inquiry level of assessment—only an EIS or PER are possible, compared to the normal EIA processes which allow for a PER, EIS or full public inquiry level of assessment, whereby a public inquiry is akin to the processes of a Royal Commission. Furthermore, the current guidelines for the 'Overburden Management EIS' (NTEPA, 2014) do not explicitly require the scenario of complete pit backfill to be included in the EIS (which is currently expected to be publicly released in late 2016), simply requesting the following information (p. 12):

- *Outline rehabilitation, including progressive rehabilitation, revegetation and closure plans on site in consideration of the changed management requirements for waste rock since the previously authorised Phase 3 project;*
- *Describe proposed post-mining land uses which have been identified and agreed on through consultation with stakeholders; and*
- *Detail the availability, sources and volumes of suitable materials required for rehabilitation, revegetation and mine closure (e.g. clay, capping materials).*

Furthermore, the risk assessments required imply that only above ground management needs to be considered and assessed, as the focus is *"… on the final pit lake water quality"* and *"… integrity of management structures"* as well as no explicit reference in the requirements for a conceptual mine closure plan to consider the scenario of complete pit backfill (p. 13).

As such, there is a clear and legitimate case for an expanded assessment scope of the future of the McArthur River project—and given the failures of the NT EIA process to date, a higher-level public inquiry is required. Although this is not allowed for in current NT EIA processes (unlike its state and federal counterparts), an effective option would therefore be a public commission of inquiry held under the NT Inquiries Act (2011). This would need to include not only the NT Government but also the Commonwealth Government, given the need to consider matters of national environmental significance under federal EIA legislation (namely the *Environment Protection & Biodiversity Conservation Act 1999*, or EPBC Act). The primary focus should be on the current status of the McArthur River site, especially a detailed audit of current mine wastes and management strategies (including an assessment of PAF and NAF wastes), future mine plans and ultimately whether the project can be operated in a manner which achieves acceptable environmental outcomes both during operations and after rehabilitation.

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A key area of investigation of such an inquiry should be the various options for final site rehabilitation, their expected environmental outcomes and the relative costs of each rehabilitation scenario. Whether mining should stop in the meantime is an important area of public debate—clearly there are many complex questions involved in the short and long-term management of the McArthur River project, with significant implications for the future of the ecosystems and communities of the region. As such, the final recommendation from this study is simply:

- Initiate and conduct a public inquiry under the NT Inquiries Act (2011) to investigate the current status and future plans of the McArthur River project, including a detailed assessment of rehabilitation scenarios which look at complete pit backfill and current regulatory requirements, especially the adequacy of the rehabilitation bond and related financial aspects—the primary issue is whether the McArthur River project can be operated and rehabilitated safely in a manner which meets legitimate community expectations for a modern mining project.

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Comments from Professor David Airey – Civil Engineer, University of Sydney, May 2017

My comments are based on material contained in Appendix N, Geotechnical Assessment Report of the Draft EIS of the Overburden Management Project

I have scanned other chapters of the report but where geotechnical parameters and stability issues are discussed the wording is very similar (usually identical) to that in Appendix N. As far as I can determine all the relevant information is in Appendix N

A thorough analysis of the NOEF stability is presented using appropriate methodology. However, any analysis is only as good as the input parameters and this is where I have some concerns.

The report presents summaries of tests performed by a range of reputable organisations, however, none of the original data has been provided. It is thus impossible to assess the methodology used to perform the tests or the methods of interpretation. In my experience, based on reviewing test reports, simply performing Australian standard tests does not guarantee the quality of the data. They need to be carefully reviewed by experienced geotechnical engineers who have a thorough understanding of soil mechanics.

My biggest concern relates to Figure 13 in Appendix N. This shows a plot of peak friction angle against “cohesion”. The first and most critical issue with this is that most clays do not have any true cohesion. This is certainly the case for reconstituted clays such as used in a CCL. The correct terminology should be “apparent cohesion”. This is central to modern understanding of soil behaviour, dating back to the work of Schofield and Wroth (Critical State Soil Mechanics) published in 1968. As there is no actual bonding the apparent cohesion arises from the tendency of soils to expand, or as may be relevant in the waste dump because of pore water suctions.

The reason why this is critical is that the stability of the steeper part of the slope of the NOEF relies on the “apparent” cohesion (c’). It can be shown by a simple infinite slope analysis with a failure plane running along the CCL layer that the factor of safety increase from 1 to 1.5 is due to the apparent cohesion. If the cohesion is assumed to be zero the factor of safety will be one, that is the CCL will be on the verge of failure, and this would represent an unacceptable risk on any critical slope. To understand the basis for the “apparent” cohesion more information is required.

Comments are made that strength will not reduce to residual values because this needs large movements. Two issues here. First it appears no tests performed so their assessment of residual friction angle is speculative and untested. Second they are correct that residual strength is not relevant to this problem as it requires large displacements, and those can only happen if the CCL fails. However, the strength will reduce from the peak to a critical state value (with zero apparent cohesion) with relatively modest strains and displacements, and this is the important point. Can they be sure peak will never be reached. Given the relatively high upper slope relative to the friction angle there is clearly a risk that this could occur locally. Nevertheless, despite my concerns it is possible that stability is acceptable, but without seeing the triaxial test data on which the parameters are based it is impossible to comment on the reasonableness or otherwise of the interpretation and analyses.

Similar comments apply to the rockfill/waste rock materials where any non-zero cohesion has been used in the analysis.

Another concern I have is with the assessment of the pore pressures in the rock dump. The pore pressures are critical to the stability. If the slope becomes fully saturated and pore pressures build up in the surface layer over the CCL (for instance due to reduced drainage capability after 100 years) this will reduce the stability of the slopes further. It is also appears to be assumed that the base drainage will continue to function effectively until 3017! Even if the window is 100 years there has to be considerable risk attached to this assumption. An analysis with no base drainage is critical to assessing the risk. This is an issue because when water flows out of the dump the stability (stable angle) is typically reduced by a factor of 2.

As input to the pore pressure analysis a series of water retention curves have been generated (text refers to report by O'Kane). The water retention curves of all materials apart from one (can't tell in B&W copy) have similar water retention to the clay and all have similar permeability – suction relations. This appears to show the materials have high percentages of fines. This of itself is not a problem but does suggest some inconsistency with the assumed strength parameters. The influence of these water retention curves on the pore pressures does not appear to have been assessed. Assuming less water retention should be investigated. However, it is not possible to assess the reliability of these water retention curves or their consistency with other data because only summary results are presented in Appendix N.

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Megan Kessler and David Morris
Environmental Defenders Office
Level 5, 263 Clarence Street
Sydney, NSW 2000

12 May 2017

Re. Environmental Impact Statement on the Expansion of the MacArthur River Mine.

Dear Megan and David

Thank you for asking me to read and comment on the Environmental Impact Statement (EIS) for the expansion of the McArthur River mine. My comments are a) based mostly on reading chapter 3, appendix T (part 1) and appendix N, of the EIS and b) concerned exclusively with future impacts on ground and surface water quality of mine activities, at, near and downstream from the site.

I note the short time over which the EIS is exhibited and, therefore, the short time available for reading such a large amount of material of such a complex nature. This appears to be, to my non-legal mind, a significant procedural impediment to a sound assessment and therefore to the protection of the environment and the well-being of the stakeholders affected by the project. All comments given below must be qualified by the short time available to read the document and submit them, and critical water quality issues, other than those identified in the comments, may exist.

I have serious concerns about both the approach taken to protect water from contaminants and the quality of predictions from the numerical modelling of groundwater contamination by heavy metals, which I detail below. These are: 1) reliance on sorption without consideration of competition, non-linearity and pH sensitivity, 2) paucity of information about base lining, 3) weaknesses in the contaminant transport numerical model and 4) lack of consideration of molecular diffusion as a contaminant transport mechanism. For each factor, I first provide a description of the problem then briefly discuss why it is important for the assessment of impacts on water quality.

I would be happy to answer any questions you may have about my comments,

Yours sincerely

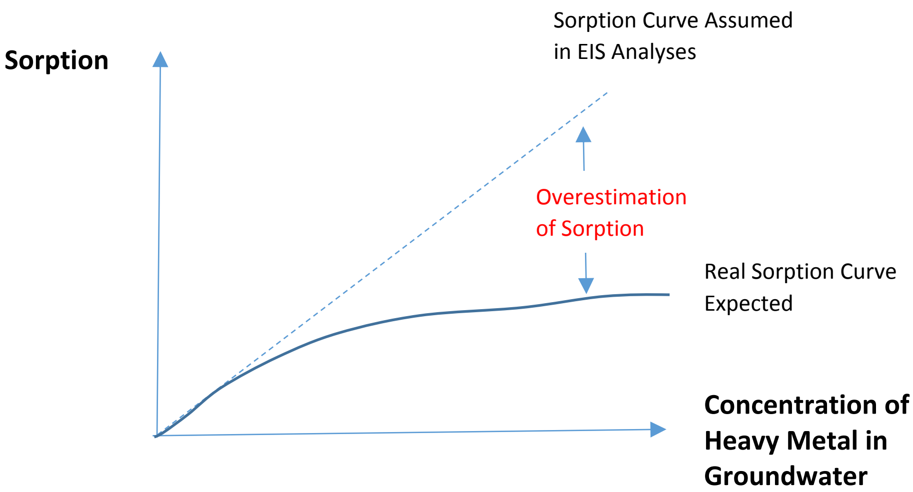
Abbas El-Zein

1. **RELIANCE ON SORPTION WITHOUT SUFFICIENT EVIDENCE**

Description

Sorption will be used by the mine operator as a primary means by which heavy metals (zinc, lead, arsenic and cadmium) are prevented from polluting surface waters downstream from the mine. Sorption is a process by which solutes in contaminated water become attached to soil particles and temporarily immobilised. This happens through various natural and spontaneous electro-chemical and physico-chemical means that depend on soil types and conditions (including its pH and organic content). There are three major problems (a., b., c. below) and one potential one (d. below), with reliance on sorption to protect groundwater in the McArthur river mine, as described in the EIS:

a. The analysis in the EIS relies on an assumption of linear sorption, as stated on page 177 of Appendix T part 1). This assumption is usually reasonable for very low concentrations of heavy metal in water, but has been shown time and again to overestimate sorption under the high-concentration loads expected in the case of the McArthur River mine (e.g., values of 115 mg/l reported in runoffs from active tailings footprint, table 5.5 of appendix U). Values of sorption distribution coefficient K_d can drop two orders of magnitude as concentrations in water increase, significantly reducing the capacity of the soil to sorb metals (see for example Vega et al., 2006). The figure below qualitatively illustrates this risk. Based on evidence in the literature, and unless the consultant can demonstrate experimentally the adequacy of a linear sorption assumption, a *non-linear sorption* relationship ought to be used in the modelling. This means that contaminants may travel much further downstream than implied by figures 157 to 162.



b. When more than one contaminant is present in the water, they are known to compete for sorption sites in the soil. This well-established process is called competitive sorption. For example, in the presence of Lead (Pb), Zinc (Zn) is sorbed significantly less by soil than in the absence of Lead (see for example, Fontes and Gomes, 2003 and Covelo et al., 2007). It is not clear from the EIS whether competitive sorption has been taken into account since there was no mention of it in the report, as far as I can see (and following an electronic search for "competitive" or "competition" in the document). If competitive sorption has not been considered in the analyses, this could significantly overestimate the extent of sorption in soil.

In relation to points a and b, the EIS makes incomplete reference to two other reports, presumably providing more details on how sorption was measured. However, these reports were not provided by the consultant upon my request. Instead, a small extract (4 tables) was provided which doesn't include any discussion of the assumptions made during the measurements of K_d and seems to confirm that sorption was taken to be linear and non-competitive.

To illustrate the point, K_d values for Zinc shown in the EIS (and used in the simulations) can be compared to values published in the literature (keeping in mind that the soils in the two documents are not the same and that this is done only to explain the risks). K_d values for Zinc shown in Table 23 (page 177 of Appendix T, part 1) range from 3.1 to 7.2 ml/g. By contrast, values of K_{d100} measured by Covelo et al., 2007, taking into account competitive sorption, can be as low as 0.8 ml/g (table 4 in that paper). It can be shown with relatively simple calculations that, if K_d is 0.8ml/g rather than 7.2 ml/g, Zinc contamination plumes may travel between 4 to 7 times further (for a given range of flow rates and dispersivities). When the effects of non-linear sorption are added, the plumes will travel even further than that.

c. Sorption coefficients, as mentioned earlier, are sensitive to pH of soil. How confident is the consultant that, given the nature of the mine chemical loads, the soil's pH will not vary over the next 100 years, and as consequence, its capacity for sorption will not decrease? There was no discussion in the report, as far as I can see, of the sensitivity to pH of the K_d values and of the heavy metal plumes, since all measurements of K_d appear to have been made under an assumption of pH=7.6 (p 126 of Appendix T, part 1). K_d values can decrease significantly with decreasing pH. For example, one review study by the US EPA found a reduction by up to a factor of 30 of the K_d for Cadmium, when going from a pH range of 5-8 to a pH range 3-5 (US EPA, 1999, table 5.4 p 5.13).

d. Sorption is a two-way process whose reverse is desorption. Desorption occurs when a soil, which carries large amounts of sorbed contaminants, is flushed through with uncontaminated water – as might happen through seasonal changes in groundwater quality. Some of the sorbed contaminants become mobilised again and available to travel downstream. It is unclear, what assumptions concerning desorption have been made in the analyses. Hopefully, the consultant has taken account of desorption in their analyses, though this needs confirmation.

In summary, the K_d factor depends on both soil and contaminant: for a scientifically valid assessment of the extent of attenuation of heavy metal contamination, sorption needs to be determined for the specific geology of the MacArthur River region while considering competition between contaminants for sorption sites, non-linear sorption conditions, sensitivity to soil pH and desorption.

Why is this Problem Important?

Judging by the EIS, the reliance on sorption for protection of surface waters downstream of the mine has not been adequately supported by the evidence provided in the EIS and carries therefore significant risks. **If sorption has been overestimated, the actual concentrations of heavy metals may be orders of magnitude larger than those predicted in the EIS and may travel manyfold further than estimated in that document.**

2. PAUCITY OF INFORMATION ABOUT BASE LINING

Description

The mine operator has chosen to provide cover lining of the overburden at the NOEF but it is unclear *where* and *when* base lining will be provided. Page 16 of Appendix N states: "Where, if insufficient in-situ clay thicknesses are encountered, a 0.5m thick basal CCL will be constructed." It would be useful for the consultant to be specific about what is considered as a suitable thickness for in-situ clay, why 0.5m thickness for basal CCL was chosen and based on what criteria of water flow and/or contaminant transport. Detailed designs of the base lining need to provided.

Why is this Problem Important?

Base lining is a central feature in preventing contaminants from travelling out of the source into the environment. Absence or inadequate design of this feature would be against best practice and may lead to contamination at the receptors.

3. LOW CONFIDENCE IN CONTAMINANT TRANSPORT MODEL

Description

The EIS offers a detailed model of groundwater flow, calibrated against measurements of hydraulic heads onsite. However, fewer details have been provided about the contaminant transport models (which uses output from the groundwater flow model to predict concentrations of contaminants at receptors). Confidence in the predictions of the contaminant transport model, based on evidence provided in the EIS, must be considered low, for the following reasons:

a. The non-uniqueness of the calibration of the groundwater model, and its high sensitivity to hydraulic conductivities, noted in the EIS, reduce confidence somewhat in the water flow model and, by extension, the contaminant transport model (which, as stated earlier, uses the output of the water flow model as part of its input).
b. Calibration of the contaminant transport model against sulphate concentrations was made for the time series of available data (2006-2014). This is a very small time interval, relative to the centuries over which model predictions are made. While this calibration time interval is probably the only possible one in the circumstances, it reduces confidence in the predictions of the contaminant transport model for sulphate and, more importantly, for heavy metals (see point c below). For example, molecular diffusion, discussed in point 4 below, may not become manifest over a few years but may still be important over a scale of decades and centuries.
c. It appears that calibration of the contaminant transport model has been made against site measurements of sulphate but not against measurements of heavy metals in soil. This means that the level of confidence in the model's predictions of heavy metal concentrations must be considered as low. We simply do not know how well the model predicts heavy metal concentrations since no comparison to measured values of heavy metals appears to have been made.
d. No details have been provided in the EIS about the boundary conditions (BCs) used for the contaminant transport model (as opposed to the groundwater flow model). Nor has an analysis of the sensitivity of predicted concentrations to these assumed BCs been reported. Assumptions made about BCs can have very large impacts on predicted concentrations at receptors. I requested information from the consultant about the contaminant transport

BCs. The consultant's reply stated that "flow boundaries have been kept consistent i.e., the flow model and the contaminant transport models boundary conditions for the flows are identical". This doesn't make scientific sense: the BCs *cannot* be identical. BCs for flow are typically expressed in terms of hydraulic heads or flow rates, while BCs for contaminant transport are given in terms of contaminant concentration or mass flux of contaminants. Does the consultant mean by "consistent" that zero water flow was applied as BCs in the water flow model and zero contaminant flux as BCs of contaminant transport? In that case, what about the boundaries where constant head or discharge rates were applied in the water flow model? All in all, more detailed information about the contaminant transport model is required for a proper assessment of the risk to receptors.

Why is this Problem Important?

The numerical model is the single most important piece of evidence on which the EIS bases its argument that the mine's activities, as planned, can be conducted while achieving the environmental standards required. Therefore, significant weaknesses in the model raise serious concerns about the future risks to water quality.

4. CONTAMINANT TRANSPORT BY MOLECULAR DIFFUSION NOT CONSIDERED

Description

In the EIS modelling shown in the report, advection and mechanical dispersion were considered as the only contaminant transport mechanisms of relevance. Molecular diffusion – a third transport process separate from the other two – was not considered. Molecular diffusion is an important mechanism especially in media with low hydraulic conductivity and relatively low flow rates. Its importance increases as the time scale of analysis increases (i.e., decades rather than years). It is therefore surprising that molecular diffusion has not been considered, given the EIS stated aim to provide protection for ground and surface water for up to 100 years and then and up to 1000 years, and given that many parts of the geology around, and downstream from, the site have low to very low hydraulic conductivities.

It may well turn out that diffusion need not be included in the modelling; however, an assessment has to be made. One way to assess whether diffusion is likely to be important is by measuring the Peclet number (vL/D) and by comparing the values of molecular diffusion coefficients to mechanical dispersion coefficients. Both of these assessments require knowledge of, not just the flow rates and dispersivities provided in the report, but of Darcy or seepage velocities below, and downstream from, the source – data which has not been included in the EIS. I made a request for such data from the consultant but this was not provided.

Why is this Problem Important?

If diffusion turns out to be significant in parts of the geology, concentration of contaminants at the source may be higher than what is predicted by the EIS report and the contamination plume would travel further than what is shown in Figures 154 to 162.

REFERENCES CITED

Covelo, E., Vega, F. & Andrade, M., 2007. Simultaneous sorption and desorption of Cd, Cr, Cu, Ci, Pb and Zn in acide soils I. Selectivity sequences. *Journal of Hazardous Materials*, 147, pp.852–861.

Fontes, M.P.F. & Gomes, P.C., 2003. Simultaneous competitive adsorption of heavy metals by the mineral matrix of tropical soils. *Applied Geochemistry*, 18(6), pp.795–804.

Vega, F., Covelo, E. & Andrade, M., 2006. Competitive sorption and desorption of heavy metals in mine soils: Influence of mine soil characteristics. *Journal of Colloid and Interface Science*, 298, pp.582–592.

Environmental Protection Agency (EPA). 1999. Understanding variations in partition coefficients K_d values. Volume II: Review of geochemistry and available K_d values for Cadmium, Caesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium and Uranium. Office of Radiation and Indoor Air, Office of Solid Waste and Emergency Response. Washington, D.C. 20460, USA.

Expert Review on Environmental Impact Statement (EIS) for the McArthur River Mine (MRM) Overburden Management

This report is the opinion of the expert Associate Professor Barry Noller

1. Name and address of the expert;

Associate Professor BARRY NOLLER,

Centre for Mined Land Rehabilitation,

The University of Queensland,

St Lucia QLD 4072,

Tel 07 3346 4069

Email: b.noller@uq.edu.au

2. I acknowledge that I have read the code of the NT Supreme Court '*Practice Direction No 4 of 2009 - Expert Reports'* **(**http://www.supremecourt.nt.gov.au/documents/practice_directions/4_of_2009_Expert_Reports.pdf**) and agree to be bound by it**;

Barry N. Noller

Signed :

Date: 12 May 2017

3. The qualifications of the expert to prepare the report;

Expert's qualifications Barry Neil Noller FRACI CChem, FRSC, FFACS, FIUPAC

Associate Professor Barry Noller holds a Ph.D. in environmental chemistry from the University of Tasmania (1978). He has worked as a Research Fellow at the Australian National University and as Principal Environmental Chemist for the Department of Mines and Energy, Darwin from 1990-1998, visiting the McArthur River mine site several times (1993-1998). From 1998 to 2006 and was Deputy Director of the National Research Centre for Environmental Toxicology (Entox) at The University of Queensland. Since 2006 Associate Professor Noller has been appointed as Principal Research Fellow and Honorary Consultant at the Centre for Mined Land Rehabilitation, The University of Queensland.

Associate Professor Noller has worked and published in the field of environmental chemistry and industrial toxicology for the past 40 years and has presented >300 conference papers and published >210 papers with a H -index of 20 covering processes and fates of trace substances in the environment, particularly in tropical environmental systems with special reference to risk management associated with the bioavailability of toxic elements in mine wastes including waters. He has undertaken detailed studies of arsenic and metal speciation of solid mine waste materials using synchrotron induced X-ray analysis and has developed speciation-based toxicity models for mine closure purposes. His professional activities undertaken at four different centres have covered processes and fates of trace substances including uranium in the environment, particularly in tropical environmental systems with special reference to risk management associated with the application and studies of the bioavailability of toxic elements in mine wastes, including acid mine drainage and waters. He was appointed in 2007 as Lead Author of the Australian Government Sustainable Leading Practice Development Program for the Mining Industry Handbook on Cyanide Management. Associate Professor Noller was project leader of the Lead Pathways Study conducted for Xstrata-Glencore Copper from 2007 to 2013. In 2014 Associate Professor Noller was appointed as a Technical Expert in Environmental testing for five years to support the activities of the Chemical Testing Accreditation Advisory Committee (CTAAC) of NATA.

Education

B.Sc. in Pure and Applied Chemistry Part-time, University of N.S.W. 1970.

Master of Chemistry, Formal coursework postgraduate degree in Analytical Chemistry. University of N.S.W. Project" Distribution of Lead in Vegetation Bordering Highways and Other Biological Materials by AAS". Supervisor: Professor L.E. Smythe. 1972.

Ph.D. Chemistry Department, University of Tasmania. Project "Development and Some Applications of Techniques for the Determination of Trace Metals by Furnace Atomic Absorption" Supervisor: Professor H. Bloom. Chemistry Department, University of Tasmania 1978.

Awards

1999 Citation Royal Australian Chemical Institute

2003 Contribution to development of Science and Technology in Vietnam VUSTA

2005 Fellow Federation of Asian Chemical Societies

2006 Environment Medal, Environment Division RACI

2011 Fellow International Union of Pure and Applied Chemistry

Other Details

Associate R.A.C.I. 1978. Committee Member Tasmanian Branch, R.A.C.I., 1976-1977, and Representative to Analytical Chemistry Division, R.A.C.I. Vice-Chairman N.T. Section R.A.C.I., 1981-1983. Fellow RACI 1989, Fellow Royal Society of Chemistry (UK) 1991, Fellow Federation of Asian Chemical Societies (FFACS) 2005, Fellow IUPAC (FIUPAC) 2011.

N.A.T.A. Assessor (Water Analysis), 198l-present. Member Environment Technical Group N.A.T.A., 1985 – 2014 (NATA is National Association of Testing Authorities).

N.A.T.A Technical Expert in Environmental testing to support the activities of the Chemical Testing Accreditation Advisory Committee (CTAAC) of NATA 2014 – 2019.

Chairman N.T. Sub-Branch R.A.C.I., 1983-1987. Immediate Past Chairman N.T. Sub-Branch, RACI 1987-1990. Committee Member N.T. Sub-Branch RACI 1990-1. Vice-President NT Branch 1992-1993. President NT Branch 1993-1995. Past-President NT Branch 1995-1997.

Member R.A.C.I. International Affairs Committee 1986 - 1988. Representative to Federation of Asian Chemical Societies 1986-1992. Member Asian Coordinating Group for Chemistry (ACGC) 1989-1997.Chairman Asian Coordinating Group for Chemistry (ACGC) 1997-present. Chair International Advisory Committee ASOMPS Conference 1997-present. Member Scientific Advisory Board ACGC Chemical Research Communications 1989-1994. Secretary ACGC CRC Board 1991-1997., Secretary-General Federation of Asian Chemical Societies 1989-1991. Co-ordinator of Projects Federation of Asian Chemical Societies 1991-1999. Member RACI International Relations Committee (reconvened) 1992-2014.

President-Elect Federation of Asian Chemical Societies (FACS) 1999-2001. President of FACS July 2001-2003, Fellow FACS 2005

Representative to Environmental Chemistry Division R.A.C.I. 1987-present. Vice-chairman Environment Division R.A.C.I. 1992-1993. Chairman Environment Division R.A.C.I. 1993-1995. Past-Chairman Environment Division R.A.C.I. 1995-1997. President-elect RACI November 1994-1995. President RACI 1995-1996. Past President 1996-1997.

Member Alligator Rivers Region Technical Committee 1995-1998 (statutory appointment)

Member of ANZAAS, Clean Air Society of Aust and NZ, Australian Society of Ecotoxicology, Australian Water Association, Geochemical Society, American Chemical Society and International Humic Substance Society

A list of my publications is given in Annexure 1.

4. The facts, matters and assumptions on which the opinion is based (a letter of instructions may be annexed);

Annexure 2 gives the letter of the Environmental Defenders Office NT, dated 24 April 2017, that requested that I undertake to: (a) review the documents listed below; and (b) prepare a written expert report that addresses the issues identified below ('Issues to address in your expert report'), and ensure that the work is prepared in accordance with the **NT Supreme Court '**Code of Conduct' indicated in (2).

5. The reasons for, any literature or other materials utilised in support of, and a summary of the opinion;

This statement of evidence was commissioned by the Environmental Defenders Office NT on 24 April 2017 who act for community members who live in close proximity to the mine and Mc Arthur River. The expert opinion is to provide a report addressing the following issues: (a) review the documents listed below; and (b) prepare a written expert report that addresses the issues identified below ('Issues to address in my expert report'). It was necessary to examine details in the draft Environmental Impact Statement (**EIS**) for MRM Overburden Management and guideline documents in order to make comments on matters related to environmental effects of the overburden handling and storage at McArthur River Mine.The report summarises the expert technical advice requested from the Centre For Mined Land Rehabilitation.

6. If applicable, that a particular question, issue or matter falls outside the expert's field of expertise;

Not applicable.

7. Any examinations, tests, or other investigations on which the expert has relied, identifying the person who carried them out and that person's qualifications;

Not applicable.

8. Details of any other expert reports read by the expert and the extent to which the expert agrees with those reports and, to the extent that there is disagreement, the reasons why;

Not applicable.

9. Declaration –

(a) I declare that I have made all enquiries which I believe are desirable and appropriate; and (b) that no matters of significance which I regard as relevant have, to my knowledge, been withheld from the Court;

10. Any qualification of an opinion expressed in the report without which the report is or may be incomplete or inaccurate;

Not applicable
and

11. Whether an opinion expressed in the report is not a concluded opinion because of insufficient research or insufficient data or for any other reason.

Not applicable

Expert Review on Environmental Impact Statement (EIS) for the McArthur River Mine (MRM) Overburden Management

By Barry N Noller

Centre for Mined Land Rehabilitation, The University of Queensland, St Lucia QLD 4072

For the Environmental Defenders Office NT, Darwin, Northern Territory

Date 12 May 2017.

1. Background

1.1 Outline of McArthur River Mine Overburden Management Project

The McArthur River Mine (**MRM**) is located approximately 45 km south-west of the township of Borroloola and 470 km south-east of Darwin, in the Gulf Region of the Northern Territory. MRM is the world's largest producer of zinc in bulk concentrate form and zinc concentrate. The draft Environmental Impact Statement (**EIS**) for MRM Overburden Management is the key item of this review.

The key elements of the Project EIS are:

- the redesign of the overburden emplacement facilities (waste rock dumps) to manage overburden geochemistry;
- repositioning and reduction of footprint of overburden emplacement facilities;
- removal and re-processing of tailings waste and placement within the open cut void on cessation of processing, and rehabilitation of the former Tailings Storage Facility area;
- a revised open cut final void closure strategy; and
- monitoring and management plans for the ongoing protection of the downstream environment.

Environmental Defenders Office NT (**EDO NT**) will be preparing a submission to the EIS on behalf of community members who live in close proximity to the mine and to the McArthur River. I was requested to give expert advice to help inform this submission.

1.2 Primary purpose of providing independent expert advice

EDO NT requested to assist in providing advice to their clients, and in helping prepare their submissions on the EIS, in the form of independent expert advice in relation to the any potential contamination issues arising from the proposed Project.
The expert report will be used as evidence in chief of my professional opinion. In providing my opinion I was advised to set out all the assumptions upon which the opinion is based. This may include, for example, facts observed as a result of field or lab work or 'assumed' facts based on a body of scientific opinion. If the latter, references are provide which demonstrate the existence of that body of opinion.

My expert report also sets out the process of reasoning which I have undertaken in order to arrive at my conclusions. (It is insufficient for an expert report to simply state your opinion or conclusion reached without an explanation as to how this was arrived at). The purpose of providing such assumptions and reasoning is to enable decision makers to make an assessment as to the soundness of my opinion.

1.3 Overview of work requested

EDO NT requested that I undertake the following work:

a) review the documents listed below; and
b) prepare a written expert report that addresses the issues identified below ('Issues to address in my expert report'), and ensure that the work is prepared in accordance with the Code of Conduct (refer to (2) above).

1.4 The documents

Full project documentation is available at: https://ntepa.nt.gov.au/environmentalassessments/register/mcarthur-river-mine-overburden.
EDO NT particularly referred to *Appendix B Terms of Reference Cross Reference Table* available at: https://ntepa.nt.gov.au/__data/assets/pdf_file/0004/407380/mrm_overburden_draft_eis_appendix B_final_EIS_ToR_cross_reference_table.pdf. This document includes a comprehensive description of where in the EIS relevant issues are discussed.

1.5 Issues to address in your expert report

EDO NT asked that my report addresses the following issues:

a) In my opinion, is the assessment of environmental impacts arising from overburden management appropriate and have any potential contaminants been appropriately characterised?
b) What, if any, are the environmental impacts likely to arise from overburden management as proposed? In providing my answer, please consider any risks arising from bioaccumulation of contaminants.
c) Provide any further observations or opinions which I consider to be relevant in regards to rehabilitation and potential contamination risks.

1.6 Key dates

The EDONT has received an extension to provide submissions to the draft EIS on behalf of its clients. The EDONT's clients' submissions are due on **17 May 2017**. To ensure your advice is available to our client and interested community members in sufficient time to complete their own submission, I was requested to send my advice by Thursday **4 May 2017**.

2. Review of Environmental Impact Statement (EIS) for the McArthur River Mine (MRM) Overburden Management

a) Assessment of environmental impacts arising from overburden management appropriate and have any potential contaminants been appropriately characterised

In my opinion, the methodology for identification of potential contaminants on the MRM lease now enables satisfactory characterisation to undertake an assessment of environmental impacts arising from overburden management. Some issues that arise are identified at a later post mining stage in this report.

The McArthur River Mine (MRM) Phase 3 development project has undergone an EIA process at EIS level and was subsequently approved by the Northern Territory Government (NT EPA 2014). Following requirements of both Northern Territory Government and the Australian Government, by Minister for Environment, Terms of Reference were developed to address changes in the project EIs which are now being reviewed (DEIS 2017 ToR Appendix B) following the key elements of the Project EIS.

The potential contaminants for each of the following headings are identified by following the key elements of the Project EIS.

(I) *The redesign of the overburden emplacement facilities (waste rock dumps) to manage overburden geochemistry*.

A key item required by the EIS was to improve the understanding of the overburden chemistry at MRM that could be linked directly to protection of downstream environment and particularly, it was claimed, the aquatic ecosystem (DEIS 2017 Exec Summary).

The 2013 review of all overburden characterisation data (DEIS 2017 Ch 6) available from drill cores, overburden classification procedures and in-pit identification and geological mark-up confirmed hanging wall overburden material was enriched in elements of potential environmental concern including sulfur, zinc, lead, arsenic, cadmium, antimony, bismuth and molybdenum and a fraction of the Non Acid Forming (NAF) material previously considered environmentally benign was found to pose a potential risk of saline drainage (SD) and neutral metalliferous drainage (NMD) (DEIS 2017 Ch 6-21).

The implementation in 2014 of the MRM Waste Classification Guide was a significant advance, at this mine, in the accuracy of characterising potentially impacting mine waste material because the geochemistry approach used was able to provide a reliable basis of geochemical criteria for the effective segregation of the various overburden classes for classification was to establish by taking into consideration all forms of acid mine drainage (AMD), in line with international leading practice as outlined by both Australian and international guidelines (AMIRA 2002; GUARD 2009). The MRM Waste Classification Guide utilises the following key measurements:

> **1. Maximum Potential Acidity** (MPA) to calculate the maximum potential acidity (MPA) of acid that can be generated by the sample: $MPA\ (kgH_2SO_4/t)=S\%\times30.6$ by assuming conservatively that pyrite (iron sulfide) is the primary source of sulfur and is completely oxidised (DEIS 2017 Ch 6-10). The 30.6 value is calculated from the stoichiometry of the equation $FeS_2+154O_2+72H_2O\rightarrow(OH)_3+2H_2SO_4$ (e.g. 1% sulfur has the potential to generate a maximum of 30.6 kg of sulfuric acid per ton (kg H2SO4/t) if all of the sulfur is oxidised); and
>
> **2. Neutralisation Potential Ratio** (NPR) is the ratio of acid neutralising capacity (ANC) over MPA. $NPR=ANCMPA$ and indicates the probability that a sample may produce acidity (DEIS 2017 Ch 6-10). Samples with NPR < 1 are considered likely to generate acidity, while samples with NPR values > 2 are considered as likely to be acid consuming. Material with NPR values between 1 and 2 are considered uncertain and need to be compared to other acid base accounting (ABA) criteria before final classification. The uncertain status is the

result of 2 possible chemical reactions that can occur during neutralization: (i) Reaction One needs only 1 ANC unit to neutralize 1 MPA unit and if the only possible reaction, then NPR > 1 would be acid consuming; (ii) Reaction Two requires 2 units of ANC to neutralize 1 MPA (DEIS 2017 Ch 6-10). The neutralization reaction depends on physico-chemical conditions in the environment and is not readily predictable. Therefore, an NPR > 2 or greater is used as a conservative criterion to classify the material as non-acid forming NAF. (DEIS 2017 Ch 6-10).

Thus 'Neutralising Potential Ratio', an accurate conservative approach for the specific geochemistry of MRM materials, replaces the less-reliable original 2005 classification (URS 2005) of MRM from 2005 – 2013 using net acid producing potential (NAPP)/net acid generation (NAG) testing pH values for evaluation of the potential acid drainage risk. The site specific potential for spontaneous combustion was also considered (DEIS 2017 Ch 6-22) and replaced.

The MRM classification system materials (DEIS 2017 Ch 3-56 and Ch 6) has five material classes that are grouped in two principal categories:

1. Environmentally Benign
Low salinity non-acid forming (high capacity) (LS-NAF(HC) material is the only MRM overburden classes considered environmentally benign, and therefore not considered a potential contaminant source. This material has a low risk of generating contaminants, and has a high acid neutralising capacity. It includes alluvial materials such as clay, silts, sands and gravels, and some shales, breccias and dolomites; and

2. Environmentally Non-benign
All other materials are considered non-benign, and therefore may represent a potential contaminant source, including: metalliferous saline non-acid forming (high capacity) (MS-NAF(HC)); metalliferous saline non-acid forming (low capacity) (MS-NAF(LC)); potentially acid forming (high capacity) (PAF(HC); and potentially acid forming (reactive) (PAF(RE).

Only LS-NAF(HC) was predicted as environmentally benign (DEIS 2017 Ch 6 Table 6-4). All other classes were considered to require some form of encapsulation to limit oxidation and some form of water management strategy to prevent contaminant movement. There is no segregation between saline drainage (SD) and neutral metalliferous drainage (NMD) risk.

When sulfide minerals in MRM ore are exposed to oxygen and water they oxidise and generate secondary oxidation products (metallic oxides, sulfates, and sulfuric acid). The metals may be soluble depending on the pH of the water. The toxicity of the oxidation products to ecosystems is variable, depending on the element, its oxidation state, the form of metals in water in which products may be transported, and the sensitivity of the flora and fauna in the receiving environment (DEIS 2017 Ch 3-56). The main kinds of contaminants are as follows:

1. Sulfur as a contaminant
The primary source of saline drainage generation from MRM overburden is from the release of soluble sulfate resulting from the oxidation of sulfide minerals and subsequent neutralisation by carbonates rather than sodium chloride or any other salt present in overburden. The potential risk of saline drainage generation is estimated using total sulfur content of the rock. The total sulfur cut-off value used in the 2014 classification was 1% sulfur and is now only applied to separate LS-NAF from MS-NAF(HC) (DEIS 2017 Ch 6-25). All other classes are considered to be potentially metalliferous saline; and

2 Metal contaminants of significance
Evaluation of the potential for neutral metalliferous drainage (NMD) used zinc, lead and copper elemental abundances in overburden material as key indicators of metalliferous enrichment for two reasons. They are the most common metals in the overburden drill cores, and high sulfur, zinc, lead and copper values were correlated to enrichment in other elements including arsenic, antimony, cadmium and selenium (DEIS 2017 Ch 6-27). Following kinetic geochemical testing undertaken though 2015 and 2016 the selected cut-off values were changed as follows: sulfur < 1%; zinc,< 0.12%; lead < 0.04%; and copper removed as deemed not significant (previously <700 mg/kg); arsenic <40 mg/kg mg/kg and cadmium <10 mg/kg (DEIS 2017 Ch 6-27).

The McArthur River Mine (MRM) Phase 3 development project has been divided into three main areas, or domains, to simplify the description of key facilities and conceptual models (DEIS 2017 Ch 3-47). The three domains that include important operational and closure features and processes, are: Domain 1 – open cut; Domain 2 – North Overburden Emplacement Facility (NOEF); and Domain 3 – Tailings Storage Facility (TSF). These three domains are linked by groundwater and surface water (DEIS 2017 Ch 3 Figure 3-1). A summary description of each of the three Project domains and the key components in each domain is provided in the following three sections.

Comment

In my opinion, there has been a significant improvement in categorising elements of potential environmental concern in the EIS. The MRM Waste Classification Guide for overburden classification system followed the comprehensive review of geochemical data and a large amount of new geochemical work undertaken by MRM (DEIS 2017 Ch 6). The overburden characterisation of materials has provided a necessary decision process for storage and disposal of mine wastes for the MRM activity.

(II) Repositioning and reduction of footprint of overburden emplacement facilities

Features of overburden emplacement facilities

Domain 2 has the North Overburden Emplacement Facility (NOEF) and other temporary emplacements. This is a complex facility that provides key components of the mining process that were modified and improved with the Overburden Emplacement Facility from the MRM Phase 3 Project (DEIS 2017 Ch 3-24-25). The efficient functioning of this facility determines if water contacting waste materials, and their reaction products, is retained within the emplacement facility or becomes seepage.

The NOEF is the principal repository for mined overburden between 2018 and 2032 (DEIS 2017 Ch 3-81). The overall Overburden Emplacement Facility (OEF) footprints were reduced by removal of the temporary South Overburden Emplacement Facility (SOEF) and East Overburden Emplacement Facility (EOEF) between the mine levee wall and the McArthur River Channel. The volume of benign NAF material from the characterisation of materials was reduced with the reclassified non-benign NAF material and is used to construct the NOEF (DEIS 2017 Ch 3-81). Non-benign material placed in the Small temporary Overburden Emplacement Facility (OEFs) is then returned to the open cut following completion of mining activities (DEIS 2017 Ch 3-32). The SOEF is a temporary OEF located wholly inside the mine levee wall on the south side of the open cut and contains overburden that will be relocated into the open cut for permanent subaqueous storage upon cessation of mining.

The redesign of NOEF construction and encapsulation methods incorporate reducing oxygen and water ingress and therefore the potential for geochemical reaction to occur (DEIS 2017 Exec Summary). The geometry of the NOEF was altered to reduce the footprint whilst maintaining sufficient capacity for storage of the majority of MRM overburden by increasing the height of the NOEF. Proposed in-pit storage of non-benign overburden allows NOEF to be completed, encapsulation and rehabilitated early in the Project life, prior to cessation of mining (DEIS 2017 Exec Summary). Approximately 575 Mt of overburden is flagged for placement in the NOEF between 2018 and 2032. This is in addition to the approximately 195 Mt of material which will already be in place. The NOEF domain will reach its maximum footprint of 775 ha in 2022 (DEIS 2017 Ch 3-28). At this point the NOEF will have reached its full extent and the associated domain infrastructure will be in place including three Perimeter Runoff Dams, sediment dams, clean water drain and benign material stockpiles. By closure, the NOEF will have approximately 7 ha of remaining infrastructure for the purpose of monitoring and maintenance including the MIA stockpile (DEIS 2017 Ch 3-28). The other 769 ha will be rehabilitated, including the NOEF cover system.

The NOEF will be permanently store material (DEIS Exec Summary 2017) in order to:

- enable placement at a rate consistent with the mine plan;
- enable the use of local resources as much as possible, including construction materials and skills;

- be a physically and chemically stable storage of mined overburden for 1,000+ years:
- which meets the closure objectives, including water quality;
- leave a landform that is consistent with the nominated post-mine land use:
- be a native fauna habitat.

The guarantee of the stability of the MRM Phase 3 NOEF is supported by the following statements that give an understanding of source-pathway-receptor chains for potential mine-derived contaminants (DEIS 2017 Ch 3-106) based on:.

- The placement methods to be used being tailored to the materials being mined, to give a degree of source control.
- An outer benign cover system will encapsulate the entire facility, including the existing NOEF, in a protective layer which acts as both a source control and a pathway control and gives a reduced footprint will result.
- The cover system will have a barrier layer in its composite profile, which will be the inhibitor of water and oxygen ingress and will provide flood protection for the interior of the NOEF, resisting the movement of floodwater into the facility, and of infiltrated water out of the facility.
- A revised closure process and timeframe giving MRM confidence in its ability to continue to achieve the Project closure objectives in the long term, beyond the operational and decommissioning phases. Scheduled periodic inspection and maintenance are proposed to rectify performance issues as the landform and systems are modified and establish a new steady state. As the facility develops (in the order of 50 years after rehabilitation), the interval between maintenance interventions will increase until a phase called Pro-active Monitoring and Reactive Monitoring is reached. Systems and resources to undertake monitoring and maintenance over these phases will be planned and allocated as part of the closure process.

Foundation works and water impacts

The objectives for the foundation of the NOEF are stated to provide a stable, low permeability base. It is claimed this will limit the risk of instability in the NOEF, and reduce exchange of waters with metals and sulfate between the NOEF and the regional groundwater. (DEIS 2017 Ch 3-115). The proposed footprint extent will be defined, with vegetation then cleared in accordance with existing site land disturbance procedures. Clay and alluvial materials are required for use in specialised layers of the NOEF. Updated investigations into the materials contained in the foundations were completed through 2014 to 2016, with models of various alluvial materials compiled to generate estimates of volumes.

The Base zone is a nominal 5 m thick zone of MS-NAFs constructed in maximum 5 m lifts to enhance geotechnical stability and to reduce air permeability. This will provide a stable platform for the Core of the NOEF (DEIS 2017 Ch 3-120). Placement of MS-NAF material is considered acceptable in this zone of the NOEF because:

- The MS-NAF in the base will be encapsulated by the low permeability foundation below and the cover system above that will limit oxidation and the ingress of water. When stored in low-oxygen environments, the generation of secondary oxidation products is significantly reduced.
- Water percolating through the NOEF will pass through the overlying PAF material and will likely have reached its solubility limits. It is unlikely to produce any additional Contaminants of Concern below the PAF material.
- The base of the NOEF will also be protected from flood waters by the 100 year flood protection barriers keyed into the basal compacted clay layer (CCL).

The Core zone provides an isolated zone in the long term with very low access to oxygen, to limit oxidation of pyrite and heat (DEIS 2017 Ch 3-120). To better understand how and why the Core zone has been planned as it has in this EIS, some explanation of the factors that influence oxidation and transport (by water) within a rock pile are included below.

Key groundwater and surface investigations (DEIS Ch 3-120-129) have been undertaken:

- **Groundwater Impact Assessment Report**. The geometry and materials of the new foundations will promote percolation as toe seepage rather than basal seepage material (DEIS 2017 Appendix III of Appendix T). The base will target performance equivalent or better to 0.5 m of compacted clay layer with a maximum saturated hydraulic permeability of 10 m/s. A subsoil drainage network will transfer collected seepage to specific collection pits at the toe of the NOEF. The foundation will be above the recorded 2013/14 wet season water table to reduce the risk of waterlogging of the base (highest recorded groundwater level in MRM records). Extracted groundwater will be managed with other surface water (DEIS 2017 Ch 8); and

- **Surface Water Impact Assessment.** The interaction of the existing NOEF foundation has preferential drainage lines incorporated into its design. The subsoil drainage systems will the collect seepage. Therefore these areas effectively have a natural basal CCL and drainage system already functioning, as evidenced by the seepage collected on the eastern side of the NOEF (DEIS 2017 Appendix P).

Conceptual Model for Air and Water Movement through the NOEF

The internal dynamics of the generation of oxidation products from pyrite (acidity), and the movement of those products through the NOEF, is complex (DEIS 2017 Ch 3-120-129). The key processes and inputs to be considered include:

- oxidation of sulfides and organic carbon generates heat;
- the heat creates a thermal gradient between the NOEF and external environment (atmosphere), which can vary both seasonally and on a daily cycle;
- the thermal gradient generates convective air currents that can deliver air deep into the NOEF and move gases into and out of the stockpile;
- air movement through the NOEF depends on the material placement method used, batter geometry, material properties and properties of internal layers; and
- air supply directly affects the oxidation rate of sulphides and organic carbon – thus, completing a loop.

The ability of the pile to draw in oxygen (the air permeability) has a large influence on the rate of oxidation and the occurrence of spontaneous combustion. The level of moisture and the material texture has an influence on the air permeability (DEIS 2017 Ch 3-120-129). Estimates of the rate of generation of oxidation products within the current NOEF were made for various levels of saturation (i.e. a measure of the moisture levels in the rock matrix) and material placement types from "Coarse" to "Compacted fine", with advection currents being a key driver of oxidation rates. From the analysis, it was concluded that portions of the existing NOEF are in the "Coarse" and "Loose fines" regimes. This gives an understanding of possible rates of generation of oxidation products that may be stored in the rock matrix of the NOEF. These results also provided the basis for designing future design for deposition and completion of the NOEF (DEIS 2017 Ch 3-120-129).

Further investigations into the role of advection currents on NOEF performance with parts of the existing NOEF PAF cell having one or more clayey-alluvial caps applied over them. The impact of these on gas flows through the existing NOEF were modelled (DEIS 2017 Ch 3-123) and showed gas movements with a south-north oriented cross-section of the existing PAF cell. Spikes above and below the '0' line indicate high air movements into and out of an uncapped PAF cell. The application of alluvial caps (or "thermal blankets") of 2 m thick (green) and 5 m thick (blue) could reduce these flows. Application of alluvial "advection barriers" to the PAF cell commenced in 2016. Further detailed assessment of the efficacy of materials placement techniques and advection barrier specifications is given (DEIS 2017 Appendix I).

Modelling for oxidation of rock through oxygen diffusion processes indicated that its penetration into a pile is related to particle size and moisture saturation. Higher moisture saturation levels lead to lower diffusion rates. Unsaturated materials will likely allow significant oxygen penetration up to 5 m into a pile, whereas 50% saturation can limit penetration to 2 m. Therefore, paddock dumping low reactivity material over more reactive rock can limit diffusive oxidation of the more reactive rock. Using this knowledge, diffusive loads were added into the conceptual model of the NOEF.

Modelling of both oxidation processes and water flow processes was completed to develop models of load transport from the NOEF over time (DEIS 2017 Appendix P). Other findings were as follows:

- Infiltrating waters in the NOEF travel largely in a vertical direction towards the foundation. Internal sloped CCLs result in only minor deflections of the seepage pathways due to the limited permeability contrast between the CCL and rock, and limited slope angles.
- Geochemical modelling indicated that concentrations of many elements in the moisture within the NOEF are likely to be solubility controlled, therefore seepage will have relatively constant values for a long time. This means that loadings from the NOEF will be directly related to the rate of water flow through the NOEF as infiltration.
- Net Percolation (NP) through the outer protective cover of the NOEF is the main potential inflow of water into the NOEF in the long term. NP is proportional to the NOEF footprint area. Therefore, for the same cover system specifications, a reduced footprint will result in smaller loadings to seepage.
- The MRM overburden is characterised by a very high acid consumption capacity, and even PAF lithologies contain a high intrinsic buffering capacity. The principal water quality related issues to manage over time are likely to be saline and neutral metalliferous drainage with elevated sulfate and zinc levels in seepage waters.
- Due to the height of the NOEF, the seasonal response of seepage movement towards the foundation is muted, with the increased wet season infiltration rates observed more as relatively constant seepage rates over a whole year at the foundation.

Design of Reactive PAF Storage, Halo Zone and Cover Zone

Reactive PAF (PAF(RE)) will be stored in one of two specific PAF(RE) cells in the core zone (DEIS 2017 Ch 3-113). The footprint of the PAF(RE) cells will be large enough to have a suitably low rate-of-rise such that the risk of large scale self-heating and combustion is limited. Critically, for the early part of PAF(RE) cell development, the cell is isolated from other operational areas to give time to refine the exact interval between advection barriers, maximum rate-of-rise, and level of compaction with low risk of heating impacting other parts of the facility. By the time the PAF(RE) cells are enveloped by the main Core zone, the methods to control the PAF(RE) need to be well understood.

Reactive PAF Cells
The PAF(RE) will be placed in 2 m lifts or paddock dumps with heavy compaction (DEIS 2017 Ch 3-123). Prior to each wet season, an advection barrier layer will be placed to seal the material off from oxygen, followed by a low lift of MS-NAF to further limit gas diffusion and water infiltration, and reduce erosion of the advection barriers. These techniques were used effectively in 2016 for managing the placement of PAF(RE). Scheduling guidelines to limit the mining of PAF(RE) during the wet season will be used to reduce the volume of PAF(RE) that is exposed to wetting, which is a known trigger of oxidation.

Halo Zone
The Halo comprises a layer placed around the top and sides of the Core (DEIS 2017 Ch 3-90). Specifically, the role of the Halo zone includes:

- acting as a thermal barrier between the Core and the barrier layer in the cover system, should any hot zones be present;
- providing a buffer between the Core and potential erosion of the outer part of the NOEF; and
- providing a suitable stable and smooth substrate/base for the cover construction.

The Halo will be constructed from MS-NAF or better, in lift heights of 7.5 m or less, with the lift height varied to suit the applicable cover construction method. The true thickness will be between 5 m and 20 m: the final thickness will depend on material availability and the cover construction technique (DEIS 2017 Ch 3-90).

Cover Zone
The role of the Cover zone is to restrict oxygen ingress, store water to promote plant growth, and shed excess water down purpose-built drains in higher intensity rain events whilst resisting erosion (DEIS 2017 Ch 3-90). It works together with the landform (overall size and shape) to achieve these

goals. It must have a high degree of constructability, using skills, methods, equipment and materials readily available and at a rate consistent with the needs of the mining schedule. The materials used in oxygen and water management controls must be resilient or easily renewed/replaced considering the life of the facility.

Comprehensive detail on the selection, modelling, and specifications of the cover system and its performance are given (DEIS 2017Appendix J), including key information below.

The cover system is the only portion of the NOEF that will be constructed from benign materials. There are slight differences between the cover system for the plateau and the batters, due to the different risks associated with geotechnical stability, water management and erosion. Whilst there are several possible cover systems that can meet the objectives required (DEIS 2017 Ch 7), the base case cover system selected is described below.
The NOEF plateau cover system (DEIS 2017 Ch 3-129) will comprise:

- A barrier layer at the base (nominally a 0.5 m CCL with a maximum saturated permeability of 1 x 10-9 m/s) placed over a thin layer of fine-grained alluvial material rolled into the halo to reduce the risk of piping failure.
- Overlain by a 0.5 m thick drainage layer of coarse LS-NAF rock, linked into the surface drainage system. This is required to convey excess water during intense rainfall events off the barrier layer, reducing ponding and NP.
- Overlain by a 1.5 m thick alluvium GM zone and topsoil. The fine-grained GM will enhance plant establishment and evapotranspiration, whilst coping with the low erosive forces present on the gently sloped plateau. A 0.1 m thick topsoil layer will be placed over this growth media.
- The plateau is to be separated into sub-catchments, with surface water runoff to be conveyed down purpose built drains incorporated into the haul ramps. The drains will include an underlying geomembrane to provide initial stabilisation through the adaptive management phase, with suitably sized coarse durable LS-NAF rock utilised for drain construction.
- The crest of the plateau will be higher than the interior where practicable, to shed water away from and prevent overtopping of the crest. Effective drainage around the crest will enhance geotechnical stability of the steeper upper slope section of the NOEF.

Following closure of the NOEF and reprocessing and deposition of the tailings into the open cut, the remaining open cut capacity (approximately 170 m from the surface) will be filled with water sourced from McArthur River to create a mine pit lake (DEIS Exec Summary 2017). This will be completed over a period of approximately five years when the McArthur River flows provide sufficient surplus to meet filling requirements. This rapid filling will enhance the mitigation of acid and metalliferous drainage from the tailings and overburden that will be stored in the open cut (DEIS Exec Summary 2017).

Infiltrated Rainwater
The initial pathway leading to the mobilisation of potential CoCs is infiltrating rainwater (DEIS 2017 Ch 3-90). When rainwater falls on a potential source, the seepage (fraction that is not lost to evaporation or shed away as runoff) will infiltrate into the landform. As the water migrates through the profile, it can mobilise soluble contaminants potentially present and transport them away from the source, eventually reporting to either surface waters through toe seepage, or infiltrating down into the shallow groundwater. Controlling the amount of rainwater infiltrating a potential source is therefore very important, and achieving a low net percolation is a critical parameter of cover system designs. MRM has undertaken a significant amount of modelling for the design of OEFs and specification of cover systems (DEIS 2017 Appendix J; DEIS 2017 Appendix P) in Support of the EIS Submission.

Groundwater
Groundwater is primarily derived from rainfall recharge and acts as a pathway by transporting the contaminants downgradient and transmitting them to surface waters in the form of base flow discharge to drains, channels, creeks, rivers and lakes (DEIS 2017 Ch 3-90). Groundwater and associated permeable units are a significant pathway and constitute a critical component of Conceptual Site Models. The site groundwater is discussed in detail (DEIS 2017 Ch 8; DEIS 2017 Appendix T). There are three main water-bearing units on site: shallow alluvium, weathered bedrock, and fractured bedrock. These units are often hydraulically connected. The permeability of the ground is variable, being high in isolated shallow gravel/sand beds but low (i.e. slower) through shallow clays

and deeper bedrock material. In rock, the shallow weathered rock can have medium permeability, which decreases with depth where the rock is less weathered. There are local fracture zones that can transmit higher flows at depth. In addition to the main three water bearing zones, a distinct shallow palaeochannel exists parallel to the original McArthur River, located within the open cut domain. The palaeochannel is characterised by higher permeability than the surrounding alluvium.

Surface Water
Surface waters include creeks, rivers, lakes, and flood waters. Surface water can be generated through surface recharge, seepage waters expressing on the surface, and when groundwater becomes baseflow recharge (DEIS 2017 Ch 3-90). They are the principal pathway for the transfer of potential contaminants off lease to the ultimate receptor, which is the downstream environment. Surface waters at MRM are discussed (DEIS 2017 Ch 8; DEIS 2017 Appendix U). The principal surface water pathways on the MRM site are Barney Creek and tributaries, Surprise Creek, Emu Creek and tributaries, and the McArthur River (DEIS 2017 Ch 3-61). Surface water flows are markedly seasonal, with significantly higher flow during the wet season (November to April) compared to the dry season (May to October). All the creek systems are naturally ephemeral with a cessation of flow during the dry season, although seepage from mine storages have led to year-round base flow in some reaches in the past. Flooding occurs seasonally in the McArthur River, and flood protection is an important mitigation strategy employed by McArthur River Mining to protect mining infrastructure (mine levee wall) and prevent the ingress of flood waters into potential sources (flood protection for the OEFs and TSF). Floods can be caused by intense rains in local catchments upstream (local flooding), or by the restriction of McArthur River outflows downstream of the mine. The latter causes greater flood depths and is the driver of flood protection design levels at site. The potential impact of floods is detailed (DEIS 2017 Ch 8; DEIS 2017 Appendix U).

Comments

In my opinion, the MRM classification system materials is both a conservative and practical consideration, because differentiating classes of NAF between saline and/or metalliferous drainage risks would be impractical to mine selectively and manage separately (DEIS 2017 Ch 6-24). This has been an important outcome of the re-evaluation acid and metal generation processes and classification of MRM waste materials. MRM overburden has a combination of high sulphide content and high acid buffering capacity which means that the NAG test pH may not be a reliable indicator of acidity owing to limitations of the procedure (incomplete oxidation of sulfides, large buffering capacity present) (DEIS 2017 Ch 6 Section 6.3.2.1). The underestimation of the acid generation risk of the material can be responsible for a large proportion of “uncertain” samples in a NAPP/NAG pH diagram (DEIS 2017 Ch 6 Section 6.3.2.1).

In my opinion, good management of the overburden emplacement facility is required and needs to be demonstrated to ensure that categorised waste materials are not dispersed by water or air. The MRM Phase 3 NOEF can meet the objectives provided that the structure shows that stable storage of mined overburden will exist for 1,000+ years and monitoring of the post mine land use is sufficient to detect adverse effects requiring remedial attention.

In my opinion the redesign of the MRM overburden emplacement has been well planned, based on the documentation cited, and is demonstrating a thorough understanding of source-pathway-potential receptor chains for potential mine-derived contaminants for this mining operation. This step provides a reasonable basis for developing progressive evaluations from decisions based on monitoring.

The review of ‘Features of overburden emplacement facilities’ shows that extensive work has been undertaken by the MRM Phase 3 development project on the design and modelling of these features. In particular the connection with geochemical characterisation has enable the following details to be summarised that connect with like characteristics of contaminant dispersion:

- Geochemical modelling indicated that concentrations of many elements in the moisture within the NOEF are likely to be solubility controlled, therefore seepage will have relatively constant values for a long time. This means that loadings from the NOEF will be directly related to the rate of water flow through the NOEF as infiltration;

- The principal water quality related issues to manage over time are likely to be saline and neutral metalliferous drainage with elevated sulphate and zinc levels in seepage waters; and

- As the water migrates through the overburden emplacement profile, it can mobilise soluble contaminants potentially present and transport them away from the source, eventually reporting to either surface waters through toe seepage, or infiltrating down into the shallow groundwater. Controlling the amount of rainwater infiltrating a potential source is therefore very important, and achieving a low net percolation is a critical parameter of cover system designs.

In my opinion, the monitoring of the completed NOEF and related facilities, based on the data and study findings presented in the MRM Phase 3 development project is required to demonstrate that all items on site are fully functional and capable of controlling contaminant dispersion.

In my opinion, the systems and resources to undertake monitoring and maintenance over the post-mining phases must be planned and allocated as part of the closure process.

(III) Removal and re-processing of tailings waste and placement within the open cut void on cessation of processing, and rehabilitation of the former Tailings Storage Facility area

Domain 3 is the Tailings Storage Facility (TSF). Its operation will continue in MRM Phase 3 with an increased height will be able to accommodate additional tailings in order to eliminate the need for additional TSF storage cells. Final storage in the open cut will mitigate generation of acid and metalliferous drainage from the tailings, once covered by a sufficient layer of water. The former TSF area will be rehabilitated and will require confirmation that the metal and salt contamination in the soil is reduced (DEIS 2017 Exec Summary).

Tailings
Tailings are the finely-ground by-product that remains after the mineral bearing component of the ore has been extracted during processing (DEIS 2017 Ch 6). The understanding of overburden geochemistry has been the main trigger for the Project EIS; the tailings remain classified as PAF(HC) as they were previously. Because the risks associated with tailings generation and management have not materially changed and so are not subject to the Project EIS (DEIS 2017 Ch 3-9). The tailings are described as having very low oxidation when kept moist and is a condition which the TSF operations will continue to maintain (DEIS 2017 Appendix R).

Tailings Deposition in Cells 1 and 2 of the TSF with Seepage Mitigation
The expert Independent Tailings Review Board (ITRB) appointed in 2015 to oversee the design and operation of the TSF (DEIS 2017 Ch 3-21) has reviewed of all dam development options for the LOM. The ITRB endorsed proceeding with a TSF strategy adapted from the MRM Phase 3 plan and proposed the following:

- Consolidation of all future tailings deposition and storage into a merged Cell 1 and 2, on top of past tailings deposition areas, continuing to use upstream construction methods. This would provide superior water management capability and reduce the disturbed footprint relative to the Phase 3 plan that incorporated development of Cells 2, 3 and a new Cell 4.
- A slightly higher dam to store the LOM tailings, due to the decreased footprint. The final height, which depends on tonnes processed, tailings placement density and settlement rates, is planned to be between 75 to 78 m AHD compared to the Phase 3 elevation of 68 m AHD. The extra 7 to 10 m of height compared to the maximum overall Phase 3 height of approximately 28 m is considered by MRM to be not material to the safety, performance or potential impacts of the facility. The revised final height will require a change to the AAPA certificate covering the TSF.

Significant Changes from Phase 3 Project

The components of the MRM operation that have changed significantly since the assessment of the Phase 3 authorisation in 2013 (or prior EIS approvals) are as follows (DEIS 2017 Ch 3-24).

- Revised TSF decommissioning and closure, including:
  - reprocessing of the tailings at the end of open cut mining and placement of spent tailings within the open cut final void;
  - additional borrow pits in the vicinity of the TSF for construction materials; and
  - elimination of the proposed TSF cell 4.

The TSF domain will cover its maximum footprint of 550 ha in 2032 (DEIS 2017 Ch 3-70) and will include the Cell 3 WMD and Process Water Dam (PWD), benign material quarries and stockpiles, and associated new haul roads (DEIS Ch 3-28).

The TSF domain is located west of the NOEF and open cut domains, on the western side of the Carpentaria Highway (DEIS 2017 Ch 3-48). The existing layout of the domain is comprised of two areas (Cells 1 and 2) which receive tailings in a slurry form from the processing facilities in the open cut domain. Cells 1 and 2 will be integrated into a single cell as the facility develops through 2017-2018, and remain combined for the rest of the LOM. Tailings are deposited around the perimeter of the cells, with excess water recovered from a central decant pond, where it is recycled back to the processing facilities. Tailings and return water are transported through pipes in a bunded corridor between the process area and the TSF.

A third cell to the southwest of Cell 1 and Cell 2, named Cell 3, is currently used to store water from the TSF and mining area. In the near term, Cell 3 will be divided into two lined water management structures; the 2 GL WMD and the 4 GL PWD. The WMD will be used to store selected waters in preparation for release under permitted conditions. The PWD will be used to store excess water from the open cut/underground and TSF, for evaporation and/or future treatment. Benign material borrow areas and stockpiles are located in the areas around the TSF.

The TSF domain during the open cut mining operations phase is required to safely and securely store the tailings and site waters to meet environmental, health and safety, visual impact and cultural heritage commitments (DEIS 2017 Ch 3-159). Additionally, benign materials required to construct the facility must be sourced from the area. The operation and construction of the TSF and associated water management dams is not materially different to current approved activities through the MMP and associated amendments. Section 3.2 describes the inclusions and exclusions from the EIS. However, information is provided at a level of detail consistent with the other major operational domains to enable the site-wide interactions and functions to be better understood (DEIS 2017 Ch 3-5).

The detailed description of the TSF related activities follows well-detailed practices and descriptions (DEIS 2017 Appendix R). The minimum standards for the design and operation of the TSF are set in the relevant sections of Australian National Committee on Large Dams (ANCOLD) Guidelines on Tailings Dam Planning, Design, Construction, Operation and Closure (ANCOLD 2012).

Comments

Because this part of the MRM operation is an extension of the MMP, there is nothing unusual regarding these operations.

In my opinion, the items that may require additional attention are those that arise with clean-up of the existing TSF footprint where metal and salinity contamination may remain in the soil. The soil contamination levels will need to be reduced to below guideline levels for the designated land use. In addition, stored waters that are planned for release must be tested and evaluated for effects on aquatic species if those waters are to be released to the McArthur River.

(IV) A revised open cut final void closure strategy

This stage of the MRM Phase 3 plan is a transition between final processing of ore, relocation of existing wastes to the void, stabilisation of the filling with solid material and final addition of water to give isolation of the solids from air in the void.

Open Cut Mining Operations Phase (2018-2037)

This part of Phase 3 is defined by the period of open cut mining and supply of ore to the processing plant and the plans for the physical progression of the site over this period to the end of 2037 (DEIS 2017 Ch 3-81). The mining of overburden from the open cut is required to expose ore underneath. To access the ore, overburden is removed and hauled to OEFs. Beneath the open cut, redundant MRM underground mine workings remain. The revised overburden characterisation practices in use since 2014 will continue to be implemented to define the various material types. The physical process of mining the overburden at MRM is unchanged for this step.

The open cut domain encompasses the open cut mining operation and the processing plant (DEIS 2017 Ch 3-48). The mine levee wall extends around the open cut area to protect the mine and associated facilities from McArthur River flooding of up to a 1,000 year annual recurrence interval (ARI) event. The McArthur River Channel connects the original McArthur River to the southwest and northeast of the mine levee wall, bypassing the operations area. Groundwater and surface runoff flows into the open cut and underground workings, and must be removed to enable operations to continue (in dry conditions). The processing plant and power station are located to the west of the open cut, inside the mine levee wall on top of Barney Hill. The processing plant is where the ore is crushed, ground and separated into the useful product (concentrates) and waste (tailings).

Tailings Rehandling Phase (2038-2047)

The tailings stored in the TSF over the LOM represent a potential long-term liability as the landform, and surface water and groundwater associated with it, must be managed to meet closure objectives (DEIS 2017 Ch 3-167). As part of a revised closure plan for the TSF, tailings is to be hydraulically mined and reprocessed before permanent disposal in the open cut deep beneath the water of the final mine pit lake. Reprocessing is set to commence shortly after ex-pit mining is complete, and is planned to occur over a 10 year period from 2038 to 2047 (DEIS 2017 Ch 3-16-17).Tailings will be supplied to the existing processing plant in slurry form. The tailings are expected to have grades from 4% to 6% zinc and 3% to 5% lead. Approximately 94.5 Mt of tailings will be removed from the TSF and reprocessed, with the spent tailings deposited into the open cut void over an approximate ten year period. This step can recover additional value from the tailings and remove the liability from the TSF footprint, with the tailings stored in a best-practice facility. The Tailings Rehandling Phase is defined by this period of reprocessing/rehandling of the TSF and deposition of the tailings into the open cut void.

Open Cut Operation

The existing MRM process plant will be utilised to reprocess the tailings at approximately 10 Mtpa over a 10 year period, with the reprocessed tailings destined for the open cut final void (DEIS 2017 Ch 3-168-170). Additionally, non-benign overburden from the SOEF, EOEF and other remediation areas will be hauled down and placed into the in-pit dump (IPD) during the tailings reprocessing phase. The reprocessed tailings streams will be mixed in the final tailings hopper before being pumped to the open cut void for disposal and is an operational phase of the project. The discharge pipe will be laid and anchored along suitably stable sections of the final void west wall to the nominated deposition depth, which will be below the final elevation of the finished tailings layer (DEIS 2017 Ch 3-169).

Tailings deposition into the final void will vary in nature between both subaqueous (under water) and subaerial (surface deposition) (DEIS 2017 Ch 3-176-178). Depending on the final void footprint at the deposition level, groundwater inflows, rainfall runoff into the final void, liberated pore water versus reclaim rates, and climatic conditions may vary. Subaqueous deposition would reduce dust emissions, reduce the rate of oxidation in both submerged tailings and overburden, and reduce water return rates, whilst sub-aerial deposition would result in a cleaner reclaim water and higher initial density.

The rate-of-rise of the tailings in the final void is variable, as the void capacity changes with elevation. The first year of deposition would see the tailings rise in the order of 100 m, around 60 m in year 2, steadily reducing to approximately 8-10 m per year in the latter years. Due to groundwater and surface water inflows, and the transport water used to deliver the tailings to the deposition area, the open cut will have water inputs during this phase. Recovery of water from the final void during operations will be achieved by floating submersible pumps or slurry pumps and will be recycled for

use in the process and tailings re-mining, with the excess managed in the Class 5/6 water management system, to be evaporated and treated via the WTP for ‘managed release’.

The settlement of the tailings in the final void and rate of release of pore water from consolidation of the tailings has been modelled and the Tailings Consolidation Modelling identifies that settling of the tailings will continue (at a reducing rate) in the long term (DEIS 2017 Ch 3-169; DEIS 2017 Appendix AC). No modification to the water chemistry has been assumed during this stage, and the ‘unmitigated’ pore water release has been a key input into the open cut final void water quality modelling (DEIS 2017 Ch 8) which predicts that water quality at SW11 will be maintain below the WDL trigger levels. This will generate poor quality pore water over the long term, after deposition has ceased. If required, the water chemistry can be mitigated either by treating the pore water directly after reprocessing of the tailings, or when the open cut is full of water prior to any interaction with the McArthur River through in-situ treatments such as lime addition to adjust pH and precipitate metals.

The final tailings in the open cut void will have its upper surface approximately 175 m below the pit crest, and post development of the mine pit lake, will be approximately 160 m under water (DEIS 2017 Appendix AC).

Open Cut Flooding and Connection to River System

The geochemical stability will be defined, managed and monitored: water quality within the mine pit lake. However, it will be necessary to manage surface water and groundwater such that environmental values and ecosystems are maintained downstream of the lease boundary in the short term (0-100 years), and within the McArthur River in the long term (100-1,000 years).

It is proposed to deal with potentially poor quality water in the disused open cut by rapidly fill it with water. This will submerge both the material stored in the base of the open cut and the open cut walls, eliminating further oxidation. As the generation of oxidation products and evapoconcentration are time dependent processes, rapid filling with fresh water (as opposed to slow filling) will result in the best quality water in the initial mine pit lake formation. A good example of the outcome of this process is Lake Enterprise at Pine Creek, NT.

After the tailings relocation to the open cut is complete in 2037, it is proposed that water from McArthur River during high flow periods will be harvested using siphons and or pumps at the rate of approximately 60 GL per year over approximately five wet seasons, and discharged into the open cut void. This will fill the void rapidly to the steady state mine pit lake water level, which is estimated to be approximately 15 m below ground level, near the base of the alluvial zone. Water treatment may be required during this filling, so these facilities would not be decommissioned immediately after tailings reprocessing.

Before flooding of the mine pit lake is completed, works will be required in the open cut area which will assist in achieving the closure objectives. The open cut design already features 18 degree (1V:3H) slopes in the upper alluvial zone to provide enhanced long-term stability in the mine pit lake setting. The batters will be topsoiled, revegetated and equipped with debris to form habitat structures suitable for a lacustrine environment. The Old McArthur River channels between the mine levee wall and the open cut will also be armoured to provide scour resistance during inflows.

Once the mine pit lake is formed, it will remain as an isolated facility (i.e. no inflow or outflow between the mine pit lake and the McArthur River) pending confirmation of the lake behaviour and evolution of its water quality (DEIS 2017 Ch 3-182). Operation of the WTP and/or lake water treatment may be required to stabilise water quality at the desired values. Based on a site-specific models of water quality within the mine pit lake over time and considering final void limnology (DEIS 2017 Appendix V) water quality is expected to remain reasonably stable in the short term while the mine pit lake is operating as an isolated system (DEIS 2017 Ch 8).

After water quality within the mine pit lake can be demonstrated to be within acceptable levels, and the models provide a confident representation of observed conditions, it is proposed that a section of the downstream levee will be removed to allow for water exchange between the mine pit lake and the McArthur River during periods of seasonal high flow. To control inflows to the mine pit lake the inlet through the mine levee wall will be constructed with an abrupt steep face on the external side to deter

entry of large fauna, and a sloped ramp on the inside (mine lake side) to reduce the risk of fall related injuries to fauna entering the mine pit lake in a flood. The introduction of external waters to the lake will also bring sediments into the mine pit lake, which will further bury the tailings and in-pit dump. Once the performance of this downstream lake scenario is demonstrated, the WTP and Cell 3 dams will be decommissioned and their disturbance footprints will be rehabilitated.

The disturbed areas will be reshaped using the benign materials remaining from the removal of the TSF embankments (DEIS 2017 Ch 3-188). The surface will be free draining to Surprise and Little Barney creeks where possible. Alluvial material and topsoil will be spread over the higher ground before revegetation with suitable species, which will function as a control for dust and erosion. The drain areas will have suitable rocky LS-NAF(HC) lining the main flow paths to reduce erosion. Sediment management systems will be installed and maintained downstream of the rehabilitated areas until erosion rates meet the closure objectives. Borrow pits that remain as depressions would require suitable vegetation adapted to the revised moisture content of that setting. Any remnant infrastructure not required for ongoing activities during the Adaptive Management phase, such as roads, powerlines, and pipelines would be removed.

After the tailings have been removed, CoCs will still be in the groundwater zones, moving slowly towards the creeks, the mine pit lake and McArthur River. It is estimated it will take approximately 120 years for the majority of the contaminant load to dissipate (DEIS 2017 Appendix T). The network of groundwater monitoring bores in use throughout the LOM would continue to be monitored. Based on current modelling, there are no plans for groundwater recovery from around the TSF domain after the removal of the tailings. Surface waters with unsuitable concentrations of elements will be recovered from Barney Creek and managed as required to meet the closure objectives, most commonly late in the dry season (DEIS 2017 Ch 3-189; DEIS 2017 Ch 8).

Mine pit lake water quality will be monitored and once it is established that discharge levels are acceptable, the northern (downstream) end of the mine levee wall will be opened to the McArthur River via an engineered weir (DEIS 2017 Exec Summary). This will create a ‘backwater’ connection with the McArthur River during high flow events. The water quality will be monitored and, once deemed appropriate, the southern (upstream) end of the mine levee wall will also be opened to the McArthur River via a similar weir structure. This will create a ‘flow-through’ connection with McArthur River during high flow events. The mine pit lake will then form a secondary channel of the McArthur River during seasonal flood events, with the McArthur River Channel maintained as the primary flow path.

The deposited tailings and overburden placed within the base of the open cut are not anticipated to materially affect the surface waters of the mine pit lake that may interact with the McArthur River (DEIS Exec Summary 2017). No modification to the water chemistry has been assumed during this stage, and the ‘unmitigated’ pore water release has been a key input into the open cut final void water quality modelling (DEIS 2017 Ch 8) which predicts that water quality at SW11 will be maintain below the WDL trigger levels. This will generate poor quality pore water over the long term, after deposition has ceased. If required, the water chemistry can be mitigated either by treating the pore water directly after reprocessing of the tailings, or when the open cut is full of water prior to any interaction with the McArthur River through in-situ treatments such as lime addition to adjust pH and precipitate metals.

A 20 year simulation of the final void mixing with McArthur River flood water shows that that there is very limited mixing below 50 m depth and therefore the sediment release tracer (zinc and sulfate) continues to fill the lower waters of the void without any significant periods of flushing (DEIS 2017 Appendix V). However this is a preliminary study and the interaction of bottom void water on exit water at the end of the dry season with water composition, such as has been observed with Whites Open Cut at Rum Jungle NT, remains to be confirmed/demonstrated during the annual cycle of the proposed MRM pit lake.

Once the mine pit lake is formed, it will remain as an isolated facility (i.e. no inflow or outflow between the mine pit lake and the McArthur River) pending confirmation of the lake behaviour and evolution of its water quality (DEIS 2017 Ch 3-182). Operation of the WTP and/or lake water treatment may be required to stabilise water quality at the desired values. Based on a site-specific models of water quality within the mine pit lake over time and considering final void limnology (DEIS 2017 Appendix V)

water quality is expected to remain reasonably stable in the short term while the mine pit lake is operating as an isolated system (DEIS 2017 Ch 8).

Comments
In my opinion, the formation of the mine pit lake will require much more detailed study and validation of exchange processes of contaminants between solid phase tailings and the water column, such as from dry season inversion, before there can be certainty that contaminant transfer to downstream aquatic species will not result in bioaccumulation of metals over reasonable time frames of tens to hundreds of years.

(V) Monitoring and management plans for the ongoing protection of the downstream environment

MRM has engaged in preparing an extensive monitoring strategy for preserving environmental values of receptors centres on an alignment with the environmental protection philosophy of their waste discharge licence (DEIS 2017 Ch 3-629). This is done to give protection of the downstream aquatic ecosystem from MRM impacts at all times. The mining activities have extensive localised temporary impact on the environment within the mineral leases. Mixing zones are part of the WDL philosophy and MRM acknowledge that effects are likely to occur in the immediate vicinity of the mining operations; off-lease effects can be managed through appropriate dilution. The potential impacts on these receptors are conservatively measured at the SW11 monitoring location just beyond the lease boundary and are measured in accordance with the WDL trigger levels. The assumption is that potential contaminants transported by groundwater that do not report to the open cut/underground will therefore eventually report to the SW11 compliance point as part of surface water flows and concentrations. Many of the WDL parameters, for which trigger levels exist, are based on national guidelines (ANZECC/ARMCANZ 2000; FSANZ 2009), while the sulfate trigger is based on the results of specific ecotoxicology testing across a range of tropical aquatic species. The experience with assessment of Ranger Uranium Mine in the Alligator Rivers Region, NT has demonstrated that site specific studies with local species are important for assessing the effects of water release on downstream aquatic species.

Contaminant Linkages
The successful management of potential contaminant generation and transport relies on the implementation of mitigation strategies that aim to disrupt the source-pathway-receptor chain (DEIS 2017 Ch 3-62). Two principal types of control are planned at MRM: source controls and pathway controls.

Source controls aim at limiting the generation of potential CoCs within the different sources. Examples of source controls at MRM include strategies to limit oxygen and water ingress into OEFs to limit the production of potential contaminants from these structures and relocating the tailings from the TSF to the final mine pit lake for subaqueous disposal.

Pathway controls include strategies to recover or divert potential CoCs in the process of being transported from the source to the receptors. As the potential contaminants have already migrated beyond the source, pathway controls are considered secondary controls and may be less effective than primary source controls. At MRM, pathway controls focus on interception of groundwater and surface water using recovery sumps, interception trenches and extraction bores.

Thus the effectiveness of mitigation strategies relies on a comprehensive monitoring program to adequately inform decision making, and corrective action if required. Monitoring also enables the validation of the implemented mitigation systems, and helps to guide further improvements if required. The MRM closure strategy makes provision for an extensive adaptive management phase following closure for this purpose.

Risk Identification and Assessment
The comprehensive risk identification and assessment program implemented by MRM to review the existing and new Phase 3 risks has used an iterative process that has been refined with the Project's stakeholder engagement program and supporting technical studies. The risk identification and assessment program has also taken into consideration the results of other in-house risk assessment

programs as well as Project risks identified and assessed by third parties. Specifically this has included and identifies and assesses any potential new Project risks:

- The Northern Territory Government, which identified a number of key risks as part of a Preliminary assessment of the Project, and has prescribed in the EIS TOR that they be assessed (or reassessed) as part of this Project EIS.
- The Independent Monitor reports. The Independent Monitor has been appointed by the Northern Territory Department of Primary Industry and Resources (DPIR) to develop annual Environmental Performance Reports on the MRM site, with the latest report having been released (ERIAS 2016). The scope of these reports is to provide an independent monitoring assessment of the environmental performance of MRM and its regulation. As part of these reports, site-wide environmental risk assessments are developed, and are reviewed and updated on an annual basis.
- The Mine Risk Register report (2016). This site-wide report was developed by an external risk specialist and encompassed all areas of MRM's operational activities plus its proposed Project activities.
- An internal Failure Modes and Effects Analysis (FMEA) process, which was conducted with the assistance of an external risk specialist.

A final Project Risk Register was developed, which incorporated the above inputs, the results of which were integrated with the Project design process. The process adopted for each identified risk included an assessment of the inherent (or Pre-Project EIS) risk, based on existing mitigation measures, and the residual (or Post-Project EIS) risk, based on proposed additional mitigation measures. A combination of the likelihood of occurrence and consequence of failure was considered for each risk event. The analysis technique evaluated the effects of such failures on the larger systems of which they formed a part, including:

- Environmental;
- Regulatory;
- Community and Stakeholder;
- Health and Safety; and
- Economic.

Water management
The water management strategy has been updated to maintain protection of downstream environmental values (DEIS Exec Summary 2017).The effective management of water resources has been an integral component of the Project development and a key focus of the EIS. The existing water management strategy, though extensive already, has been updated to maintain protection of downstream environmental values. These include:

- aquatic and terrestrial ecosystems;
- primary industries including stock drinking water, irrigation and general water uses;
- recreation and aesthetics; and
- cultural and spiritual values.

The adopted surface water quality indicators relevant to protecting the downstream environmental values are those documented in McArthur River Mining's Waste Discharge Licence (WDL) and are measured at several locations on and off-site, including the downstream compliance point (SW11).
McArthur River Mining has undertaken fieldwork and groundwater model calibration to develop a robust understanding of the levels and movement of groundwater, and its interaction with surface water systems and Project infrastructure. The work has demonstrated that beyond the influence of the open cut dewatering drawdown zone, groundwater flows regionally towards the McArthur River, and locally towards the local ephemeral creek system, where discharge occurs. Thus, groundwater migrates into surface water on the lease, or into the dewatered open cut/underground water management system.

The catchment area is predominately characterised by flat areas bordered by low hilly land that is subject to flooding during the wet season, with most of the mine site located within the McArthur River floodplain. The surface water quality within the MRM region is naturally affected by seasonal stream

flows and elevated levels of metals, particularly copper, lead, zinc and aluminium. The groundwater system has three main groundwater bearing units which extend across the Project area, these include: alluvium, weathered bedrock and bedrock (fractured and intact) and are generally connected hydraulically.

MRM implements a comprehensive groundwater and surface water management system as part of daily operations. Since 2015, McArthur River Mining has implemented a water classification system which includes six water classes. Wherever possible, water at MRM is managed in a way that separates water classes to limit the volume of poor quality water and process water within the system. Updates to the existing water management system and water balance have accommodated the proposed changes to the mine site layout and maintain protection of downstream environments. The management system has adjusted according to the mine activities and in response to climatic events and monitoring.

The water balance modelling results indicate that with the proposed additional water management measures in place, the proposed water management system will be robust and will have adequate storage capacity to manage surface water runoff generated within the MRM site for a wide range of possible climatic conditions, including extended wet and dry periods.

The water management system has been designed to manage and mitigate the following potential effects associated with mine infrastructure to protect downstream environments:

- modified groundwater baseflow discharges to creeks, rivers and diversions;
- sulfate migration within the groundwater system down-gradient of mine overburden, TSF and water management facilities during the life of mine; and
- increases in sulfate loads to the Barney Creek Channel, primarily associated with long-term seepage from the NOEF, peaking post-closure following establishment of the mine pit lake.

The flood modelling results indicate the proposed flood management measures would adequately mitigate the potential impacts of flooding on and downstream of the MRM site. Flood modelling results also indicate the mine levee wall provides flood protection to the open cut area from the McArthur River for flood events up to the 0.1% Annual Exceedance Probability with a 0.4 m freeboard during the proposed Project operations.

McArthur River Mining currently operates a comprehensive surface water monitoring network and data collection program within and in the vicinity of the mine site to collect:

- water level and flow data in the McArthur River, Barney Creek and Surprise Creek;
- water quality data in the natural streams upstream and downstream of the mine site, and through the mine site;
- water quality data in MRM's water storages and sumps on the mine site; and
- water quality at the site compliance station, SW11 that represents all water from the site.

Currently, surface water is monitored at 32 stream locations within and in the vicinity of the mine site and at 55 artificial surface water sites, including 48 storages and sumps. A number of minor refinements to improve and expand the current surface water monitoring program are proposed to account for changes in site layout and better understand the site surface water characteristics. No changes are proposed to the existing suite of parameters monitored or the monitoring frequency presently. McArthur River Mining plans to continue to implement the current groundwater monitoring program.

Additions are proposed to regularly verify the timing and magnitude of impacts to groundwater values and to improve the understanding of source-pathway-receptor processes across the site. The program will be based on early preventative action should monitoring suggest impacts may occur at different receptors, or different to that predicted by the modelling works.

Biodiversity
The potential risks that the Project poses to biodiversity values are assessed, with a particular focus on species protected under the TPWC Act (DEIS 2017 Ch 9) and those of National Environmental

Significance under the EPBC Act (DEIS 2017 Ch 10). The approach taken for assessing risks to biodiversity values in each chapter is similar and has included the following:

- data from field surveys and publicly available databases are used to generate a list of protected species that may be present within the region;
- the likelihood of each species being present on-site is individually assessed, which is then used to generate an inherent risk (risks without control measures) of being impacted by the Project; and
- for species considered to be of medium to high inherent risk of impacts, potential impacts are discussed in detail and mitigation measures are proposed with residual risks being assessed.

A monitoring program is proposed to test if the mitigation measures employed will protect endangered species. Ongoing monitoring is also designed to enable the timely detection of unanticipated impacts of the Project.

Air quality
The assessment predicted that potential off-site air quality impacts are within acceptable criteria for the townships of Borroloola, Devils Spring, Campbell Springs and the identified areas of temporary occupation (DEIS Exec Summary 2017.

Potential on-site air quality related impacts were associated with fugitive dust emissions from operational activities and sulfur dioxide emissions from reactive overburden and tailings. The MRM mitigation measures to manage the impacts of sulfur dioxide emissions and potential spontaneous combustion include adoption of selective handling and placement of overburden material, in order to reduce the potential for water and oxygen ingress into the NOEF. Additionally, spontaneous combustion will also be managed through adoption of various monitoring programs, including:

- in-pit thermal monitoring prior to and during drill and blast operations to detect potentially problematic material;
- daily NOEF visual and thermal inspections to detect areas of material with the potential to combust (abnormal surface moisture, elevated temperatures, cracks, heaving, or efflorescent salts);
- daily gas monitoring including sulfur dioxide levels on the NOEF to identify potential hazards and areas requiring intervention; and
- development of weekly NOEF hazard maps of temperature and gas levels to identify areas of concern.

There are several dust mitigation measures which are implemented at the MRM site. An operational air quality management plan for the management of offsite air quality is currently being developed at MRM in consultation with government agencies.

MRM Community Reference Group
MRM has an established Community Reference Group (CRG) providing an overarching management tool to enable MRM to monitor impacts of the Project on the community and facilitate the provision of Project information and receipt of feedback (DEIS Exec Summary 2017. All community members are invited to attend. MRM will continue to host CRG meetings throughout the life of mine, with the aim to:

- report on the progress of activities and commitments;
- respond to community enquiries and complaints;
- resolve disputes with stakeholders;
- develop action plans with stakeholder involvement for ongoing social and community support;
- monitor through stakeholder feedback the effectiveness of their community engagement processes; and
- adjust mitigation strategies to achieve optimal outcomes for all parties.

Health and Safety
In accordance with MRM's Health, Safety, Environment and Community Management System (HSEC MS) requirements, operational risk assessments have been undertaken to identify and assess

existing operational health and safety risks on site (DEIS Exec Summary 2017. The findings of this risk assessment indicate the key site risks were mostly associated with the following activities:

- mining activities;
- aerodrome incidents;
- blasting;
- mobile equipment and maintenance;
- ore processing;
- dewatering operations;
- tyre management; and
- supply of hazardous substances/explosives.

Comments

The ongoing monitoring and management plans for the ongoing protection of the downstream environment that are undertaken by MRM are extensive as evidenced by the extent of detail recorded. It is not directly obvious if there are any gaps in the monitoring program as such as monitoring is currently being done intensively. The offsite and downstream water quality monitoring is highly focussed on the SW11 monitoring location downstream of the lease boundary and contaminant levels are measured and evaluated in accordance with the respective guidelines. This also applies to food items such as fish and accumulated metal levels that are compared with the FSANZ (2009) food guidelines. In the case of assessing effects of contaminants on organisms, it is assumed that if a contaminant does not exceed its guideline value for sediment or water, then an organism exposed to that contaminant will not experience any apparent effect.

For aquatic species such as fish and invertebrates contaminants in the food change may effect particular species in the food chain and not be detected by physico-chemical monitoring.

In my opinion, the effects of water release at the downstream site SW11 should be assessed for aquatic species for both acute and chronic exposures using approaches described by ANZECC/ARMCANZ (2000), such as with assessment of water release from the Ranger Uranium Mine in the Alligator Rivers Region, NT has demonstrated that site specific studies with local species are important for assessing the wellbeing of the aquatic ecosystem. This may also include longer surviving aquatic species by developing biopsy monitoring and biomarker techniques that do not result in mortality of the animal.

Following my comment in (IV) regarding the need for detailed study and validation of exchange processes of contaminants between solid phase tailings and the water column in the proposed pit lake there needs to be:

- additional study to understand contaminant transfer to downstream aquatic species from the pit lake following completion of the tailings deposition in the pit void;
- development of methodology to measure both physico-chemical transfer of heavy metals into the water column of the pit via transfer processes; and
- studies in a mesocosm with in-situ aquatic species to follow bioaccumulation of metals over reasonable time frames in the pit lake that can be extrapolated tens to hundreds of years.

In my opinion, a large experimental mesocosm facility needs to be set up with associated infrastructure that can be used to conduct simulate experiments and enable the exchange of tailings in water at depth and accumulations of metals over several lifetimes of short-lived aquatic species, including 10-20 years for turtle and crocodile via biopsy monitoring and biomarker techniques that do not result in mortality of the animal.

b) What, if any, are the environmental impacts likely to arise from overburden management as proposed? In providing my answer, please consider any risks arising from bioaccumulation of contaminants.

MRM monitors the potential risks posed to the health and safety of Project employees, contractors, visitors and the surrounding communities are similar to the existing approved operation and

consequently many of the potential risks are already known, understood and managed using well-established health and safety procedures are currently in place and these procedures will be applied to the Project with all necessary variations and adaptions. Where there are new potential health and safety hazards identified for the Project, MRM indicate they develop revised management and mitigation measures and integrate these into the existing HSEC management systems of the Project.

However, there does not appear to be routine exposure assessment to metals including cadmium and lead of the local population who consume aquatic foods taken from the McArthur River below MRM. Dust monitoring is performed offsite and may also be a source of lead and cadmium to local people. Consumption of foods with bioaccumulation of metals adds to the exposure they receive. Monitoring of metal levels in fish and other aquatic species from McArthur River is also performed by Northern Territory Department of Primary Industry and Resources (DPIR) as described (ERIAS 2016).

Local members of the community who live in the areas surrounding MRM eat aquatic foods such as fish and freshwater prawns as part of their diet. It is also possible that local people will eat certain long lived species such as turtles and crocodiles are more likely to bioaccumulate heavy metals, particularly lead and cadmium. Zinc is at higher concentration than cadmium but is much less toxic to humans.

The approach used for estimating the diet exposure of human beings is to compare accumulated metal levels in fish and other aquatic foods and are compared with the FSANZ (2009) food guidelines; i.e. there is no direct monitoring of the exposure of the local population for heavy metal intake.

The food guideline approach for assessing ‘health risk’ from local aquatic food consumption equates with the ‘Hazard Assessment’ step of the Australian health risk assessment framework (enHealth 2012). In order to have a complete ‘Risk Characterisation’ of a population member it is necessary to undertake ‘Exposure assessment’ (enHealth 2012).

In my opinion, exposure monitoring of local people who consume fish and other aquatic foods should be undertaken for lead and cadmium, as they are likely to receive exposure to dusts from the MRM mine site activities.

c) Provide any further observations or opinions which I consider to be relevant in regards to rehabilitation and potential contamination risks.

The Independent Monitor is appointed by the NT DPIR to develop annual Environmental Performance Reports on the MRM site, with the latest report having been released (ERIAS 2016). The scope of these reports is to provide an independent monitoring assessment of the environmental performance of MRM and its regulation. As part of these reports, site-wide environmental risk assessments are developed, and are reviewed and updated on an annual basis.

The Independent Monitor (ERIAS 2016) comments on the investigation and assessment of potential impacts of bioaccumulation of heavy metals in McArthur River and tributaries (Hydrobiology 2016). This review assessed potential heavy metal contamination in aquatic foods dispersed from MRM, as well as determining background levels in the broader region based on existing data with a focus on potential effects on human health from consumption of affected aquatic species. Based on the data reviewed for heavy metals, including lead in fish and prawns, lead was at highest levels in fish caught within the mine site from the Barney Creek diversion channel, at and above the Barney Creek haul road bridge; the risk to human health posed by consumption of fish from the McArthur River system was considered to be low based on comparison with the FSANZ (2009) guidelines.

Comparison of the McArthur River results for bioaccumulation of heavy metals in fish and prawns with a similar study at Mount Isa along the Leichhardt River, it was also found that lead at satisfactory levels and was only bioaccumulated at concentrations exceeding the FSANZ (2009) guideline in the downstream river at and below the Mount Isa Mines operations (Noller et al. 2014).

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Annexure 2

Letter of the Environmental Defenders Office NT, dated 24 April 2017

ENVIRONMENTAL DEFENDERS OFFICE NT

7 Searcy Street, Darwin, NT
GPO Box 4289 Darwin NT 0801
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24 April 2017

Dr Barry Noller
Principal Research Fellow Centre for Mined Land Rehabilitation
Sustainable Minerals Institute
The University of Queensland

By email: b.noller@uq.edu.au

Dear Dr Noller

McArthur River Mine Overburden Management Project

The McArthur River Mine (**MRM**) is located approximately 45 km south-west of the township of Borroloola and 470 km south-east of Darwin, in the Gulf Region of the Northern Territory. MRM is the world's largest producer of zinc in bulk concentrate form and zinc concentrate. A draft Environmental Impact Statement (**EIS**) for MRM Overburden Management is available for public comment until **Wednesday 3 May 2017**. The key elements of the Project EIS are:

- the redesign of the overburden emplacement facilities (waste rock dumps) to manage overburden geochemistry;
- repositioning and reduction of footprint of overburden emplacement facilities;
- removal and re-processing of tailings waste and placement within the open cut void on cessation of processing, and rehabilitation of the former Tailings Storage Facility area;
- a revised open cut final void closure strategy; and
- monitoring and management plans for the ongoing protection of the downstream environment.

Environmental Defenders Office NT (**EDO NT**) will be preparing a submission to the EIS on behalf of community members who live in close proximity to the mine and to the McArthur River. We request your expert advice to help inform this submission.

Primary purpose to provide independent expert advice

To assist in providing advice to our clients, and in helping prepare their submissions on the EIS, we are briefing you to prepare independent expert advice in relation to the any potential contamination issues arising from the proposed Project. We do not ask you to be an advocate for our client. You are requested to prepare an independent report that is clear and well-written.

In this respect, we draw your attention to NT Supreme Court Practice Direction for Expert Reports and the Expert Witness Code of Conduct (**Code of Conduct**)[1]. We are of the view that the same Code of Conduct should be adhered to in this instance. Clause 2 of the Code of Conduct states that:

> *(1) A person engaged as an expert witness has an overriding duty to assist the Court impartially on matters relevant to the area of expertise of the witness.*
>
> *(2) An expert witness is not an advocate for a party.*

[1] Available at: http://www.supremecourt.nt.gov.au/documents/practice_directions/4_of_2009_Expert_Reports.pdf

Your expert report will be used as evidence in chief of your professional opinion. In providing your opinion you must set out all the assumptions upon which the opinion is based. This may include, for example, facts observed as a result of field or lab work or 'assumed' facts based on a body of scientific opinion. If the latter, you should provide references which demonstrate the existence of that body of opinion.

Your expert report must also set out the process of reasoning which you have undertaken in order to arrive at your conclusions. It is insufficient for an expert report to simply state your opinion or conclusion reached without an explanation as to how this was arrived at. The purpose of providing such assumptions and reasoning is to enable decision makers to make an assessment as to the soundness of your opinion.

Overview of work requested

We request that you undertake the following work:

a) review the documents listed below; and
b) prepare a written expert report that addresses the issues identified below ('issues to address in your expert report'), and ensure that the work is prepared in accordance with the Code of Conduct.

The documents

Full project documentation is available at: https://ntepa.nt.gov.au/environmental-assessments/register/mcarthur-river-mine-overburden.

We particularly refer you to *Appendix B Terms of Reference Cross Reference Table* available at: https://ntepa.nt.gov.au/__data/assets/pdf_file/0004/407380/mrm_overburden_draft_eis_appendix B_final_EIS_ToR_cross_reference_table.pdf. This document includes a comprehensive description of where in the EIS relevant issues are discussed.

Please let us know as soon as possible if you require further information for the purpose of giving your expert opinion.

Issues to address in your expert report

We ask that your report address the following issues:

a) In your opinion, is the assessment of environmental impacts arising from overburden management appropriate and have any potential contaminants been appropriately characterised?
b) What, if any, are the environmental impacts likely to arise from overburden management as proposed? In providing your answer, please consider any risks arising from bioaccumulation of contaminants.
c) Provide any further observations or opinions which you consider to be relevant in regards to rehabilitation and potential contamination risks.

Key dates

The EDONT has received an extension to provide submissions to the draft EIS on behalf of its clients. The EDONT's clients' submissions are due on 17 May 2017. To ensure your advice is available to our client and interested community members in sufficient time to complete their own submission, we would appreciate receiving your advice by Thursday 4 May 2017.

Duty of confidentiality

Please treat your work as strictly confidential until your expert report is submitted, unless authorised by us.

Fees and Terms

Thank you for agreeing to provide your advice in this matter for a capped fee of $2,000 + GST. EDO NT and our clients rely on experts such as you to assist in matters such as this with very little or no financial compensation.

Please note the following terms:

a) your work will only be used by EDO NT to assist our client respond to the draft EIS (We note it is likely that your report will be provided to the Northern Territory Environment Protection Authority as an attachment to our clients' submission;
b) EDO NT will take all reasonable steps to prevent your work being used for purposes other than that mentioned above, but we accept no responsibility for the actions of third parties;
c) regardless of the above points, EDO NT may choose not to use your work; and
d) you will not be covered by the EDO NT insurance while undertaking the above tasks.

If you would like to discuss this brief further, please contact the EDO NSW Scientific Director, Megan Kessler on (02) 9262 6989 or email megan.kessler@edonsw.org.au.

We are grateful for your assistance in this matter.

Kind regards

Environmental Defenders Office (NT) Inc

David Morris
Principal Lawyer

McArthur River Mine Overburden Management Project

Expert opinion

Report for Environment Defenders Office

April 2017

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Version: Version 1, 28 April 2017
Citation:

contents

1. Purpose of this report

The following is a concise report on a short, desktop review undertaken by Dr Geoff Vietz, Director of Streamology. The review is undertaken on the request of David Morris, Principal Lawyer, Environment Defenders Office.

2. Capability to provide expert opinion

I have 20 years of experience in waterway science and management as a consultant and academic. I am a qualified Fluvial Geomorphologist (soil and water interactions) and an experienced Ecohydraulic modeller (computational simulation of water movement in natural environments). I am currently the Principal Scientist and Director of Streamology, a consulting company focused on waterway management, and a Senior Research Fellow with the University of Melbourne.

The opinion is provided impartially, focused on the field of interest outlined above, namely waterway geomorphology and hydraulics. The fields of groundwater hydrology, water quality and geotechnical assessment are not my core expertise and I therefore cannot provide substantial comment on these.

I am not advocating for any parties. I am aware of the requirements of the practice code for expert reports (2009).

3. Documents reviewed

The documents reviewed are as specified in the EDO letter from David Morris to Geoff Vietz dated 18 April 2017, and provided by email from Megan Kessler on 27 April 2017. The review of documents is not exhaustive and was targeted to sections considered relevant to my area of expertise.

Consideration of the impacts is reliant on a purely desktop review and without a field-based understanding of the site requires considerable interpretation and inference.

4. Questions addressed

The following questions were provided by the EDO for my targeted review.

4.1. Will the proposed rehabilitation outcomes, specifically the long-term surface water management and associated geomorphology, ensure a safe and stable environment?

The report provides a thorough investigation of the hydrology and hydraulics of the proposal. Fluvial geomorphology is less thorough. My response to this includes the following.

a) The greatest concern with the proposal is passing flow through the mine pit lake that contains potential acid sulfate soils. I therefore recommend a limnological expert consider this component.

b) To avoid any risks associated with passing flow through the mine pit lake an obvious alternative is to not connect the mine pit lake and adequately size the diversion channel.

c) The redirection of the McArthur River through the mine tailings could impact on bedload sediment transport conveyance from the McArthur River upstream of the mine pit lake to downstream of the mine pit lake. All but the finest of sediments will be trapped within the mine pit lake. The impacts of reducing bedload sediment transported (in this case sands and gravels) through the river system include increasing clearwater erosion downstream of the mine pit lake. Clearwater erosion is

where the flowing water preferentially increases erosion of the channel due to a lack of sediments to transport i.e. the river has more energy to do work on eroding the channel. This may also reduce channel diversity (for habitat). It appears the effects of bedload sediment transport and the effects on the downstream River reaches has not been investigated (only suspended sediments, Section 8.6.2). If the McArthur River channel remains open for the duration then the impact will be minimised.

d) Diverting flow to the lake mine pit is likely to lead to deposition of sediments, and aggradation, in the upper reaches of the diversion channel, i.e. large flows that would otherwise mobilise this sediment will be diverted into the mine pit lake. This relates to the performance indicator for 'no erosion or deposition of sediment within the surface water courses beyond natural fluctuations' (Chapter 15).

e) There is a risk that once completely open the channel passing through the mine pit lake could capture the entirety of flow from the McArthur River. This would lead to considerable erosion and reduce flow and sediment through the diversion channel. This depends on the bed level grades and interfaces, all of which are not evident in the reporting.

f) The monitoring period for water quality in mine pit lake will be critical in the period prior to connecting the McArthur River to the mine pit lake and immediately after opening the downstream, then upstream end to the main channel.

4.2. Are the predictions of long-term surface water behaviour (and the associated management of on-site contaminants) appropriate? Please provide reasons for your answer.

a) Validation of hydrologic and hydraulic models appears to be thorough and robust (Appendix U). This is important considering the surface water hydraulic model is developed on a coarse grid (10m grid, when considering small tributaries). The hydraulic model uses relatively conservative values (such as roughness) so would be expected to, if anything, overestimate flood levels and as such provides a reliable prediction of flood levels with a reasonable factor of safety.

b) The influence of floodwaters on tailings storage on the floodplain have been assessed to be adequate for a 1 in 1000-year Annual Recurrence Interval flood event with freeboard. The long-term topography of the mine site appears to have been designed to these levels and this should result in no significant inundation and concerns as reported.

4.3. Does the proposed rehabilitation as it relates to surface water management and geomorphology, adequately consider future climate change impacts?

The methodology used is based on the well-regarded CSIRO and BOM approach. The sensitivity analysis approach adopted is a valid approach to understanding the influence of climate change under a range of agreed levels of change. Modelling highlights the significant increase in flows and flood levels through the site under climate change.

Climate change is also likely to increase sediment loads (namely suspended sediment). This is due to numerous factors including reductions in vegetation and increases in rainfall. This is not considered but also may not necessarily have a significant influence on the success of the proposed option.

4.4. Further observations or opinions considered relevant in regards to surface water management and geomorphology

Monitoring of surface water levels is undertaken throughout the life of the project. These channels will change and the rating curves used to relate water level (as monitored) to discharge. The revision of rating curves is an ongoing task if reliable data on discharge is to be captured. This task was not evident in the monitoring program.

5. Declaration

There were no further enquiries required in the preparation of this report and no matters of significance have been withheld.

Dr Geoff Vietz
Director, Streamology

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A limnological assessment of McArthur River Mine Overburden Management Project Environmental Impact Statement

May 9th 2017

To whom it may concern,

I have reviewed the full EIS particularly focusing on the limnological aspects as that is my area of expertise and herewith have highlighted those aspects that raise concern as to the future health of the McArthur River ecosystem.

The issue that raises the most concern for me is "subject to water monitoring, McArthur River Mining ultimately plan to open the upstream and downstream sections of the mine levee wall to enable water to flow through the original path of the McArthur River." The purpose of the movement of the tailings into the open cut void for permanent underwater storage is to mitigate the generation of biologically harmful drainage occurring from the tailings. The key in that statement is permanent underwater storage. If the river is allowed to be restored along its original path that has a high potential to move the tailings from storage into downstream parts of the river and possibly riparian zones and thus no longer mitigating the generation of harmful drainage. As well biota will then be able to enter the pit lake and potentially get trapped there. This may negatively affect movements of migratory species particularly threatened ones such as *Pristis pristis*. Finally, the inclusion of a deep pit lake into the channel of the McArthur River adds in a habitat not typical in the previous river ecosystem which could have some unanticipated negative impacts to the overall health of the ecosystem.

In the Final Void Limnology Assessment Report discussion section the authors describe how the pit lake will change once the river is rerouted "In contrast when the river flows begin, the epilimnion is readily flushed by the river waters as shown in the last panel (Water Age) of Figure 6. Looking closely at the sediment release tracer in the epilimnion it is notable that whilst there is a gradual increase in concentration over time (caused by constant but low level release and mixing and being about one order of magnitude less in concentration compared to the hypolimnion) there are also periods of more intense mixing that bring the sediment release material into the surface waters." Their statements highlight concern about restoring the river along its original path as maintaining the stratification of the water column in the pit lake is important in continuing to mitigate the tailings and here they state that the river flows may at times cause 'periods of more intense mixing'.

In the Aquatic Ecology Impact Assessment Report the authors discuss how the McArthur River diversion channel is being used by biota including *Pristis pristis* and how biodiversity levels of most vertebrate species are similar there to reference sites. They also mention how more work needs to be done to rehabilitate the diversion channel and riparian areas to greater benefit for macroinvertebrates as biodiversity in edge habitats are not similar to reference sites. They also highlight many areas of concern (e.g. adverse effects to migratory species, inclusion of a very different habitat type to the river channel (pit lake)) regarding re-establishing the original path of the river through the pit lake and a very large number of mitigation options to counter the potentially numerous negative impacts of including the pit lake into the river system.

After review of the EIS and in particular the two reports mentioned above if the diversion channel continues to be rehabilitated and monitored showing continued use by migratory species and biodiversity levels similar to reference sites then leaving the diversion of the river in place permanently is safer to the future health of the whole McArthur River ecosystem than re-establishing the original path. The possible negative consequences to the McArthur River food web and those that rely on the food web by re-establishing the original path through the pit lake could be catastrophic and long-lasting such as the potential local extinction of an already threatened species *Pristis pristis.*

Please don’t hesitate to contact me if I can be of any further assistance.

Sincerely,

Dr. Erica Garcia