

Final Report

McArthur River Mine

North Overburden Emplacement Facility – Independent Expert Panel Report

Prepared for: *Department of Lands, Planning and Environment, Northern Territory
Government; and McArthur River Mining Pty Ltd*



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Executive Summary

ES1 Introduction

McArthur River Mine is an open pit zinc, lead and silver mining operation in the Northern Territory (NT), located approximately 700 kilometres (km) southeast of Darwin, and approximately 45 km southwest of the township of Borroloola. McArthur River Mining Pty Ltd (MRM) is the authorised operator of McArthur River Mine, and is a wholly owned subsidiary of Glencore Plc.

The North Overburden Emplacement Facility (NOEF) at McArthur River Mine is the main waste rock dump on the site and represents a potential geochemical hazard. Effective risk management requires a comprehensive understanding of the geochemical composition / characteristics, as well as the physical (geotechnical and hydraulic) characteristics of the overburden (waste rock) material to ensure that management systems effectively minimise, if not eliminate, aspects contributing to the risk. The overall environmental objective against which the performance of the NOEF is measured is the protection of the health of the McArthur River along its entire length from impacts related to licenced mining activities.

On 1 July 2024, regulation of mining in the NT became subject to the *Environment Protection Act 2019* (EP Act) administered by the Department of Lands, Planning and Environment (DLPE). Effective 1 July 2024, operations at McArthur River Mine became subject to the conditions of deemed environmental mining licence DML0059-01 (the licence) (NT DLPE, 2024). In accordance with section 304 of the EP Act, licence DML0059-01 comprises the approved Mining Authorisation and Mining Management Plan (MMP) (MRM, 2024a). Other regulatory approvals of relevance to the operation of McArthur River Mine have been issued under the NT *Water Act 1992* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (then DAWE (now DCCEEW, 2022).

The MRM MMP (MRM, 2024a) outlines key controls to manage identified risks associated with the NOEF:

1. Management of Acid and Metalliferous Drainage (AMD) seepage during construction and operations.
2. Management of airflow to control the resupply of oxygen and reduce the likelihood of reaction with overburden.
3. Management of long-term seepage using a specifically designed cover system that includes a low permeability layer to control long term net percolation of water into the NOEF.

ES2 NOEF Independent Panel of Experts

Under the licence an Independent Panel of Experts must be set up for the NOEF (NOEF Panel) and coordinated through an Independent Chairperson. The NOEF Panel focusses on providing external and transparent oversight and reporting to advise the NT Minister for Lands Planning and Environment (hereafter 'the Minister') on the NOEF performance. The overall purpose of the NOEF Panel is to provide the Minister with robust, independent technical advice regarding the effectiveness of NOEF management to achieve secure storage of waste rock so as to protect the health of the McArthur River from mine related impacts.

Following public calls for expressions of interest from suitably qualified and recognised technical experts, the Minister appointed Dr. Alan Robertson as the independent chairperson for the NOEF and TSF panels. The Minister subsequently advised MRM to directly engage and commission the ministerially appointed Independent Chairperson and Panel members consistent with the conditions of the licence.

The Independent Chairperson and NOEF Panel members were selected and appointment based on their internationally recognised expertise and experience in their respective fields:

- Dr. Alan Robertson – Chairperson with expertise in mine waste and water geochemistry;
- Dr. David Jones – AMD and water quality data assessment;
- Chris Dickinson – Hydrogeological and groundwater quality assessment; and
- Mike O’Kane – Geotechnical aspects of overburden landform construction and management.

The NOEF Panel members bring a diversity of skills, experience and views from a range of scientific backgrounds of relevance to achieve delivery of the scope of works.

ES3 Scope of Work and Methodology

The NOEF Panel has completed an independent technical review of the effectiveness of NOEF management by MRM to achieve secure storage of overburden (waste rock) and protect the health of the McArthur River from mine related impacts.

The methodology used by the NOEF Panel to complete the technical review was as follows:

1. Review general documentation such as the licence, relevant sections of NT EPA Assessment Report 86 (NT EPA, 2018), and MRM’s Mining Management Plan (MMP) (MRM, 2024a) (including those documents and data referenced in **Section 6**).
2. Undertake a site visit from 14 to 16 April 2025 to assist with familiarisation with the site, and, in particular, the NOEF and potential downstream receptors.
3. Review documentation specific to aspects for review, such as the MMP (MRM, 2024a), relevant chapters of the Overburden Management Plan – Environmental Impact Statement (OMP EIS) (MRM, 2017), Unplanned Closure Plan (MRM, 2024b), and technical construction guidance (NOEF Management and Construction Guidelines 2020).
4. Review construction / engineering reports and guidance materials and consider against approved construction methodology.
5. Review results from monitoring programs such as NOEF temperatures, surface water and groundwater quality data; and compare against environmental outcomes predicted in environmental impact assessments (e.g. the OMP EIS) (MRM, 2017).
6. Review cover system trial results and consider against predicted environmental outcomes.
7. In consideration of the above, develop consensus conclusion as to whether the construction and management of the NOEF is achieving the overarching environmental outcome – the protection of the health of the McArthur River.

The NOEF Panel review has been structured to broadly address the requirements of DLPE (2022) as described and updated in the RGS Scoping Document submitted to DLPE and MRM (RGS, 2025).

ES4 Benchmarking NOEF Performance against Assessment Criteria

The technical review work has been completed to allow benchmarking of NOEF performance against the assessment criteria detailed in **Section 3.4** of this report. The benchmarks used by the Panel to evaluate the level of assessment criteria met by MRM are provided in **Table ES1**.

Table ES1: Benchmarks used to evaluate level of NOEF Assessment Criteria met by MRM

Level of Assessment Criteria Met	Definition
	The assessment criterion is generally not met
	The assessment criterion is in early stages of being met
	The assessment criterion is met most of the time
	The assessment criterion is met almost all of the time
	The assessment criterion is consistently met in full

A summary of the performance of the NOEF against the assessment criteria is provided in **Table ES2** and a detailed explanation of the matters considered by the NOEF Panel to arrive at these findings is in **Section 4**.

The NOEF Panel believes that the post-2016 design of the NOEF is consistent with the design assessed and approved by the Minister. The post-2016 NOEF design and construction to date exceeds current best practice in the mining industry and can be considered world leading practice for ground up source control.

The post-2016 design of the NOEF is suited to the particular circumstances of the site and operations with particular regard to the geochemical and physical characteristics of the materials, climatic conditions and the need to protect the receiving environment including protection of the health of the McArthur River.

Table ES2: MRM performance against NOEF Assessment Criteria

#	Assessment Criteria	Finding
1	Is the design of the NOEF consistent with the design assessed and approved by the Independent Certifying Engineer ?	
2	Has the design of the NOEF been developed in consideration of current best practice in the mining industry?	
3	Is the design of the NOEF suited to the particular circumstances of the site and operations?	
4	Is construction of the NOEF proceeding in accordance with the approved design?	
5	Are the environmental outcomes as indicated by monitoring in line with predictions and expectations?	
6	Are there any significant issues affecting environmental performance and progress to achieving closure objectives and land use commitments?	
7	Does the overarching environmental outcome of protecting the health of the McArthur River from mining related impacts attributable to the NOEF continue to be met?	

ES4 Conclusions

The NOEF Panel has completed an independent technical review of the effectiveness of NOEF management by MRM to achieve secure storage of overburden (waste rock) and protect the health of the McArthur River from mine related impacts. Overall, the NOEF Panel considers that potential risk of the NOEF to the surrounding environment is being managed to an acceptable level and the health of the McArthur River is being protected from mining related impacts from the NOEF.

The technical review work program has been completed to allow benchmarking against the NOEF assessment criteria detailed in **Section 4** of this report. The benchmarks used by the Panel to evaluate the level to which assessment criteria have been met by MRM are also provided in **Section 4**.

The NOEF Panel has found that:

- The post-2016 construction of the NOEF is consistent with the design intent and is consistent with the design assessed and approved by the Minister. The post-2016 NOEF construction to date exceeds current best practice in the mining industry and can be considered world leading practice for ground up source control.
- The post-2016 design of the NOEF is suited to the particular circumstances of the site and operations, with particular regard to the geochemical and physical characteristics of the materials, climatic conditions and the need to protect the receiving environment including protection of the health of the McArthur River.
- The post-2016 construction of the NOEF is proceeding in accordance with the approved design intent. Remediation measures at the pre-2016 parts of the NOEF indicate improved performance (e.g. reduced internal NOEF temperature). However, the greater than 80 m design height for the NOEF cannot be achieved until cultural approvals are in place and this may have implications for the long-term NOEF performance at the pre-2016 areas which currently cannot be closed out. The pre-2016 construction followed the old design with no compacted clay base nor drainage layer. The final cover system has not been built, with the uncovered surface of the dump continuing to ‘wet up’ because there is no cover material above the core of the legacy part of the NOEF.
- The post-2016 NOEF construction and previous modelling indicates that the environmental outcomes as indicated by monitoring are expected to be in line with predictions and expectations. However, there is currently insufficient internal NOEF monitoring data associated with parameters such as gas, temperature, and water dynamics to predict if that will continue into the future or not.
- The previous modelling (KCB, 2017) of the NOEF for the OMP-EIS (MRM, 2017), did not model NOEF construction on a year-by-year basis. The schedule and location of overburden material placement is not as per plan in the pre-2016 areas due to delays in cultural approvals and therefore plan execution. It is

therefore not possible to evaluate if environmental outcomes as indicated by monitoring are in line with prediction and expectations because the NOEF construction design sequencing as actually executed was not modelled. Notwithstanding, surface water quality monitoring data from 2023 to 2024 at SW11 indicates that water quality target parameters are met almost all of the time.

- The monitoring network (external to the NOEF) is mature and well distributed, and the site applies a range of visualization and interpretation tools allowing for both continued improvement in the conceptual understanding of the site, and for analysis of exceedance of water qualities (and differentiation of source) which may occur.
- It is important to acknowledge that any exceedance of water quality which might occur at WDL compliance location SW11 would trigger analysis to identify the causes of unacceptable water quality and would be the collective outcome of all flows reaching that location (including those of the Glyde River), and the various potential mine sources of impact. For this reason, the conceptualisation, monitoring network and predictive modelling tools must be capable of understanding this broader issue and must also allow differentiation between potential source of impacts that may be observed.
- The post-2016 NOEF construction and previous modelling suggest that the environmental outcomes, as indicated by monitoring, are expected to be in line with predictions and expectations. However, there is currently insufficient internal NOEF monitoring data associated with parameters such as gas, temperature, and water dynamics to predict if that will continue into the future or not.
- The tri-modelling approach applied to predicting the environmental performance of the NOEF and the manner of integration of predictions with monitoring observations is leading practice (KCB, 2017). The geochemical, phase, temperature, and saturation profiles of the NOEF are far too complex to integrate directly with a regional flow simulator. In addition, the flow simulator at the site must be capable of informing MRM of net impacts from a range of mining infrastructure, not limited to the NOEF. The tools applied and level of complexity is fit-for-purpose and periodic updates to these simulation tools will continue to assist in design and construction verification.
- Previous modelling of the NOEF for the OMP-EIS (MRM, 2017) did not model NOEF construction on a year-by-year basis. In the pre-2016 areas, the schedule and location of overburden material placement has deviated from the original plan due to delays in cultural approvals for the NOEF design height and therefore plan execution. It is therefore not possible to evaluate if environmental outcomes as indicated by monitoring are in line with prediction and expectations because, the NOEF construction design sequencing actually executed was not modelled. Notwithstanding, surface water quality monitoring data from 2023 to 2024 at SW11 indicate that water quality target parameters are met almost all of the time. In addition, data may exist to support a more detailed review of construction modifications with the intent to improve seepage management for the facility.
- Key environmental risks to air quality related to the NOEF are associated with dust (particulate matter) and sulfur dioxide (SO₂) emissions, however 2023-2024 monitoring data indicates that the risk of impacts from NOEF operations on air quality with respect to community health and the environment remains low.
- The biggest single issue that has the potential to affect environmental performance at the NOEF is the change to the NOEF construction design sequencing at the pre-2016 areas where the schedule and location of overburden material placement is not as per the construction schedule. This is mainly attributable to delays in cultural approvals for the greater than 80 m NOEF height and hence plan execution. Substantial work has been completed by MRM to restrict rainfall ingress and oxygen inflow into PAF materials by covering the pre-2016 areas with benign material. Additionally, a bituminous geomembrane (BGM) has been in place for three years over some areas. However, this part of the NOEF has still not been completed according to the original plan. If the cultural approvals for the NOEF height were in place the planned design could be executed therefore minimising the potential for future negative effects on the environmental performance of the NOEF.

ES5 Knowledge Gaps for Rehabilitation

There are a number of NOEF rehabilitation-related knowledge gaps:

- The current NOEF 80 m height restriction prevents the NOEF design based on greater than 80 m being implemented, noting that the Panel's review conclusions are substantively based on the implementation of the full NOEF design height;

- The performance of the placed BGM barrier layer material after extended exposure to NT climatic conditions on the batter slopes of the pre-2016 NOEF combined with elevated internal NOEF temperature conditions. It is acknowledged that MRM is working with leading researchers to optimise the use of BGM and the conditions under which it is placed at the NOEF; and
- MRM is currently not making use of (“mining”) all of the relevant available surface water, seepage, groundwater and other relevant data as input for ongoing predictive modelling.

ES6 Opportunities for Improvement

The main opportunities for improvement at the MRM NOEF are associated with:

- Completion of the targeted research program into the characteristics of the BGM liner with respect to the field conditions under which it is applied at the NOEF.
- Ensuring that the QC / QA associated with the BGM storage and handling, and seam joining process is optimised as part of the next stage of implementation of the BGM cover concept.
- Obtaining cultural approvals for the greater than 80 m NOEF height and consequently plan execution.
- Until such time as cultural approvals for the greater than 80 m NOEF height are in place and the pre-2016 parts of the NOEF can be completed to the “as-designed” height, it may be prudent to consider covering the BGM with a layer of appropriate non-acid forming (NAF) overburden material.
- Completion of the cover system (the material over the top of the BGM, on the pre-2016 NOEF areas) as soon as cultural approvals for this action associated with the NOEF height are in place.
- Interpretation of the complete surface, seepage and groundwater monitoring data sets coupled to other relevant information to essentially “mine that data” to develop an updated model that provides:
 - (i) Higher confidence conceptualisation / understanding of the NOEF, which translates to
 - (ii) Improved predictive modelling capability and reduced non-uniqueness in derived solutions.

With more comprehensive data sets, it may also be of value to conduct area specific evaluations to determine the degree of improvement which may have occurred from improvements in design and construction practices. The HDPE lining of SPROD is a good example of this.

- Improving the current knowledge base regarding the likely performance of the planned final NOEF cover system by developing and monitoring cover system trials against predicted environmental outcomes.

The NOEF Panel, in consultation with MRM and the DLPE, considers that there are no other specific matters relating to the NOEF currently requiring attention.

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1 Introduction

McArthur River Mine is an open pit zinc, lead and silver mining operation located in the wet/dry tropics of Northern Australia in the Northern Territory (NT), approximately 700 kilometres (km) southeast of Darwin, and approximately 45 km southwest of the township of Borroloola. McArthur River Mining Pty Ltd (MRM) is the authorised operator of McArthur River Mine, and is a wholly owned subsidiary of Glencore Plc.

The mining and mineral processing operations at McArthur River Mine include the open cut pit, North Overburden Emplacement Facility (NOEF), Concentrator and Tailings Storage Facility (TSF), which are located to the northwest of the McArthur River as illustrated in **Figure 1-1** (Marianelli et al., 2025).



Figure 1-1: McArthur River Mine site setting and layout

The NOEF is the main waste rock dump on the site and represents a potential geochemical hazard. Over the life of mine (until 2048), approximately 800 million tonnes (Mt) of overburden will be placed over an area of 775 hectares (ha) at the NOEF and will contain some pyritised dolomitic shales with an elevated sulfide content.

Effective risk management of this geochemical hazard requires a comprehensive understanding of the geochemical composition / characteristics, as well as the physical (geotechnical and hydraulic) characteristics of the overburden (waste rock) material to ensure that management systems effectively minimise, if not eliminate, aspects contributing to the risk (NT Department of Lands, Planning and Environment [NT DLPE], 2022) (**Attachment A**). The overall environmental objective against which the performance of the NOEF is measured is the protection of the health of the McArthur River, along its entire length, from impacts related to licenced mining activities (NT EPA, 2018).

MRM commenced operating as an underground mine from 1994 to 2005 following the original Environmental Impact Statement (EIS) in 1992. The mine progressed from an underground to an open pit facility from 2005 to 2013 following preparation of the 2005 open pit EIS and work completed during that time included diversion of the McArthur River. The open cut operation was expanded from 2013 to 2018 which resulted in the development of an Overburden Management Plan EIS (OMP-EIS) in 2018. The current phase of mining is planned to continue until 2048.

During the open cut expansion phase from 2013 to 2015 several spontaneous combustion incidents were experienced at the NOEF and an improved waste rock classification and management strategy and storage methodology was developed during that period and implemented in 2016 to better manage more reactive waste rock materials within the NOEF profile and control the potential for spontaneous going forward. Throughout this Independent NOEF Panel Review report there are references to pre-2016 and post-2016 waste rock management practices at the NOEF and the relevant areas of the NOEF where these management practices were applied.

In 2020, MRM submitted updated NOEF designs to the Minister for approval to achieve secure storage of overburden under the *Mining Management Act 2001* (MMA). The designs included reclassification of overburden under a robust 5-tier geochemical system, as well as material placement plans, that recognises the full spectrum of material with the potential to contribute to the generation of Acid and Metalliferous Drainage (AMD) (Marinelli et al, 2024). Figure 15 of the current approved MRM Mining Management Plan (MMP) (MRM, 2024a) provides information on the NOEF Concept Design and has been reproduced in **Figure 1-2**.

On 1 July 2024, the MMA was repealed and the regulation of mining in the NT became subject to the *Environment Protection Act 2019* (EP Act) administered by the NT DLPE. An overview of DLPE Governance in the NT is provided at **Attachment B**. Effective 1 July 2024, operations at McArthur River Mine became subject to the conditions of deemed environmental mining licence DML0059-01 (the licence) (NT DLPE, 2024). In accordance with section 304 of the EP Act, licence DML0059-01 comprises the Mining Authorisation and Mining Management Plan (MMP) under assessment on 30 June 2024 and approved on 23 July 2024 (MRM, 2024a). Other regulatory approvals of relevance to the operation of McArthur River Mine have been issued under the NT *Water Act 1992* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (then DAWE (now DCCEEW, 2022).

The MRM MMP outlines key controls to manage identified risks associated with the NOEF:

1. Management of AMD seepage during construction and operations.

Specific controls to manage and minimise seepage include:

- a) Progressive cover system placement and rehabilitation of the NOEF;
- b) Reducing air flow capacity by using compacted alluvium on Potentially Acid Forming (PAF) cells, shaped geometrically, and staged construction;
- c) Installing liners in dams and associated drains from the NOEF; and
- d) Installing a layer of compacted *in situ* clay or a constructed clay liner with a thickness of 0.5 m as a foundation during construction of new sections of the NOEF as well as an overlying drainage layer.

2. Management of airflow to reduce the likelihood of reaction with overburden.

Specific controls to manage air flow and potential overburden reaction include:

- a) Placement of overburden in specific lift height dependent on overburden classification to limit air flow, and placement of compacted alluvium as air flow barriers on inter-stage faces of the NOEF, with a halo layer comprising Non-Acid Forming (NAF) material providing a further barrier to air flow;
- b) Excavating, cooling, and rehandling actively combusting material;
- c) Reconfiguring berms and outer batter slopes of the NOEF to remove preferential air pathways and limit air transport into the overburden material; and
- d) Placement of a barrier on the batter and plateau of the NOEF to further reduce bulk air transport into the overburden material.

3. Management of long-term seepage using a specifically designed cover system that includes a low permeability layer to control long term net percolation of water into the NOEF.

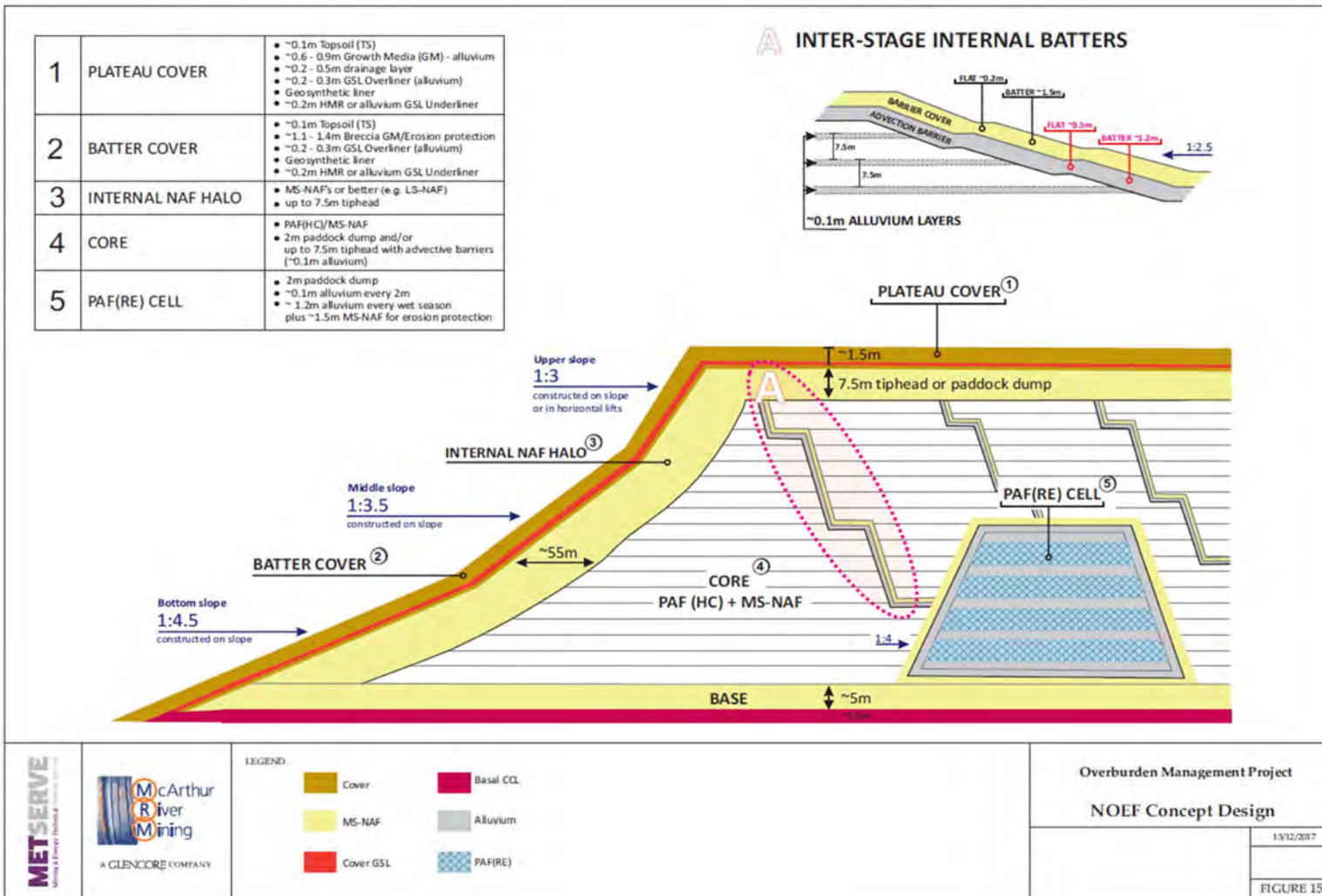


Figure 1-2: NOEF concept design

2 NOEF Independent Panel of Experts

Under the licence an Independent Panel of Experts must be set up for the NOEF (NOEF Panel) and coordinated through an Independent Chairperson. Other regulatory approvals of relevance to the operation of McArthur River Mine have been issued under the NT *Water Act 1992* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The NOEF Panel focusses on providing independent and transparent oversight and reporting to advise the Minister on the NOEF performance. The overall purpose of the NOEF Panel is to provide the NT Minister for Lands, Planning, and Environment (hereafter ‘the Minister’) with robust, independent technical advice regarding the effectiveness of NOEF management to achieve secure storage of overburden so as to protect the health of the McArthur River from mine related impacts.

Following public calls for expressions of interest from suitably qualified and recognised technical experts, the Minister appointed Dr. Alan Robertson as the Independent Chairperson for the NOEF Panel. The Minister subsequently advised MRM to directly engage and commission the ministerially appointed Independent Chairperson and Panel members consistent with the conditions of the licence.

The NOEF Chairperson worked with MRM and the NT DLPE to coordinate establishment of the NOEF Panel. The composition of the NOEF Panel has been approved by the Minister with the appointment of the following three recognised experts in their respective fields:

- Dr. David Jones – AMD and water quality data assessment;
- Chris Dickinson – Hydrogeological and groundwater quality assessment; and
- Mike O’Kane – Overburden landform construction and management.

The NOEF Panel Members were selected based on their technical expertise and experience to fulfill the specific requirements of NT DLPE (2022); including the requirement that “the members appointed will bring a diversity of skills, experience and views from a range of scientific backgrounds of relevance to achieve delivery of the scope. At a minimum the NOEF Panel will include hydrogeological, geotechnical, and water quality data assessment skills and expertise”.

The NT DLPE (2022) requires that the NOEF Chairperson and Panel members not undertake any contractual review or reporting regarding MRM operations during the interim period between each triennial review and reporting period. It is acknowledged that members of the NOEF Panel may engage with the project between reviews for the purpose of maintaining a contemporary understanding of matters of importance. Such interactions are recorded and provided to the NT DLPE consistent with the Communication Protocol in **Section 3.2**.

3 NOEF Technical Review Assessment Criteria and Methodology

3.1 Reporting Obligations and Process

The NOEF Panel is an independent advisory body, limited to providing technical assessment and advice regarding performance of the NOEF. The NOEF Panel is not a decision-making body or regulatory body and must submit a report to the Minister within 12 months of establishment; and subsequently, on a triennial basis from the date of the first report submission. The report must detail the review assessment criteria and methodology; and the Panel's conclusions regarding performance of the NOEF and its effectiveness in achieving the overarching environmental objective. This report has been prepared by the NOEF Panel to fulfill the detailed requirements.

As required by the NT DLPE (2022), the draft report was submitted to MRM and the DLPE for factual review on 1 December 2025, two months prior to final submission, and the advice received has been incorporated into the final report.

The NOEF Panel has had regular interactions with the Chairperson of the Mine Closure Panel (Mr Carl Grant) throughout 2025. The NOEF Panel Member, Mr Chris Dickinson, is also a member of the Mine Closure and TSF Panels and is focussing on hydrogeology and groundwater quality assessment. Dr David Jones is a member of both the NOEF and the TSF Panels and is focussing on AMD and surface water quality assessment. The NOEF panel intends to meet with other independent bodies (e.g. the Community Reference Group and Independent Monitor) and government agencies to discuss its findings, and it is understood that this will be arranged in consultation with the NT DLPE and MRM in 2026 in accordance with the Communication Protocol in **Table 3-1**.

The NT DLPE will provide a copy of the final report to other agencies, the Community Reference Group, and the Independent Monitor; and publish the report on the department's website¹.

The structure of the NOEF Panel and the Terms of Reference (TOR) will be reviewed by the Minister every six years from the date the TOR are finalised; or sooner if required.

3.2 Scope of Work

As Independent NOEF Chairperson, Dr. Robertson provided leadership to the NOEF Panel including:

- Working with MRM and NT DLPE representatives to identify and select potential nominees for the NOEF Panel.
- Seeking NT DLPE support for the NOEF Panel members and ensuring that any potential conflict of interest is notified / discussed prior to commissioning of Panel members by MRM.
- Convening and running meetings as required, including overseeing that appropriate meeting records (e.g. minutes) and correspondences are kept.
- Being the point of contact for the NOEF Panel members and advising on their specific roles and responsibilities.
- Developing the scope, content, assessment criteria and timeline for review (for approval by MRM and the NT DLPE).
- Overseeing the preparation and submission of the draft and final reports.
- Overseeing the receipt of feedback provided by MRM and the NT DLPE on the draft report and amendment of the report to the extent required to correct factual inaccuracies.
- Arranging information requests and discussions with MRM, the NT DLPE, and other relevant groups.

The NOEF Panel members identified in Section 2 completed a technical review of the performance of the NOEF. This report details the findings including:

¹ [McArthur River Mine independent expert panels | Department of Lands, Planning and Environment](#)

- The stability, surface condition, internal temperature, internal pore gas composition, reactions, seepage quantity, and characteristics of the NOEF to ensure that the overarching environmental outcome can be met;
- Surface runoff and seepage monitoring results, and in particular trends in the contaminant concentrations in groundwater and loads entering creeks and McArthur River; and
- Cover trial results, construction quality records, critical controls, stability assessments, cover performance, and performance of progressive rehabilitation of the NOEF.

Table 3-1 outlines the protocol for any communication that took place between MRM, the NOEF Panel, and other relevant bodies as amended from NT DLPE (2022). The intent of the Communication Protocol was to ensure that a transparent process was followed and the NOEF Panel can be seen to operate independently.

Table 3-1: NOEF panel communication protocol

Relevant Matter	Approved Communication Method	Other requirements
Request from Panel for reports and data from MRM	Chairperson to contact MRM directly via email	Copy to be sent to the NT DLPE
Provision of reports and data from MRM to Panel	RGS set up a SharePoint database and provided links for direct access by MRM, NT DLPE, Panel and Closure Chairperson	Copy of RGS SharePoint database link to be sent to the NT DLPE
Clarification / discussions	Direct discussion between Panel and MRM to address issues raised by Panel Direct discussion between Panel and the NT DLPE NT DLPE to facilitate discussion between Panel and other agencies, panels and the Independent Monitor (as required).	The NT DLPE to be informed of engagement where it related to report findings / conclusions
Provision of draft reports / findings by Panel	Chairperson to issue directly to MRM by 30 November 2025	Copy sent to the NT DLPE (and circulated by the NT DLPE to the Independent Monitor and Community Reference Group as appropriate)
Provision of comments on draft reports / findings by MRM and NT DLPE	MRM and NT DLPE to issue to Chairperson in December 2025	Copy of all comments sent to MRM and the NT DLPE
Provision of final report by Panel	Chairperson to issue to MRM and the DLPE by 31 January 2026	The NT DLPE to distribute report to NT DEPWS, Independent Monitor and Community Reference Group and publish the report on the NT Government's website
Panel site visits / other meetings	Chairperson to inform the NT DLPE of site visits / meetings and arranged with MRM directly	The NT DLPE to be offered opportunity to participate in site visits / meetings

Key aspects considered by the NOEF Panel members in their review of the performance of the NOEF against the objective of protecting the health of the McArthur River from mining related impacts are detailed in the following sections.

3.2.1 Construction and Engineering

Review of the NOEF Mining Management Plan (including the NOEF Management Plan at Appendix G) (MRM, 2024a) with respect to construction and engineering matters including:

- a) Structural and internal stability and surface condition by reference to approved designs and construction specifications for:
 - i. Foundations including basal compacted clay liner;
 - ii. Advective barriers (advection and diffusion);
 - iii. PAF reactive (RE) cell;
 - iv. Internal halo;
 - v. Covers;
 - vi. Independent Certifying Engineer (ICE) sign off records for hold points;
 - vii. Materials tracking and placement against the sulfur-block model;
 - viii. Compliance to plan with respect to the block model;
 - ix. Compliance to plan that material is placed in the correct location;
 - x. Compliance to plan with respect to daily, weekly, and monthly scheduling; and
 - xi. Materials mass balance consistency with construction schedule.
- b) Material identification and placement by reference to:
 - i. Approved overburden classification criteria;
 - ii. ICE signoff records for hold points; and
 - iii. Materials tracking and placement against the sulfur-block model.
- c) Risk management and control:
 - i. Adequacy of existing controls and requirements of the NOEF internal drainage system.
- d) Key conditions of licence (DML0059-01) (NT DLPE, 2024) specific to overburden management and NOEF construction (see **Attachment C** herein); and
- e) Key variation of approval conditions under the EPBC Act 1999 (then DAWE [now DCCEEW, 2022) specific to overburden management and NOEF construction (see **Attachment D** herein).

3.2.2 Performance

Review of the NOEF performance considering:

- a) Physical stability (structural and internal);
- b) Surface runoff and seepage monitoring results;
- c) Compliance to material plan scheduling for NOEF landform;
- d) Status of oxidation (through advective and diffusive processes) with respect to:
 - i. Advective barriers;
 - ii. Pore gas composition;
 - iii. Material placement lift heights;
 - iv. Internal temperatures;
 - v. Kinetic column testing;

- vi. Predictive modelling; and
- vii. Seepage quantities and quality (including performance of the NOEF internal drainage system).

3.2.3 Rehabilitation

Review of the cover system and related works considering:

- a) Rehabilitation trials and outcomes of liner testing;
- b) Rehabilitation trials and outcomes of constructability test pads (including outcomes of reactive PAF overburden trials 2018 to 2025); and
- c) Knowledge gaps and timelines to completion (including consideration of the appropriate duration of post-closure monitoring).

3.3 Assessment Methodology

The general steps undertaken by the NOEF Panel to complete the review were as follows:

1. Review general documentation such as the licence, relevant sections of NT EPA Assessment Report 86 (NT EPA, 2018), and MRM's Mining Management Plan (MMP) (MRM, 2024a) (including those documents and data referenced in **Section 6**).
2. Undertake a site visit from 14 to 16 April 2025 to assist with familiarisation with the site, and, in particular, the NOEF and potential downstream receptors.
3. Review documentation specific to aspects for review, such as the MMP (MRM, 2024a), relevant chapters of the Overburden Management Plan – Environmental Impact Statement (OMP EIS) (MRM, 2017), Unplanned Closure Plan (MRM, 2024b), and technical construction guidance (NOEF Management and Construction Guidelines 2020).
4. Review construction reports and consider against approved construction methodology.
5. Review monitoring program results, such as NOEF temperatures and groundwater quality monitoring, and consider against environmental outcomes predicted in environmental impact assessments (e.g. the OMP EIS (MRM, 2017).
6. Review relevant guidance materials and consider against approved / implemented construction methodology.
7. Review cover system trial results and consider against predicted environmental outcomes.
8. In consideration of the above, develop consensus conclusion as to whether the management of the NOEF is achieving the overarching environmental outcome – the protection of the health of the McArthur River.

3.4 Assessment Criteria

Where relevant, for each of the reviewed aspects, findings have been provided on whether:

1. The design of the NOEF is consistent with the design assessed and approved by the Minister;
2. The design of the NOEF has been developed in consideration of current best practice in the mining industry;
3. The design is suited to the particular circumstances of the site and operations;
4. Construction of the NOEF is proceeding in accordance with the approved design;
5. The environmental outcomes as indicated by monitoring are in line with predictions and expectations; and
6. There are significant issues affecting environmental performance and progress to achieving closure objectives and land use commitments; and
7. The overarching environmental outcome of protecting the health of the McArthur River from mining related impacts attributable to the NOEF continues to be met.

4 NOEF Technical Review

This section of the report focusses on the key aspects that have been considered by the NOEF Panel members in their technical review and include detailed information on:

- NOEF construction and engineering;
- NOEF performance; and
- NOEF rehabilitation.

The detailed information provided in this section facilitates an informed assessment of performance of the NOEF against the overall objective of protecting the health of the McArthur River along its entire length from impacts related to licenced mining activities (NT EPA, 2018).

The NOEF Panel review has been structured to broadly address the requirements of NT DLPE (2022) as described and updated in the RGS Scoping Document submitted to NT DLPE and MRM (RGS, 2025). It has also considered other potentially applicable NT, Australian, and international information related to managing sulfidic mine waste materials (COA, 2016; INAP, 2026; Team NT, 2004; NT EPA, 2013, 2019).

The technical review work has been completed to allow benchmarking against the NOEF assessment criteria previously described in **Section 3.4**. The benchmarks used by the Panel to evaluate the level of assessment criteria met by MRM are provided in **Table 4-1**.

Table 4-1: Benchmarks used to evaluate level of NOEF Assessment Criteria met by MRM

Level of Assessment Criteria Met	Definition
	The assessment criterion is generally not met
	The assessment criterion is in early stages of being met
	The assessment criterion is met most of the time
	The assessment criterion is met almost all of the time
	The assessment criterion is consistently met in full

A summary of the performance of the NOEF against the assessment criteria is provided in **Table 4-2** and a detailed explanation of the matters considered by the NOEF Panel to arrive at these findings is provided in the remainder of **Section 4**.

Table 4-2: MRM performance against NOEF Assessment Criteria

#	Assessment Criteria	Finding
1	Is the design of the NOEF consistent with the design assessed and approved by the Independent Certifying Engineer?	
	<p>The Panel believes that the post-2016 design of the NOEF is consistent with the design assessed and approved by the Minister based on:</p> <ul style="list-style-type: none"> • Material placement within the NOEF as per plan including design specifications such as material compaction, advection layers and controlled lift heights; • Lower permeability clay layer and associated drains underlying the NOEF; and • Cover system placement to date including bituminous geomembrane (BGM). <p>Whilst the pre-2016 parts of the NOEF were not constructed to the same design criteria, remediation measures such as the BGM have reduced internal NOEF temperatures and by extrapolation the exothermic oxidation / neutralisation reactions in this part of the NOEF.</p>	
2	Has the design of the NOEF been developed in consideration of current best practice in the mining industry?	
	<p>The panel considers that the post-2016 NOEF design and construction to date exceeds current best practice in the mining industry and can be considered world leading practice with respect to this type of ground up source control.</p>	

3	<p>Is the design of the NOEF suited to the particular circumstances of the site and operations?</p>	
	<p>The post-2016 design of the NOEF is suited to the particular circumstances of the site and operations, with particular regard to the geochemical and physical characteristics of the materials, climatic conditions and the need to protect the receiving environment including protection of the health of the McArthur River.</p>	
4	<p>Is construction of the NOEF proceeding in accordance with the approved design?</p>	
	<p>The post-2016 construction of the NOEF is proceeding in accordance with the approved design intent. Remediation measures at the pre-2016 parts of the NOEF indicate improved performance (e.g. reduced internal NOEF temperature). However, the greater than 80 m design height for the NOEF cannot be achieved until cultural approvals are in place and this may have implications for the long-term NOEF performance at the pre-2016 areas which currently cannot be closed out. The pre-2016 construction followed the old design with no compacted clay base nor drainage layer. The final cover system has not been built, with the uncovered surface of the dump continuing to 'wet up' because there is no cover material above the core of the legacy part of the NOEF.</p>	
5	<p>Are the environmental outcomes as indicated by monitoring in line with predictions and expectations?</p>	
	<p>The post-2016 NOEF construction and previous modelling indicates that the environmental outcomes as indicated by monitoring are expected to be in line with predictions and expectations. However, there is currently insufficient internal NOEF monitoring data associated with parameters such as gas, temperature, and water dynamics to predict if that will continue into the future. The previous modelling (KCB, 2017) of the NOEF, did not model NOEF construction on a year-by-year basis. The schedule and location of overburden material placement is not as per plan in the pre-2016 areas due to delays in cultural approvals and therefore plan execution. It is therefore not possible to evaluate if environmental outcomes as indicated by monitoring are in line with prediction and expectations because the NOEF construction design sequencing as actually executed was not modelled. Notwithstanding, surface water quality monitoring data from 2023-2024 at SW11 indicates that water quality target parameters are met almost all of the time. Key environmental risks to air quality related to the NOEF are associated with dust (particulate matter) and sulfur dioxide (SO₂) emissions, however 2023-2024 monitoring data indicates that the risk of impacts from NOEF operations on air quality with respect to community health and the environment remains low.</p>	
6	<p>Are there any significant issues affecting environmental performance and progress to achieving closure objectives and land use commitments?</p>	
	<p>The biggest single issue that has the potential to affect environmental performance or progress to achieving closure objectives and land use commitments at the NOEF is the changes to the NOEF construction design sequencing for the pre-2016 areas where the schedule and location of overburden material placement is not as per plan. This is mainly due to delays in cultural approvals for the greater than 80 m NOEF design height and plan execution. Substantial work has been completed by MRM to restrict rainfall ingress and oxygen inflow into PAF materials by covering the pre-2016 areas with benign material. Additionally, BGM has been in place for three years over some areas. However, this part of the NOEF has still not been completed according to the original plan. If the cultural approvals for the NOEF height were in place the planned design could be executed therefore minimising the potential for future negative effects on the environmental performance of the NOEF.</p>	
7	<p>Does the overarching environmental outcome of protecting the health of the McArthur River from mining related impacts attributable to the NOEF continue to be met?</p>	
	<p>Surface water quality monitoring data from 2023 to 2024 at SW11 indicates that water quality target parameters are met almost all of the time.</p>	

4.1 NOEF Construction and Engineering

The NOEF Panel has reviewed the NOEF MMP (MRM, 2024a) with respect to the following construction and engineering design described in **Section 3.2.1**. However, to fully appreciate the NOEF MMP, it is foundational to first understand the rationale for design and construction of the NOEF itself described in **Section 1** and illustrated in **Figure 1-2**.

Specifically:

1. Managing and reducing elevated temperatures within the pre-2016 NOEF;
2. Placement of lower field saturated hydraulic conductivity (k_{fs}) or lower permeability material (i.e. compacted clay material) with appropriate gradient as a layer at the base of the NOEF prior to placing any additional overburden;
3. Inclusion of sufficient lateral drainage capacity above the lower permeability layer under the NOEF to direct NOEF seepage to sump / drain / pump systems;
4. Placement of highly reactive overburden in lower lifts and / or with vertical and lateral layers to create cells, the lateral and vertical extent of which is dependent on the inherent reactivity of the overburden, all of which limits internal NOEF vertical and lateral airflow capacity as the NOEF is being constructed; and
5. Progressive placement of a 'final landform' cover system to limit net percolation, and oxygen ingress, into the NOEF.

Figure 4-1 (Peterson et al., 2003) illustrates the relationship between uncertainty and level of control. The 'upper left-hand quadrant' (ULHQ) represents high uncertainty and a low level of control; when in this quadrant, the tool for informing on decision making is 'Scenario Planning'. Scenario-based planning is a process, usually qualitative, that involves exploration of a wide set of alternative 'futures', such that the scenarios developed provide the opportunity to resolve 'conflict' in multiple and competing objectives.

In the context of the MRM NOEF, it might be the need to optimise ore recovery and construct the NOEF for the lowest cost possible, while creating and maintaining geomorphic, geotechnical, and geochemical stability, and eventually having the NOEF meet its post mining land use expectations. Hence, management responses to scenarios should consider the degree of uncertainty associated with drivers and their effects, the resources available, and legal mandates as well as social and economic consequences.

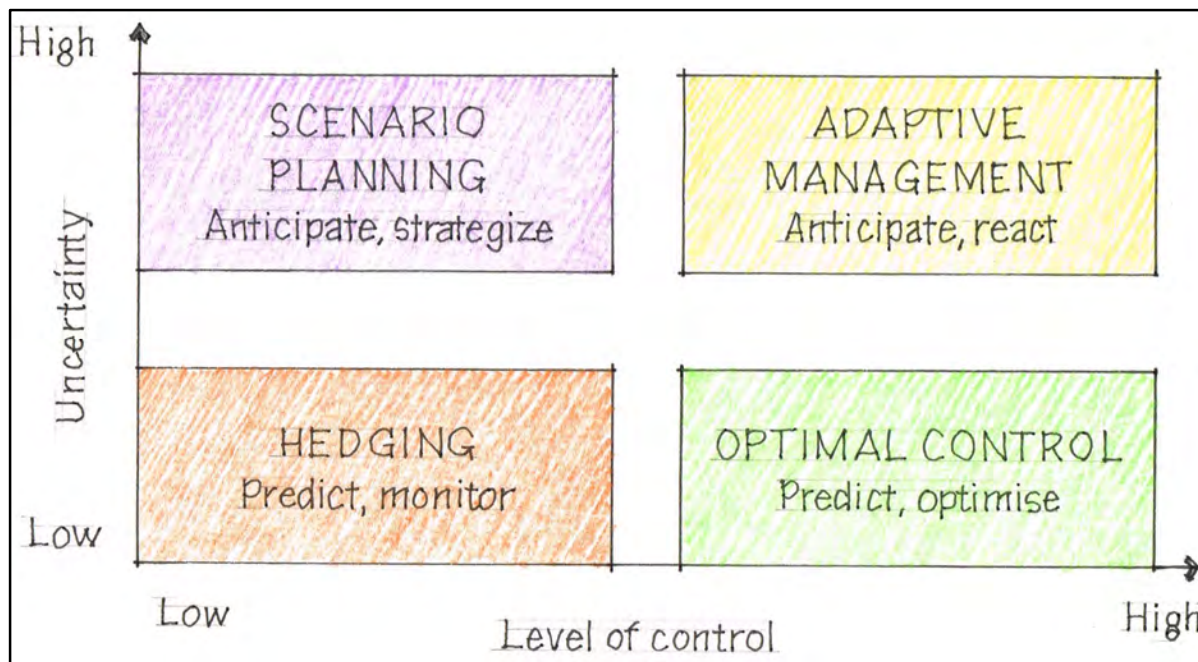


Figure 4-1: Uncertainty vs level of control (after Peterson et al., 2003)

The NOEF Panel consider that at the time MRM began ‘re-design’ of the NOEF as part of the environmental assessment process, whether explicitly stated or un-intended, MRM was in ‘Scenario Planning’ conditions. A high level of uncertainty existed in respect to managing AMD and spontaneous combustion hazards and environmental risks as a result of the presence and any expansion of the NOEF, and a low level of agreed upon controls were in place, or planned to be in place, for hazard and risk management.

Figure 4-2 (Marianelli et al., 2024; 2025) illustrates the status of the NOEF pre-2016 where the initial landform had been based on a binary NAF / PAF geochemical classification scheme where the potential for neutral metalliferous drainage (NMD) and Saline Drainage (SD) were not fully considered as potential environmental hazards; and the reactivity of the some of the PAF materials was underestimated. A high lift end dumping method was used with limited internal barriers to oxygen flow and net percolation of rainfall. This led to spontaneous combustion events at the NOEF in 2014 / 2015 (Beamish et al., 2018) and the development of an OMP-EIS specifically for the NOEF in 2016. The post-2016 NOEF conceptual design and overburden material classification and management practices were progressively improved and currently reflect those described in the approved MMP (MRM, 2024a) as previously summarised in **Section 1** and **Figure 1-2**, herein.

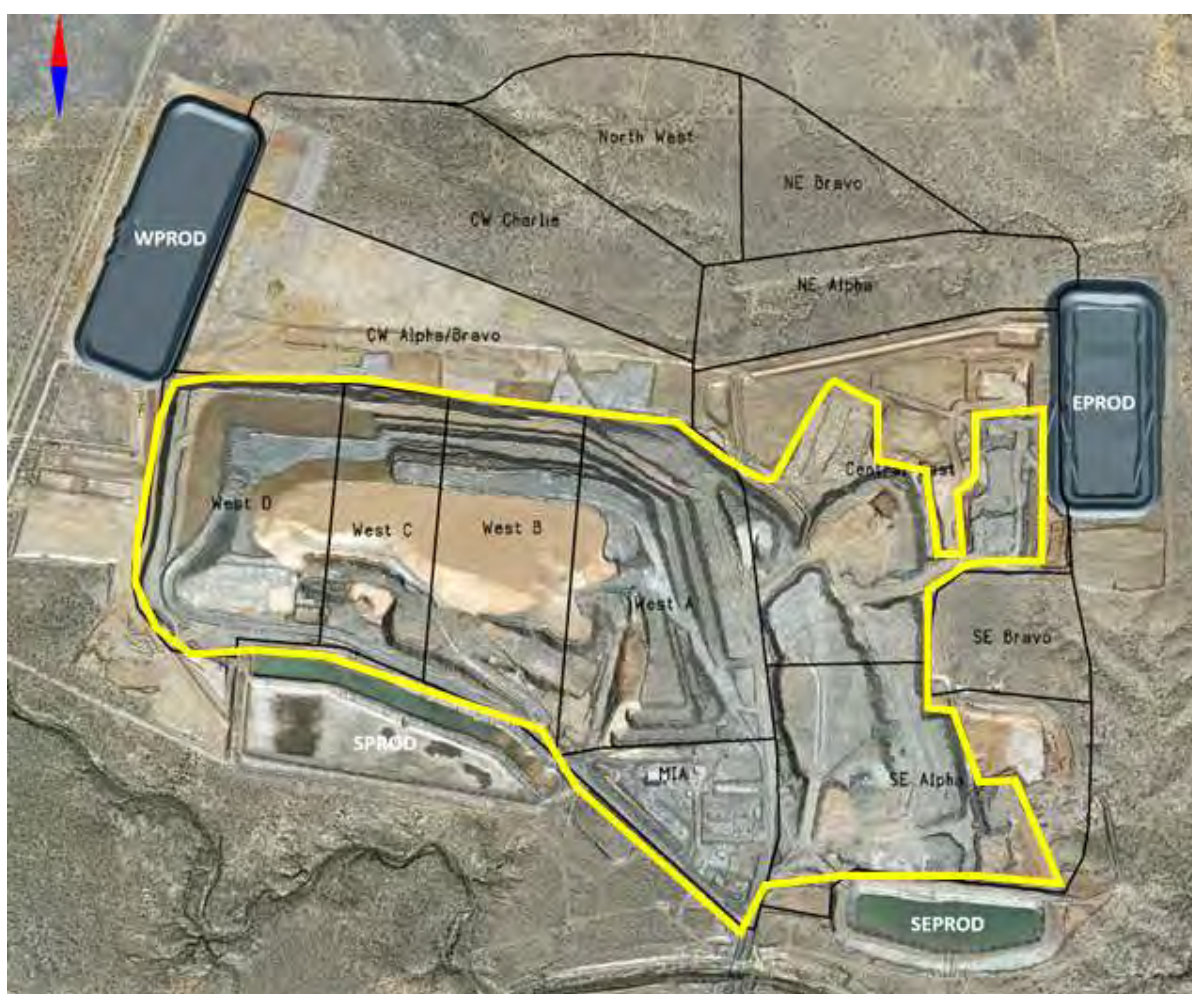


Figure 4-2: Pre-2016 NOEF Development (Marianelli et al., 2025)

Undertaking studies to characterise, physically, chemically, and biologically, the materials planned for extraction from the MRM open pit, such as developing an AMD overburden classification scheme, and the associated schedule (mass/volume by month or quarter) is an example of ‘moving to’ the ‘lower left-hand quadrant’ (LLHQ). Reducing uncertainty in respect of NOEF materials, their characteristics, and schedule, results in substantive increase in capacity to predict performance and monitor with confidence.

In contrast, actively characterising the materials to confirm they are being extracted from the open pit as per plan, and placed compliant to plan, is an example of utilising adaptive management, the ‘upper right-hand quadrant’ (URHQ), to manage AMD risk in respect of the NOEF. Constructing the NOEF to manage re-supply of oxygen, and thus reduce AMD and spontaneous combustion risk, is an example of reducing uncertainty. The controls to achieve reduction of oxygen mass-flux, lower lifts to reduce material segregation during placement, and layer compaction to reduce lateral and vertical air flow capacity are examples of management controls used to increase in the level of control.

Numerical modelling to confirm that reduction in oxygen re-supply reduces risk of AMD and spontaneous combustion, because of the way that the material is placed is a form of uncertainty reduction. In contrast, monitoring of in situ internal NOEF conditions following placement of overburden, such as pore-gas composition, temperature, and moisture conditions represent a management control.

The lower permeability layer under the NOEF, its associated overlying drainage layer and drains / sump / pumps represent an increase in the level of control. Any material characterisation and numerical modelling of the underdrainage system represent an effort to reduce uncertainty with performance enhance the capacity to predict performance. As with internal NOEF material placement and compliance to plan, the NOEF Panel consider that quality control and quality assurance (QC / QA) in respect of the drainage system underlying the NOEF as being an increase in the level control. As would be monitoring seepage flow and water quality.

The NOEF closure cover system is an additional level of control; its presence, associated QC / QA, and associated monitoring. Material characterisation and numerical modelling of the cover system design are tools to reduce uncertainty in respect of predicted performance.

In summary, the varying efforts undertaken, or planned and in progress, represent combined efforts to achieve ‘optimal control’; the ‘lower right-hand quadrant’ (LRHQ) in **Figure 4-3**. Practically, optimal control in the context of the NOEF represents the combined reduction in uncertainty and increase in level of control such that overall environmental objective against which the performance of the NOEF is measured, which is protection of the health of the McArthur River adjacent to the mine lease from impacts related to licenced mining activities, is achieved.

In addition to the context of ‘Scenario Planning’ as described by Petersen et al. (2003), it is useful to gain alignment in respect of the foundational differences between the concepts of ‘adaptive management’ and ‘hypothesis testing’ because the combined frameworks provide the basis for evaluating NOEF Design and Construction.

Adaptive management can be either active or passive. Active adaptive management involves directly imposing site-specific controls to evaluate understanding of system processes and controls and evaluate the management strategy. Passive adaptive management, as illustrated in **Figure 4-4**, relies on historical information to construct a conceptual model of how a system works and how it will respond to changing conditions.

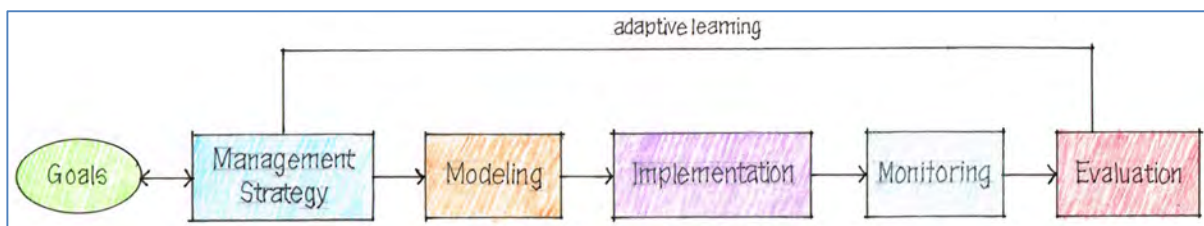


Figure 4-3: Active adaptive management (after Linkov et al., 2006)

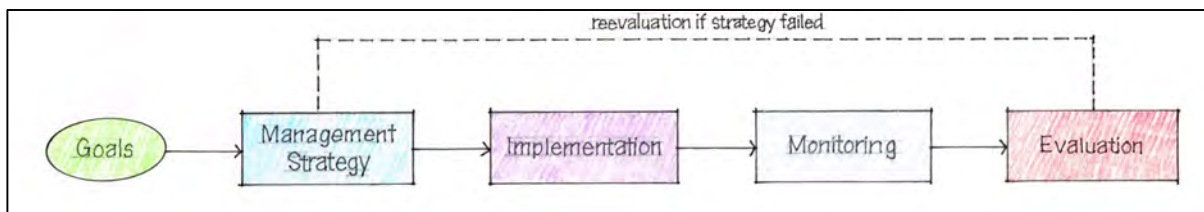


Figure 4-4: Passive adaptive management (after Linkov et al., 2006)

In contrast to the depiction of active management, based on the discussion in respect of Scenario Planning, it is the NOEF Panel’s opinion that the design and construction of the NOEF is applying the concepts of hypothesis testing and active adaptive management, as illustrated in **Figure 4-5**. Such that, there is opportunity for adaptive learning and hypothesis testing, provided appropriate field performance monitoring is in place to evaluate these two different aspects of scenario planning.

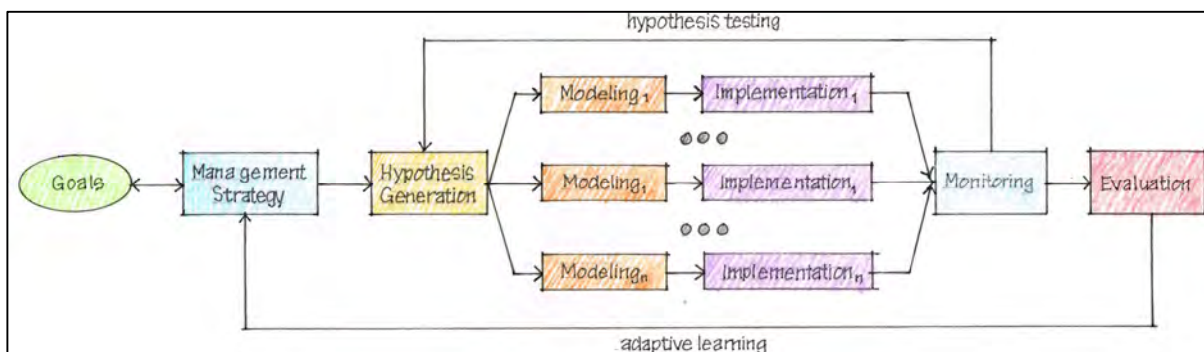


Figure 4-5: Active adaptive management and hypothesis testing (after Linkov et al., 2006)

The post-2016 MRM NOEF is being constructed according to the design principles recently presented by Marianelli et al. (2024; 2025) and summarised in **Figure 4-6**.

1. Reduce sulfide oxidation rates during construction
 - Control of spontaneous combustion
 - Reduce contaminant load generation
 - Low lift construction methodology
 - Regular interim barriers (advection barriers)
 - Temporary wet season covers
2. Segregation of highly reactive material
3. Optimise use of available materials
4. Implement progressive rehabilitation
5. Plan on existing technologies
6. Decrease reliance on cover system
7. Implement monitoring
8. Plan for long-term management needs

Figure 4-6: Post 2016 MRM NOEF Design Principles (after Marianelli et al., 2025)

4.1.1 Structural and Internal Stability and Surface Condition of NOEF

The structural and internal stability of the NOEF landform was evaluated from the perspective of:

- i) communication and adherence to design intent;
- ii) compliance to construction / execution plan; and
- iii) existence of recurring themes in respect of construction.

4.1.1.1 Foundations Including Basal Compacted Clay Liner

The NOEF Panel reviewed the design documentation, internal QA records, and independent monitoring reports (GHD, 2019) relating to the foundation preparation and basal compacted clay liner (CCL) of the post-2016 NOEF structure. Collectively, these demonstrate that the works were constructed in accordance with the design intent and consistently verified through independent oversight.

The design intent of the foundation system is to provide a low-permeability base and stable load-bearing platform that minimizes seepage into underlying geological units while supporting subsequent NOEF lifts. The foundation achieves this through the placement of a compacted clay liner underlain by a competent subgrade and overlain by a higher permeability waste rock layer, with dedicated, engineered very high permeability drainage lines to direct seepage along the CCL to nominated extraction points. Together, these components form a composite hydraulic barrier that also provides mechanical stability for the overlying waste-rock lifts.

Field implementation followed this intent. Subgrade materials were stripped of organics, proof-rolled, and scarified to create bonding between layers. The CCL was placed in two lifts (200–300 mm loose each) and compacted to $\geq 95\%$ maximum dry density (MDD) at optimum moisture content (OMC) $\pm 2\%$, achieving a target field saturated hydraulic conductivity (k_{fs}) less than or equal to 1×10^{-9} m/s. In most areas, a continuous liner was keyed into foundation batters and drainage embankments to ensure hydraulic continuity.

Independent monitoring by GHD confirmed that the construction “appeared to have been completed in accordance with the design specifications and general design intent.” GHD’s monthly QC / QA summaries show that density and moisture criteria were consistently met, and hold-point inspections verified each stage of the workflow (proof-roll → layer 1 → layer 2 → final scan → rock cover). Localized issues, such as reduced liner thickness (750 to 700 mm) near vibrating-wire piezometer cables and occasional rework following rainfall, were fully documented and rectified prior to sign-off.

GHD also emphasized recurring attention to moisture management and desiccation control, including watering of open cells and removal of dried clay before cover placement, confirming proactive QA management under variable weather conditions.

In conclusion, both internal and independent evidence demonstrate that the foundation preparation and basal CCL construction achieved the intended hydraulic and structural functions, consistent with the approved design. The system provides a sound, low-permeability platform for subsequent NOEF lift placement and supports the overall environmental objective of limiting seepage migration.

4.1.1.2 Liner Construction and Placement for Seepage Prevention

The liner system beneath the NOEF forms an engineered seepage-control barrier designed to prevent percolation from reactive overburden into the underlying hydrogeologic units. It consists of three integrated elements: i) the CCL, a dense, low-permeability layer placed in two compacted lifts and keyed into the foundation; ii) the Drainage and Underdrain Network, a granular drainage blanket and finger drains positioned above the CCL to collect and direct any seepage to the BGM-lined sump and extraction tower; and iii) the higher permeability layer adjacent to the CCL, to form a permeability contract and encourage water to flow, instead of mounding in any particular area.

The liner was designed with a surface grade of at least 2 % toward the sump system, ensuring positive drainage. Adjacent foundation stages (e.g. NE Bravo and NE Alpha) were required to overlap the CCL and filter materials to maintain continuity and eliminate preferential seepage paths.

Independent QA verification by GHD (2019) confirms that the liner was constructed to plan. Nuclear-density, moisture, and permeability testing demonstrated compliance with design targets across all test lots. Where isolated non-conformances occurred, principally due to weather-related moisture variability or tie-ins with instrumentation, they were addressed through re-working or moisture conditioning prior to re-compaction.

GHD's monthly conclusions repeatedly stated that "the works have been constructed in accordance with the specifications and design intent."

Recurring QC / QA themes identified by GHD reinforce the Panel's own observations:

- Moisture-content control is critical to maintaining low permeability values;
- Interface preparation and continuity between drainage and liner materials require careful supervision; and
- Weather impacts must be managed through controlled re-work and clear documentation rather than field improvisation.

When considered alongside internal construction records and Independent Certifying Engineer (ICE) hold-point sign-off process, the independent monitoring evidence confirms that the liner system functions as a continuous, low-permeability composite barrier. It successfully delivers the intended seepage-reduction role, underpinning the broader NOEF control strategy that combines hydraulic containment at the base with airflow limitation within the overlying structure.

4.1.1.3 PAF Reactive (RE) Cell

The Panel reviewed the design intent, construction specifications, and independent QA observations for the Potentially Acid Forming – Reactive Encapsulated (PAF (RE)) cells constructed within the NOEF. The design intent of the PAF (RE) cell is to control oxygen ingress and water movement within zones of highly reactive overburden by managing both the physical configuration and material properties of the placed waste. This is achieved through short lifts, inter-lift advective barriers, and lateral encapsulation by non-reactive (MS-NAF) material, thereby reducing the internal airflow capacity and interrupting the resupply of oxygen required for oxidation and acid generation.

Consistent with leading industry practice, design parameters for PAF (RE) Cells within the NOEF include:

- Lift height: less than or equal to 2 m, with short cycles to limit segregation and exposure time;
- Advective barriers: 0.1 m alluvium between lifts and 0.5 m along batters;
- Encapsulation: Lateral and vertical containment within MS-NAF halo material;
- Temporary wet-season capping: 1.2 m alluvium + 1.5 m MS-NAF for dormant or completed cells; and
- Grades: gentle, negatively graded (~1:80 to 1:100) toward production drains to manage surface water and minimize infiltration.

Independent monitoring by GHD from 2019 to 2025 did not identify deviations from the approved PAF (RE) design intent (GHD, 2019 to 2025). GHD noted that placement and encapsulation activities were undertaken in accordance with hold-point inspections, with proper sequencing and QA testing of barrier thickness, material type, and compaction. GHD's findings align with MRM's internal QC / QA results showing compliant placement of alluvial barrier layers and appropriate moisture conditioning before sealing.

The recurring QC / QA challenges; namely, maintaining moisture at optimum, avoiding desiccation prior to encapsulation, and ensuring batter barriers are installed within the one-month or four-lift rule, are consistent with the inherent sensitivities of finer-textured advective barriers. These matters were managed through timely reworking and watering, and none were found to compromise design function.

In conclusion, the PAF (RE) cells have been constructed consistent with the approved design and design intent. Independent and internal QC / QA records confirm that the cell geometry, layer sequencing, and encapsulation achieve the intended control over advective gas movement and water infiltration, effectively reducing oxidation potential and supporting the long-term geochemical stability of the NOEF.

4.1.1.4 Internal Halo

The Internal Halo comprises MS-NAF overburden or better quality (e.g. LS-NAF) and forms the intermediate encapsulation zone between the reactive PAF (RE) core and the outer benign cover materials (**Figure 1-2**). Its design intent is to further limit internal air flow and provide a structural and hydraulic transition between the PAF (RE) cells and the final halo shell. This layered configuration maintains both chemical containment and geotechnical stability.

Design features of the Internal Halo include:

- Material type: Moderately benign to non-acid forming (MS-NAF) material with low air permeability;
- Lift height: typically less than or equal to 7.5 m, but up to 15 m, where justified through segregation and barrier-risk assessment;
- Barriers: 0.1 m alluvium on lift surfaces exceeding 2 m and ~0.5 m on batters to restrict lateral air ingress;
- Interface management: tie-in details ensure continuity between successive stages, avoiding vertical “chimneys” that could promote airflow; and
- Slope geometry: batters between 1V:3H and 1V:4.5H; inter-stage berms with 0.5 m alluvium + 0.2 m MS-NAF to maintain encapsulation and drainage.

The design rationale is consistent with the NOEF’s broader objective of creating lower-permeability, diffusion-dominated zones surrounding reactive material. By maintaining finer-textured continuity in both vertical and lateral directions, the internal halo acts as a secondary advective barrier, ‘buffering’ the core against seasonal thermal and pressure gradients that could drive oxygen resupply.

Independent monitoring and MRM QA records show that construction of these intermediate zones adhered to plan. The key QC / QA themes identified (moisture-density control, lift-height management, and interface tie-in verification), were monitored closely. GHD (2019 to 2025) generally reported that “works appear to have been constructed in accordance with the specifications and general design intent,” and confirmed that barrier and lift geometries matched design drawings within tolerance.

Where temporary adjustments occurred (e.g. adopting thicker MS-NAF lifts to maintain trafficability during wet conditions), the Panel notes that these were approved field modifications within the bounds of design risk assessment, not departures from design intent / philosophy.

In summary, the internal halo construction has met the intended design purpose by i) providing a continuous, low-permeability envelope around PAF (RE) cells, ii) maintaining geometric and material consistency with design, and iii) reinforcing both the advective airflow restriction and hydraulic separation functions central to the NOEF’s performance.

Independent verification and documented QA evidence confirm that this aspect of NOEF design is functionally compliant and aligned with leading practice for reactive waste encapsulation and long-term stability.

4.1.1.5 Cover System and Landform Design

In the mining industry, landforms include TSFs, waste rock dumps (WRDs), ore stockpiles, low-grade ore (LGO) stockpiles, heap leach facilities (HLFs), open pits, back-filled pits, and underground workings (AGI, 2021). Ideally, consistent with the Landform Design Institute guidance (LDI, 2024), a mine landform design begins during strategic planning for a mining project, or expansion.

Considering spatial scale, as defined by the Landform Design Institute, a mine landform is on a large (approximately km x km) scale. The regional scale represents multiple mines in a valley or region, whereas the lease (or landscape) scale represents a single lease or property (e.g. on a 10 km x 10 km scale) consisting of multiple landforms. A lease, or mine site, can consist of several domains, typically organised on a surface water sub-catchment basis. Domains can have a number of landforms, and landform elements, within a singular domain. Landform elements are specifically designed physical subcomponents of a mine landform, ranging from the 10 m x 10 m scale to multiple hectares, and therefore include features such as cover systems, wetlands, hummocks and berms. As per LDI (2024), microtopography represents small additions to the landform, or the landform’s elements, which are typically ‘field-fit’ for enhancing flora and fauna, and consist of roughening, and mounds / swales, amongst many things.

Landform design is inclusive of cover system design, and vice versa; whereby one cannot be designed, constructed or its performance evaluated, conceptually or otherwise, in isolation of the other.

Cover Systems

A cover system is a technology in the mining industry, which falls within the broad range of applied sciences aimed at preventing and / or mitigating potential risk arising from mining activity. More specifically, cover systems are exactly that; systems, because their performance, including performance expectation, is intimately linked to the underlying material and hydrologic conditions (i.e. the landform itself), as well as vegetation and site-specific climate conditions. Hence, while cover systems are frequently labelled as ‘caps’, ‘liners’, or

'covers', a cover system is much more than the cover material itself. An incorrect thought process and thus a potentially flawed design approach will often result, if a cover system is thought of as the cover material only, because the tendency is then to design each layer in isolation of other factors that may influence cover system performance.

Cover systems are the building blocks for achieving agreed-upon land uses and support, as a general purpose, surface reclamation of a mine landform, while also providing a stable, reliable, and sustainable interface between the landform and the environment. Purposefully, within the mining industry, this interface is planned as being one that develops into either an aquatic ('water cover') or terrestrial ecosystem ('dry cover'); either may also include a riparian zone. More simply, cover systems support reclamation of the surface of landforms created from mining activity, and typically are expected to limit net percolation, and / or control oxygen ingress into the landform during operations and in closure, as a means of managing AMD / NMD / SD risk.

Global Framework and Application to the NOEF

The design and implementation of a mine waste cover system represent one of the most critical elements of achieving long-term geochemical and geotechnical stability for an overburden emplacement facility. Global best practice, as reflected in the INAP (2017) Global Cover System Design – Technical Guidance Document, recognises that a successful cover system must be conceived and implemented as a functional component of the landform, rather than an independent engineering layer. In this context, the NOEF cover system design reflects a deliberate evolution toward a system that integrates hydrological control, oxygen limitation, erosion resistance, and progressive rehabilitation within the broader closure landform framework.

Global Framework and Functional Objectives

INAP (2017) identifies that cover systems can be grouped into functional types depending on their dominant performance mechanisms:

- Store-and-release cover systems, which rely on water storage and evapo-transpiration to limit net percolation;
- Enhanced store-and-release or composite systems, which combine both approaches through layered configurations that include a sealing or capillary barrier within a store-and-release profile; and
- Barrier-type systems, which rely on lower-permeability engineered layers to impede water and gas flux (in INAP 2017, a barrier-type cover system as a layer, or layers, that have a permeability less than 1×10^{-9} m/s).

In general, all cover types must satisfy four overarching performance objectives, the extent of which is based on site-specific conditions:

- Control of net percolation, to limit the volume of meteoric water infiltrating into potentially reactive underlying waste material;
- Control of oxygen ingress, to restrict the supply of oxygen required for sulfide oxidation;
- Surface stability and erosion resistance, to maintain integrity over decadal to centennial timescales under variable climatic and ecological conditions; and
- Sufficient available water-holding capacity to meet plant-water use.

Design Approach and Integration with Landform Function

The INAP framework emphasises that optimal performance cannot be achieved through material specification alone. Instead, it results from a system-level design that integrates local climate, material availability, topographic configuration, and post-closure land use. Cover system performance is thus a function of both design logic and implementation quality, requiring early alignment between conceptual modelling, material characterisation, and construction sequencing.

For the NOEF, these principles have been applied through an integrated process involving Okane Consulting Pty Ltd (OKC) (OKC, 2016) and Klohn Crippen Berger Pty Ltd (KCB) (KCB, 2017). Both studies build upon INAP's conceptual hierarchy but tailored to the unique climatic and geochemical context of the McArthur River Mine. The site-specific design approach recognises that the NOEF is exposed to high-intensity monsoonal rainfall followed by extended dry seasons, necessitating a system that:

- Maximises storage and retention of wet-season rainfall in finer-grained upper layers;

- Promotes near-complete release of that water through evapotranspiration during the dry season; and
- Maintains the functionality for oxygen diffusion-limited environment that inhibits oxygen ingress to reactive materials.

Evolution from Global Principles to Site-Specific Application

In line with the INAP framework, the NOEF cover system evolved through successive phases of modelling and refinement:

- Conceptual Design Phase: adoption of the store-and-release concept as the baseline, recognising its alignment with local climatic cycles and material availability;
- Functional Design Phase: evaluation of enhanced and barrier-type cover system configurations through predictive modelling (OKC, 2016) to evaluate combinations of natural and engineered layers; and
- Validation Phase: Application of mechanistic unsaturated flow and oxygen diffusion modelling (KCB, 2017) to confirm performance under realistic climatic and material variability.

Through this process, the NOEF cover system design transitioned from conceptual alignment with global principles to a validated, site-specific configuration capable of meeting performance objectives for both infiltration and oxidation control. The final system integrates the store-and-release function with a lower-permeability barrier layer (inclusion of a bituminous geomembrane (BGM) geosynthetic layer).

Adaptive Management and Performance Verification

Consistent with INAP's emphasis on adaptive management, the NOEF cover system design incorporates performance monitoring provisions to verify and refine model predictions through field data. These include moisture balance monitoring, net percolation, and internal pore-gas measurements to track oxygen concentration and temperature evolution. This approach embodies the hypothesis testing and active adaptive management framework outlined in **Section 4.1**, providing both feedback and control within the life-of-mine closure strategy.

Comparative Modelling Summary – OKC (2016) and KCB (2017)

Qualitative Comparison

Both OKC and KCB agree on the underlying performance objective: to create cover system that minimises net percolation to less than 1–2 % of annual rainfall and restrict oxygen ingress to levels that do not sustain sulfide oxidation at depth. However, the approaches diverge in complexity and conservatism:

OKC (2016) evaluated a range of 'store and release' configurations, from simple single-layer systems to multi-layer composite covers, emphasising the importance of functional layering rather than 'singular' layer. The best-performing cover systems were those that maximised water storage within the finer-grained upper layers during the wet season and promoted complete evapotranspiration release during the dry season. OKC's focus was on achieving oxygen limitation indirectly, by maintaining elevated moisture content and limiting internal air exchange, not through a discrete impermeable barrier.

KCB (2017) adopted a more mechanistic, numerically coupled unsaturated flow and gas diffusion approach using TOUGH2. Their analysis incorporated the full vertical sequence of materials, seasonal boundary conditions, and potential heterogeneities. KCB evaluated not only store-and-release cover systems but also composite designs that included a CCL or geosynthetic clay liner (GCL) to quantify the incremental reduction in infiltration and oxygen flux. Their focus was to confirm that the selected cover system configuration could sustain low rainfall percolation and oxygen ingress rates over multi-decadal timescales, including post-closure climatic variability.

Both closure planning support studies converge on the principle that maintaining near-saturated conditions in an upper finer-grained layers strongly supports reducing oxygen ingress, and both demonstrate that inclusion of a lower-permeability layer (natural or engineered) provides significant performance benefits in the long term in respect of net percolation of rainfall.

4.1.1.6 ICE Sign Off Records for Hold Points

When considered alongside internal construction records and ICE hold-point sign-off process for the NOEF landform, the independent monitoring evidence confirms that:

- the **liner system** functions as a continuous, low-permeability composite barrier that successfully delivers the intended seepage-prevention role, underpinning the broader NOEF control strategy that combines hydraulic containment at the base with airflow limitation within the overlying structure;
- the **PAF (RE) cells** have been constructed consistent with the approved design and design intent. Independent and internal QC / QA records confirm that the cell geometry, layer sequencing, and encapsulation achieve the intended control over advective gas movement and water infiltration, effectively reducing oxidation potential and supporting the long-term geochemical stability of the NOEF;
- the **internal halo** construction has met the intended design purpose by i) providing a continuous, low-permeability envelope around PAF (RE) cells, ii) maintaining geometric and material consistency with design, and iii) reinforcing both the advective airflow restriction and hydraulic separation functions central to the NOEF's performance. Independent verification and documented QA evidence confirm that this aspect of the NOEF design is functionally compliant and aligned with leading practice for reactive waste encapsulation and long-term stability.
- **The NOEF cover system** design is consistent with the INAP (2017) emphasis on adaptive management and incorporates performance monitoring provisions to verify and refine model predictions through field data. These include moisture balance monitoring, net percolation, and internal pore-gas measurements to track oxygen concentration and temperature evolution. This approach embodies the hypothesis testing and active adaptive management framework outlined in **Section 4.1**, providing both feedback and control within the life-of-mine closure strategy.

4.1.1.7 Materials Tracking and Placement Against the Sulfur-Block Model

Historically, the resource model boundary criteria were reliant on proxy parameters in order to estimate waste classes. Following extensive improvement to the resource model throughout 2014 and 2015, resource model boundary criteria are now identical to the geochemical waste classification criteria (**Table 4-3** and in **Section 4.1.2**), completely dispensing the need to rely on proxy indicators and thereby rendering the block model estimations more reliable. The criteria / indicators used are:

- Total sulfur (S %) used as an indicator for material with the potential for generating AMD and SD dominated by sulfate;
- The calculation of the Net Potential Ratio (NPR) using the Acid Neutralising Capacity (ANC) and Maximum Potential Acidity (MPA); and
- Zinc (Zn) and Lead (Pb) contents as the key indicators for the potential to generate metalliferous drainage.

The operational processes used to track and place materials classified in the sulfur-block model are detailed in **Section 4.1.2**.

4.1.1.8 Materials Mass Balance Consistency with Construction Schedule

Materials mass balance consistency with the construction schedule is relevant for the overall mine design if completed according to the current design intent and is especially relevant for unplanned closure if, for example, the TSF tailings are not reprocessed and remain in situ requiring a cover system (MRM, 2024b). That is, is there enough of each material type available to ensure that the NOEF can be closed at any time according to the implemented design. Table 6 in Section 5.2.2 of the Waste Characterisation Report (MRM, 2018) lists the quantities of each material to be mined between 2018 and 2037 based on the then mine block model and the mine plan. One of the key issues relates to unplanned closure when additional benign material would be needed to cover the TSF in situ.

The NOEF Review Panel has been provided with the most recent yearly materials balance data for mined material extending out to 2040. In summary, the data show that there will be insufficient LS-NAF mined from the main pit stages to complete the required rehabilitation works, for;

- The current Unplanned Closure Plan Scenario;
- An Unplanned Closure scenario that was to occur in future years; and
- The current Planned Closure Scenario.

However, it had been identified in the OMP EIS that there would be a shortfall of LS-NAF from the main mining pit stages to complete all the required rehabilitation works and, therefore, the Woyzbun Quarry was included and approved in the OMP EIS.

The Woyzbun Quarry is a small pit sitting off the southeast of the main pit (Figure 3-12 in *Chapter 3 - Project Description and Justification of the Draft OMP EIS*) and targets a known source of benign LS-NAF material, southeast of the Woyzbun Fault. In the OMP EIS, the Woyzbun Quarry was indicated to contain up to 54 Mt of LS-NAF. The materials balance data indicates a maximum of approximately 17.5 Mt of LS-NAF material would be required to be mined from the Woyzbun Quarry to complete closure / rehabilitation works during any future Unplanned Closure scenario. Hence, there is sufficient LS-NAF available to cover this contingency.

It should also be noted there is abundant topsoil available for rehabilitation purposes, largely because all the topsoil from the pit area was stockpiled and won't be required for pit rehabilitation under any closure scenario.

4.1.2 NOEF Overburden Material Identification / Classification

Figure 4-7 provides a cross section illustrating the MRM mine geology and general mine stratigraphy showing the final open cut extents for the Phase 2 and Phase 3 final pits. The various overburden material types have different geochemical characteristics and are classified by MRM according to the Waste Characterisation Report entitled AMD Management (2018), and as Appendix F in the MMP (MRM, 2024a).

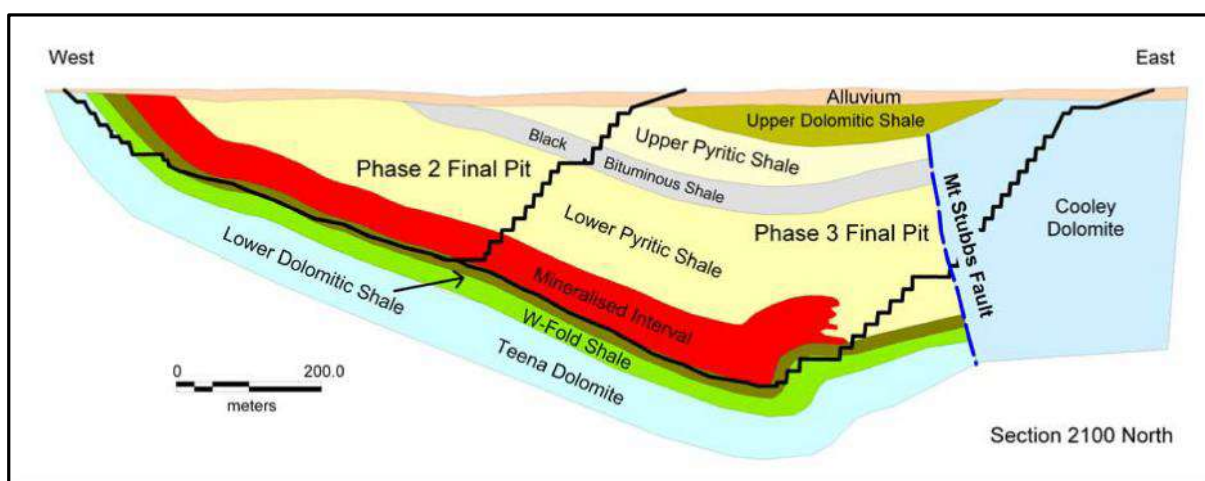


Figure 4-7: MRM mine geology and general mine stratigraphy showing final open cut extents

4.1.2.1 Approved Overburden Classification Criteria

Waste material is classified according to the MRM overburden classification criteria (**Table 4-3** and **Table 4-4**), developed from the recommendations of the 2013 McArthur River Mine Waste Classification Guide by KCB, and detailed in the MRM Waste Characterisation Report (Mining Management Plan – Appendix F (MRM, 2024d)). This characterisation scheme is based on material reactivity and its ability to generate AMD, NMD and SD consistent with industry leading practice in both Australian and international guidelines (AMIRA, 2002; DITR, 2007; DIIS, 2016; INAP, 2026). It also specifically identifies the waste type(s) prone to spontaneous combustion. This scheme replaced in 2014 the prior classification system (in place from 2005 to 2013 inclusive) that essentially split waste into only two types – potentially acid forming (PAF) and non-acid forming (NAF). The consequences of applying such an overly simple classification to the range of sulfidic waste types at MRM became manifest in 2010-2014 with runaway spontaneous combustion occurring in the original section of the NOEF. This triggered a major revision of the waste management process, and re-design of the waste emplacement facility at MRM.

The geochemical characteristics documented in **Table 4-3** and **Table 4-4** determine where the material is placed consistent with the NOEF design specification (KCB 2015, Marianelli et al., 2024; 2025). In practice, segregation of Class 2 and Class 3 materials during mining is not practical and therefore NAF overburden typically represents a combination of high and low-capacity acid consumption material (NOEF Management Plan, 2020). The classes reflect the respective AMD generation effects, and each class is managed to minimise undesirable effects. A single lithostratigraphic unit may contain several rock classes, and the classes do not

correspond to specific rock types. Therefore, the classes are geochemically based and are independent of lithology or lithostratigraphic origin.

The highest sulfide (>20 %S) material PAF (HW) will be stockpiled and contained separately to the NOEF. The material is planned to be segregated from both the PAF (HC) and PAF (RE) material because it forms a distinct stratigraphic horizon (located within the Lower Pyritic Shale (LpH) unit and can therefore be selectively mined. It will be handled differently and at the end of mine life will be disposed of sub-aqueously in the mine pit lake, as per the OMP EIS (MRM, 2017). In the interim it will be stored above grade in a dedicated Eastern Overburden Emplacement Facility (EOEF), constructed to a similar design specification as for containment of PAF (HC) waste in the NOEF.

Ongoing static and kinetic geochemical test work (KCB, 2019) using a combination of oxygen consumption rate, humidity cells, leaching columns and field barrel test work has confirmed that the classification scheme described in **Table 4-3** and **Table 4-4** is fit-for-purpose. That is, to ensure that the different waste types are appropriately placed for containment in the NOEF according to the design specification.

The kinetic test work has been carried out over a range of moisture contents to establish the dependence of oxidation rate on moisture content. This provides important input into the modelling being undertaken to predict the likely future behaviour of the NOEF in terms of surface and seepage quality and potential for impact to the McArthur River. The kinetic test work has also been used to infer the composition of seepage that has been input into the model(s) used to predict seepage load from the NOEF (OKC, 2016; and KCB, 2022).

Table 4-3: MRM / KCB overburden classification criteria

Criteria	Class	Description
NPR ≥ 2 and S < 1 % and Zn < 1,200 ppm and Pb < 400 ppm and As < 40 ppm and Cd < 10 ppm	LS-NAF (HC)	Low Salinity High-Capacity NAF. Material considered at low risk of generating AMD. Generally characterised by a high acid consumption capacity.
NPR ≥ 2 and S ≥ 1 % and Zn ≥ 1,200 ppm and Pb ≥ 400 ppm and As ≥ 40 ppm and Cd ≥ 10 ppm	MS-NAF (HC)	Metalliferous Saline High-Capacity NAF. Material considered at low risk of generating AMD but higher risk of generating Saline Metalliferous drainage. Generally characterised by a high acid consumption capacity.
1 ≤ NPR < 2	MS-NAF (LC)	Metalliferous Saline Low-Capacity NAF. Material considered at low risk of generating AMD but higher risk of generating Saline Metalliferous drainage. While non-acid forming, this material is likely to provide limited acid consumption capacity.
NPR < 1	PAF (HC)	High Capacity PAF. Material considered at risk of generating AMD and is likely to have a significant capacity to do so. Samples classed as undefined according to DITR 2007 classification are included in the PAF (HC) category at MRM.
NPR < 1 and S ≥ 10 % and BbH	PAF (RE)	Reactive PAF. Material considered at high risk of generating AMD, and at high risk of self-heating which progress into spontaneous combustion.
S ≥ 20 %	PAF (HW)	Hanging wall pyrite, which is the most pyritic material at MRM. PAF material considered at high risk of generating AMD, and at high risk of self-heating which can progress into spontaneous combustion.

Notes: NPR= Neutralisation Potential Ratio; S = sulfur; Zn = zinc; Pb = Lead; As = arsenic; Cd = cadmium and BbH = black bituminous shale

Table 4-4: Six classes of overburden at MRM (after Marianelli et al., 2024; 2025)

	Class	Criteria	Risk Profile	Quantities	
NAF	1 Low salinity NAF High acid consumption capacity	NPR ≥ 2 and S < 1% and Zn < 0.12% and Pb < 0.04% and As < 40 ppm and Cd < 10 ppm	Environmentally Benign	51 Mt (9%)	327 Mt (58%)
	2 Metalliferous Saline NAF High acid consumption capacity	NPR ≥ 2 and S ≥ 1% or Zn ≥ 0.12% or Pb ≥ 0.04% or As ≥ 40 ppm or Cd ≥ 10 ppm	Saline and Neutral Metalliferous	140 Mt (25%)	
	3 Metalliferous Saline NAF Low acid consumption capacity	1 ≤ NPR < 2	Saline and Neutral Metalliferous	136 Mt (24%)	
PAF	4 PAF High acid generation capacity	NPR < 1	Acid Metalliferous	198 Mt (36%)	229 Mt (42%)
	5 Reactive PAF High self heating propensity	NPR < 1 and S ≥ 10% and BbH	Acid Metalliferous Spontaneous combustion	26 Mt (5%)	
	6 Hanging Wall Pyrite	S ≥ 20%	Acid Metalliferous Spontaneous combustion	5 Mt (1%)	

Notes

- The overburden classes take into consideration the effects of AMD, NMD and SD, as well as the potential for spontaneous combustion.
- Spontaneous combustion is realization of the potential for some sulfide and carbon rich overburden materials to self-heat due to rapid oxidation. It is characterised by high temperatures and the emission of gases, in particular sulfur dioxide.
- NPR= Neutralisation Potential Ratio; S = sulfur; Zn = zinc; Pb = Lead; As = arsenic; Cd = cadmium and BbH = black bituminous shale

4.1.3 NOEF Overburden Placement Control and Validation

4.1.3.1 Overview

The most critical operational element of the construction of the NOEF is the tracking of overburden types from the source in the pit to ensure correct final placement in the NOEF according to the design intent. This tracking is essential to minimise the risk of misplacing overburden types, which would compromise the functional integrity of the engineered containment system. In essence, the NOEF is now (post-2016) being constructed as a layered cellular system (**Figure 1-2** provides a cross-sectional schematic diagram), with the most reactive material in the core, and surrounded by layers of progressively lower reactivity overburden materials. The outermost layer of waste (the lowest reactive classification) essentially functions as an oxygen scavenging layer to prevent the ingress of oxygen into the deeper more reactive layers within the core of the NOEF.

The NOEF Panel visited site from 14 to 16 April 2025. This provided the opportunity to hear presentations from senior MRM site personnel regarding NOEF construction and management, and to view the various phases of construction development in progress at the time. **Photo 4-1** illustrates the construction of the cell structure containing the PAF (RE) overburden material according to the design intent and specification.



Photo 4-1: Active working face showing construction of a PAF (RE) cell (David Jones, April 16, 2025)

The site visit did not allow for an audit to be made of the systems underpinning the overburden material classification and selective handling and placement processes. However, the NOEF Panel members were able to review the specific findings from an audit conducted in 2022 by the Independent Monitor Advisian (Waste Rock Handling Procedures Audit 2022), coupled with additional information supplied to the NOEF Panel via the request for information (RFI) process.

The overburden (waste rock) placement procedure was reviewed by the Independent Monitor in 2022. The audit reviewed operator processes associated with overburden material classification, mining and haulage as well as the NOEF design, construction and operation. Key activities undertaken as part of the audit included:

- Auditing implementation of overburden handling procedures in accordance with relevant management plans; and
- Reviewing overburden handling processes and outcomes against stated key objectives for the NOEF design, construction and operation.

The audit found that MRM was achieving a 'good' to 'very good' level of implementation of the NOEF MMP requirements.

4.1.3.2 Geochemistry Based System for Waste Placement Control

Two systems are currently in place at MRM to track and log the movement and placement of overburden materials in the NOEF.

The first is the GPS-based “Modular” tracking system commissioned in 2019 that directs trucks to the correct location based on geochemical data from the mine block model, sampling of the blast hole pattern (one sample per ten blast holes) and daily inspections of waste boundaries by the site geologist. The inspection findings are entered into a mobile phone app and added to the three-dimensional mine model. Daily grade control meetings are held by MRM and overburden classification issues can be addressed, if required. The procedures that describe how the blasting pattern is sampled and tested are documented in Waste Characterisation Report - AMD Management 2018 (Appendix F of the MMP (MRM, 2024a)).

An average blast block consists of approximately 500 holes. Fifty drill holes are sampled for analysis per blast block (1 in 10 drilled). A representative slice (spear) is taken from each sampled drill cutting mound or cone that forms around the drilling stem, then dried, ground and homogenised for analysis. Direct measurements of sulfur, Zn, Pb and the indirect estimate of NPR are used to classify the overburden into the six classes previously identified in **Table 4-3** and . A map of the blast block is produced by the Mine Geologist for the Mining Engineers and production crews to plan and execute extraction and appropriate placement in the NOEF. The blast pattern sampling is used to confirm and refine at a closer spatial level, the assignments in the mine block model that were derived from the original drilling and characterisation of the orebody and surrounding overburden materials.

Details of how information is fed into the Modular system in real time and how it is used to direct mine traffic to the correct dump areas are described in Table 3.1 in the Advisian report. Prior to Modular a “manual” system called APS was used. The Advisian audit team found that since implementation of Modular, mis-dumps have been almost eliminated, and in the event corrective action is required a response can occur quickly. A control room dispatcher managing fleet operation using the Modular system is shown in **Photo 4-2**.



Photo 4-2: Control room dispatcher managing MRM NOEF fleet operations using the modular system

The material compiled in Table 3.1 in the 2022 Advisian audit report notes that any mis-dump rehandling response can occur on the same shift, or the next morning in daylight following a night shift. This is an improvement on past practices and minimises the possibility of ‘dumping over’ different classifications of overburden. Avoiding ‘dumping-over’ minimises the volume of overburden that otherwise may potentially require removing, rehandling and transporting to the correct emplacement location.

The Advisian audit team was informed that the Mine production team is “mindful” of not exposing PAF (RE) material to the atmosphere or rainfall for extended lengths of time (i.e. months) after blasting, before transporting it to the NOEF. The Mine production team has implemented an ‘as required’ approach to blasting to reduce the period blasted waste rock resides in the pit and avoid potential oxidation reactions before being transported and placed in the NOEF.

The audit team was also advised that since the implementation of Modular, only inadvertent human error can result in a mis-dump (dumping a load in an incorrect location) and this is now “extremely rare”. However, no quantitative metrics were supplied in the 2022 audit report, so the NOEF Panel requested that these data (from 2019 to 2025) be provided as part of its assessment. The information provided in response to this request is summarised in **Table 4-5**. The mis-dump load data come from a daily process conducted to validate the load and dump locations of trucks using truck GPS data (Modular). If there is an observed ‘mis-dump’ (waste material dumped in the wrong dump location) during this check, an investigation is carried out to verify the source location. From the investigation, it is determined whether remediation is required or not. A BSAFE incident is entered for the mis-dumps that are significant in terms of tonnage / truck count. For any mis-dumps, an investigation report is completed.

The data in **Table 4-5** illustrates that mis-dumps represent only a minute fraction (<0.01 %) of the total number of loads that are placed each year. Of that very small number, most were not rectified as they represented a small amount of overburden material and / or the construction had already progressed beyond that point.

Of course, the Modular placement control system “assumes” that the overburden has been correctly classified prior to placement. Geochemical sampling of placed overburden is also undertaken twice-weekly at the NOEF as part of the broader program, following the procedures documented in PRO-3500008 - OEF Sampling Procedure). The aim of this monitoring program is to characterise the placed overburden and provide final verification that materials have been placed in the designated locations within the NOEF.

Table 4-5: Summary of modular detected mis-dump events 2019-2025

Year	Total Number of Dumps*	Number of mis-dumps	Number rectified
2019	166,437	5	5
2020	266,007	2	1
2021	234,010	8	1
2022	240,233	5	0
2023	218,276	2	0
2024	186,767	4	1
2025	114,361	12	3

* truck factor used to calculate number of dumps.

The Quality Assurance / Quality Control (QC / QA) program samples NAF, PAF and mineralised overburden on the NOEF, with an average of 250 samples collected each year. Overburden samples (10 to 26 samples of approximately 3 kg) are collected from randomly selected locations within the active placement areas. Sampling density is proportional to the amount of material moved and is based on international guideline recommendations (INAP, 2026) for numbers of samples needed to characterise a defined mass of material. However, this guidance was modified to account for the different levels of risk of the material, so for example the reactive PAF (RE) has twice the number of samples per Mt than PAF (HC).

In the event that the sampling program identifies areas that have apparently been mis-classified by the blast hole sampling and hence mis-directed to the wrong dumping area by Modular an investigation is undertaken to determine if the issue is material.

The “raw” data from the PRO-3500008 NOEF sampling program was provided in spreadsheet format to the Panel via the RFI process. However, this was not able to be assessed because no information was provided

about how this data was assessed or acted upon by mine personnel. Fortunately, a number of well-documented action reports that did demonstrate how the sample data were used were provided in the package of information provided to the Panel. It is not known if similar reports are generated routinely when a non-conformance is found. As such it has had to be assumed that each such non-conformance detection is worked through with such rigour. An example of the forensic approach that has been applied is provided in a detailed report produced by Mining Technical Services-Geology (OEF Non-Conformance Report, June 2022). Several locations that had been sampled were flagged as being inconsistent with the waste classification scheme.

Rigorous analysis of the results and comparison with the source formation showed that for two of the cases the initial non-compliance fell within the material heterogeneity that was intrinsic to the source formation in the pit. Hence in this instance it was not required to rehandle the material. However, in one case the material was found to have been wrongly classified and needed to be rehandled and placed in an area of the NOEF consistent with its actual classification. It should be noted that in such instances the dumping coordinate information contained in Modular is invaluable for tracking back to the original source in the pit. In the fourth case it was recommended that in the event where not all of the results from the blast hole samples have been returned at the time of material delineation, that the material be conservatively designated as a higher PAF classification and placed accordingly in the NOEF. This was an example of a positive feedback loop into the materials handling system.

In some cases, non-conformances have been triggered by material that has been mis-classified by being displaced sideways or down edge slopes during a blast (OEF Non-Conformance Report September 2024). As a result of this the original spatial designation determined by the pre-blast analysis of blast hole drill samples is compromised. This type of occurrence cannot be picked up by the Modular system which uses the blast pattern data to assign dump locations and illustrates the importance of this post dump sampling process to identify such material after it has been placed.

In another instance, human error resulted in the wrong characterisation polygon being entered into modular and a substantial amount of PAF (HC) material was placed on a batter slope (NOEF Non-Conformance Report March 2025).

The Panel requested that summary information be provided about the annual performance of the waste QC / QA system from 2019-2025, in parallel with the request for the information about the performance of Modular. Specifically, the number of areas sampled, the initial number of non-conforming areas, the final number of non-conforming areas, and the number of areas rectified. These data are summarised in **Table 4-6**.

Table 4-6: NOEF sampling procedure (PRO3500008) findings

Year	Number of areas sampled	Initial Number of nonconforming areas	Final number of nonconforming areas ¹	Number of areas rectified
2019	18	16	4	3
2020	32	17	14	0
2021	63	17	4	0
2022	64	21	8	1
2023	61	57	9	0
2024	54	61	2	0
2025	40	39	3	0

¹ The program of post-dump random sampling can pick up some potential instances of non-compliance. However, the initial non-compliance can be assessed to be either the result of expected heterogeneity in the source formation in the pit or relate to very small quantities of material which are inconsequential in terms of overall risk – so no further action was needed. Hence, the need for both columns 2 and 3.

The data contained in **Table 4-6** indicates that the post placement sampling audit program has an initially very high proportion of non-conformance detections compared with the number of locations sampled. However, after forensic investigation (examples from investigation reports provided above) all years apart from 2020 show that only a small fraction was found to be actual non-conformances. Of these very few were rectified, for operational reasons such as the material involved having been covered prior to receipt of the assay data. However, this occurrence is very rare owing to the frequency of checking.

The operational control aspects of the materials characterisation and placement processes have been highlighted above. However, the meticulous record keeping will also provide a three-dimensional record of NOEF construction which will facilitate a well-documented, characterised and understood landform at time of completion.

4.1.4 Risk Management and Control

The geochemical based controls that are in place to ensure correct placement of waste types in the NOEF have been described above in **Section 4.1.3.2**. In addition to these there are measurements being regularly made to identify areas of dumped materials that may be at risk of spontaneous combustion. Instrumentation has also been installed both vertically and laterally into the NOEF to measure the internal temperatures to track how actual performance is comparing with model predictions. These additional risk control measures are described below.

4.1.4.1 Spontaneous Combustion Monitoring

Additional monitoring procedures are in place for the identification of spontaneous combustion at MRM. Because spontaneous combustion is time dependent and represents a potential safety hazard in addition to its implications for production of AMD, early detection and remediation is essential for its successful management. This monitoring is done in addition to relying on the spatial geochemical information contained in the mine block model and the data provided by the analysis of blast hole samples to identify at risk material. The monitoring activities listed below are carried out.

- In-pit Monitoring: Thermal monitoring is undertaken prior to and during drill and blast operations enabling the early detection of potentially problematic material.
- Daily NOEF inspections: Daily visual and thermal inspections are conducted by Mining personnel for early detection of reacting material. The aim is to identify areas showing early signs of increased reactivity (abnormal surface moisture, elevated temperatures, cracks, heaving, or efflorescent salts) prior to the onset of spontaneous combustion.
- Gas Monitoring: Daily gas measurements including sulfur dioxide levels are undertaken on the NOEF to identify potential hazards and areas requiring remediation / intervention.
- Thermal imaging: Weekly thermal imaging of the NOEF has been undertaken from January 2019 onwards using a survey drone equipped with a thermal camera. The method will enable the rapid and precise identification of problem areas of more rapid heating which require specific management during the NOEF staged construction process.

4.2 NOEF Performance

The NOEF Panel has reviewed the NOEF MMP (MRM, 2024a) with respect to the following performance matters.

4.2.1 NOEF Design Philosophy

The key document that describes the design and management philosophy for the NOEF is the NOEF Management and Construction Guidelines 2020, attached as Appendix G to the MMP (MRM, 2024a). Figure 11 from that report (reproduced as **Figure 4-8** below) shows the overall layout of the NOEF, including the locations of the seepage collection perimeter runoff dams (PRODs) around the NOEF perimeter toes.

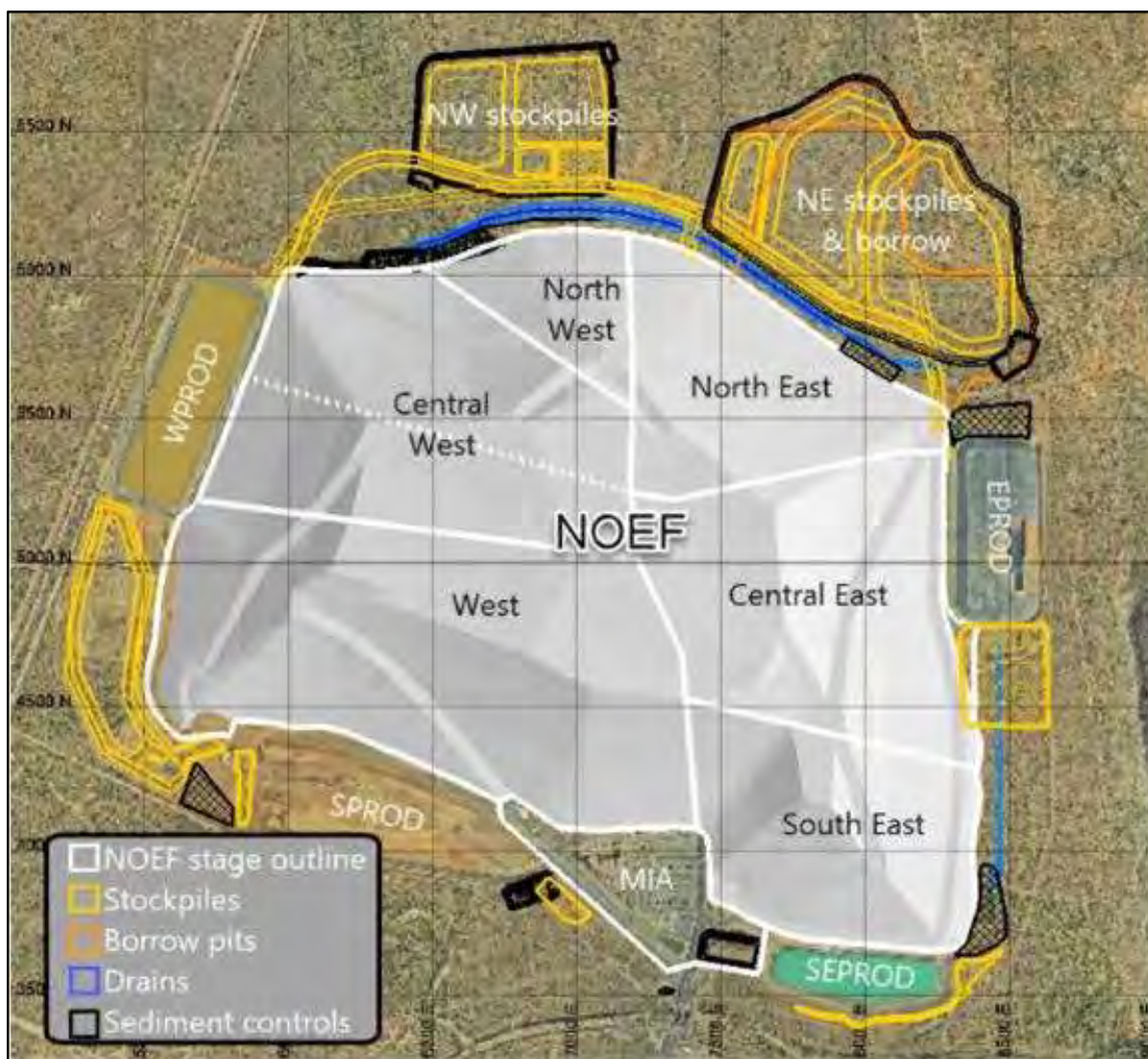


Figure 4-8: NOEF Layout

The primary construction objective for the NOEF is to limit oxidation of the sulfidic wastes at the source, thereby reducing the quantity of potential contaminants that could harm the environment. Measures to limit the transportation of contaminants from the NOEF to the receiving environment are used, with surface water and seepage management being examples of these (e.g. the four PROD collector dams shown in **Figure 4-8**).

Post-2016, priority has been placed on source control methods of construction that prevent or limit the oxidation of materials in the NOEF that have the potential to cause environmental harm, with the construction methodology documented in the NOEF Management Plan (Appendix G to the MMP (MRM, 2024e)).

However, pre-2016 not all of the NOEF were constructed using these advanced design principles. In particular, the original south and southwest parts of the NOEF (the West zone in **Figure 4-8** were constructed using conventional high lift end dumping between 2009 and 2015. This method of construction did not limit advective and convective airflow from the base of the dump.

The history of the construction of the NOEF is thus a “tale of two parts”. The original design produced by URS in 2008 (URS, 2008) was based on the simplified NAF and PAF waste classification system that was being used at the time. A schematic cross section is shown in **Figure 4-9** (source: p86 Plate 2 Unplanned Closure Plan April 2024).

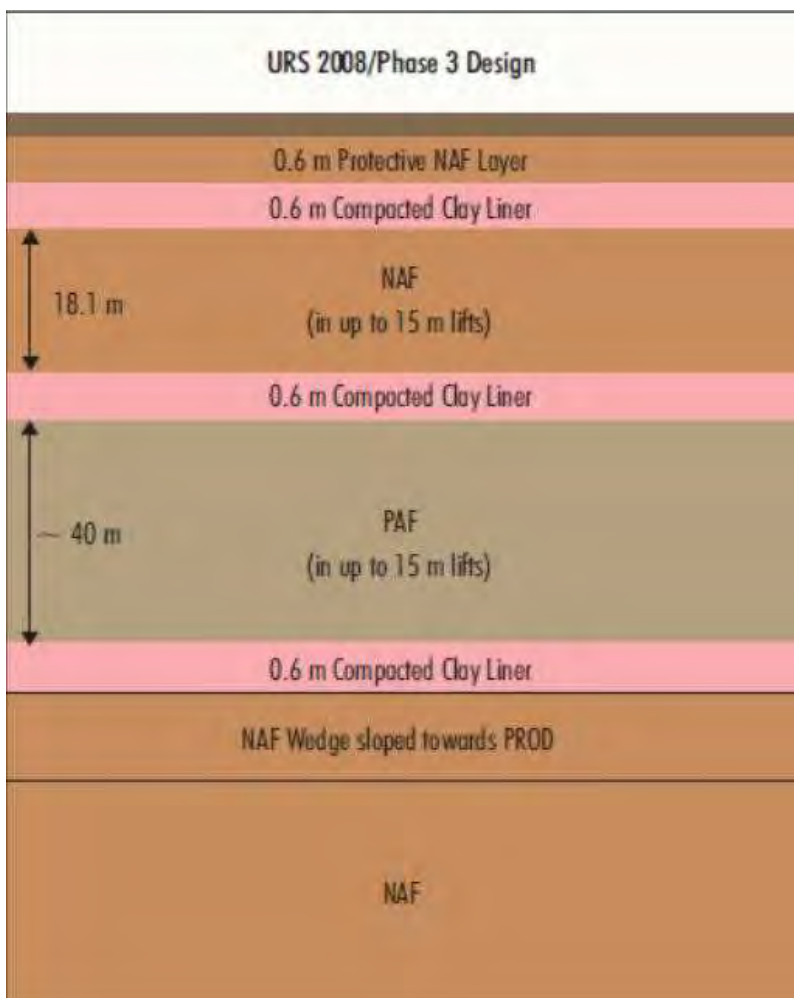


Figure 4-9: Cross section of original NOEF construction method

The waste was deposited on compacted clay layer on top of which was a seepage collection layer. The material was deposited in 15 m high end-dumped lifts with the core of PAF material being surrounded by NAF. West A, B and C were built as per this design. The West stage Lift 1 was built in 2-3 m lifts of various NAFs and alluvium, sloping towards the SPROD. A minimum 0.6 m thick CCL sits on top of the wedge and under the PAF cell above, with the aim of promoting infiltrating water to report to SPROD. The PAF cell lifts were typically 15 m high with the outer surface of the PAF cell flattened off to a 1V:4H slope before being covered by a fine-grained wet season cap.

This original design did not incorporate measures for control of the advective movement of air through the mass. In 2012-2013 internal self-heating resulted in spontaneous combustion of what was subsequently classified as PAF (RE) material. Considerable efforts were directed to subduing this combustion, which included opening up the combusting material to cool it down, before re-covering with benign-NAF material, and finally a BGM to limit oxygen ingress and water infiltration.

NOEF modelling carried out in 2016 (OKC, 2016) showed that the root cause of the combustion was essentially uncontrolled advective transport of air into the mass, which was effectively operating as a chimney and flue with the air being drawn laterally into the lower region of the NOEF, driven by the thermally buoyant rising gas. The only way of preventing this from happening in the future was a fundamental re-design of the NOEF, which is what is currently being implemented.

The theoretical underpinning of the use of advection barriers (source control) to minimise oxidation rate is clearly explained in the modelling work done in 2016 in support of the EIS process (OKC, 2016). In particular, the likely effectiveness of layers of low air permeability being placed between relatively thin (2 m) paddock-dumped lifts of reactive material was shown.

This concept has been implemented in the construction of the high PAF (RE) cells that are being built in the core of the new sections of the NOEF. A schematic of this amended design is provided in **Figure 4-10**, as reproduced from the MRM Unplanned Closure Plan (MRM, 2024b). The members of the NOEF Panel observed this construction in progress during their site visit in April 2025 (see previous **Photo 4-1**).

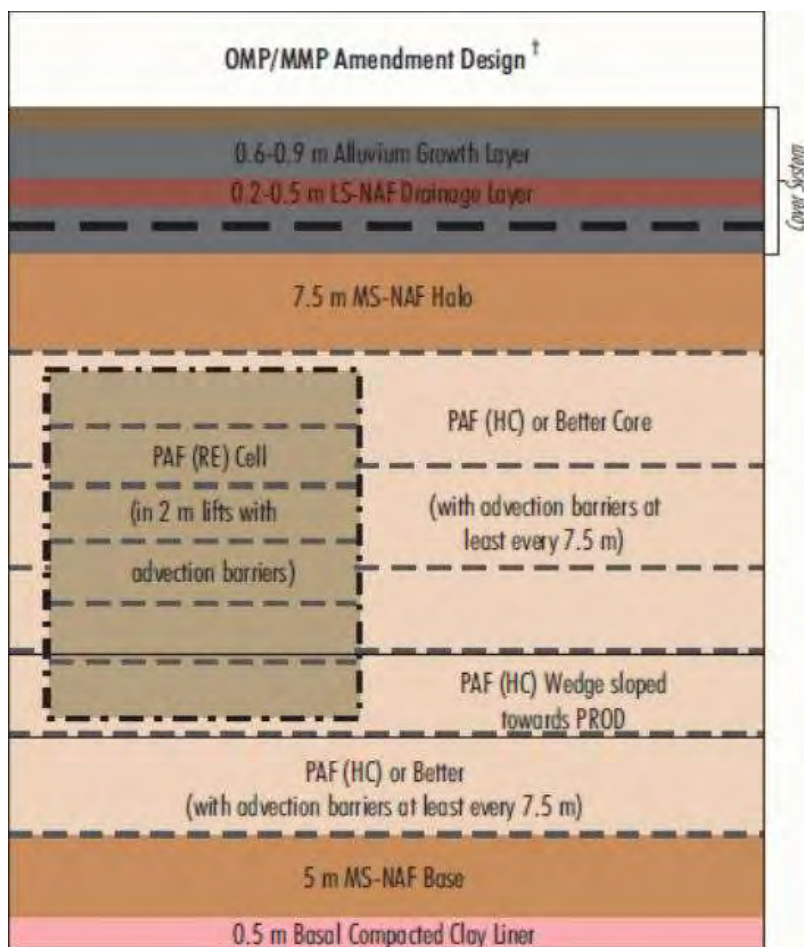


Figure 4-10 Cross section of original NOEF construction method

4.2.2 Temperature Monitoring within the NOEF

4.2.2.1 Monitoring of effect of remediation works at pre-2016 NOEF areas on temperature

It has recently been reported by MRM (Marianelli et al; 2025) that temperature monitoring data recorded from 2017 to 2021 at the pre-2016 parts of the NOEF, indicates that there is also a reduction in temperature due to the remediation works completed (excavation, improved geometry, improved drainage, placement of a wet season cover and clay capping). This finding is illustrated in **Figure 4-11** and **Figure 4-12** for the temperature monitoring results observed at monitoring points 2017 – 22 – Wb and 2017 – 24 – Wb from 2017 to 2021, which clearly demonstrates a marked reduction in temperature within the pre-2016 parts of the NOEF at depth over time. The locations of these bores are shown as white dots 22 and 24 on **Figure 4-14**.

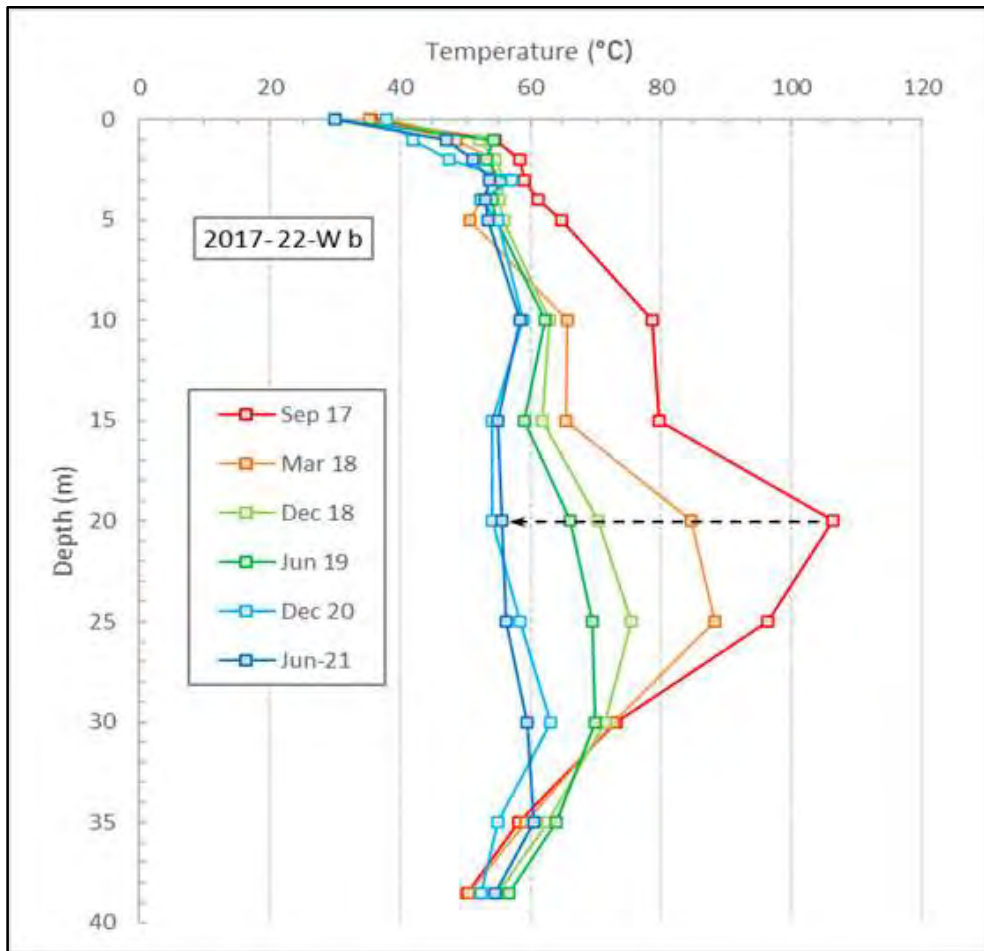


Figure 4-11: The NOEF temperature monitoring results form 2017-22 – Wb

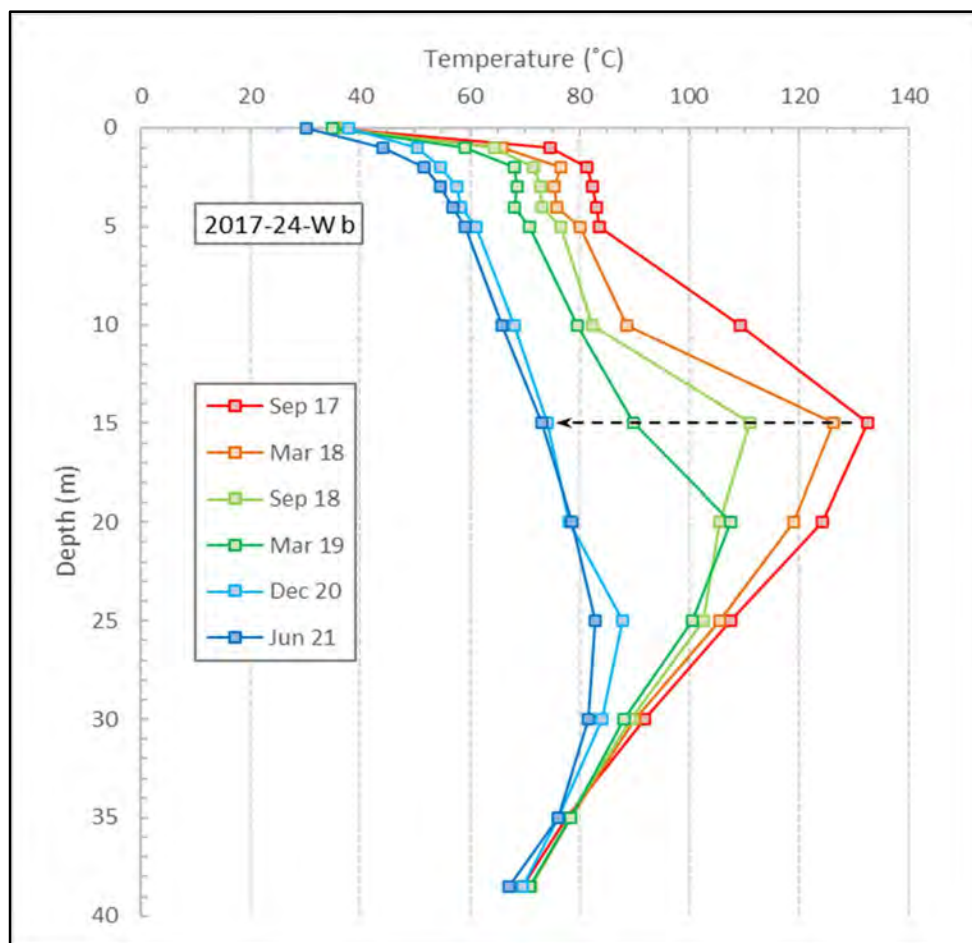


Figure 4-12: The NOEF temperature monitoring results from 2017-24 – Wb

4.2.2.2 Temperature monitoring at NOEF (2023-2024)

In addition to the above activities that are focussed on the surface of the NOEF, temperature monitoring is also undertaken at depth using vertical and horizontal arrays of thermocouples that penetrate from the outer to the inner layers of the structure.

An annual temperature monitoring report is produced that documents the locations of the currently active monitoring bores and the data they are producing. The most recent report provided to the NOEF Panel is for 2023-2024 period (NOEF Temperature Monitoring Report 1 May 2023 to 30 April 2024) (MRM, 2024f). The descriptive text below and the location schematics were excerpted from this report, with the NOEF Panel adding additional commentary.

Two separate types of instrumentation are currently being used to monitor internal temperatures at eight locations within the new section of the NOEF (**Figure 4-13**):

- Vertical temperature monitoring bores - Six vertical temperature monitoring bores (green in **Figure 4-13**) provided data over the 1 May 2023 to 30 April 2024 reporting period.
- Horizontal instrumental arrays - Two horizontal instrumental arrays (blue in **Figure 4-13**) provided data over the 1 May 2023 to 30 April 2024 reporting period.

The vertical monitoring wells are instrumented with high temperature thermocouples rated to 380°C. All bores extend the full depth of the PAF cells (between 40 to 50 m) with sensors every 5 m (5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 m) below surface.

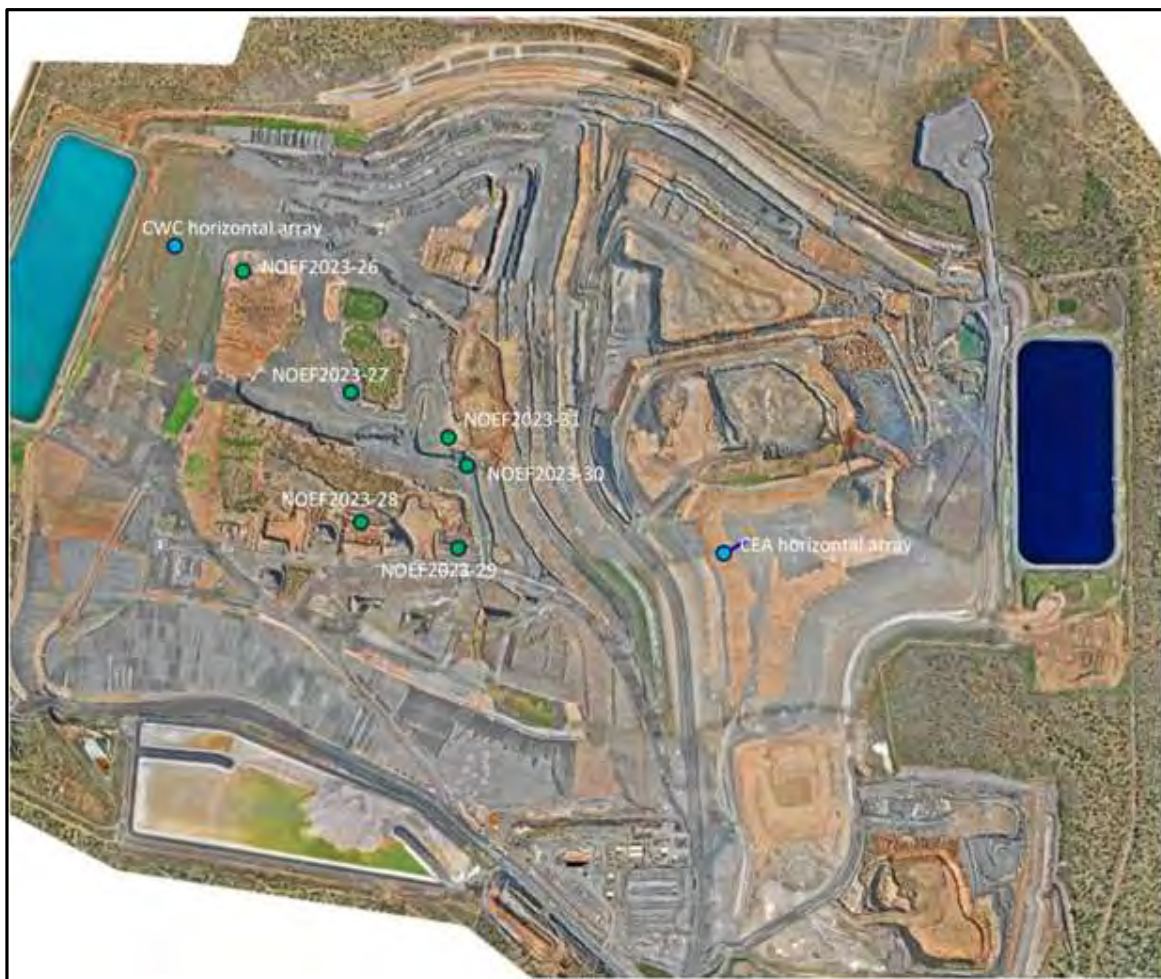


Figure 4-13: Current temperature monitoring locations in the new post-2016 section of the NOEF

The horizontal arrays (CWC and CEA on **Figure 4-13**) were installed in 2021 following the redesign of the NOEF as part of the OMP EIS. These are designed to complement the vertical temperature bores by targeting the temperature and gas exchanges in the batters of the NOEF, in particular the zone closest to the atmosphere consisting of the MS-NAF halo, alluvial advection barrier and outer PAF cell. They are being used to confirm that the method of construction is yielding the outcome that was predicted by the numerical modelling of dump behaviour. That is, thin lift with advection barrier layers is preventing the ingress of oxygen that will trigger accelerated oxidation and potentially spontaneous combustion.

The temperature monitoring instrumentation was installed 25 m above the base of the PAF cell and extends horizontally approximately 71 m into the NOEF from the edge of the batter through the MS-NAF halo, fine grained alluvial advection barrier and into the PAF cell (see figures 3-4 in the 2023-24 monitoring report for location and construction details). It consists of 10 thermocouples, 10 oxygen sensors and 10 soil moisture sensors.

The water content sensors in the CEA array have failed but those in the CWC array continue to operate. All sensors show a marked response to the wet season with a rapid increase in moisture content with the onset of rainfall followed by a period of desaturation associated with the dry season. While there is some variability between sensor locations, there is a general increase in volumetric water content over time. While this may be biased by the impact of the very high rainfall in the wet season 2023-2024, the trend likely reflects the cumulative impact of successive wet season on the moisture content in the waste rock.

The temperature data from the horizontal arrays in the new section of the NOEF indicate that the post-2016 design is performing as predicted (MRM, 2024f). That is, the architecture of the PAF (RE) cells which combine

2 m lifts with regular horizontal advection barriers are effective at inhibiting sulfide oxidation and controlling the development of spontaneous combustion.

An additional three vertical temperature monitoring bores (NOEF 2023-32, NOEF 2023-33, NOEF 2023-34) were drilled in the pre-2016 parts of the NOEF in December 2023 (**Figure 4-14**) The purpose of these bores was to monitor the internal temperatures in the upper section of the batter following installation of the bituminous geomembrane (BGM) which is to be used as the barrier layer in the final cover system. The bores are located in the southwest corner of the NOEF as the corners are a particularly susceptible to increase sulfide oxidation (and higher internal temperatures) due to the potentially higher oxygen ingress created by the large batter areas on two sides.

All measured temperatures in the vertical temperature monitoring bores shown in **Figure 4-14** (with the exception of those in bores 32 and 33) remain well below the temperature required to potentially initiate spontaneous combustion (>100 °C) and indicate that the batter geometry and alluvial cover is effective at minimising oxidation of sulfides. Bores NOEF 2023-32 and NOEF 2023-33 show very similar temperature profiles characterised by a general increase in temperature with depth, reaching a maximum of 100 °C and 92 °C at 30 m, which was the maximum depth of these bore installations. The temperature was still increasing at this depth, indicating that there may have been higher temperatures further down in the profile.

The consistently elevated temperature seen in NOEF 2023-32 and NOEF 2023-33 at depth is indicative of ongoing sulfide oxidation at this location, likely resulting from the unfavourable geometry of the area, i.e. the close proximity of batter crest with batters on two sides resulting in higher rates of oxygen ingress. Both bores are located in the pre-2016 parts of the NOEF, which does not benefit from the OMP-EIS design (lower construction lifts, segregation of PAF and reactive PAF, no internal advection barriers) which is likely results in the more elevated temperatures. This reinforces the need for continued vigilance and targeted management of this part of the pre-2016 NOEF and emphasises that the originally planned remedial works and NOEF design should be implemented as soon as cultural approvals are in place.

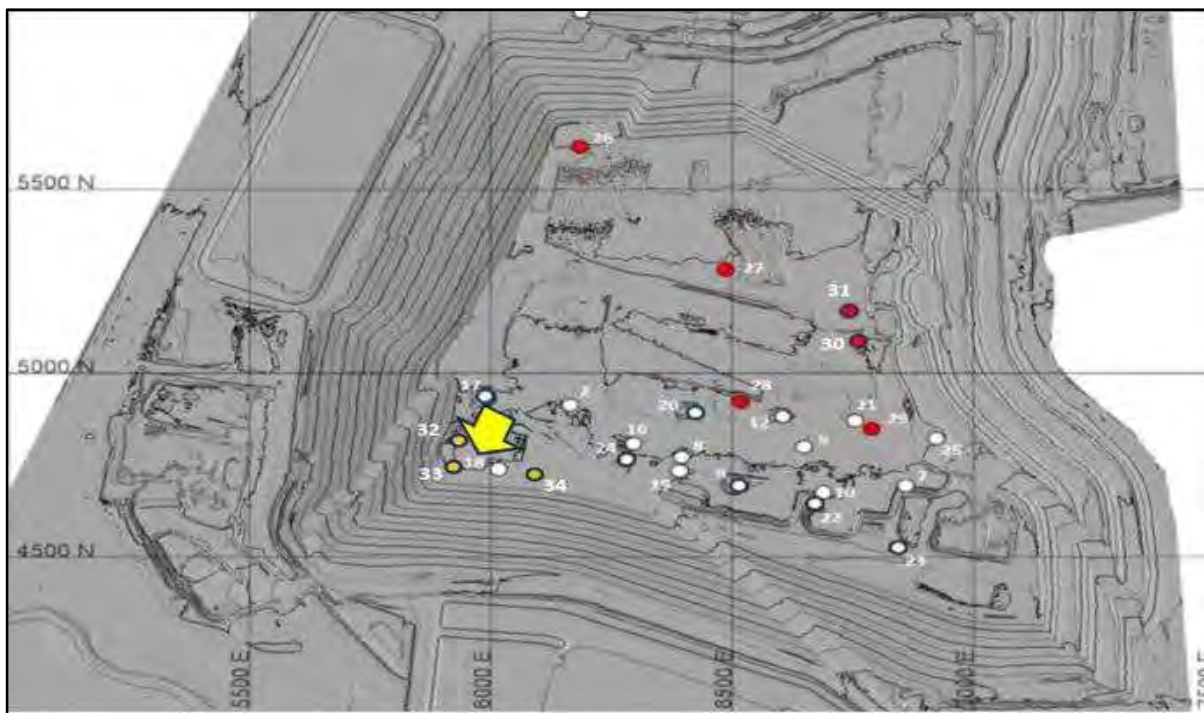


Figure 4-14: Location of vertical temperature monitoring bores with bores 32, 33, 34 installed in 2023 in the SW corner of NOEF marked by the yellow arrow.

As a result of the relatively elevated temperatures recorded in the upper section of the southwest corner of the NOEF at bores NOEF 2023-32 and 33, additional mitigation actions were implemented for the dry season of 2024 and included improvement to the geometry of the plateau to limit air ingress, improved drainage control to ensure limited ingress of water, and placement of a wet season cover to further protect the area from percolating rainwater and reduce sulfide oxidation rates.

4.2.2.3 Temperature monitoring at NOEF (2024-2025)

The temperature monitoring report for 2024-2025 (MRM 2025a) contains the most comprehensive compilation and interpretation of monitoring data that has yet been made. An additional nine vertical temperature monitoring bores were installed in between January and April 2025 in order to:

- Extend monitoring to the more recent stages of the NOEF (Central West Charlie and Northwest stages)
- Replace decommissioned bores (West stage)
- Investigate localised areas of known or suspected elevated temperatures.

The locations of these new bores are marked on **Figure 4-15** with the prefix 2025. Also shown are the previously installed and still functioning horizontal and vertical monitoring arrays. It is to be noted that the nomenclature used for the bores was changed in this most recent reporting year to a consistent framework.

In particular bores 32 and 33 which were the subject of specific discussion above were changed to 2023-05-Wd and 2023-06-Wd, respectively.

Beside the bore name in **Figure 4-15** is the maximum recorded temperature in the array at that location. The maximum temperature recorded for each of the pre-2025 locations is consistent with that reported above. However, bores 2025-10-CWC and 2025-11-CWC in the new area showed a maximum of over 100 °C (114 and 128 °C respectively).

The profiles show that the high temperatures are restricted to very specific depths and do not extend vertically through the profile. The rapid increase in temperature and the very limited vertical extent suggest that the oxidation is most likely driven by lateral rather than vertical advection, and that it is probably restricted to a single lift in the outer batters. Both areas are currently under investigation to determine the likely cause (e.g. waste rock type, origin and construction history) and whether further remediation action is required.

In the case of 2025-11-CWc (eastern batter of Central West Charlie), the area south of the bore required remediation in 2023 because the fine-grained advection barrier was omitted from the second lift of the PAF (HC) cell for an extended period and there were external signs of excessive temperatures (sulphur dioxide, secondary salts). While no visible signs of combustion are present following remediation of the batter, localised elevated temperatures and will be the focus of ongoing monitoring over the next reporting period.

The highest recorded temperature was 161 °C in the profile 2025-12-Wa, which is located on the original northern batter area of the pre-2016 landform. The vertical profile shows a progressive increase in temperature with depth reaching a maximum of 161 °C at 30 m below the surface. Below 30 m, the temperature progressively decreases but remains above 100 °C at the base of the bore. This profile indicates sulfide oxidation is occurring at this location to a depth of at least 30 m with significant air advection. The 2025 profile is very similar to the profile measured in 2017 and 2019 in bore NOEF 2017-25A. This shows that while the temperature is significantly elevated, it has remained stable over time and there is no indication of runaway thermal heating leading to spontaneous combustion. It also indicates that this specific area has not cooled over time, as opposed to the other former areas of elevated temperatures in the West stage.

The absence of cooling in this locations compared to others in the area is most likely because the region intersected by 2025-12-Wa has remained in close proximity to the original batter of the pre-2016 landform and hence is more likely to be influenced by lateral advection into the stockpile driven by significant convection. MRM will be undertaking a more detailed investigation of the area in 2025 to determine the best approach to manage sulfide oxidation at this location.

The elevated temperatures at bores 2023-05-Wd and 2023-06-Wd (formerly 32 and 33) again reported, with the statement that *“All three locations are under investigation to determine the best course of action and what type of controls are required.”*

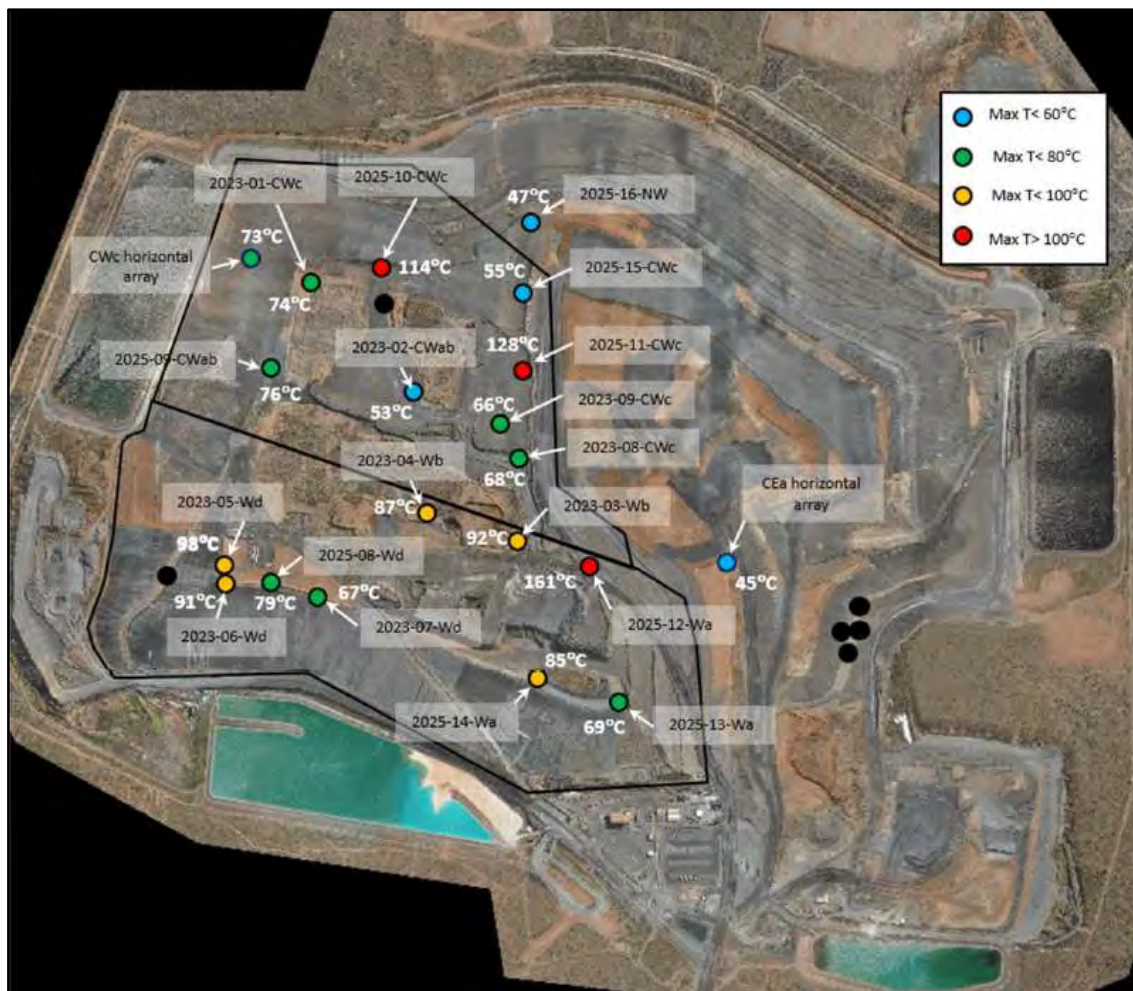


Figure 4-15: Maximum temperatures recorded in monitoring arrays (Fig 11 in MRM 2025a).

It is understood that MRM expects the mitigation measures implemented at the pre-2016 NOEF area such as excavation, improved geometry, improved drainage, placement of a wet season cover and clay capping may not yet have resulted in a material reduction in temperature at this specific area and that further controls are being considered.

During the site visit, the NOEF Panel was informed by MRM of a failure of the BGM that had occurred in this corner of the NOEF in early 2025. The extent of the damage was captured by a drone survey in February 2025 (**Photo 4-3**). This damage was repaired prior to the site visit by the NOEF Panel in April 2025.

This relatively small failure may have been due to seams between BGM sheets parting as result of problems with the joining method that was used. The NOEF Panel understands that MRM has committed to place some focus on the QC / QA associated with the BGM storage and handling, and seam joining process in the next stage of implementation of the BGM cover concept.

It is also possible that 'bulging' of the NOEF in this specific area placed tensile strain on the BGM seams, which failed due to the bitumen exhibiting viscous creep in the direct hot sun. The Panel understands that MRM has commissioned targeted research into the characteristics of the BGM liner with respect to the field conditions under which it is applied at the NOEF.

Another possibility is that the higher temperatures recorded in this specific part of the NOEF could have been a contributing factor to the failure, noting that softening temperature of the BGM material is approximately 150 °C. During the April 2025 Panel site visit it was noted that some of the rolls of BGM located at the MRM storage area prior to intended use at the NOEF were stored directly on the ground in the open instead of on the metal rollers under cover and this may also have the potential to impact upon the integrity of the applied

BGM layer. There is therefore an opportunity for improvement in some of the storage and handling practices for the BGM liner.



Photo 4-3: MRM drone image of NOEF BGM cover taken 16-02-25

It should be noted that one of the main mitigation measures for the pre-2016 parts of the NOEF was to go higher towards the final design height as fast as possible to prevent further wetting up of the material and reduce oxygen ingress from the top, as well as placement of the BGM on the batters. It is therefore possible that no temperature improvement in this specific pre-2016 NOF area will materialise until the NOEF is lifted higher by at least 20 m or an impervious cap is placed on the plateau. Any increase in NOEF height beyond 80 m is currently subject to the cultural approvals process.

In summary, the post-2016 systems that are in place to characterise source waste material, to place it correctly in the NOEF, and to do final audit checks on placed material demonstrate a very high level of rigour and leading industry practice (as previously detailed in **Sections 4.1.2 to 4.1.4**). This highly developed and implemented approach should minimise the possibility of wrong placement of material and hence maximise the design functionality of the post-2016 sections of the NOEF. In particular, the findings to date from the comprehensive in situ temperature and oxygen monitoring programs indicate that:

- The fine-grained alluvial barriers and the lower lift construction appear effective in reducing sulfide oxidation rates within the PAF cells, noting that internal temperatures in the historical West stage appear higher than in the more recent Central West Charlie stage (See **Figure 4-2** for NOEF locations and **Figure 4-15** for temperature data); and

- The oxygen concentration profile from the Central West Charlie horizontal array shows that oxygen concentrations in the outer PAF cell (15 m below the batter) are close to 1 %, indicating the halo + fine grained advection barrier is effective at reducing oxygen advection into the batter material.

However, the pre-2016 section of the NOEF will require continued vigilance and implementation of management practice that addresses its specific legacy issues in order that it does not compromise the long-term environmental performance of the structure. In this context it should be noted that the elevated internal temperatures are being measured in bores NOEF 2023-32 and NOEF 2023-33 in the southwest quadrant of this area, and the very high internal temperatures at bore 2025-12-Wa located adjacent to the original northern batter

Again these findings can also be related to the current NOEF height restriction of 80 m rather than the design height as cultural approvals are required before this height restriction can be addressed and the pre-2016 parts of the NOEF built to the planned design. If the design of the NOEF at the Pre-2016 areas can be implemented as soon as possible, the Panel expects that the likelihood of potentially higher oxygen ingress and elevated temperature at the southwest quadrant of the pre-2016 areas can be reduced, and consequently, also the potential for any future BGM layer failure in this area.

4.2.3 Air quality

The Mine is located approximately 44 km and 28 km from the nearest identified sensitive receptor locations of Borroloola and Devils Springs respectively and therefore the influence of air emissions from the Mine on the townships is likely to be low. Notwithstanding, MRM operates in accordance with the *MRM Air Quality Management Plan (MRM, 2024e)*, which outlines the operational management measures and monitoring programs implemented to minimise air quality related impacts from the Mine's operations with respect to community health and the environment.

Key environmental risks to air quality related to the NOEF are associated with dust (particulate matter) and sulfur dioxide (SO₂) emissions. According to the MRM Adaptive Management Plan (MRM, 2022) the main air quality objective as the mine is to "*minimise air quality-related impacts from the Mine's operations with respect to community health and the environment*".

MRM currently implements its Air Quality Management Plan to monitor, assess and manage potential air quality impacts at the mine site and the Bing Bong Loading Facility (BBLF). Dust is being monitored on several locations at the mine site including the NOEF, TSF, open pit, ROM, mill and the camp facilities. Todoroski Air Sciences Pty Ltd (TAS) concluded in the 2023-2024 Environmental Monitoring Report (MRM, 2024h) that:

- particulate monitoring data (including lead and zinc) showed that elevated results were confined to areas near to the mine processing and mining areas. The mine monitors located further from these areas (i.e. greater than approximately 1km away) generally recorded low pollutant concentrations which would be considered at or near to the likely background pollutant concentrations for the area.
- Particulates only travel a short distance before they are dispersed and/ or deposited and it was inferred that dust concentrations (due to the mining activities) at Borroloola and Goolminyini would likely not be discernible from background concentrations. The data indicated a very low risk of any potential health impact in any known community due to inhalation of mining related air emissions.
- It is important to minimise the emissions of lead from the operation to the lowest feasible concentrations as it is a toxic pollutant which can enter and damage the surrounding environment and may lead to health issues for workers.
- Depositional dust levels adjacent to the Carpentaria Highway have remained relatively low and consistent with previous April – June periods. It is unlikely there would be any impacts from dust emissions on Carpentaria Highway users or the environment at this location

While depositional dust in the vicinity of the Barney Creek Diversion Channel adjacent to the NOEF remained higher than other locations during the 2023-2024 reporting period, the elevated dust levels were primarily attributed to wheel-generated dust emissions on the unsealed haul roads, in particular near the Barney Creek Haul Bridge. This can also be due to the increase in haulage of waste rock from the Open Pit to the NOEF.

Consistent with previous years, these elevated dust levels are likely to impact the fluvial sediments within the Barney Creek Diversion Channel. Fluvial sediment quality will be assessed and, if required under the Adaptive Management Plan (MRM, 2024c), will be remediated prior to the onset of the wet season. MRM is currently investigating options to reduce dust levels in this area via the use of binding agents for haul road surfaces.

The NOEF Panel has reviewed the internal monitoring that is being completed within the NOEF to confirm that the construction practice is reducing oxygen ingress and suppressing spontaneous combustion in the most reactive material. The SO₂ measurements in the 2023 / 2024 reporting period indicate that this is the case and there were no exceedances of the National Environmental Protection Measure (NEPM) standard for SO₂ at monitoring locations SO2VAN01 and SO2Village. Therefore, if reactivity is being suppressed then it follows that SO₂ emissions to air from the NOEF will also be reduced. This is illustrated by SO₂ monitoring data recorded as part of the routine MRM monitoring program where SO₂ values are well below the applied Australian standard.

4.2.4 NOEF as a Solute Source

A drilling program carried out in 2015 and 2016 (Appendix A, OKC 2016) showed that the reacted material in the original footprint of the NOEF contains a substantial mass of leachable oxidation products. This is a legacy issue that needs to be acknowledged, since this original section of the NOEF will always be different to the new (much larger part) that is being constructed from the ground up to reduce oxidation of the contained high PAF material, and hence minimise the legacy load of contained solutes.

Groundwater monitoring bores were installed during the 2015/2016 drilling program. Importantly no free water was intersected at any level within the NOEF, and the material was characterised by a relatively low moisture content. This can largely be attributed to the elevated temperatures (65 °C and above) pertaining when the material was initially deposited, and the subsequent extremely high temperatures generated by spontaneous combustion.

The DumpSim modelling conducted in 2016 (Table ES.1 in OKC, 2016) shows that the leachable oxidation products contained in the original reacted section of the NOEF will potentially contribute by far the majority (80 %) of the future load that could come from the NOEF footprint, given the likely order of magnitude reduction in solute load from the rest of the NOEF predicted to result from the implementation of the current method of construction. The key conclusion is that the historic “pre-existing” stored load sets a minimum load that can be achieved by ongoing management by cover systems of NOEF water balance at the site.

One of the questions that is asked is will measurements of current seepage composition inform how the NOEF will perform in the long term? The relevant issues are discussed in Section 6.6 -Pore Water Geochem module of DumpSim (OKC, 2016), with the following extract providing a summary.

Extensive NOEF water quality monitoring data are available, although water quality of samples collected from the NOEF drains are likely to be influenced by surface runoff, interflow, and seepage. The proportion of water from each of these sources at the time of sampling is unknown. Similarly, the extent of geochemical reaction within the drain from seep to sampling point are also unknown, which would affect trends in non-conservative ions (e.g. ferrous). Thus, it was not possible to simply assume the East and Interception drain water quality represented pore-water chemistry within the NOEF. Hence, geochemical modelling was required to determine likely pore-water quality and solubility controls, based on ‘concentrated-up’ field data.

It is also stated in the most recent conceptual groundwater report (KCB, 2022) that the water stored in the PRODs is transferred from other areas of the Mine as part of MRM’s site water management and thus may not be reflective of seepage or runoff from the NOEF.

Central to making a robust / reliable prediction of future salt and metal / metalloid loads from the NOEF is being able to estimate the concentrations of solutes in pore water within the mass of the overburden. These are the key data required for input into models that have been used to predict the dynamic course of loads from the NOEF during operations and post closure. The starting point for this for both the OKC (2016) and KCB (2017) modelling assessments has been the composition of leachate generated from samples collected during the 2015 / 2016 NOEF drilling program. These data are compiled in OKC (2016), Appendix E for each of the five effective overburden types identified in **Table 4-7**.

The liquid to solid ratio used for the laboratory leach test work is more than an order of magnitude greater than the ratio that was calculated to be present within the NOEF. Hence, the concentrations measured in the leach extracts needs to be effectively “concentrated up” by multiplying by this scaling factor. However, this will produce a solution composition that is supersaturated with many mineral phases at the prevailing pH. A thermodynamic geochemical numerical model was used to predict the final equilibrium concentrations that would be present in solution, after allowing for the precipitation of supersaturated mineral phases. A similar approach was applied by both OKC (2016) and KCB (2017).

The tabulated composition of predicted porewater compositions for each of the five waste categories provided in OKC (2016) and it is understood that these data were used for the KCB (2017) modelling to ensure that a consistent dataset was used for the two modelling approaches. This compilation is reproduced in **Table 4-7** below for reference in the following discussion. The term “Concentration Factor” in the table refers to the scaling factor applied to concentrate up the leachate produced by the leach test work conducted on the overburden waste types.

Table 4-7: Predicted porewater composition for waste types (OKC, 2016)

Waste Type	Units	LS-NAF (HC)	MS-NAF (HC)	MS-NAF (LC)	PAF (HC)	PAF (RE)
Concentration Factor		44	50	46	35	48
pH	pH units	8.07	6.83	7.02	7.55	6.16
Aluminium	mg/L	0.001258	0.0002533	0.0003082	0.0000452	0.00031
Arsenic	mg/L	0.8593	2.406	1.052	0.583	0.930
Barium	mg/L	0.003946	0.0108	0.01072	0.00704	0.00972
Boron	mg/L	2.15	3.58	7.23	4.11	7.52
Calcium	mg/L	39	209	160	627	503
Cobalt	mg/L	0.2148	0.0009357	0.1349	0.128	0.000054
Copper	mg/L	0.0001149	0.0004014	0.0005188	0.000911	1.43E-11
Iron	mg/L	0.0004718	1.303	0.5678	0.00298	6.78
Lead	mg/L	0.04297	0.4221	0.4198	4.51	2.24
Magnesium	mg/L	108	1,016	421	298	5,222
Manganese	mg/L	0.57	6.27	2.35	0.93	20.60
Nickel	mg/L	0.05	0.69	1.55	0.32	2.90
Uranium	mg/L	0.07	0.1	0.08	0.006	0.05
Zinc	mg/L	0.26	2.6	8.1	5.9	20.1
Sulfate	mg/L	2,114	8,185	7,481	6,300	28,525

Notes: The porewater composition data used for some of the PAF (HC) and PAF (RE) materials appear anomalously low compared to that used for the various NAF materials for aluminium, cobalt, copper and iron (as marked in yellow highlight).

The fundamental question is how realistic these numbers are in the context of what will actually be present in seepage that will be produced through time from the NOEF. How can these numbers be validated? There are two approaches that can be used. Firstly, to use measured water quality data from collection points exterior to the NOEF. The intrinsic problems associated with this approach have been summarised in italics previously in this section.

Dissolved (i.e. filtered) water quality data extracted from the MRM monitoring program from 2016 / 2017 are compared to the predicted / modelled results in **Table 4-8** (Tables 6 and 7 reproduced from KCB (2017)). Importantly, the data for the wet season was excluded to reduce impacts of rainfall dilution on the analysis. No details of where these water samples were collected from were provided in the KCB report, and the cited source (MRM/Ecological 2017) was not provided in the reference list. Hence the IRP was not able to independently verify the provenance of these data.

Given the assumptions that were made in the modelling calculations, the measured dissolved (i.e. filtered) water quality data and the modelled concentrations for As, Cd and Pb are comparable, although measured dissolved Zn and SO₄ concentrations tend to be higher than predicted.

There is an opportunity to revisit this comparison (between predicted and seepage WQ) with current monitoring data, noting that the water coming out of underblanket drainage system installed under the new section of the NOEF should be able to provide seepage water samples that are not compromised by surface runoff.

Table 4-8: Tables reproduced from KCB (2017)

Table 6: Water Quality Data from the NOEF (MRM/EcoLogical, 2017)						
	pH - Field	Sulphate (mg/L)	Zn (mg/L)	As (mg/L)	Cd (mg/L)	Pb (mg/L)
25th Centile	6.75	3,800	0.154	0.0018	0.0002	0.0004
50th Centile	7.01	7,305	0.578	0.0035	0.001	0.0012
75th Centile	8.07	15,755	6.035	0.0091	0.0102	0.0051
90th Centile	8.13	18,940	8.99	0.0099	0.0135	0.0073

Table 7: Modelled Water Quality Data for 2018											
	pH	SO4		Zn		Pb		As		Cd	
		mg/L									
25th Centile	7.35	6254	7935	0.82	1.28	0.012	0.022	0.006	0.011	0.0031	0.0011
50th Centile	7.40	6503	8647	0.86	1.34	0.013	0.025	0.006	0.020	0.0035	0.0011
75th Centile	7.46	6823	9075	0.92	1.38	0.014	0.026	0.007	0.027	0.0039	0.0015
90th Centile	7.50	7021	9399	0.95	1.49	0.015	0.033	0.008	0.030	0.0041	0.0017

The second approach to validation is to compare the measured porewater composition within the NOEF with the composition inferred from the leachate test work input to the predictive model. There is only one bore (GWNOEF1NSL) in the NOEF that is screened through the overburden waste profile, and which has been regularly sampled since 2016 (Figure 4-16).



Figure 4-16: Location of Bore GWNOEF1NSL

The 75th percentile dissolved (i.e. filtered) water quality data for this bore for the monitoring period 2016 to 2022 are compiled in Table 4-9. The 75th percentile has been used as this is typically used to screen data for compliance with water quality guidelines and will capture the bulk of a dataset.

Table 4-9: 75th percentile dissolved values for Bore GWNOEF1NSL (2016 – 2022)

Parameter	Units	Value
pH - Lab	pH units	7.5
Dissolved Oxygen (%)	mg/L	41.9
Calcium	mg/L	520
Magnesium	mg/L	5,158
Sulfate	mg/L	18,144
Nitrate	mg/L	19.2
Cobalt	mg/L	0.028
Copper	mg/L	0.007
Manganese	mg/L	9.49
Nickel	mg/L	0.064
Thallium	mg/L	0.047
Zinc	mg/L	10.8
Boron	mg/L	0.54
Selenium	mg/L	0.026

The composition of the water in GWNOEF1NSL is very similar to both the water sampled from around the toe of the NOEF (**Table 4-8** from KCB (2017) reproduced above) and to the predicted composition of porewater from the PAF (HC) and PAF (RE) overburden waste categories in **Table 4-9** above from OKC (2016). One notable difference is the elevated level of nitrate which comes from blast residues in the overburden and is not a product of sulfide oxidation.

The concentration of nitrate in seepage from the NOEF needs to be addressed as part of the ongoing management of seepage from the NOEF. Thus far, nitrate has not been explicitly included as part of the predictive regional groundwater and surface water quality modelling conducted by KCB (KCB, 2024), noting that it was recommended in the Annual Groundwater Monitoring Report 2023 / 2024 that elevated levels of nitrate measured in bores in the vicinity of the NOEF required further monitoring as the nitrate source is most likely the ammonium nitrate used in blasting.

Based on the above multiple lines of evidence it is concluded that the solute concentrations that have been used for input to the predictive solute load modelling are fit-for-purpose. This applies also to the pre-2016 footprint as the concentrations of solutes in seepage will be subject to the same solubility pH constraints as the new section of the NOEF. However, as stated above, the leachable oxidation products contained in the original reacted section of the NOEF will contribute by far the majority (80 %) of the future load that could come from the NOEF footprint as a whole, assuming that the new section of the NOEF performs as predicted.

In particular, the conclusions summarised below from KCB (2017), and consistent with the conclusions in OKC (2016), are appropriate.

- MRM can expect to manage pH-neutral, high sulfate, high magnesium water with varying proportions of other ions.
- For most metals / metalloids solubility and mobility will be relatively low due to the pH circum-neutral to mildly alkaline water that is predicted to occur.
- For the Contaminants of Potential Concern, Zn concentrations are expected in the range of 5 to 10 mg/L, while the other metals used as indicators are expected to remain similar to current concentrations.

The numerical modelling conducted by OKC (2016) predicts that the seepage load expected to come from the base of the NOEF will reach a quasi-steady state whilst the NOEF is being built and then decline as the final infiltration limiting cover systems are being put in place. This is the result of solute concentrations being solubility constrained. **Figure 4-17** and explanatory text from OKC (2016) describes this for sulfate.

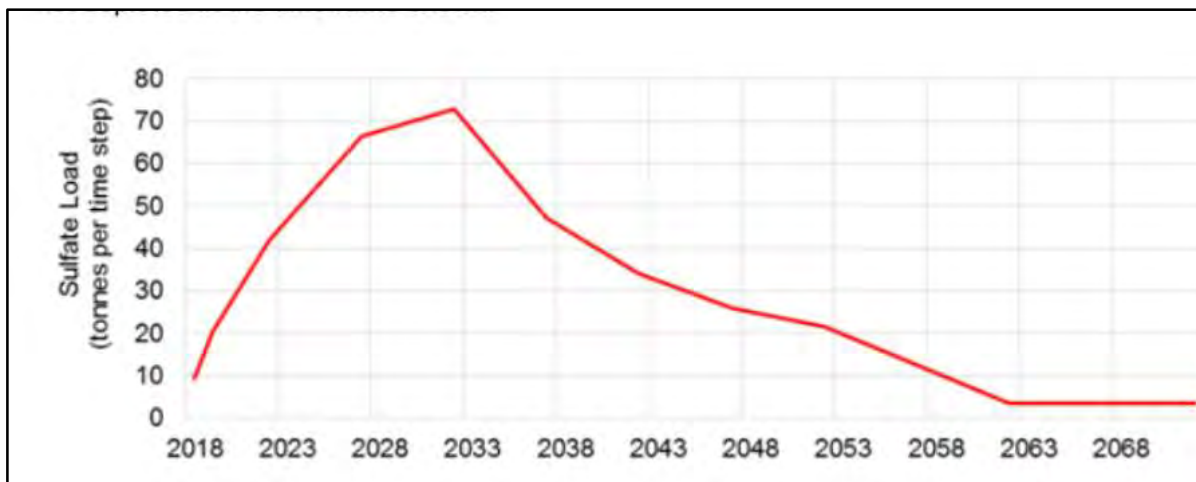


Figure 4-17: Predicted sulfate load over time (source Figure ES.4 in OKC, 2016)

Subsequent work by KCB has employed a more sophisticated numerical modelling approach using Tough 2 to predict the behaviour of the NOEF at several points in time (KCB, 2017). However, this modelling does not incorporate the dynamic landform evolution time series approach, specifically in the context of the water going into storage during each wet season, as done by OKC (2016).

The conclusion reached by KCB, 2017 using Tough 2 is essentially the same as predicted by the DumpSim modelling (OKC, 2016). Specifically, provided that the new design (use of thinner lifts coupled with interlayer advection barriers) is implemented the:

- Water quality from the NOEF is expected to be similar to that currently observed.
- Salinity and sulfate levels will increase over time and stabilise within about 50 years after operations.
- The drainage water will be pH neutral, high sulfate / high magnesium with varying proportions of other ions. For most metals/metalloids, solubility and mobility will be relatively low due to the circum-neutral, to mildly alkaline water.

Time series plots of the predicted pH and concentrations of key solutes in both basal and toe seepage are provided in Figures 3.11 to 3.16 in KCB 2017.

The focus of this section has been on assessing the reliability of the predictions of concentration and loads of solutes emanating from the base of the NOEF through time. Whether or not these values are significant in the context of protecting the McArthur River (the ultimate performance measure) can only be determined by integrating the NOEF into its hydrogeological landscape and using a solute transport model to predict the downstream outcome. This modelling has been done and is the subject of **Section 4.2.6** of this report.

4.2.4 Surface Runoff and Seepage Monitoring Results

4.2.4.1 Seepage Management

There are four fundamental aspects of seepage management from the NOEF which need to be considered:

- The natural setting within which the NOEF is constructed – being the hydrogeology, the geology and geologic structure, the hydrology, and the climate variability within which the facility must operate. These also define the potential for pathways for seepage migration to develop, and their interaction with receptors such as creek / diversion discharge.
- The design and construction process of the NOEF, including progressive redesigns implemented to improve the generation and management of seepage risk and potential need for mitigation, and consideration of the planned closure conditions for the landform. Particularly, liner and cover designs, their strategy and schedule for deployment, and internal (NOEF) management practices to address the presence and permanence of water, and its effective control during operations and closure.

- Predictive work undertaken to assess seepage impacts of the NOEF on the local groundwater system and to the noted receptors of local water systems including the McArthur River. This includes those models used to estimate losses from the NOEF, and models designed for three-dimensional flow field analysis to represent the travel and re-emergence of seepage derived from the landform. This aspect of seepage management is further complicated by the uncertainty which surrounds the prediction of pore water compositions and their 'blend' with other waters once they egress the NOEF as previously noted in **Section 4.2.4**.
- Collection and interpretation of observational data to support the process of impact prediction assessment, to implement future impact mitigation strategies and to potentially trigger design modifications to the NOEF, the PRODs, or to surface water or groundwater receptors at risk of unacceptable impacts. This observation component is also critical in improving the predictive outcomes of numerical models through reduction in model non-uniqueness, and in informing closure requirements for the mine as conceptual confidence improves and matures.

4.2.4.2 Design and Operational Philosophy

MRM's general stated key objectives associated with water management of the NOEF include that the facility:

- Controls surface water runoff to meet MRM's commitments on surface water quality at the statutory compliance points.
- Limits seepage water quantity and solute loads such that compliance point SW11 thresholds are not exceeded.

Compliance point SW11 is located east of the collective mining leases of the MRM operations (**Figure 4-18**). At this location the McArthur River comprises the collective flows of the McArthur River, Barney and Surprise creeks, Emu Creek, and the Glyde River. Water quality at SW11 is therefore an outcome of combined flows from each of these catchments, which route around the major mine area domains of the TSF, the open pit, and the NOEF. The McArthur River emerges from the mine area through a topographic low in a north-south trending ridgeline located east of the mine. The Glyde River joins the McArthur River to the east of this feature.

Conceptual interpretation of the area reported in KCB (2024b) shows hydrology of the catchments reporting to this location are highly connected to shallow groundwater systems, and that they exhibit very strong seasonality in groundwater elevations and surface drainage flows, particularly in response to peak events (such as cyclones).

This location of SW11 somewhat complicates the manner in which the performance of, and potential impacts from, the NOEF are to be differentiated from other mine domains. The regional scale approach (entire mine site and surrounding geology) to determining the performance of mine domain scale impacts requires a method to reasonably differentiate the performance of the NOEF whilst respecting the influence of other mine domains on groundwater and surface water qualities.

This scalability challenge is important in the review process, particularly in determining a suitable balance of 'granular detail' of prediction tools whilst maintaining reasonable complexity and functional integration of predictive tools with system performance and adaptation.

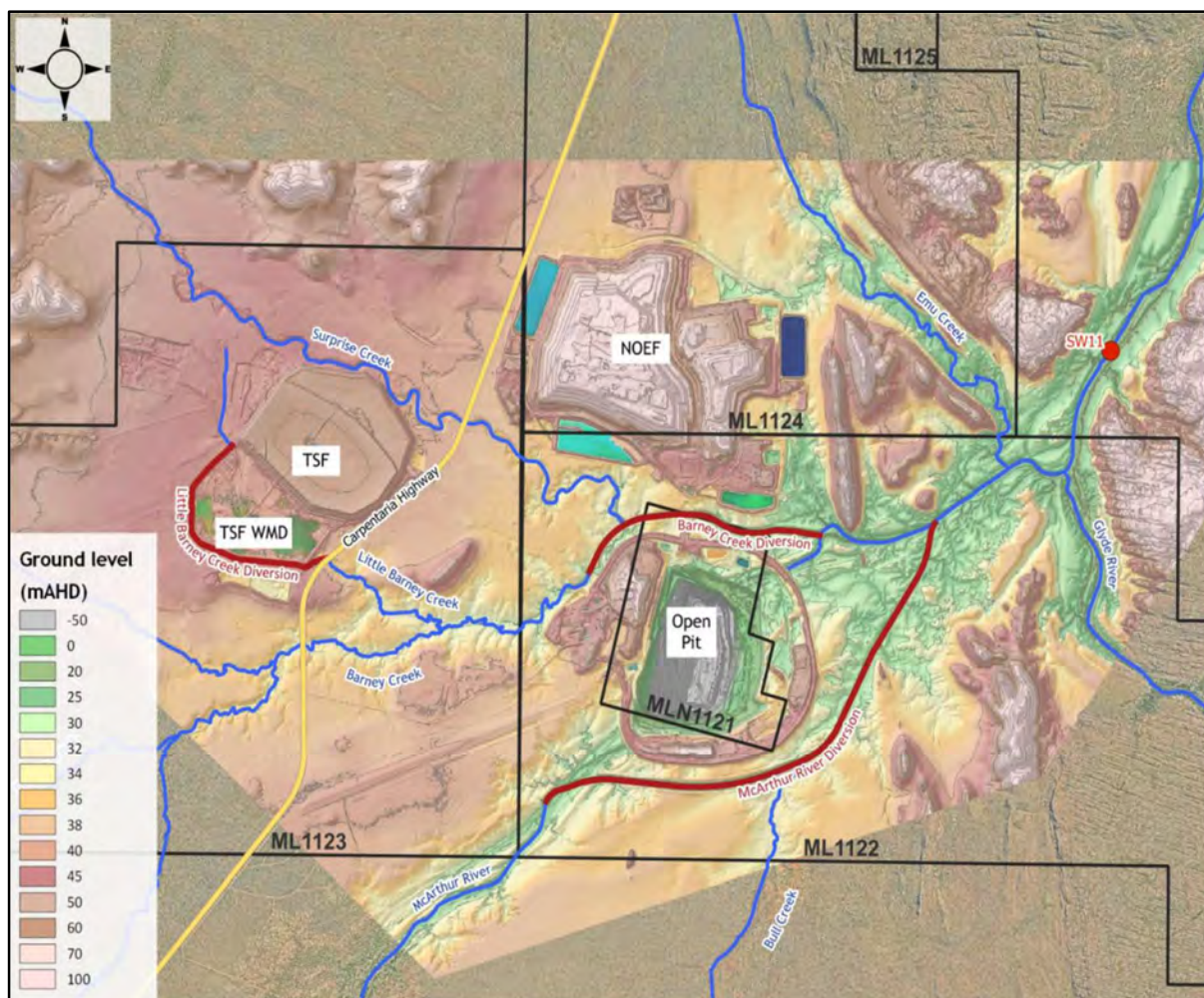


Figure 4-18: Major Drainages (Natural and Diversions) and Topography of the Mine Area, and Location of Compliance Site SW11 (WRM, 2024)

4.2.4.3 Adaptive Approach to NOEF Operational Improvements

Evaluation of the performance of a facility such as the NOEF is best served through vigilant performance review, collection and interpretation of a wide range of technical data, conceptualisation updates which constantly challenge and seek to improve the initial site evaluations, progressive improvement in numerical predictive tools which are then used to forecast NOEF performance and to influence future design and construction practices as needed. The basic concept of this approach is provided in **Figure 4-19**.

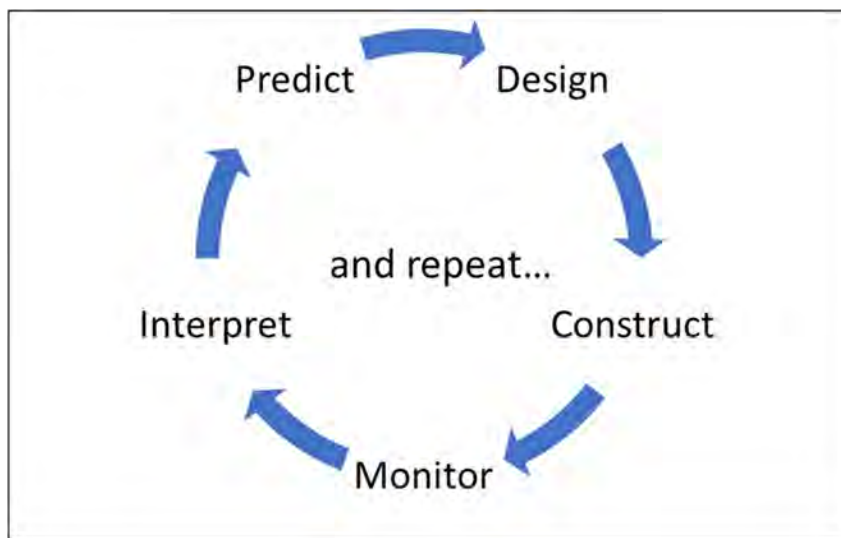


Figure 4-19: Key aspects of continual improvement

The NOEF is a complex and meticulously constructed structure. This review has sought to consider the rolling cycle of performance evaluation and design and construction improvement in the context of water related risk to Compliance Point SW11, applying these fundamental principles:

- **Design:** Have improvements to design been applied with intent (among others) to reduce risk of problematic seepage or water loss from the facility and; what have been the drivers of this change and the intended change to performance required?
- **Construction:** Has construction practice met design and performance intent, with specific focus on potential of the NOEF to generate seepage related impacts? Construction in this context includes the lifecycle of NOEF development, as well as the post-closure period.
- **Monitoring:** Does a suitable monitoring network exist which adequately allows review of NOEF performance and the collection of data to improve conceptual understanding of the site?
- **Interpretation:** Have the monitoring and performance data been evaluated, and the outcomes of this process applied to ongoing design. This is a particularly important aspect to the cycle as too often the collection of data is seen as a means to improve model calibration. These data must be applied to:
 - Improve the conceptual understanding of the setting within which the NOEF is constructed, and in doing so, aim to reduce non-uniqueness in predictive model outcomes;
 - Provide early indication of excursion of NOEF performance from design or from that predicted, so that design or construction can be improved, or, if required, mitigation measures can be considered; and
 - Improve the calibration performance of numerical predictive tools.
- **Prediction:** Predictive tools are a critically important aspect to facilities such as the NOEF. Measurement of internal performance is very difficult due to the internal dual phase conditions and the access complications on ongoing construction. Interaction of seepage with the natural environment is also challenging due to the complex nature of local pathways and the degree of interaction that occurs with other sources of water.

Interaction of the NOEF with the natural environment is therefore based on prediction of water quality egressing the structure, prediction of the locations and rates of seepage which occur, prediction of the timing of this release (seasonally, and within the full construction lifecycle), and the prediction of interaction of these losses with natural and other mine affected waters.

- **Process Repetition:** Continual improvement requires constant repetition of this process within reasonable timescales for lessons to be learned, adaptations to design to be constructed, and collection of new monitoring data to verify improvements and to revise predictions of performance as outcomes of this improvement.

A key reason for the importance of this process is that groundwater impacts, and related surface water impacts, cannot be eliminated in design, and when they occur, cannot be easily and quickly mitigated. Pathways are often tortuous or chaotic, and the quality, location, rate, and timing of losses generally occur beyond the reach of direct measurement.

Leading practice in this regard is associated with application of the process described, rather than a singular aspect of design, construction or performance.

4.2.4.4 Source-Pathway-Receptor Approach to Assessing Performance

The preceding content describes the challenges of evaluating the hydrogeological and hydrological performance of the NOEF.

Collection and interpretation of monitoring data play a key role in the process of improvement – locating of monitoring infrastructure and establishment of data collection regimes (groundwater levels, samples, creek flows, etc) needs to be aligned to the conceptual understanding of the NOEF and the hydrogeology within which it resides.

No impact from the NOEF to Compliance Point SW11 is possible without both groundwater and surface water flow paths creating the 'link'. There is a significant contrast in timing of these pathways which needs to be considered.

- Surface water flows may report to SW11 within hours, or days. A key design intent of the NOEF remains the prevention of losses to surface water drainages, predominantly due to this risk.
- Groundwater velocities are much slower, being a product of aquifer permeability, hydraulic gradient and porosity. These velocities are further complicated by heterogeneity and tortuosity of pathways within their hydrogeological setting.

A Source-Pathway-Receptor (SPR) concept approach to evaluating groundwater risks associated with the NOEF is applied in this review and is aligned with the general approach to evaluation of mine impacts to regional waters.

The **source** of potential impacts is the NOEF and contact water egressing the facility either through foundation seepage, or lateral emergent seepage and contact with surface water features. Key aspects of the source include the design and construction process of the NOEF, the conditions of the landform during and post construction, the saturation and residence profile within the structure which will generate the quality of water potentially available for seepage, and the pressure and pathway conditions which will allow water to exit the landform.

The **pathway** for contact water is the fundamentally the hydrogeological system within which the NOEF is constructed, noting this includes both shallow and deep-seated groundwater pathways of varying levels of interconnection, under various mining related and natural stresses, and surface water drainages and storages.

The **receptor** for the performance of the NOEF is the surface water monitoring station SW11.

This simplified description of the challenge of managing NOEF seepage risk does not adequately address the changing conditions of the landform, or the improving knowledge of the performance of the landform that occurs with time. The development of a conceptual understanding of the site and the prediction of system performance is not a static process.

On a timeline from initial design to current, the first stages of NOEF design and construction (following the decision for the mine to proceed) represents the lowest point of knowledge of the site's lifecycle. This is an important observation. The management of a structure like the NOEF is a dynamic process which requires constant adaptation and improvement in design, construction and operational practices. This process also results in improved understanding of the site through the collection and analysis monitoring data, additional drilling and testing, construction records, and interpretation improvement using this information.

4.2.4.5 Hydrogeological Setting of the NOEF

The purpose of the hydrogeological conceptualisation of the NOEF and surrounding area is to provide a data informed and scientifically interpreted description of the site hydrogeology to determine (i) the nature and distribution of hydro-stratigraphic units of relevance to the NOEF, (ii) to identify the potential pathways for groundwater movement or pressure translation from and around the facility, and (iii) to define the receptors at risk from seepage from the NOEF which need to be considered in NOEF design and construction, groundwater

and surface hydrology monitoring strategies, and predictive modelling work to forecast system performance and mitigation requirements.

Key aspects of the conceptualisation should comprise:

- Definition of hydro-stratigraphic units (aquifers and aquitards) including description of their distribution, their hydrogeological properties, and their water balance componentry.
- Presentation of the data used to define the conceptualisation and the monitoring data collected to understand transient processes of relevance to impact evaluation
- Hydrogeological process definition which includes recharge and discharge conditions for each of the hydro-stratigraphic units, horizontal gradients, vertical gradients across the profile and seasonal variability they may expect to experience.
- Groundwater, surface water, NOEF water quality and climate condition understanding.
- Description of the interaction between the NOEF and natural conditions.

Much of the following discussion of the conceptualisation of the site and the monitoring network and its observations is sourced from two primary documents: KCB (2024a) being the Annual Groundwater Monitoring Report for the 2023 / 2024 period, and KCB (2024b) being the draft 3D groundwater modelling update, which includes an updated conceptual description provided as Appendix I of this report, and a dedicated description of the monitoring network for the mine as Appendix II.

These are each the most current versions of their respective content and they therefore comprise the most current interpretations and updated datasets.

4.2.4.6 Regional Setting

The mine is located within middle Proterozoic basement rocks of the Umboloola Subgroup of the McArthur Group (NT GS, 1991, and KCB, 2024b).

All of the mine domain lies on the McArthur River floodplain, which is deposited upon and around outcrop of the Proterozoic basement. The floodplain exists due of the topographic constraint of the north-south ridgeline (**Figure 4-20**), which has created an effect of damming mobilised material from the various drainages that merge to form the McArthur River. The Emu Creek has also created a breakthrough of the ridgeline, which flows to the southeast and merges with McArthur River prior to the Glyde River joining the system.

The regionally mapped Cainozoic (Cz) shown in **Figure 4-20** within the floodplain is a geological simplification but is intended to show the general nature and distribution of the floodplain deposits beneath the NOEF, as they relate to the more regional hydrological form of the McArthur River and its subordinate drainages, and the relatively shallow basement which protrudes through the floodplain deposits where elevations allow.

More locally, the NOEF sits on the Emu Plains between the Carpentaria Highway to the west and Barramundi Dreaming (also known as Mount Stubbs) in the east. The landform has a maximum design footprint of 775 ha, and a (to be approved) construction height of greater than 80 m. The NOEF is designed to facilitate storage of a range of overburden types in a physically and chemically stable structure. To achieve this, the NOEF has various zones within its structure in which different material types with different properties are stored. Each zone stores an assigned set of material types and corresponding placement methodologies for those materials.

From MRM (2023) *“The operational schedule for the stage is uncertain, due to the delay in approvals to construct the upper NOEF lifts above the current 80 m height limit. The timings presented here assume the granting of the required approvals by the end of 2022 – if delays to this are experienced, the NOEF construction schedule will proceed faster than stated here.”*

Cumulative Rainfall Departure (CRD) is used throughout the various technical studies to provide a description of climate conditions at the mine and to assist in the understanding of groundwater response to recharge, and interactions of groundwater to surface water. CRD is a commonly applied method to show short term (seasonal) and long-term trends in climate data and aligns well with hydrogeological evaluations. Long term average annual rainfall is 866 mm, with most rain falling within the wet season period of October to March inclusive. Since 2011 the CRD has exhibited a season-scale variation of 400 mm to 800 mm, with a slight decline noted in the longer-term trend from 2011 of about 30 mm/yr.

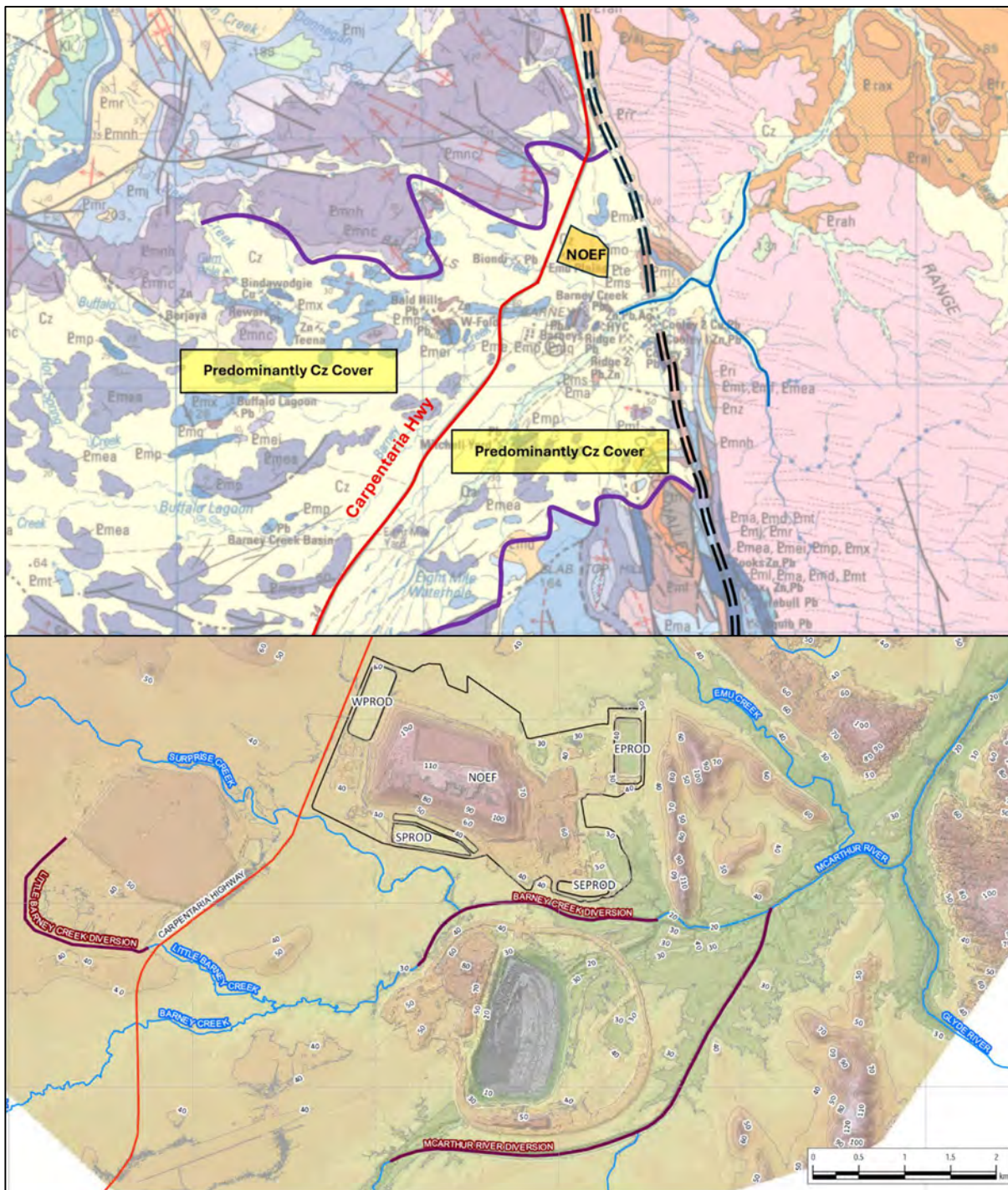


Figure 4-20: Upper - 1:250,000 Geology (Bauhinia Downs SE 53-3, NT GS (1991) Showing Extent of McArthur River Floodplain (Cainozoic, Cz) Upstream of the North-South Trending Ridgeline, and Approx. NOEF Location, Lower – Local Topography and Drainage Features of the NOEF at 2019 (KCB, 2024b)

4.2.4.7 Site Wide Hydro-Stratigraphy

The geological sequences of the site are summarised in Table 3.2 of Appendix I of KCB (2024b), reproduced in **Figure 4-21**. The system is broadly summarised into four generalised hydrogeological domains (italicised descriptions are from KCB 2024b directly):

- Alluvium / unconsolidated cover: ... *Unconsolidated sand and gravel have been deposited along the main drainage channels across the Mine. Where saturated and of suitable thickness, these typically form narrow, elongated coarser grained unconfined aquifers generally of local scale. Outside of the drainage channels, the alluvium is either absent, of insignificant thickness or comprised of finer-grained silts and clay less conducive to water storage and transmission. Subordinate alluvial sediments of smaller creek systems remain important as they influence shallow hydraulic conductivity and provide a potential pathway for migration of mine-affected water. Their depth, width, continuity and aquifer conditions are generally a function of their size and local influences*
- Weathered Bedrock: ...*includes localised, unconfined to semi-confined aquifers located at the boundary between soil / weathered bedrock and contiguous bedrock (local or perched).*
- Bedrock: ...*includes both fresh (intact) and fractured bedrock. Groundwater within the bedrock occurs in open vugs or solution channels, fractures, joints and faults.*
- Structures (faults): ... *Major structures at the Mine are Emu Fault, Western Fault Block, Whelans Fault, Woyzbun Fault and the Barney Trend Corridor. Further review and definition of the structural framework have continued since the EIS-S, and a new fault, the Myrtle Fault, and other potential structures have also been identified.*

Mine scale distribution of these units with the locations of major mapped structure is provided in **Figure 4-21** and a summary of the hydro-stratigraphy in the mine area is provided in **Figure 4-22**.

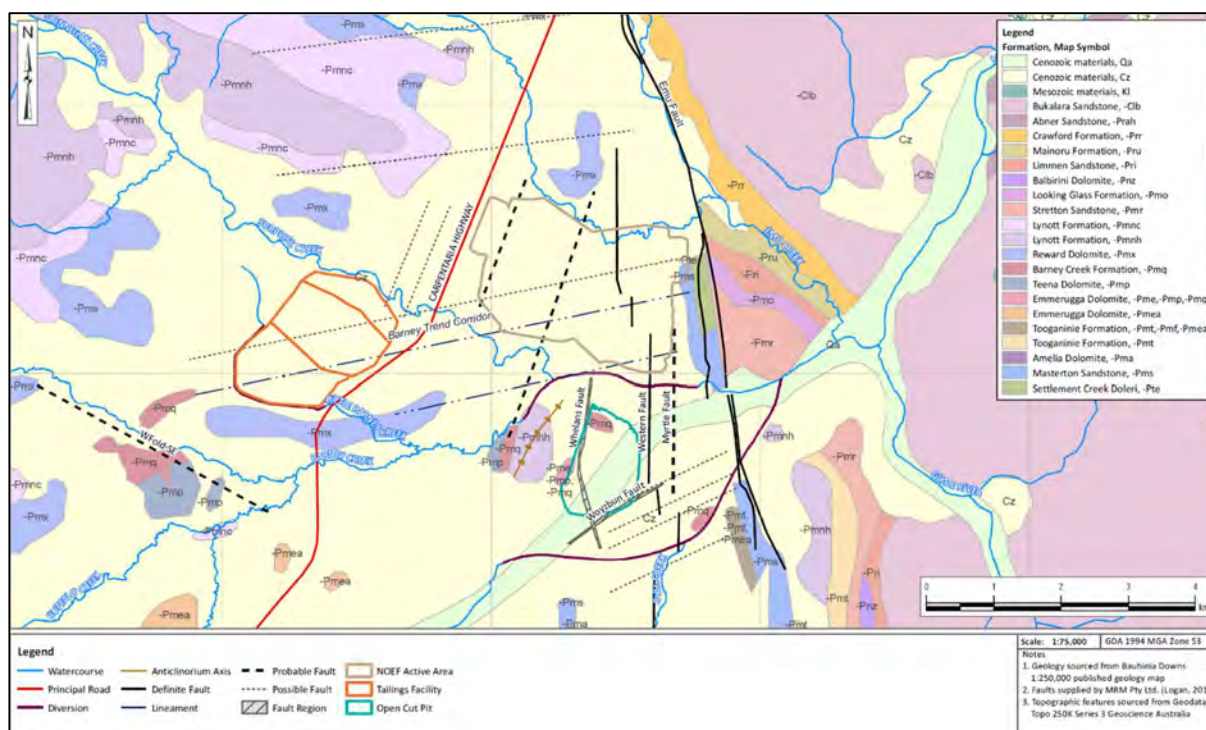


Figure 4-21: Mapped Surface Geology and Major Structural Features of the Mine Area (KCB, 2024b)

Table 3.2 Summary of Stratigraphy, Lithology and Hydrogeology

Period	Geologic Formation	Member / Unit Name	Lithological Description
Quaternary	Alluvium	Alluvium	Unconsolidated granular and fine material deposited under fluvial and flood conditions, often reworked.
		Palaeochannel	Mostly gravel and coarse sand deposited in the McArthur River Palaeochannel.
Proterozoic (McArthur River Group)	Reward Dolomite	Reward Dolomite	Laminated dolomitic siltstone and claystone with minor sandstone. Units may be cross-bedded, thin to massive, sometimes brecciated and slumped in places.
		Here's Your Chance (HYC) Pyritic Shale	Pyritic Shale.
		Main Talus Breccia (Cooley Dolomitic Breccia)	Chaotic breccia, with clasts which range in size from a few millimetres to several tens of metres.
		HYC Pb-Zn Ore	Thin bedded to laminated dolomitic siltstone characterised by a high carbonaceous content.
		W-Fold Shale	Shale and dolomitic siltstone and shale with interbeds of green vitric tuff.
	Teena Dolomite	Coxco	Massive dark grey and sometimes vaguely bedded dolostone with numerous interbeds of orange weathering mudstones.
		Lower Teena	Very thin bedded, massive, dark pink and grey dolomite.
	Emmerugga Dolostone	Mitchell Yard Dolostone	Dark grey weathered, uniform, massive, karstic dolomite which has undergone extensive vadose alteration.
		Mara Dolostone	Laminated dolomite. Interbedded with thin beds of flake and randomly oriented intraclast breccia, occasional recessive interbeds of fine dolomitic sandstone, dolomitic siltstone, and silty massive dolomite. The silty units sometimes contain chert.

Figure 4-22: Summary of the hydro-stratigraphy of the mine area (KCB, 2024b)

MRM (2019) provides additional discussion with direct relevance to the construction updates of the Central East Alpha Stage. *“The shallow weathered bedrock is also likely to promote migration of NOEF seepage. The Cooley Dolomite bedrock, the Western Fault and the fracture network associated with the Western Fault are situated to the east of the NOEF and are also potential long-term pathways for seepage migration.”*

Essentially, it is stated that *“The primary receptors for NOEF seepage are Surprise Creek to the southwest of the facility and Barney Creek diversion to the south and southwest of the facility. These two creeks represent the lowest points in the topography surrounding the NOEF and existing hydraulic gradients orient pathlines towards these surface water features.”*

4.2.4.8 Geological Structure

KCB (2024b) notes six major structural features have been identified in the mine area: the Emu Fault, the Western Fault Block, Whelan’s Fault, the Woyzbun Fault, Myrtle Fault and the Barney Trend Corridor. All of these features have the potential to influence seepage pathways and connectivity with other mine areas from the NOEF. The location of these structures is provided in **Figure 4-23**, from KCB (2024b).

A description of these from the same reference is provided:

Emu Fault – is a major, regionally mapped north-south structure which defines the ridgeline which constrains the McArthur River floodplain. This fault is located east of the NOEF.

“This fault is characterised by horst blocks of Masterton Sandstone, displaced upwards from the base of the McArthur Group. Seismic data suggest the fault comprises several near vertical faults, is about 150 m wide and is deeply weathered (Golder Associates 2004). Hydraulically, there is little evidence of groundwater transmitting through this structure in the area of drilling completed in 2019. This aligns with the assumption in the EIS and EIS-S numerical model that the structure is a barrier to flow.”

Western (Block) Fault – strikes north-south and is mapped from the eastern side of the open pit mine, passing beneath the lower section of the Barney Creek Diversion, beneath SEPROD and adjacent to the eastern side of the NOEF.

“The Western Fault is a series of north-south trending thrusts which dip steeply towards the east and is coincident with the “Cooley Breccia”. Previous drilling programs have indicated that the Western Fault, within MRMs levee wall, has low hydraulic permeability. URS (2008) specifically describe the Western Fault as having no inflows, which implies the fault was intersected by underground workings. However, the mapped extent of underground workings suggests it is also possible that the Western Fault was not intersected.”

Whelan’s Fault – is mapped to parallel the western pit extent, extending north-south toward the Barney Creek Diversion however, is not mapped beyond this feature.

Woyzbun Fault – is a northeast – southwest trending structure located on the southside of the pit. While not directly relevant to the NOEF, it is believed to have displaced the southern extent of a number of northerly striking structures such as the Western Fault and the Myrtle Fault.

Myrtle Fault – is located east of and parallel to the Western Fault, also extending beneath the Barney Creek Diversion, and through SEPROD, parallel to the eastern margin of the NOEF.

“This is a steep east-dipping thrust, with drilling data (one hole) indicating rubble and fault gouge and an open and permeable fabric. This is also located to a high yielding pumping bore.”

Barney Trend Corridor - is a major cross cutting structural zone which passes through the NOEF, from SEPROD in the southwest, to the northeast edge terminating near the Emu Creek fault.

“This is a dominant east-west (or southwest-northeast) trending fault corridor, which dislocates the Western Fault. The corridor is likely the youngest geological structure, comprising an 80° trending, 400 m wide fault corridor, which passes beneath the southern end of the NOEF from the TSF. 2016 ERI data suggest that the faults are conductive, inferring they are porous and / or permeable.”

Structural features, and their secondary splays and deformation effects, have the potential to modify hydrogeological conditions. This is not exclusively related to the creation of planar boundaries or flow corridors; these effects can translate vertically through weathered profiles and may impact surface drainages and interactions with surficial unconsolidated aquifers. Their distribution and relationship to other hydro-stratigraphic units is therefore an important component to understanding NOEF performance.

Karst - Karstic zones are known to occur and have been recorded in drill logs and investigated with dedicated programs such as that undertaken by Ross Logan and Associates (2017). These conditions have been identified as sediment filled cavities, voids and vughs: the OMP-EIS reported that the evidence of karst is restricted, with occurrences of open voids in the upper ~50 m of the dolomite bedrock (KCB, 2024b). Several technical reports have also noted the presence of karst near to the NOEF, particularly to its east and associated with significant north-south faulting.

“The bedrock underlying the alluvium materials in the Central East Alpha Stage (OKC, 2016) is predominantly the acid-consuming Cooley Dolomite, characterised by karstic features resulting in greater permeability than the surrounding rock units. Geophysical conductive zones (possibly faults) are indicated in the bedrock by ERI and interpolation. The groundwater data does not indicate that these potential features influence groundwater movement in the area.”

The conductive zones referenced above are generally associated with the southeastern area of the NOEF, including SEPROD, and appear associated with the Western Fault, and potentially with the cross-cutting eastern extent of the Barney Trend Corridor. The correlation of drill encountered karst with major geological structure as assessed by Ross Logan and Associate (2017) are presented in Figure 5.11 of KCB (2024b), reproduced herein as **Figure 4-23**. These show a clustering of karst conditions aligned to the Western and Myrtle faults, passing through the lower section of the Barney Creek Diversion, and for those features associated with the Western Fault, directly beneath SEPROD. Karstic zones associated with faults (e.g. the Myrtle Fault) have been identified as a potential preferential flow path for seepage from the NOEF (OKC, 2016; KCB, 2024).

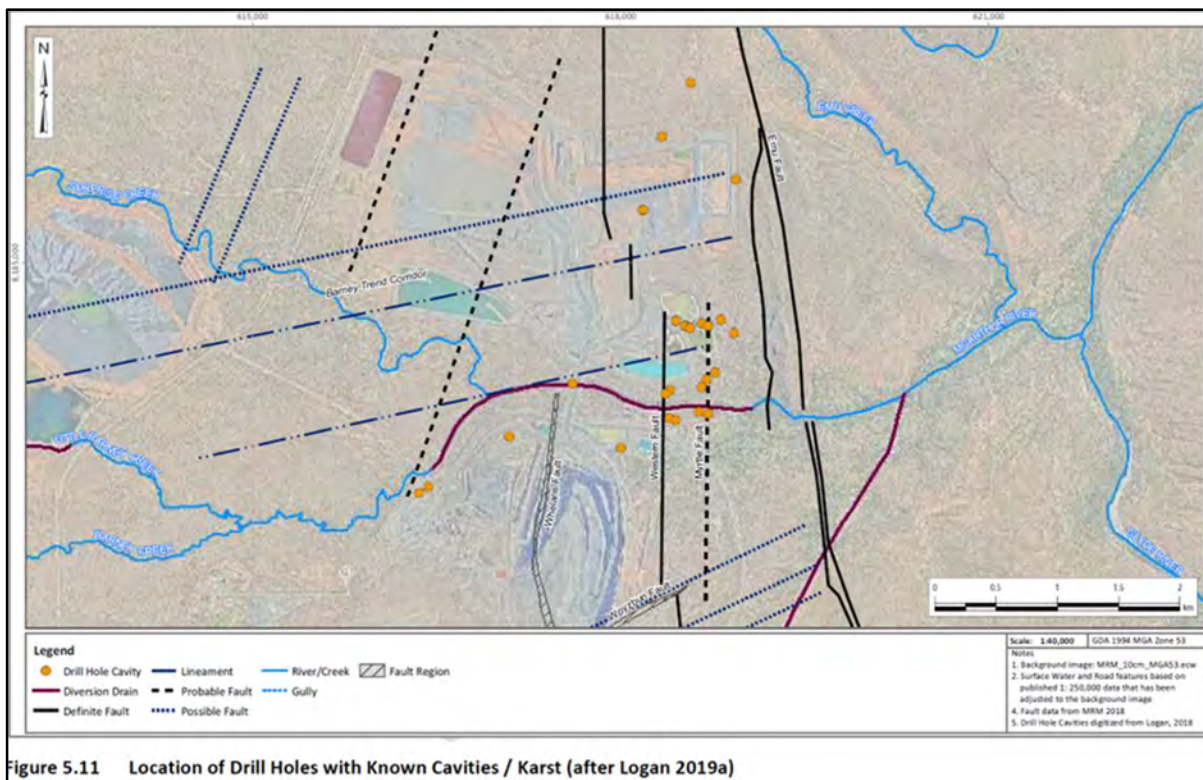


Figure 4-23: Distribution of drill holes with known Cavities / Karst (after Ross Logan and Associates 2017)

The relevance of these features to understanding seepage pathways from the NOEF pose several questions:

- Is karst connected with surface drainages, and do they have the potential to shorten the groundwater travel time between NOEF source and receptor?
- Is karst efficiently connected to, and is their hydrogeological condition linked with, the dewatering operation of the open cut mine?
 - If so, are they artificially disconnecting the pathway from the bed of the McArthur River and drawing seepage toward the mine void under dewatering induced gradients?
- Is karst connected to, and is their hydrogeological condition linked with the operation of the Emu Creek Borefield.
 - If so, how will cessation of groundwater abstraction from this borefield change flow dynamics in the rock hosted seepage pathways, and how has this been evaluated?
- How will post mining conditions of the mine void impact these pathways, and the water quality that reports to the post mining pit lake or, which may report to creeks and diversions.

These zones have been considered in 3D flow field modelling undertaken by KCB (2024b), with model zonation around the refined / updated geological faults and the improved understanding of the higher hydraulic conductivity zones associated with the karstic conditions applied.

4.2.4.9 Emu Creek Borefield

The mine augments water supply via on-tenement production from five borefields. Most have no relevance to the NOEF. One borefield (Emu Creek) is located north of the Barney Creek Diversion and close to SEPROD (Figure 4-24).

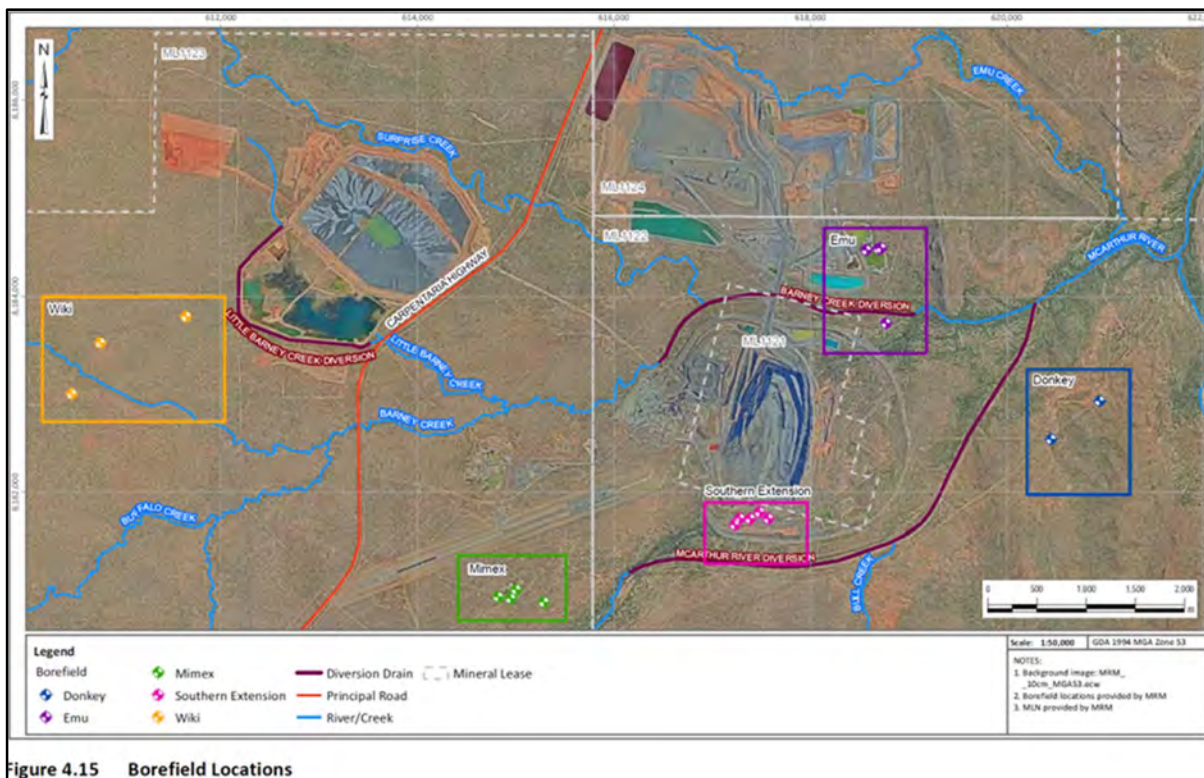


Figure 4-24: Location of the Emu Creek Borefield

The Emu Creek Borefield comprises four production bores completed to around 50 m depth each within fresh rock. These bores have been in operation since 2013 / 14, producing between 318 ML/yr and 675 ML/yr (10-21 L/s) for mill processing, civil construction and potable water needs (KCB, 2024b). These bores are mostly distributed on or near to the Western and Myrtle faults, north of the SEPROD (with one bore located to the south nearer the pit). The location of these bores coincides with the location of mapped karst previously noted in **Figure 4-23**.

Ongoing operation of this borefield at 450 ML/yr (~14 L/s) is planned to 2030 (KCB, 2024b). Understanding the drawdown effects of this borefield during operations (particularly as they relate to the potential for lowered local groundwater conditions beneath the Barney Creek Diversion), and the result of the borefield decommissioning in 2030 (and local groundwater rebound) will be important factors in determining long term risk to flow dynamics in the NOEF / Barney Creek Diversion area.

4.2.4.10 Groundwater Potentiometry

KCB (2024a) presents groundwater elevation for the alluvium and weathered bedrock (presented as a water table aquifer representation) for dry and wet season conditions for 2023 / 24 (**Figure 4-25**). These data indicate:

- A west to east / southeast flow direction with elevations ranging from 33 m AHD near WPROD to 18 m AHD on the eastern extent of SEPROD. Across ~4.5 km, this equates to a gradient of about 1:300.
- Wet season conditions for the same geometry range between 36 m AHD in the west, to 20 m AHD in the east, with a similar gradient and direction, and a raised groundwater condition of about 2-3 m.

These contoured data appear constrained to a subset of the total monitoring network. A closer review of data is possible using the hydrograph trends presented in this report, discussed in a general spatial context as follows for the period 2016 to late 2024.

West of the NOEF, there are three bores with a complete period of record for that presented, all showing strong seasonality and a wide range of dry to wet season conditions. These range between 29 m AHD and 38 m AHD, with season-to-season variability of about 4 m, with one exception of GW122D showing up to 8 m

of vertical range from dry to wet season. To the west of the NOEF is unmodified ground, so these bores would be expected to respond to recharge which may occur. A similar response is noted in those bores of the area northwest of SPROD.

South of the NOEF, or southwest of SPROD, groundwater levels show muted response to seasonality, particularly the case after 2018. This is an important observation which might be related to the lining of SPROD and changed local conditions in this area. The rainfall CRD indicates a slightly below average period from 2011, which might translate to a decline in season-to-season groundwater levels in this area. It will be important to continue to evaluate this local condition to assess the potentially positive impact of the SPROD lining.

Southeast of the NOEF, or, south of SEPROD, groundwater levels show strong seasonality again with annual variance of 4 to 6 m, and a range of 16 m AHD to 23 m AHD. Most bores show responses which match each other, and of similar scale from season to season, indicating a good degree of connectivity.

East of the NOEF, bores show little vertical variance, which is to be expected as this zone is perpendicular to the direction of groundwater gradient. Levels vary between 20 m AHD and 25 m AHD. Not all wet seasons show a groundwater level response. For example, the 2019 / 20 and 2020 / 21 wet seasons showed very little rise in groundwater level. This may be related to the location of this area being down gradient of the NOEF and potentially being constrained in access to recharge from this structure.

North of the NOEF there is limited data with only one site containing a complete record for the period presented. This location (GW106) showed levels to range between 29 m AHD and 34 m AHD, with seasonal fluctuations of about 4 to 5 m. Similar to the east of NOEF area, not all bores showed a wet season response to all wet seasons.

Fresh rock and impacts of structure on deeper groundwater elevations is not expressly presented, although is generally discussed with the interpretation of structure, karst, the discussion of borefields, and of mining impacts (**Figure 4-26**). It is understood that in the area of the NOEF, mining and borefield effects have resulted in a fresh rock and structured (faulted zone) potentiometry significantly deeper than the water table conditions expressed in the monitoring report. Such conditions establish a strong downward gradient although the elevations of sites may result in disconnection of the two systems and locations of perched shallow groundwater separated from deeper hydrogeology. While mining and borefield extraction continue, these conditions are expected to remain. Closure conditions and the potential for fresh rock potentiometric conditions to rebound should be addressed in future works in consideration of understanding post closure conditions.

KCB (2024b), Appendix II, lists the monitoring network inventory for the NOEF and includes 102 locations. The summary does not provide details of monitored sequence, or completion depth of each bore. Some bores appear to have 'S' and 'D' identifiers which are assumed to be shallow and deep. If the network allows for evaluation of vertical gradients, or, identification of the separation of the hydrogeological systems, this would be valuable additional information to add to the conceptual hydrogeology in future updates.

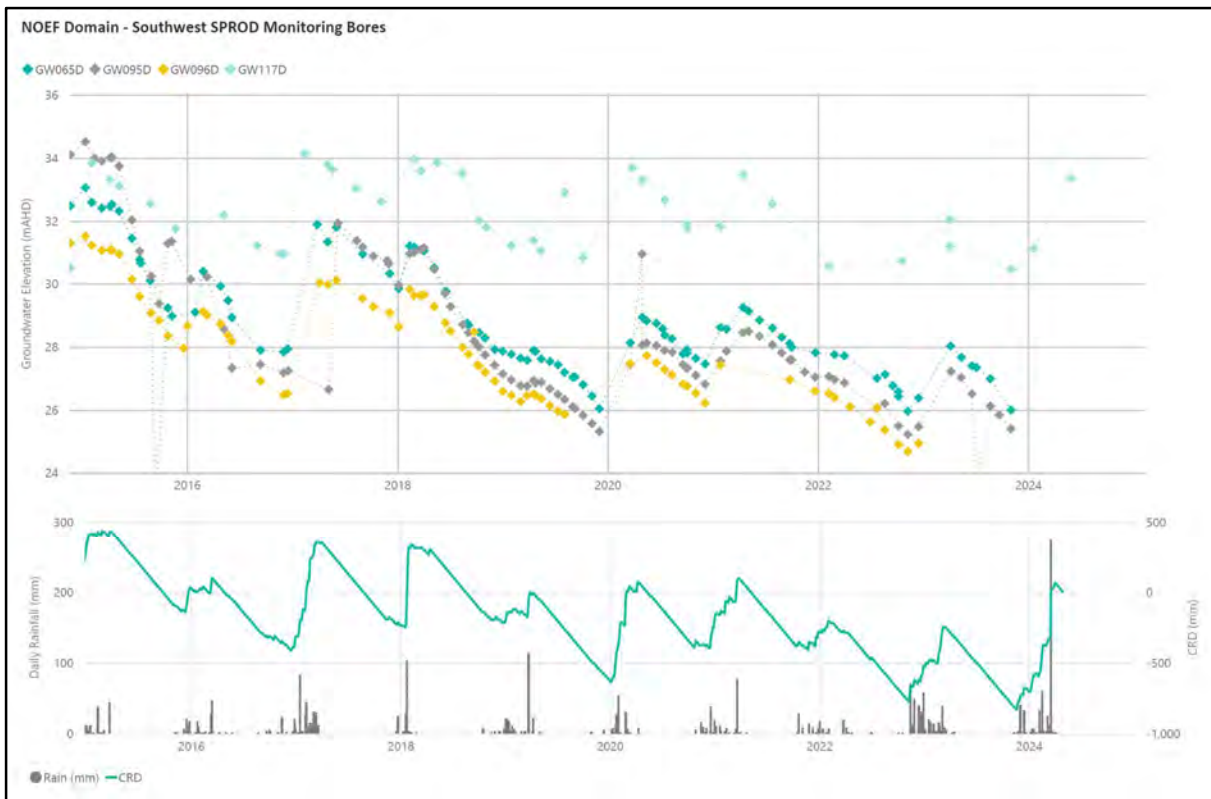
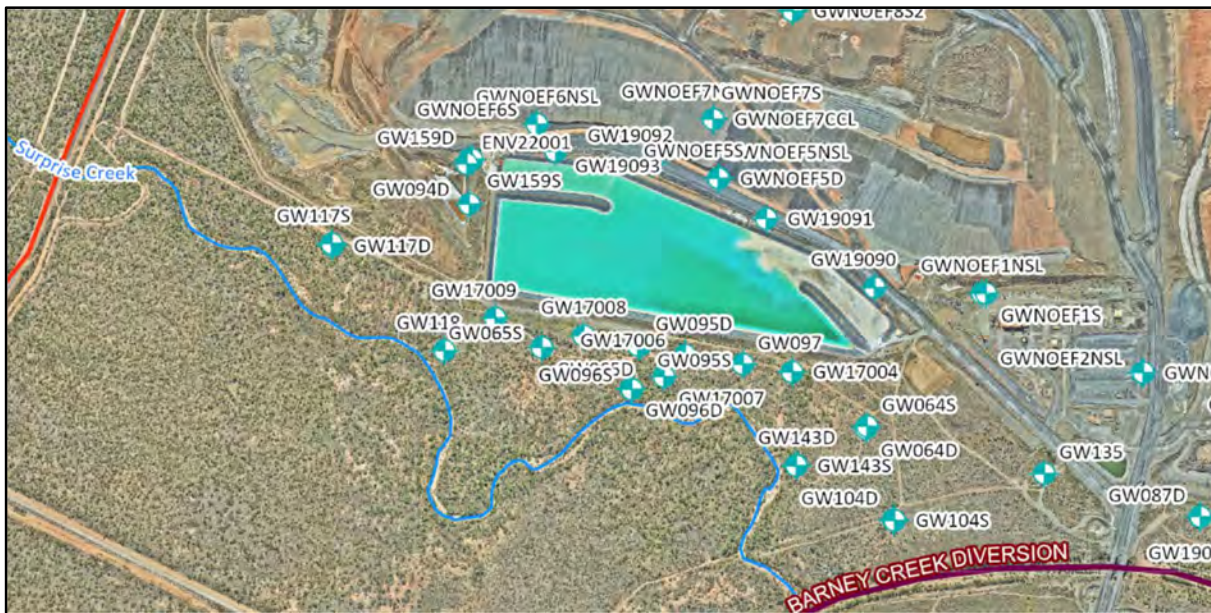


Figure 4-25: NOEF Southwest and area of SPROD transient hydrograph data (KCB, 2024a)

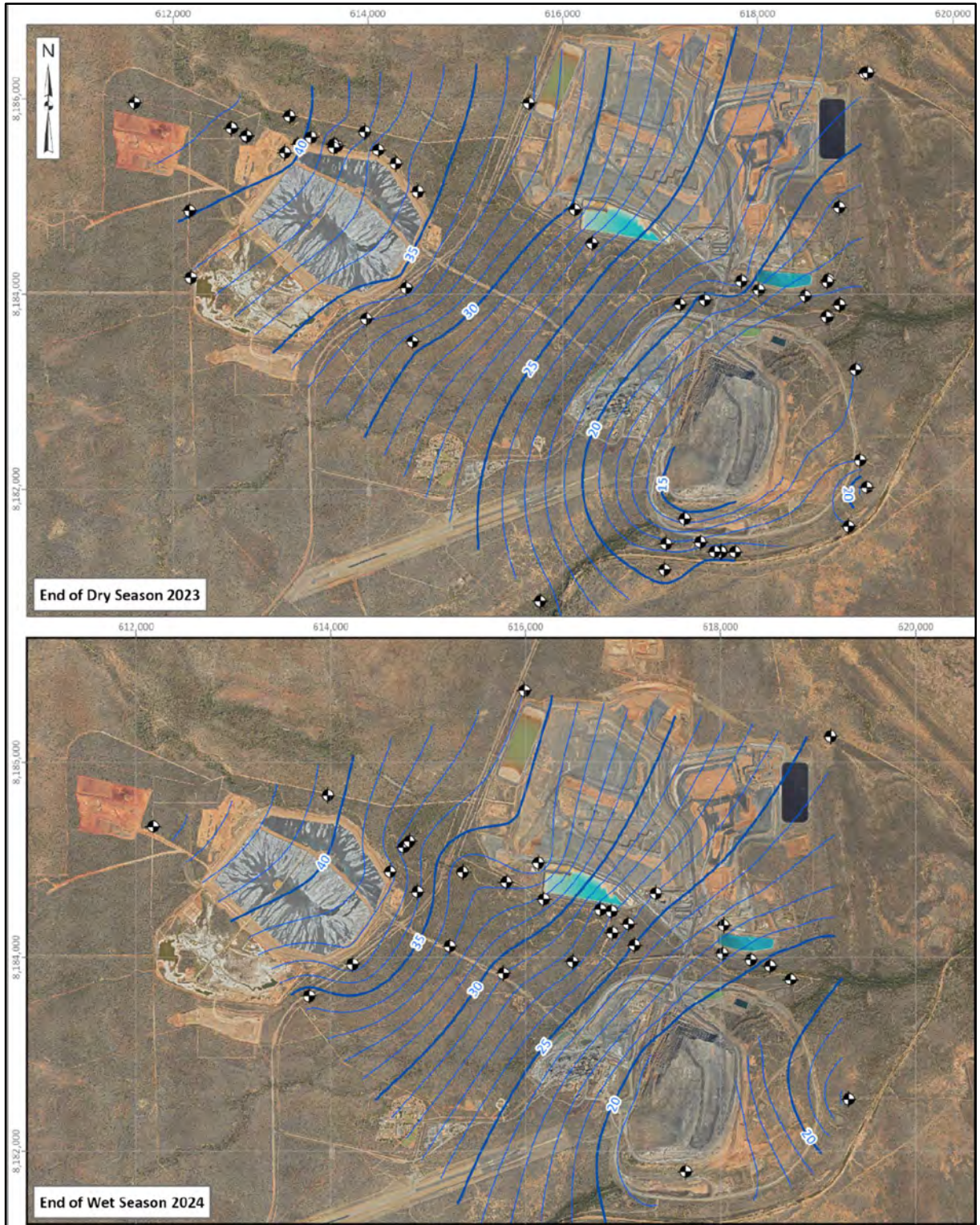


Figure 4-26: Contoured groundwater (water table) conditions for the End of Dry and End of Wet of the 2023 / 24 Wet Season, KCB (2024a)

4.2.4.11 Groundwater Quality

Water quality of the NOEF is previously discussed in **Section 4.2.4** of this report.

A broader review of hydrochemistry across the mine site is presented in KCB (2024b) and considers pH, electrical conductivity (EC), sulfate, lead, zinc, arsenic and nitrate. Transient groundwater quality is reported in KCB (2024a) presented by domain for the complete mine site. **Figure 4-27** provides a Durov diagram of the NOEF domain, which is an informative tool for differentiating water types, and potential mixing effects.

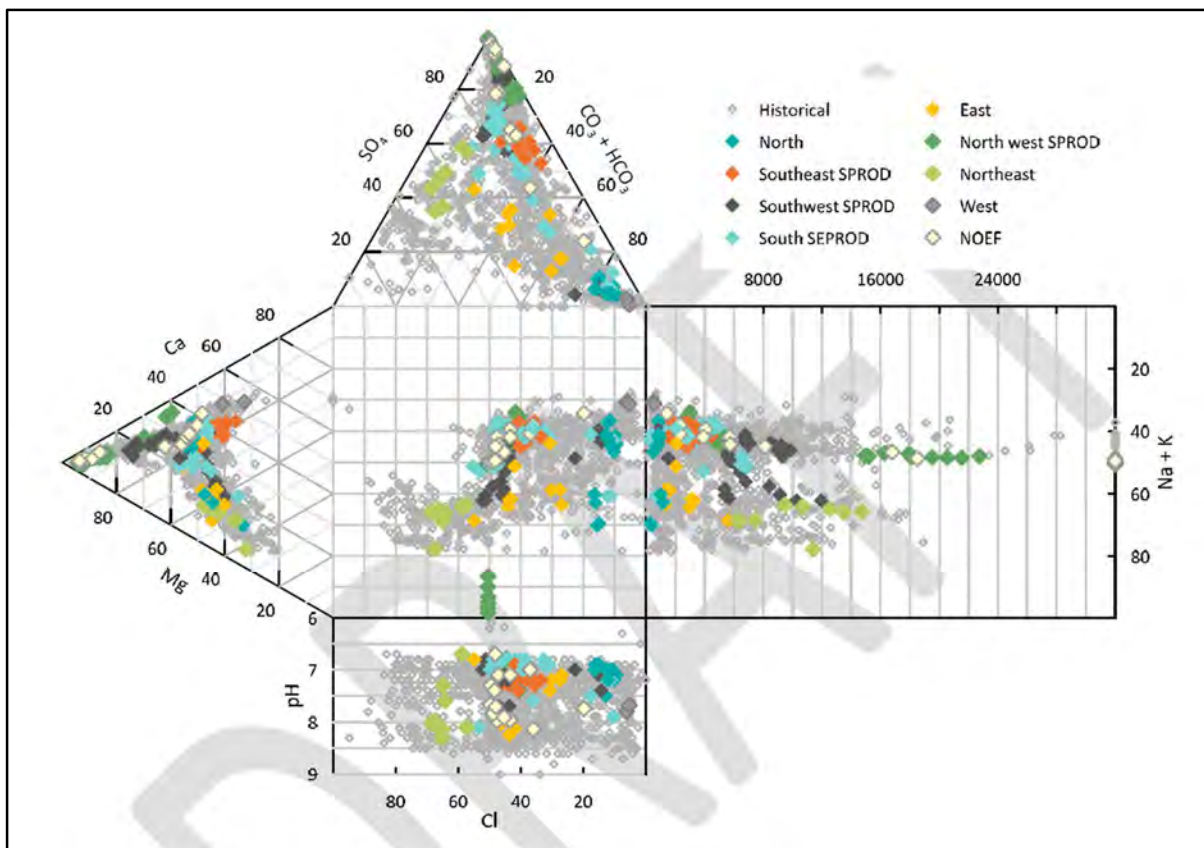


Figure 4-27: NOEF Domain Durov Diagram for Groundwater (KCB, 2024a)

The NOEF water qualities show a relative clustering of the ‘source’ water quality, and a very wide range of ionic speciation of groundwater around the perimeter of the NOEF, respective of their location to potential sources and the interactions with natural groundwaters and rainfall recharge.

The zones southeast of SPROD and southwest of SPROD appear to have closest similarity to the NOEF water type (**Figure 4-27**). South of SEPROD and northwest of SPROD zones are similar however, these have a more varied ionic content and wider ranging values of pH and EC, indicative of additional mixing effects from local groundwater or recharge. Lineal trends are noted in a number of source areas (**Figure 4-28**) – South SEPROD in particular, which show ionic, EC and pH variation within the period shown, although dates of samples are not provided so it cannot be assumed if these are natural ranges, or indicative of a progressive shift in quality (historic data not able to be considered in the format presented).

KCB (2024b) discuss five zones of different water quality signatures, all of which appear discussed in the context of bedrock variability. This deeper source discussion should include discussion of interconnectivity with the ‘water table’ conditions of the alluvium and weathered rock generally represented around the NOEF.

Artificial and natural surface water quality data are presented in Appendix III of KCB (2024b) for the period 2018 to 2022., Key observations for the NOEF PRODs and internal water management are summarised as:

- Show wide ranging pH generally in the range of 6 to 9 although, WPROD and SPROD do exhibit periods of more acidic waters with pH <5.

- Sulfate levels in the PRODs occur below 10,000 mg/L, although periods of accumulation occur in WPROD UD (underdrain) and SPROD, and to a lesser extent SEPROD, where they can exceed 20,000 mg/L.
- Elevated zinc and arsenic occur in WPROD UD the WPROD.
- Periods of accumulation most prominent within sulfate, and EC/TDS data (and for zinc, lead and to a lesser extent arsenic in WPROD), generally align with the dry season, although this is not observed in all years presented. KCB (2024b) acknowledges these events, and notes “the water stored in the PRODs is transferred from other areas of the Mine as part of MRM’s water management and is not reflective of seepage or runoff from the NOEF”.

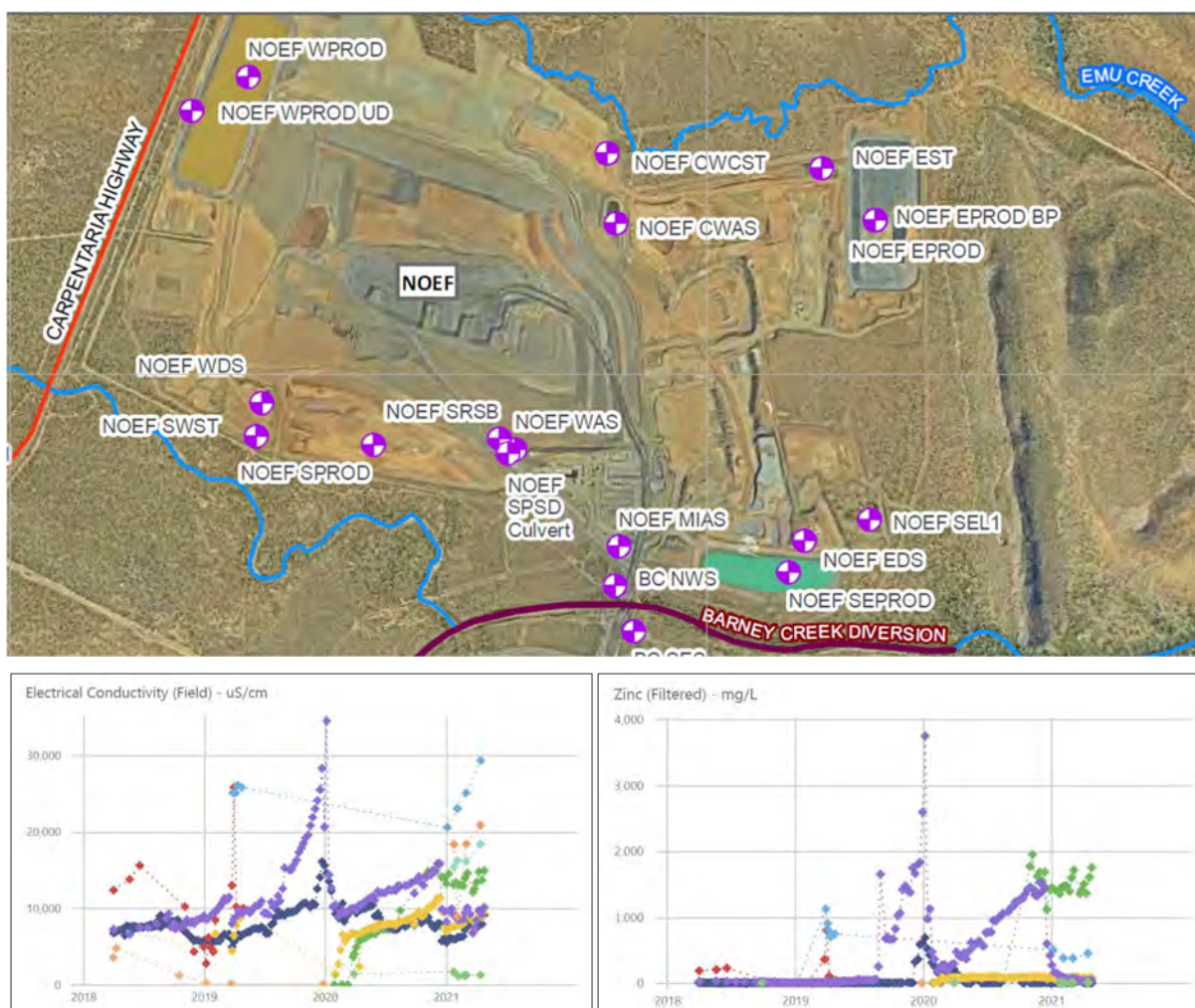


Figure 4-28: NOEF PROD monitoring locations, and examples of accumulating exceedances for EC and zinc (KCB, 2024b)

For the NOEF local surface drainages, Surprise Creek (SW02, SW34, SW24), Emu Creek (SW26), Barney Creek Diversion (SW18, SW19, SW20 and SW06, and McArthur River (SW12 and SW11) (Figure 4-29):

- The reach of Surprise Creek south of the NOEF shows strong seasonal variability in pH (6.5 to 8.5), with occasional periods of brief higher levels of lead (>0.01 mg/L) and nitrate (in 2020, >4 mg/L). EC is generally <5,000 μ S/cm, with sulfate <3,000 mg/L, although the record is brief. Zinc is generally <0.05 mg/L.
- The reach of Barney Creek Diversion south of the NOEF show similar pH to range in most samples between 7.0 and 8.8, slightly more alkaline than the Surprise Creek reach. EC profiles and sulfate profiles are similar to Surprise Creek. Levels of zinc are higher in Barney Creek Diversion up to 0.15 mg/L

although appear to be in decline (this section of Barney Creek Diversion is representative of water quality from the Surprise Creek and the upstream extension of Barney Creek).

- Emu Creek is showing a gradual season-to-season rise in pH along its reach, initially (6.5 to 7.0 (in ~2018), most recently 7.0 to 8.5 (2022). pH variability appears to be largest at SW30 which is about 4km upstream of SW26 and does not appear to be influenced by local mining activity. At SW26, nearest to the NOEF, seasonal variation in pH generally ranges between 7.0 and 8.4. Levels of EC can experience local highs but are generally very low, <200 $\mu\text{S}/\text{cm}$ and likely reflective of surface runoff unimpacted from mining. Occasional nitrate levels have exceeded 3 mg/L.

McArthur River, downstream of the mine, shows a range of pH generally between 7.0 and 8.5, with EC typically less than 2,000 $\mu\text{S}/\text{cm}$ although occasional peaks in the record offcut with spot measurements at SW12 exceeding 5,000 $\mu\text{S}/\text{cm}$ on eight occasions between 2008 and 2022. Sulfate levels are typically less than 200 mg/L however do show several periods of accumulation to as high as 800 mg/L at SW12 – noting these correspond to the SW12 peaks of EC. SW11 does show some accumulating periods of sulfate with a maximum of about 650 mg/L occurring in 2014. Levels of sulfate at either SW12 or SW11 have not exceeded 500 mg/L since 2016. Lead and zinc are typically consistently low, while arsenic shows seasonal variability of between 0.001 mg/L and 0.003 mg/L. Nitrate levels at SW11 up until 2016 were typically lower than 2 mg/L during peak events, and may be increasing (several events were above 2 mg/L in the period 2016 to 2022).

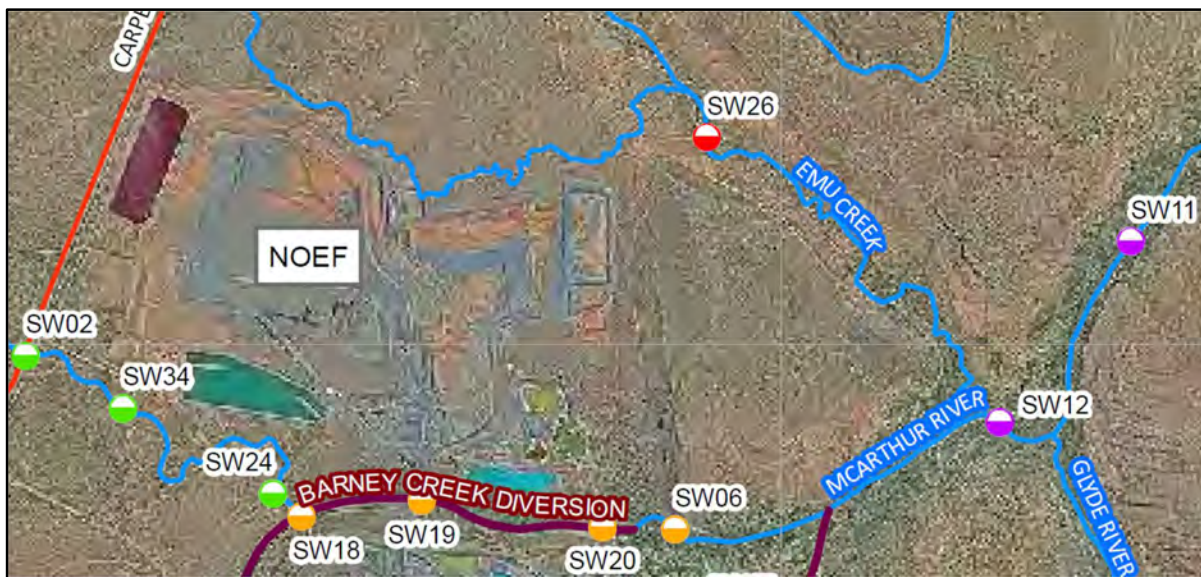


Figure 4-29: NOEF surface water monitoring locations (KCB, 2024)

4.2.4.12 Surface Water – Groundwater Interconnectivity

Possibly one of the most critical aspects of the conceptualisation is the understanding of the relationship between the shallow groundwater system and the major perimeter drainage surrounding the NOEF, which comprise Surprise Creek (between the Carpentaria Highway (SW02) and the merge with the Barney Creek Diversion (SW18), and the Barney Creek Diversion from SW18 to SW06.

Several layers of information have been used to understand these systems, including detailed geological modelling and interpretation, survey and topographic data for the drainage alignment and the bedload elevation estimate of the drainages, groundwater monitoring and bore to bore interpretations, surface water chemistry and groundwater quality, other specialised evaluations, and consideration of these data at the seasonal scale (dry and high flows), and on a long-term scale against a climate indicator such as CRD.

The elevation of groundwater with respect to the invert of the respective drainages is primary physical data which allows the interpretation of periods of groundwater discharge to the surface features, and for periods where discharge is unlikely due to physical separation of the two layers. Due to the large vertical ranging of groundwater measured in numerous bores around the NOEF, and the varying nature of flows within the creeks and diversions, these conditions are not permanent and will vary throughout the wet-dry season cycle and across longer term conditions where periods of above or below rainfall are sustained from year to year.

Surprise Creek typically flows 3 to 5 months of the year (KCB, 2024b). A detailed fence diagram of this system is presented in KCB (2024b) and is a very useful visual method to overlay multiple data sets to interpret the potential interactions between groundwater and surface water. This is provided in **Figure 4-30** and shows geology, structure, topography, groundwater level (end of mining and post closure (+30 years) from modelling output), groundwater bore locations relative to the section and measured range of dry and wet conditions from these bores (in this case) for the 2018 / 2019 season). Observations from this section are:

- At chainage 200 m, near GW108, wet and dry season groundwater levels at near to or slightly below the invert level of Surprise Creek.
- Between chainage 600 m and 2,000 m (GW175S and D to GW1700S), dry season groundwater levels are near to or below the invert of the creek, while wet season high groundwater appears to be 3 m higher than the invert of the creek. This zone might be expected to experience wet season contributions to the creek (depending on elevation of water flowing) and may experience local areas of dry season contributions.

GW96D is located at about chainage 1,800 m and is assumed (based on the section) to be screened within bedrock. The hydrograph for this bore on this fence diagram showed groundwater levels to be consistently above 30 m AHD up to about mid-2015, with two more wet season peaks occurring in 2017 and 2018 to about 30 m AHD. **Figure 4-31** of this report provides a longer record for this bore, which shows groundwater levels at this bore are consistently below 28 m AHD. Lining of SPROD occurred in 2019, and the invert of the Surprise Creek at this location is estimated from the fence diagram at about 28 m AHD. This presents the possibility that post lined SPROD conditions are now lower, and the interaction with the creek has reduced. This aspect of local connectivity should be reviewed in more detail as it is a very important aspect to understanding the potential for seepage interaction from the NOEF to the relatively fast pathway of Surprise Creek.

- A similar section is produced for the reach of Barney Creek Diversion south of the NOEF and SEPROD. Along most of this section, dry season groundwater levels appear below the invert of the diversion, with only some locations showing wet season conditions above the invert. This indicates most of the year for most of this diversion reach, groundwater is not likely to discharge to the drainage. Current and future conditions (where mine dewatering effects are more prominent (indicate any seepage from the NOEF which are under pathways flowing toward the diversion, may bypass the creek and report to the mine, which imposes a model predicted drawdown of 5 to 10 m from chainage 1,200 m to end of fence diagram. The model predicted (2067) groundwater level is near to the currently monitored groundwater elevations for most of the sections.

KCB (2024b) also reported a low flow sampling campaign of these two surface flow reaches and compared (using Stiff diagrams) the results of this program to the nearby groundwater qualities from bores between the NOEF and potential discharge zones in the drainages. The results of this are shown in **Figure 4-32** and indicate:

- Water quality in surface water drainage is relatively consistent although there is a subtle change between the Surprise Creek and Barney Creek Diversion sectors.
- Groundwater stiff diagrams are far more variable and do not show a strong correlation with the surface drainage, noting those groundwater locations around SPROD show a high level of local variability. Conditions east of this, and near SEPROD, are far more consistent, although still strongly contrasting to those in the diversion.

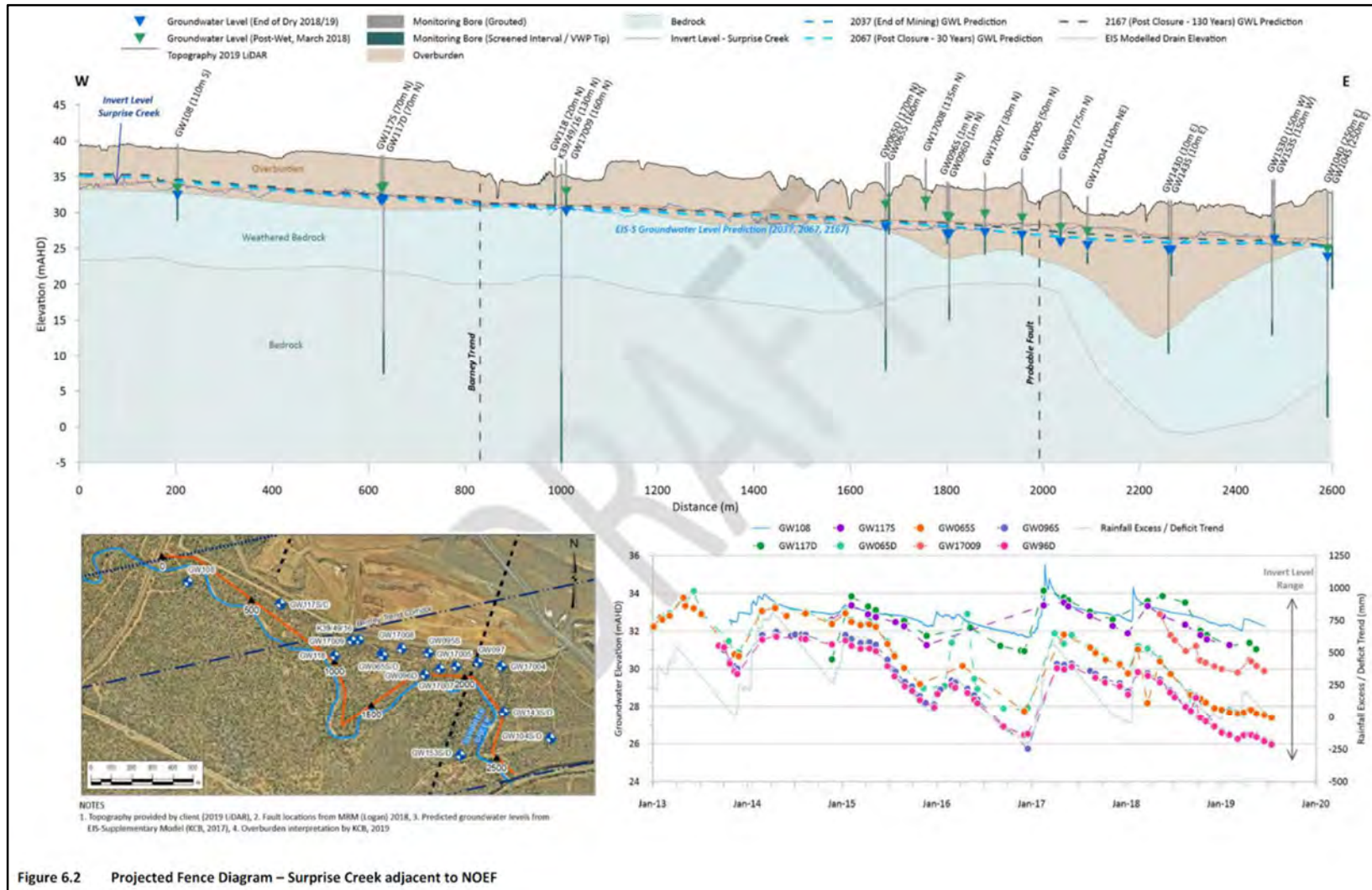


Figure 4-30: Surprise Creek Fence Diagram – Carpentaria Highway to Barney Creek Diversion (south of NOEF), from KCB (2024a)

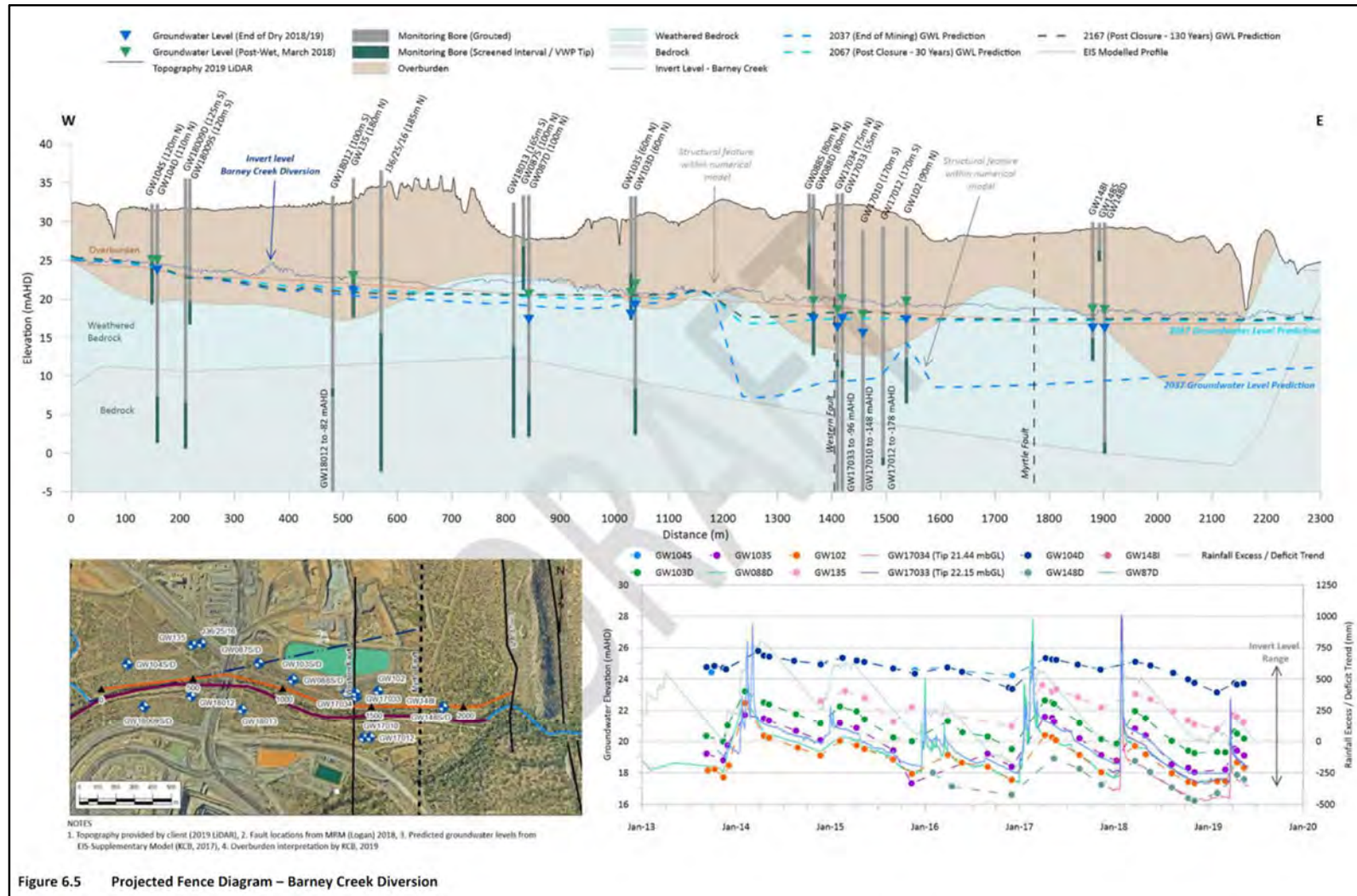


Figure 4-31: Barney Creek Diversion Fence Diagram – from Surprise Creek termination (south of NOEF), from KCB (2024a)



Figure 6.6 Stiff Diagram – 2018 Low-Flow Surface Water (Yellow) and Groundwater (Green)

Figure 4-32: Surprise Creek and Barney Creek Diversion, Low Flow Sampling of Surface Waters and Nearby Groundwaters Stiff Diagram Variability (south of NOEF), from KCB (2024a)

4.2.5 Predictive Modelling

4.2.5.1 Preamble

Model platforms have evolved significantly over the past two decades in terms of presenting varied options for hydraulic stress or boundary condition representation, and in allowing for increasing spatial detail and complexity. Monitoring data plays an important role in model construction and development. It is used to inform the initial construction, and it provides basis for calibration, and assists in understanding the quality of model output. Post modelling output has also evolved to include sensitivity and uncertainty analysis to better frame the level of confidence that numerical predictions provide.

A challenge of any model is that of non-uniqueness. Non-uniqueness refers to different combinations of model inputs or boundary conditions which can produce model output that matches observational data.

The numerical environment must reasonably define the conceptual setting and predictions of future performance with a reasonable level of complexity. This is the challenge with any modelling solution – achieving a workable model scale, capable of representing key hydrogeological stresses without the simulator becoming unmanageable and unrealistically complex.

This review aims to address:

- How well the conceptual hydrogeological environment is represented in the numerical environment.
- How complex or numerically detailed the model is in terms of the predictive requirements of the NOEF and achieving a balance of model functionality and reliability.
- How well conventional measures of model performance, usually framed on model calibration statistics and uncertainty analysis (as described in the Australian Modelling Guidelines (Barnett et al., 2012), is achieved.
- How well model predictions align to monitoring performance, and thus the confidence in forecast conditions which might be expected (and the adequacy of the monitoring network to be considered).
- How well concepts of water and pressure in the system are replicated in the model outside of traditional model calibration performance (for example, correct vertical gradient reproduction).

A final consideration is of ‘multi-generational modelling’.

Frequently, groundwater models are constructed for single usage. The modelling completed for the NOEF (and elsewhere across the site) has evolved over multiple iterations, or ‘generations’. An advantage of this approach is one of progressive improvement that should aim to reduce the non-uniqueness and conceptual uncertainty in model boundary conditions.

This approach provides an opportunity not only to re-calibrate the model, but it also allows for earlier derived concepts built into the model to be challenged and improved.

4.2.5.2 Multi-Model Approach to the Site

Predictive modelling of the performance of the NOEF, has been achieved with three separate model platforms.

- The saturation profile of the NOEF has been modelled using Tough2, an approach which generates the profiles of seepage egressing the facility.
- The water chemistry of the NOEF has been modelled using GoldSim (supported by PHREEQC and Geochemists Workbench).
- Groundwater flow and fate of seepage from the NOEF has been modelled using Modflow / Surfact.

It is stated in KCB (2017) that:

“The sequence of modelling is needed to represent the spatial and temporal domains as well as the physico-chemical processes that cannot be simulated in sufficient detail by any single modelling code. Since there is

From KCB (2017) “The most important aspect to highlight is that as the NOEF grows the associated surface water from the footprint of the NOEF in the form of toe seepage will decrease. With the low permeability base in place, flows to groundwater stay relatively stable during operations and then decrease significantly as the system progresses into the closure period. In the long-term, the basal flows dominate as the rate of flow becomes controlled by the low permeability BGM cover.”

An example of model output is provided for the immediate post closure condition (**Figure 4-34**). Observations from this graph include:

- Surface water runoff from the cover dominates the facility water balance with peak rates during the wet season exceeding 300 L/s.
- Basal and toe seepage diminishes with time, with basal seepage generally less than 5 L/s in later stages of the simulation.
- This is also reflected in estimates of net infiltration in the NOEF post cover placement, with infiltration rates at 2023 of >53 L/s, reducing to 0.3 L/s in 2033 (with ‘Full cover Soil + alluvium Breccia + BGM’).

KCB (2017) acknowledge that “This is a result of the strong seasonality and intensity of the rainfall, the high permeability of the waste rock (overburden) and the fact that the placed waste rock allows the development of strong matrix suction to occur at certain periods. These factors encourage rapid infiltration rates. Once the cover is in place, the relative proportion of rainfall infiltration greatly decreases”.

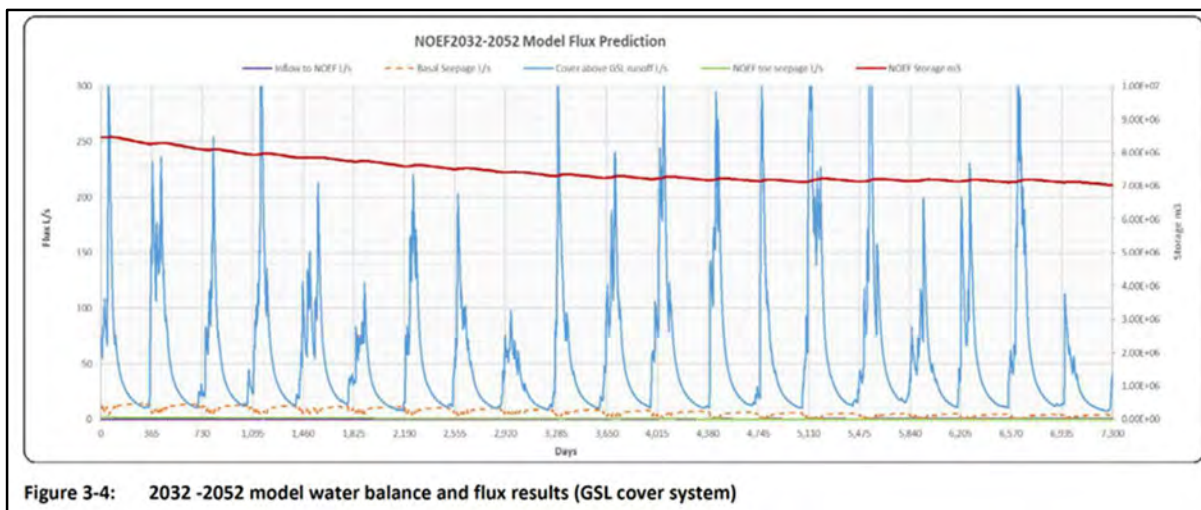


Figure 4-34: Example Tough2 Transient Model Output, from KCB (2017)

Modelling of a CCL cover was also completed and resulted in higher infiltration (net percolation) estimate post closure of 9 to 11 % of rainfall, respectively.

Modelling also predicts a low level of internal saturation of the NOEF after the drain down period has completed (**Figure 4-35**). This is the driver for long term low seepage egressing the facility and forms key model input for the regional scale groundwater flow simulator.

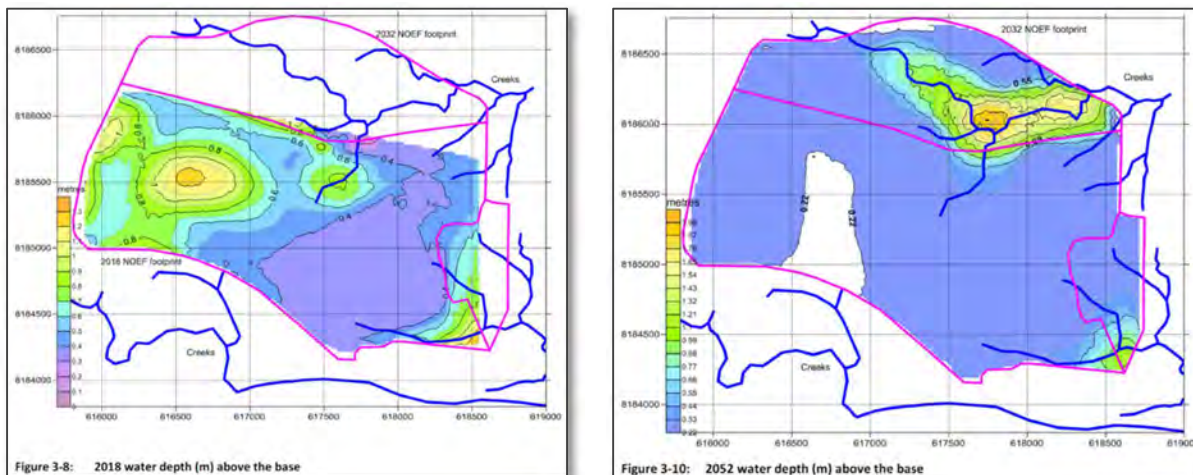


Figure 4-35: Tough2 Generated Saturation Profiles of the NOEF at 2018 (left) and 2052 (right) (from KCB, 2017)

The results of the flow modelling from KCB (2017) indicate:

- Flows (losses) vary as a function of footprint and NOEF construction – pre-cover placement, the facility maintains a higher level of saturation and a higher consequent basal loss compared to conditions post closure.
- Toe seepage is initially high and becomes negligible in the long-term. This is a function of the short-term mounding above the low permeability base which diminishes and has reducing influence on the flanks of the NOEF as it matures. Following placement of the cover, internal saturated mounding is limited and toe seepage rates become very low. **Figure 4-36** shows the prediction of conditions in 2052 and indicates there is less than 0.5 m of saturated thickness across most of the facility with remnant saturated seepage occurring in the basal drainage geometry of the NOEF.
- Basal seepage will decrease significantly over time. Elevated basal seepage persists in the period immediately after placement of the BGM cover, while the accumulated storage drains down. This is also reflected in the progressive decrease of water mounding above the base of the NOEF.

Basal seepage water quality is also discussed in KCB (2017) and forms a key considering in the assessment of potential impacts to regional groundwater.

Examples of this output are provided for basal and toe seepage in the following. Using sulfate as a guide of changing long term chemistry, basal seepage sulfate levels are predicted to peak at about 40,000 mg/L in about 2080, then reduce to the end of the simulation to about half this amount.

Toe seepage sulfate levels peak at about the same time although with lower levels lower at approximately 18,000 mg/L, before beginning to reduce.

In comparison, measured sulfate ranged between 3,800 and 18,940 mg/L in 2016 / 17 (KCB, 2017). These measured data are comparable to toe seepage levels predicted in early Tough2 periods (**Figure 4-35**).

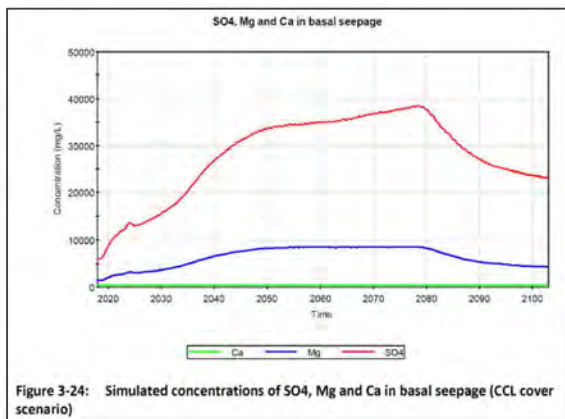


Figure 3-24: Simulated concentrations of SO₄, Mg and Ca in basal seepage (CCL cover scenario)

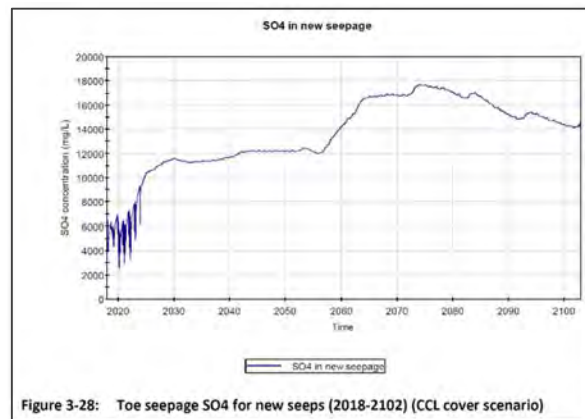


Figure 3-28: Toe seepage SO₄ for new seeps (2018-2102) (CCL cover scenario)

Figure 4-36: Tough2 Generated Sulfate Concentrations for Basal and Toe Seepage, from KCB (2017)

Key outcomes from the KCB 2017 Tough2 modelling of the NOEF comprise:

- Infiltration into the NOEF will be relatively uninhibited during construction, with significant reductions occurring once the final cover is placed.
- A post-closure drain down of the NOEF is predicted and over time, a significant reduction in flow exiting the NOEF will occur. Seepage flows and their geochemical loads will be in relatively stable state once the final cover is placed (within the first 50 years after closure).
- The water quality modelling suggests that if the NOEF is operated in a manner consistent with the project plan and design for the NOEF, that seepage and basal losses from the facility will remain pH neutral to slightly alkaline.
- Results suggest that the nature of the water quality from the NOEF will be similar to that currently observed; however, salinity and sulfate levels will increase over time and stabilise within about 50 years after operations.
- For the Contaminants of Potential Concern, zinc concentrations are expected in the range of 5 to 10 mg/L, while the other metals/metalloids used as indicators are expected to remain similar to current concentrations.
- From **Figure 4-36**, basal seepage sulfate concentrations are expected to peak in around year 2080, at between 35,000 mg/L and 40,000 mg/L, then reduce over the next two decades to about 20,000 mg/L to 25,000 mg/L. Current levels of sulfate in the PRODs as a surrogate of basal seepage quality (KCB, 2024b) are generally 10,000 mg/L or less, however do rise to more than 30,000 mg/L during periods of accumulation.

The results from the NOEF modelling have been directly used in the groundwater and surface modelling assessments. Greater context of the overall environmental implications and management is provided by the reports which address the site-wide results from those models (KCB, 2017).

4.2.5.4 Groundwater Flow Modelling and Prediction of Seepage from the NOEF

Modelling of the fate of seepage from the NOEF is achieved using a 3D groundwater model comprising 14 layers, and a domain which captures the entire McArthur River site. The latest model build was completed in 2024 and applied a number of structural improvements to that of the previous build. It is noted that this is a leading practice approach to model evolution. Often, generational models are simply revisited and recalibrated. It is however important to review and modify as needed, fundamental assumptions of the boundary conditions and mathematical functions used to replicate them that define water movement within the domain.

The current model is now constructed with MODFLOW-USG, which provides unstructured grid optimisation enabling preferential grid refinement in areas of greater focus. This code update also enables greater flexibility in representation of the distribution of faults, implements an ‘upstream weighting’ of groundwater flow which better simulates cell drying and rewetting cycles, and the contaminant transport model accommodates solute migration as part of the solution in the model domain (KCB, 2024b).

The original build of this model completed in 2017, comprised 14 layers and 674,600 active cells. The current update comprises the same layering, but grid detail improvements have increased the active cell count to 1,213,130 cells.

The model domain comprises 14 layers representing mining landforms and the natural geology of the site. Only one layer is used to represent the NOEF as prediction of seepage from the NOEF is modelled using the Tough2 simulator (KCB, 2024).

From KCB (2024b), and relevant to the NOEF:

- *The model has been developed as an impact assessment tool. The conceptual model was based on available geological and hydrogeological data.*
- *General head Boundary conditions have been applied to simulate mining activities in the areas of SPROD and SEPROD. Boundary conditions are placed in cells on the uppermost layer of the model with reference heads and conductance values based on site measurements to represent these features.*
- *Simplifications to representation of geological structure has been made to permit representation in the numerical domain. The fractured bedrock groundwater flow system has been represented by the EPM (equivalent porous medium) method.*
- *Regional and local faults have been represented as vertical features with varying hydraulic properties.*
- *The groundwater flow model assumes that the hydraulic properties are uniform for each hydro-stratigraphic layer or zone.*
- *Seepage from the NOEF has been simulated as time-varying recharge to the uppermost aquifer system in the groundwater flow model – these seepage rates are based on the multiphase (Tough2) model developed for the EIS-S (KCB, 2017)*
- *The major water courses of the McArthur River and Barney Creek diversion are represented using the MODFLOW River package. A river boundary allows groundwater to discharge into the river (groundwater seepage) when the groundwater level is higher than the river stage; and river water recharges the groundwater system under the opposite case.*
- *Other watercourses (creeks) in the model domain are represented using the MODFLOW Drains package (DRN), noting in most cases such creeks are ephemeral.*
- *Historical water quality data for the various mine water storages such as the PRODs have been used.*
- *The 2024 update to groundwater modelling conforms with the Australian Modelling Guidelines (Barnett, 2012). The key modelling objectives were to update the groundwater flow and contaminant transport model.*

Groundwater and surface water systems surrounding the mine are highly connected as presented in the conceptual hydrogeological understanding. Basal seepage from the NOEF adds to the groundwater balance within the numerical model. This seepage migrates vertically until it reaches the groundwater table, where it can then migrate horizontally (subject to the local groundwater gradient) and report to surface water systems distant from the source) (KCB, 2024b). (Toe seepage daylights at the toe of the facilities and is collected in drains and sumps as required and therefore does not form part of the groundwater model.)

The 2024 update of the model included a calibration process which addressed three operational phases (KCB, 2024b):

- Steady-State Model – Pre-mine (before 1995).
- Transient Model Tr1 – Early mine (01/01/1995 – 31/10/2009).
- Transient Model Tr2 – River Diversion (01/11/2009 – 31/12/2022).

A combination of manual calibration and automated (using PEST++ IES) model calibration was used for the model calibration.

From KCB (2024):

- *A preliminary steady-state model simulation, which excluded mining operations, was used to establish the initial groundwater levels for the first period of transient calibration. The steady state calibration was applied for the broad-scale optimisation of hydraulic parameters and boundary conditions.*
- *The first transient calibration model considered the period January 1995 to October 2009 to account for the influence of early mining operations on the groundwater system. The model was briefly calibrated as limited data was available for the period, however, the model was validated at the end of the simulation and the observed levels from early bores (mostly drilled 2005 and 2009) to provide an approximate initial condition for the second transient model calibration.*
- *The second transient calibration was conducted for the period November 2009 to December 2022 to account for the influence of river diversions, open pit mining, dewatering, and recharge / discharge on the current groundwater system. The major model parameters including hydraulic conductivities, storage properties and recharge factors were preliminarily calibrated with the far larger number of monitoring targets available for the second stage of transient calibration. The transient calibration allowed available time-variant data (e.g. watercourse levels, dewatering rates, and monitoring groundwater levels) to be simulated in the groundwater model.*

Detailed description of calibration performance for each of the three stages of calibration are documented in KCB (2024b). These include statistical summaries of calibration outcomes, final calibrated model parameters and boundary condition assumptions. Of note, documented in the KCB report are direct reference to model non-uniqueness:

With the use of PEST automated calibration, several strategies to reduce model non-uniqueness were incorporated, including:

- *Incorporation of all available shallow and deep geology information to constrain the three-dimensional limits of the major hydro-stratigraphic zones within the model domain. This constrains the measured heads as a function of specific geological units and also relies strongly on the inferred geological and hydrogeological units that have been developed independently by KCB and by Glencore for geology.*
- *Setting calibration targets for hydraulic conductivity based on measured values from field-based aquifer testing. This constrains the bounds of the calibration to the field measured ranges for each unit so that implausible parameter ranges are not assigned on the basis of achieving a better statistical fit.*
- *Adjusting aquifer parameters within field-measured ranges.*
- *Adjusting aquifer parameters within plausible bounds to achieve a reasonable calibration match to measured groundwater fluxes to the underground mine voids (deep geology influences flux) and to the open cut (both shallow and deep geology influences flux).*
- *Calibrating to multiple distinct hydrological conditions, including rainfall variation, river diversions, response to leakage from water management dams, and underground and open pit dewatering. Application of multiple stresses to the system prevents numerical forcing of the flows to meet calibration metrics and allows the processes to be mimicked as a key part of the calibration process.*

The second transient calibration includes evaluation of model prediction of sulfate levels against measured sulfate data. This approach extends the value of the calibration process to include consideration of mixing and dilution effects of the model. The calibration process comprised manual adjustment of boundary conditions and use of PEST for automated calibration optimisation, following an initial steady state simulation to establish starting conditions for the transient simulation (KCB, 2024b). Groundwater data from 245 monitoring bores were used for this calibration process, with the addition of water quality data (KCB, 2024). This calibration focus was twofold:

- *Groundwater level variation and the ability of the model to follow the seasonal and monthly groundwater trends.*
- *Water / Mass balance – groundwater flow and plume mitigation.*

Starting source terms (sulfate distributions) within the model are an important consideration in understanding sulfate predictions from the model. **Figure 4-37** provides an indication of the distribution of sulfate within the model, noting this represents values assigned to the active flow domain of the model (seepage (basal) water quality from the NOEF is an outcome of the Tough2 / Goldsim modelling process).

Sulfate levels are noted to vary naturally within the mine area. **Figure 4-38** shows on the left, higher range values associated with the mine domains of the TSF, the NOEF, and the pit, while on the right, increased granularity in sulfate levels is provided to understand areas of naturally occurring higher levels. Generally, non-mine-infrastructure have starting values up to 2,000 mg/L.

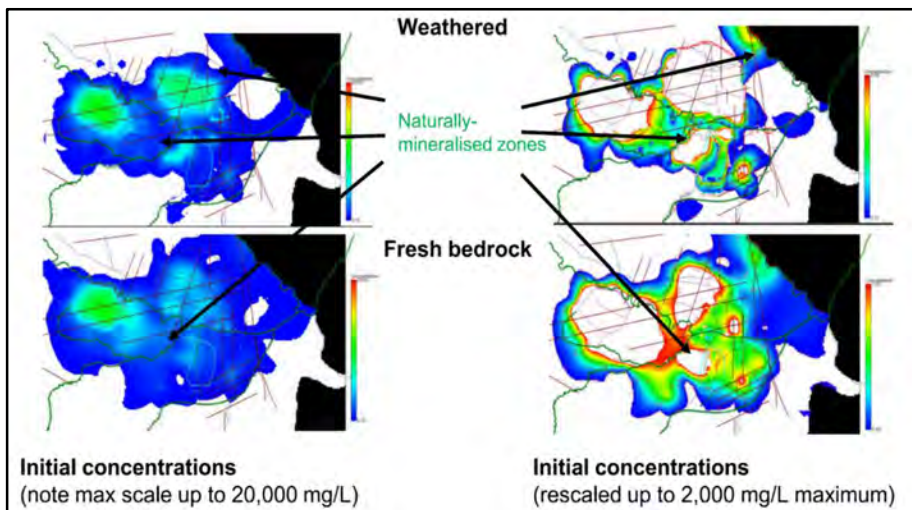


Figure 4-37: Variability in sulfate source terms applied to the Modflow model domain (KCB, 2025)

Increased granularity in sulfate levels is provided in KCB (2017), as shown in **Figure 4-38**.

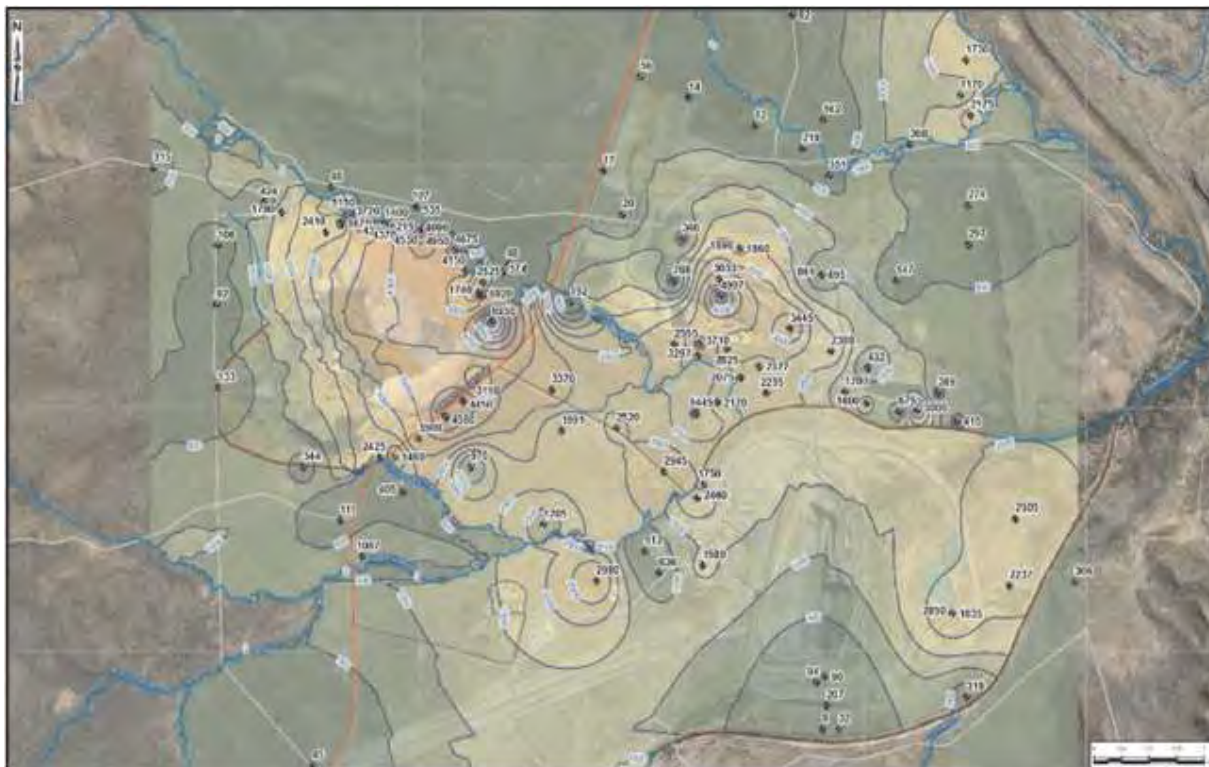


Figure 4-38: Average Sulfate Concentration Contours (KCB, 2017)

Sulfate levels of the PRODs are typically below 10,000 mg/L but have occasionally exceeded 30,000 mg/L, with Surprise Creek showing levels generally less than 3,000 mg/L (highest late in the dry season), and the Barney Creek Diversion reach south of NOEF generally less than 2,000 mg/L.

With respect to the groundwater of the alluvium and weathered rock around the NOEF:

- In the NOEF footprint monitoring bores, sulfate has historically been less than 10,000 mg/L, although some bores are showing levels in recent years of up to 20,000 mg/L.
- Otherwise, sulfate levels are quite variable, and likely an outcome of proximity to seepage impacts from the NOEF and naturally occurring levels, which may be associated with differing rock types and the presence of structure. **Figure 4-37** reflects this spatial variability in the upper right image.

Spatial distribution of sulfate is a valid approach to establishing model starting conditions. It is noted that some bores around the NOEF have changing sulfate levels with time. Source terms should therefore be based on the simulation timestamp and levels of sulfate that occur at the same time.

Model calibration statistical targets are summarised for each of the calibration steps in KCB (2024b). Barnett et al., 2012, provides guidance on model complexity and calibration performance.

A target confidence level classification for the model should be defined – guidance is provided for model classification noting there are three classes of groundwater model defined across several model characteristics. Models generally do not singularly conform to a set class in all criteria. The site model, based on classification criteria provided in the Australian Groundwater Modelling Guidelines, is a Class 2 / 3 simulator and is likely to transition to more Class 3 criteria as it is continually improved.

Performance measures of the groundwater model calibration process refer to the match of model generated data to historical measurements. Guideline values from Barnett et al. (2012) are used to determine calibration performance and are (for this model) model convergence, water balance error of less than 1 %, RMS (Root Mean Squared) of less than 10 m, Scaled RMS (SRMS) of less than 10 %, simulated reproduction of the conceptual hydrogeology and spatial water quality variation. Each of the three stages of model calibration met or exceeded the guidelines criteria.

While an SRMS of 10 % is used in this model calibration process, it is noted that the two transient calibration stages achieved an SRMS almost half this amount, at 5.8 % and 5.1 % respectively.

Further from Barnett et al., 2012 with respect to model calibration:

- **Guiding Principle 5.1:** *All available information should be used to guide the parameterisation and model calibration. All parameters should initially be considered to be uncertain.*
- **Guiding Principle 5.2:** *The calibration process should be used to find model parameters that prepare a model for use during predictions of future behaviour, rather than finding model parameters that explain past behaviour.*
- **Guiding Principle 5.3:** *The modeller should find a balance between simplicity (parsimony) and complexity (highly parameterised spatial distribution of some properties). Non uniqueness should be managed by reducing the number of parameters or by regularisation, which is a way of ensuring that parameter estimates do not move far from initial estimates that are considered to be reasonable.*
- **Guiding Principle 5.4:** *Performance measures should be agreed prior to calibration and should include a combination of quantitative and non-quantitative measures. The scaled root mean squared error (SRMS) is a useful descriptor of goodness of fit when the only objective is to fit historical measurements of heads but is less useful when automated calibration methods are used. A target SRMS of 5 % or 10 % is only meaningful when those setting the target know that it is achievable for a particular kind of problem and a particular environment with a known density of informative data.*
- **Guiding Principle 5.5:** *Sensitivity analysis should be performed to compare model outputs with different sets of reasonable parameter estimates, both during the period of calibration (the past) and during predictions (in the future).*
- **Guiding Principle 5.6:** *A formal verification process should only be attempted where a large quantity of calibration data is available, and it is possible to set aside a number of key observations that could otherwise be used for calibration.*

Barnett et al. (2012) notes further “In many modelling projects the conceptualisation, calibration and predictive analysis will be updated and revised as more information becomes available and as modelling results illustrate the need for such revisions. It may be necessary to revise expectations of the confidence levels associated with the model outputs.”

This model, due to the detailed construction, supporting level of monitoring information and confidence in the conceptualization, should be considered a mixed Class 2 / 3 model build. Future builds and improvements should consider this recognition in model detail, performance expectations and predictive confidence, however future model improvements are not necessarily singularly attributed to improved calibration statistics – reduction in non-uniqueness and adaptation to improved conceptualisation remain important aspects of future improvement.

4.2.5.5 Model Calibration Discussion

Groundwater level calibration is presented in transient format, which is an important aspect to prediction of groundwater response in an environment highly responsive to wet and dry season cyclicality. Examples of these are provided in **Figure 4-39** from KCB (2024a). Data within the report are presented for model layers 1 through 8 for the NOEF area, noting:

Layers 1, 2 and 3: **Overburden**, comprises 22 bore locations with a range of calibration performance from very good (matched elevation and seasonal response, e.g. GW133S) to poor (mismatch in elevation and seasonal trends, e.g. GWNOEF2NSL.). Seven of the 22 bores for these three layers observed an underprediction in groundwater elevation, none over-predicted groundwater elevations.

Layer 4: **weathered bedrock**, comprises 26 bore locations, with most generally reproducing groundwater level and seasonal fluctuation outcomes. The weathered rock appears less susceptible to shallow system processes that have the potential to impact predictions.

Layers 5, 6, 7 and 8: **upper bedrock and faulting**: comprises 41 bore locations with similar predictive performance to those bores in layer 4, generally a matched groundwater elevation showing appropriately scaled seasonal fluctuations.

While there are some bores in these data which have not matched observed conditions, generally the predictive capacity of the model appears very good, particularly the case in layers 4 and deeper, representing weathered and upper bedrock and faulted conditions.

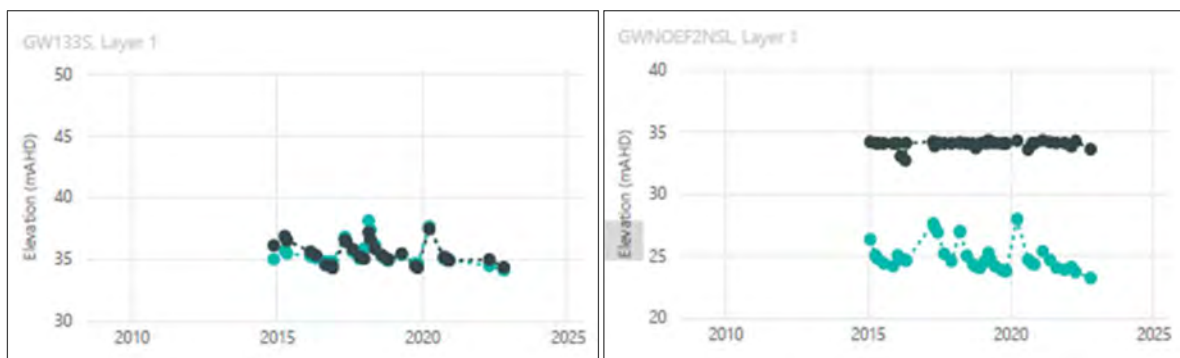


Figure 4-39: Example groundwater elevation calibration match to measured data (good – left, poor – right)

Sulfate calibration (undertaken as part of the stage 3 calibration process) is also presented in transient format. Data are presented for model layers 1 through 8 for the NOEF area, noting:

Layers 1, 2 and 3: **Overburden**, comprises 12 bore locations showing generally good correlation to observed conditions. Event based peaks in the observed data are generally not reproduced in the model, however this is to be expected due to the unique nature of these events and the time discretisation for the model. Regional trends however are reproduced to good effect, example shown in in GW096S (layer 2), and in GW088D (layer 3) (**Figure 4-40** and **Figure 4-41**).

Layer 4: **weathered bedrock**, comprises 22 bore locations, with similar predictive outcomes replicating regional trends in many cases very well, noting some locations have very low sulfate conditions without rising or changing trends.

Layers 5, 6, 7 and 8: **upper bedrock and faulting**: comprises 34 bore location with similar predictive performance to those bores in layer 4, generally predicting a matched groundwater elevation and seasonal fluctuations.

Prediction of sulfate conditions is considered very good across the dataset.

An example of paired groundwater level and sulfate prediction showing this is provided for GW065D as shown in **Figure 4-40**.

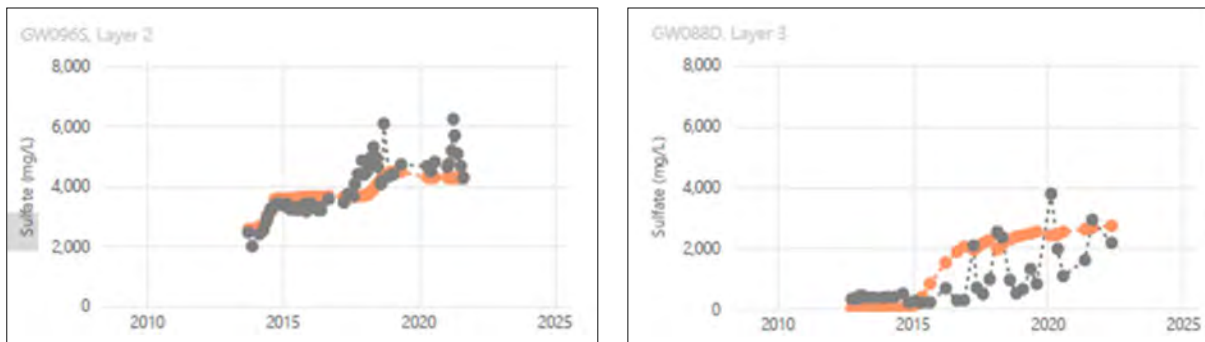


Figure 4-40: Overburden Sulfate Calibration Examples, GW096S and GW088D (KCB, 2024b)



Figure 4-41: Example Groundwater Elevation and Sulfate Calibration Outcomes, GW065D, Groundwater Elevation (left), Sulfate Content (right), KCB (2024b)

The metal parameters of concern (As, Cd, Pb and Zn), however, are assessed by KCB to be attenuated in the aquifer matrix during migration through the aquifer pathway and therefore, their plume extents are contracted in comparison to sulfate. Zn is the most mobile of these metals under the current neutral pH conditions.

Seepage from mine infrastructure and migration of mine affected water is expected to occur primarily in the weathered and upper rock profile (KCB, 2024b).

The migration of contaminants of concern will be primarily controlled by advection and dispersion within the aquifer pathways (KCB, 2024b). Since sulfate is a conservative parameter (i.e. not assumed to be subject to reaction processes and attenuation) its plume migration will generally represent the maximum extents for the given source-pathway-receptor mode (KCB, 2024b). Sulfate ‘plume’ development across several model layers is provided to allow an understanding of the contaminant transport processes and the likely pathways and locations of discharge of affected waters is likely to occur (sulfate source terms used in the model are previously described in this section).

An example of site wide sulfate conditions is taken from KCB (2024b) and is shown in **Figure 4-42**:

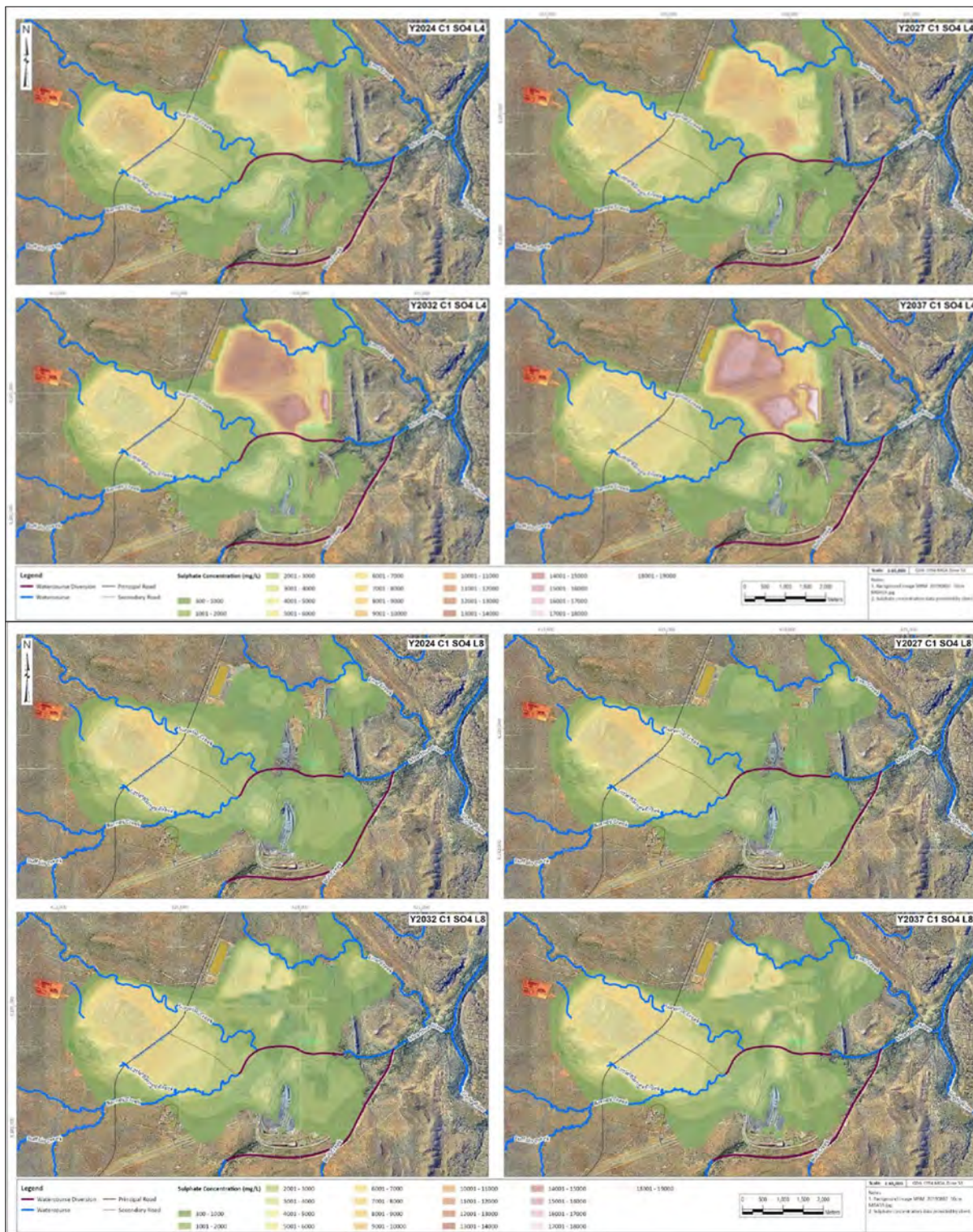


Figure 4-42: Transient sulfate plume predictions – weathered rock (upper) and intact rock (lower), at years 2024, 2027, 2032, 2037 (KCB, 2024b)

- The upper image shows sulfate plume predictions for the weathered rock directly underlying the NOEF. Sulfate levels beneath the NOEF progressively increase to over 10,000 mg/L. The strongest gradient development away from the NOEF appears to be located in the south of SEPROD, likely associated with preferential fault pathways connected to the mine. In this area, the plume is perpendicular to the Barney Creek Diversion, in an area where the conceptual understanding indicates the shallow groundwater table system lies beneath the invert of the drainage system.
- The lower image shows a lower level of sulfate distribution with the same lineament initially apparent as sulfate levels less than 300 mg/L. These lower levels in 2024, increase in a north-south arrangement to over 4,000 mg/L (beneath the Barney Creek Diversion), towards the mine void.
- Sulfate levels generated from predictive modelling, as discussed above, should not be considered a direct or singular outcome of the NOEF. From **Figure 4-37**, it is noted that rock also has areas of high sulfate (>2,000 mg/L, used in starting conditions for simulations). In the area beneath Barney Creek, the Western Fault and an East-West structure parallel and south of the Barney Corridor, have such a noted high sulfate condition. In considering predictions of sulfate source, fate and pathway, it is important to recognise the three dimensionality of the pathways and the abrupt change that structure can impose. This also highlights the relevance of a whole-of-site 3D simulator for groundwater movement and interactions.

Plume distributions for long term post-mining conditions are not presented but will become important in understanding if these pathways, which are passing beneath the Barney Creek Diversion and toward the mine void, change in elevation and potential extent of connectivity with the surface water drainage.

4.2.5.6 Baseflow Estimates to Creeks

Typically, during the dry season there is little or no flow in Barney Creek and Surprise Creek. However, periods of prolonged baseflow are often recorded in Barney Creek and Surprise Creek upstream of the diversion, which is considered to be related to localised elevated groundwater levels (MRM 2017b).

Model-predicted groundwater discharge to creeks and rivers are provided in KCB (2024b) for zones 17_2 and Zone 3, which represents Surprise Creek between the Carpentaria Highway and the confluence with Barney Creek, and the Barney Creek Diversion to the immediate south of the NOEF. Predicted discharge shows strong wet / dry season cyclicality with initial rates of 4-8 L/s, reducing to 1-5 L/s by year 2037. The model does not predict complete cessation of groundwater discharge in the dry season. WRM (2017) discussed flow in the Surprise Creek at the Carpentaria Highway, noting that this system only flows for short periods. Median flows December and May range between 14 ML/month and 140 ML/month (or, about 5 to 50 L/s) (**Figure 4-43**). Surface flows are a combination of rainfall runoff, accumulation from upstream drainages, and groundwater baseflow. The modelling of KCB (2024b) only presents predictions of this baseflow. Future iterations of the groundwater model may seek to achieve lower, or dry, dry season contributions if conceptualisation supports this change.

Sulfate load estimates for the reaches of Surprise Creek and the Barney Creek Diversion south of the NOEF are provided and predict initial loads as high as (peak) 2,000 kg/day, abating to less than 1,000 kg/day by simulation year 2034 (KCB, 2024b). These loads occasionally reduce to zero during dry season low flow conditions. Reach Surprise 17_2 is predicted to receive a larger load of sulfate than the Barney Creek Diversion sector – potentially an outcome of the manner in which sulfate loads are predicted from the Tough2 simulation reflecting the earlier design and construction standards of the NOEF in the area of SPROD, and the period of SPROD operation prior to HDPE re-lining (**Figure 4-44**).

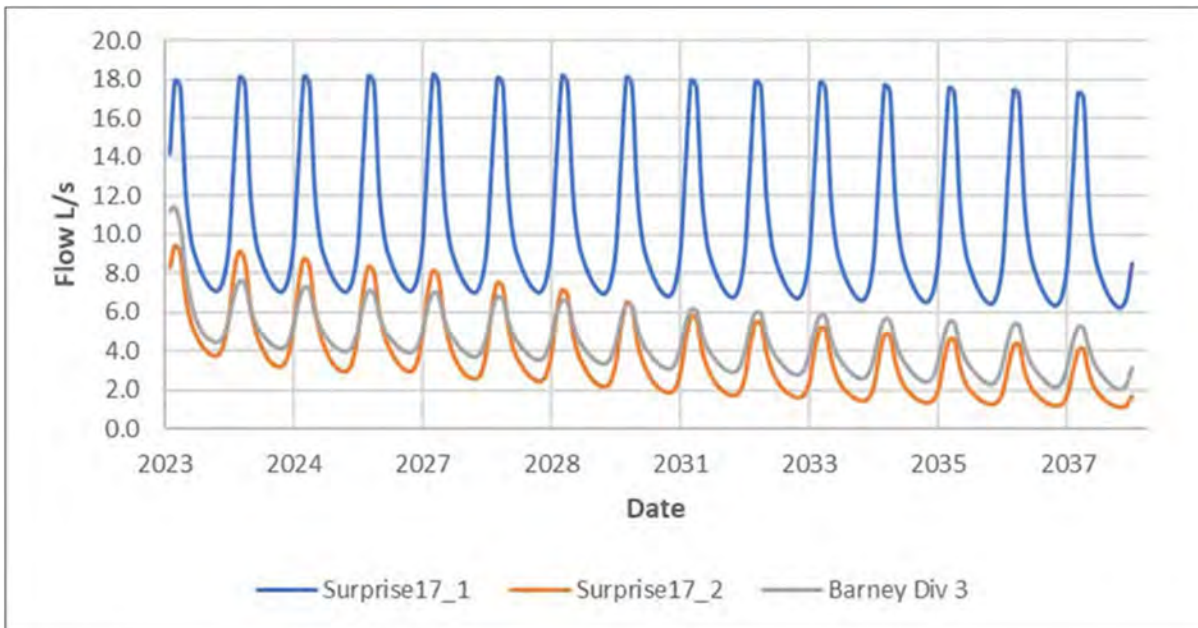


Figure 3.10 Life of mine monthly baseflow predictions for Surprise Creek and Barney Creek diversion

Figure 4-43: Baseflow discharge predictions to Surprise Creek and the Barney Creek Diversion south of the NOEF (KCB, 2024b)

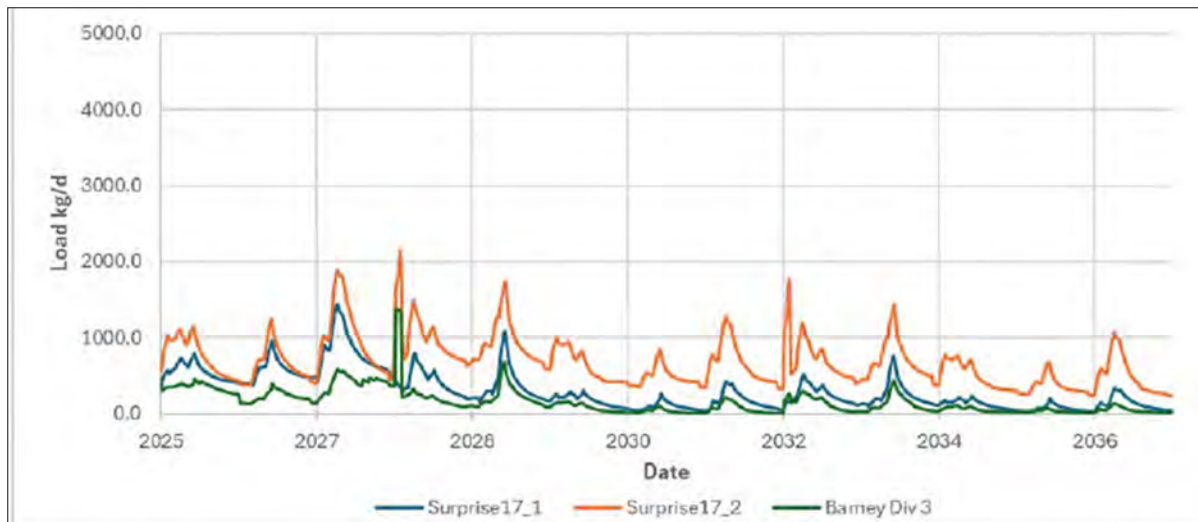


Figure 3.14 Life of mine monthly sulfate load predictions for Surprise Creek and Barney Creek diversion

Figure 4-44: Sulfate load predictions to Surprise Creek and the Barney Creek Diversion south of the NOEF (KCB, 2024b)

4.2.6 Monitoring of the Performance of the NOEF

4.2.6.1 Groundwater Monitoring

Groundwater monitoring is perhaps the most critical element to the management of seepage risk from the NOEF. The monitoring network serves several purposes as it evolves, matures and is adapted to the changing needs of the NOEF and the broader mine site:

The monitoring network informs the construction of the hydrogeological understanding of the foundation conditions of the NOEF, and in doing so influences the design and construction practices of the facility.

The progressive improvement, expansion and maturation of the monitoring network improve the conceptualisation and also assists in reduction of non-uniqueness in model predictions. This is an important point – monitoring data should not only be used to calibrate or validate a model. This data needs to continually improve the conceptual understanding and ensure this improvement in knowledge translates to the predictive environment.

The network assists in understanding groundwater surface water interactions and inter-aquifer connectivity and pathways, critical to determining risk of seepage impacts and then designing or managing their reduction.

The network collects the data needed to identify the presence of impacts to groundwater – either physical (pressures / flows) or chemical (seepage loads contributing from sources).

Monitoring networks must evolve and be developed to address the risks they are intended to understand and to adequately represent the hydrogeological system.

Monitoring networks must also be constructed compliant to guidelines and standards, and their suitability for ongoing monitoring should always be reviewed.

KCB (2024b), the *McArthur River Mining Pty Ltd Annual Groundwater Report* is the latest reported update of conditions at the mine and due to its recent completion is the most contemporary reference to monitoring available for this review. Much of the discussion in the following section is taken verbatim from this reference.

Raw data has not been assessed as part of this review.

4.2.6.2 2023 / 24 Annual Groundwater Report (KCB, 2024)

MRM's groundwater monitoring program was developed to achieve the following objectives (KCB, 2024b):

- Characterisation of water quality at monitoring sites upstream of Mine operations and in zones of natural mineralisation.
- Identification of adverse or unexpected trends in groundwater quality that may harm the receiving beneficial uses and environmental values.
- Assessment of measured groundwater quality against predicted groundwater impacts.
- Validation of the source–pathway–receptor model; and
- Assessment of the efficacy of controls implemented by MRM to prevent contamination from the sources.

The monitoring program identifies monitoring bores across four domains: Mine, TSF, NOEF and BBLF. Groundwater monitoring was undertaken in accordance with MRM's Groundwater Monitoring Procedure (PRO-2200024). This review has focussed on the NOEF domain. The key environmental management objectives for the Mine are included in the Mine's Adaptive Management Plan (MRM, 2022), and are described as follows:

- Protect the McArthur River's beneficial uses and community values from mining impacts.
- Facilitate development of the ecosystems and their functions along the McArthur River Diversion Channel for terrestrial and aquatic flora and fauna.
- Achieve a recovering trend in the water quality and ecosystem function in creeks on the Mine site within 20 years of cessation of mining; and
- Minimise air quality-related impacts from the Mine's operations with respect to community health and the environment.

Three 'main' hydro-stratigraphic units are considered at the site in the context of groundwater monitoring:

- Alluvium (overburden), which is an unconfined perched system collectively known as the overburden aquifers.
- Weathered bedrock, comprising localised, unconfined to semi-confined aquifers at the boundary between soil / weathered rock and contiguous bedrock.
- Fresh bedrock aquifer, which are a fractured flow system heavily influenced by structure (such as faults) and local rock characteristics (such as karst).

Primary groundwater quality indicators used in determining potential impacts from operations are sulfate, pH, lead, zinc, and nitrate. Groundwater sampling at the NOEF domain for the period reported had planned on 102 bores to be sampled. Only 30 bores were actually sampled, well below the intended data collection. Reasons cited included monitoring bores being decommissioned due to operational activities / changes, access issues due to wet weather or unsafe conditions, monitoring bores becoming dry (e.g. groundwater level below the base of the screen), or insufficient groundwater to collect a representative sample. Cyclone Megan had a significant impact on collecting samples during March and April 2024.

The NOEF groundwater monitoring network in 2024 is shown in **Figure 4-45**.

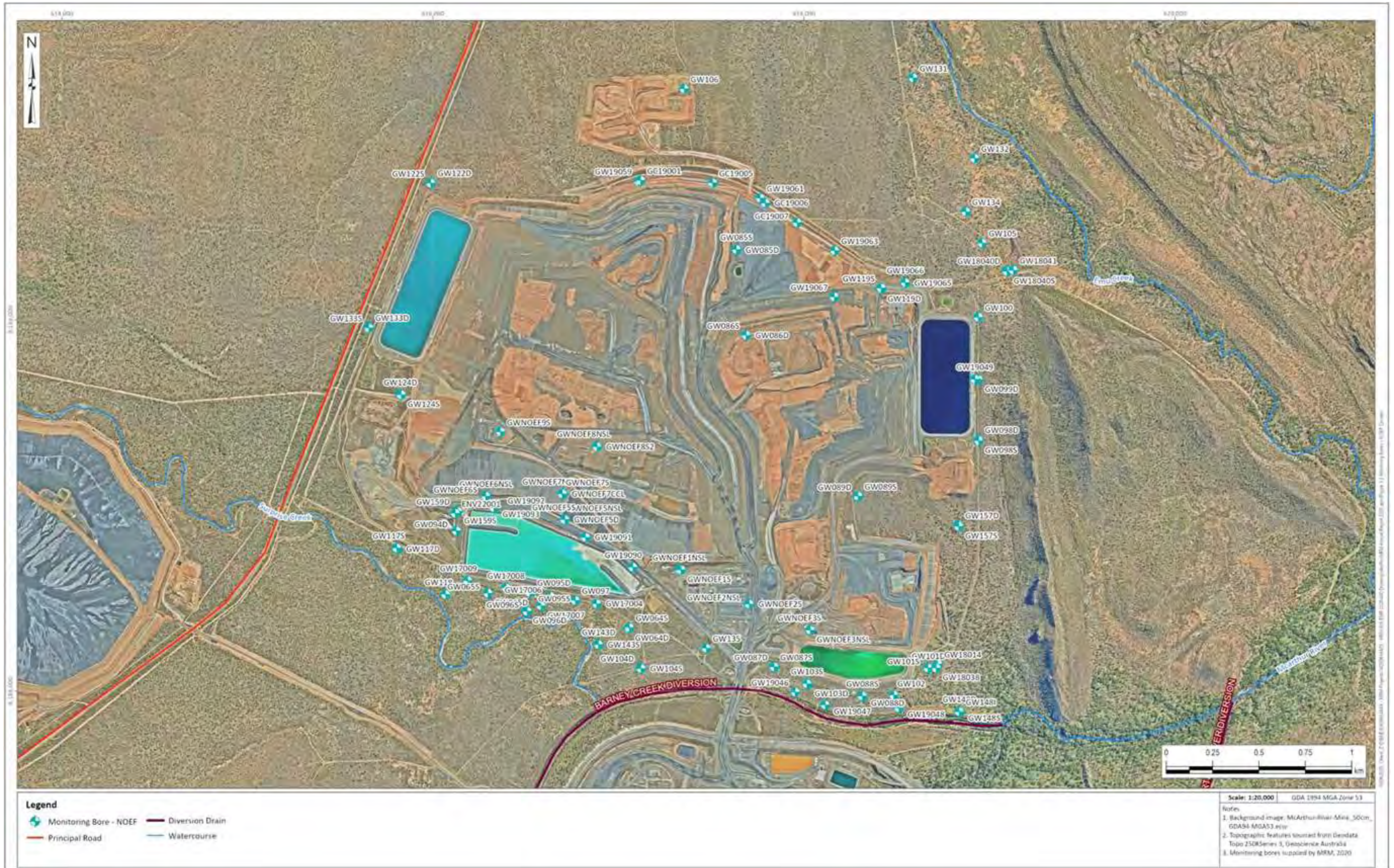


Figure 4-45: NOEF domain groundwater monitoring network (KCB, 2024b)

4.2.6.3 Groundwater Trends

Regional groundwater elevation mapping is presented by KCB (2024a) using a subset of the mine's available network. This contouring does not appear to differentiate between hydro-stratigraphic unit, nor does it account for local effects to groundwater movement that might be expected from significant fault sets.

The respective domains are each considered in more detail and in the context of previous reports.

For the NOEF, local groundwater level trend observations for the reporting period are summarised across zones around the facility (noting the period included a cyclone in March of 2024 which provided a period of rainfall excess of about 380 mm over a few days (the month of March 2024 recorded a total rainfall of 511 mm). The KCB report (2024a) indicates that:

- The NOEF footprint bores show a similar response to previous reporting periods, noting the impact of the 2024 wet season is notable with highest levels on record for bores GWNOEF1S and GWNOEF3S. These are located between SPROD and SEPROD 300-400 m north of the Barney Creek Diversion. Most bores in this domain exhibit a strong seasonal relationship to the CRD, with annual elevation variance of about 2 to 4 m in response to seasonal CRD variance of about 500 mm. Dry season groundwater level declines are about 2 to 3 m over a 9-month dry. Bore GWNOEF1NSL is located east of SPROD and shows an atypical groundwater level trend with very little vertical variation, noting this is completed within fill / waste material of the NOEF. Elevated zinc, rising EC / TDS, rising sulfate and period spikes of lead and nitrate are apparent in the data.
- East of the NOEF (east of EPROD) are GW099D and GW100 (GW19049 not located) that generally show correlation with CRD.
- West of the NOEF show good matching to CRD with one bore, GW122D exhibiting a 5 m rise in response to the March 2024 cyclone. This is the only bore in this area with a post-cyclone groundwater level, and while all bores in this area show seasonal variation, bore GW122D exhibits wet and dry season variability approximately two times larger than the other bores (GW133D and GW133S). These latter bores are located between the western most edge of WPROD, and the Carpentaria Highway. It is unclear what depths these are recording levels at, noting that they are similar which may indicate local vertical connectivity. Bore GW122D is located north of WPROD and has a groundwater level consistently lower (up to 3 m) than the GW133S and GW133D pairing.
- Northwest of SPROD is monitored via bores EN22001, GW094D and GW159S and GW159D. Lowered pH and raised sulfate and nitrate, and elevated zinc, arsenic and lead are apparent in GW159S. Some of these trends are beginning to also occur in GW159D (sulfate and nitrate). The report identifies construction problems with these bores as the likely cause (and not SPROD) although the reporting of this was not viewed as part of this review. The groundwater elevation in GW159S is consistently 0.5 m above groundwater of GW159D.
- South of SEPROD is represented by a large suite of bores (12 in total) clustered from near to the Barney Creek Diversion to the southeastern most area of the NOEF domain (about 500 m southeast of SEPROD eastern extent). Most bores show similar 'clustered' groundwater level and water chemistry data. Groundwater levels show significant seasonality and strong correlation to the CRD. Up to 6 m of vertical rise is apparent in response to some wet seasons. Gradients between bore elevations throughout the seasonal variations are generally constrained, indicating the system 'breathes' as a single unit with almost all levels falling and rising together. Groundwater chemistry is generally consistent although it is of note that the highest sulfate levels occur south of SEPROD near to the Barney Creek Diversion, and the lowest sulfate levels occur approximately 500 m southeast of the SEPROD. Whilst water chemistry attributes are not excessively elevated a change is apparent and may indicate modifying conditions with recharge which will ultimately need to be considered in numerical modelling. Levels of pH are consistently higher than 6.5 and levels of electrical conductance are consistently lower than ~8,000 µS/cm.
- Southeast of SPROD represents the area between SPROD and the drainage merge of Surprise Creek with the Barney Creek Diversion. Bore GW014D is the furthest from SPROD and the nearest to the Barney Creek Diversion and shows (as with other bores) strong alignment with the CRD. Levels nearer SPROD are about 2 m higher than GW104D thus horizontal gradients are moderate toward the drainage features. Wet season rises in groundwater elevations of up to 4 m are not uncommon and gradients from bore to bore remain consistent throughout the dry and wet season conditions. GW135 has the lowest groundwater levels and is located midway between SPROD and SEPROD, about 250 m north of the Barney Creek Diversion. Groundwater qualities appear relatively stable, although long term reduction in

some attributes is apparent in the data (such as sulfate for GW17004, closely located to SPROD), and hydrochemistry attributes are low.

- Southwest of SPROD groundwater levels show similar wet and dry season cyclicity aligned to the CRD with bore-to-bore gradients generally maintained, although there has been a notable declining regional trend of about 6 m in nearly all bores from 2015 to 2024. High nitrates were recorded in this earlier period with low sulfates, with this trend reversing between 2018 to current. Bore GW117D does not align with the other bores in this grouping, noting it is upgradient of SPROD and the other bores, and has maintained a high consistent groundwater level. Groundwater chemistry from this bore has also differed from the others which are all located between SPROD and Surprise Creek. Elevations of groundwater and the locations of these bores with respect to Surprise Creek are important aspects to the conceptualisation and these responses may be related to changed local conditions around SPROD as a result of the HDPE lining of this facility in 2019.

Complementing these observations is performance monitoring screening completed to identify areas of impact and groundwater chemistry exceedance. MRM reviews the groundwater monitoring data on a quarterly basis or as needed following sampling. This is completed using control charts, to visualise the data and identify any trends or anomalies and instigate the appropriate actions. In the most recent report (KCB, 2024a), this notes five bores with exceedance (not all) in the area of the NOEF, of pH, sulfate, arsenic, lead, nitrate and zinc.

- GW102 – sulfate concentrations deviating from model predictions, likely related to operational practices in the local area.
- GW103D - sulfate concentrations deviating from model predictions likely related to operational practices in the local area.
- GW159S (pH, zinc, lead, sulfate, arsenic) and GW159D (sulfate and nitrate) - MRM completed investigations into the cause of change in these bores and identified they are not fit-for-purpose due to poor bore construction. Replacement bores are being commissioned and an overlap in water chemistry monitoring is occurring.
- GW096D – sulfate concentrations deviating from model predictions. Although the general trend follows the predictions, the concentrations are elevated above the predicted concentration.

4.2.7 Surface Hydrology

4.2.7.1 SW Monitoring Plan 2024 WRM

MRM has developed a Natural Surface Water (NSW) monitoring program, which specifies the sampling requirements and procedures for the monitoring of the McArthur River, its tributaries, and the surrounding receiving environment (**Figure 4-46**). The objectives of the monitoring, as detailed in the Mine's Water Management Plan (WMP) (MRM, 2022b), are to:

- *Characterise water quality at monitoring sites upstream and downstream of Mine operations;*
- *Assess the potential impacts on the receiving waters from Mine operations;*
- *Assess the measured surface water quality against WDL 174 Site-Specific Trigger Values (SSTVs) to verify compliance (monitoring location SW11);*
- *Identify the potential sources of contamination measured at water monitoring sites; and*
- *Assess the efficacy of controls implemented by MRM to prevent contamination of receiving waters downstream of the Mine in the McArthur River.*

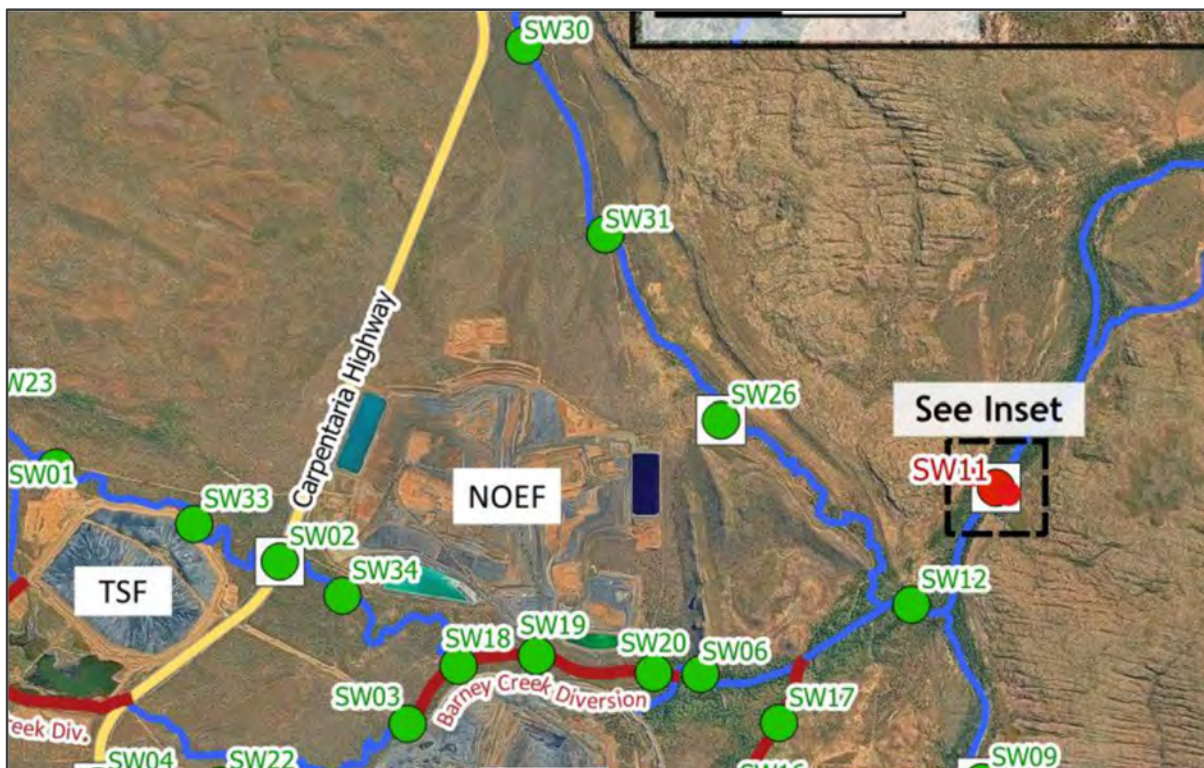


Figure 4-46: Distribution of natural surface water monitoring sites relative to the NOEF (WRM, 2024)

MRM has also developed an Artificial Surface Water (ASW) monitoring program which specifies the sampling requirements and procedures for monitoring water in designated water storage facilities. ASW sites consist of ponds, sumps, dams and sediment traps, which are used as part of the site water management system to collect, store, or manage potentially mine-affected water and sediments. The objectives of the ASW monitoring program, as detailed in the Mine’s WMP (MRM, 2022b), are to:

- *Identify potential contamination in water to determine risk and appropriate management options.*
- *Identify suitable water storage options and determine whether offsite discharge is a viable disposal option.*
- *Collect data to assess environmental performance and provide information for contamination source investigations.*

The ASW monitoring locations are situated at major mine infrastructure (**Figure 4-47**) and have been classified into common domains, which include a dedicated domain for the NOEF.

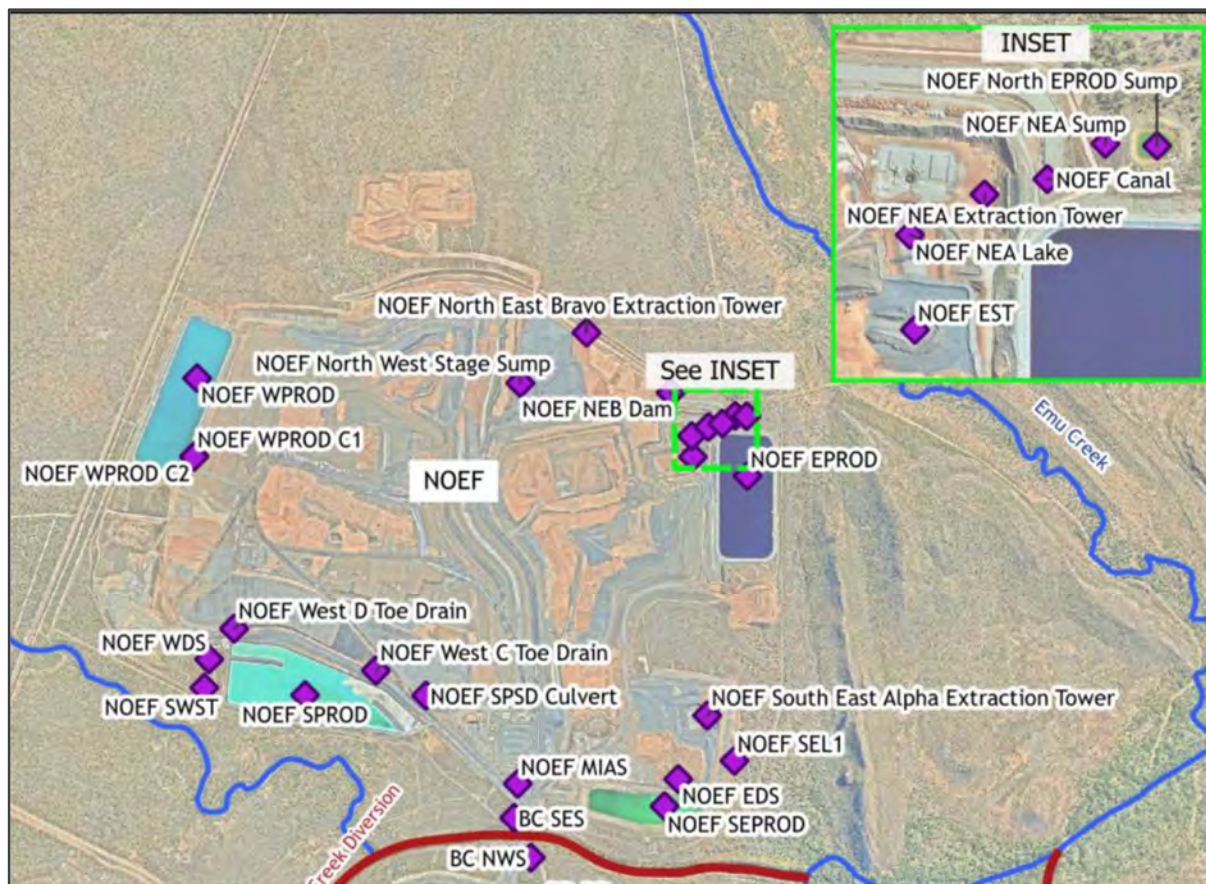


Figure 4-47: Distribution of artificial surface water monitoring locations (WRM, 2024)

WRM (2024) noted that “A significant amount of rainfall, the 7th wettest (5 % exceedance probability) on record according to an analysis of available rainfall data, occurred at the mine during the reporting period as a result of Ex Tropical Cyclone Megan (Ex-TC Megan). Approximately 1,235 mm of rainfall was recorded at the Mine over the 2023 / 24 reporting period, which is much higher than average (722 mm). The majority of rainfall occurred over the wet season months between November and April”.

Summarised monitoring results of the period from WRM (2024) are provided:

A neutral field pH was reported across all NSW monitoring locations, including those located in the onsite tributaries. Sulfate concentrations were low and recorded concentrations were less than 50 mg/L across all the McArthur River monitoring locations, including the SW11 compliance point, for a majority of the reporting period. Sulfate concentrations at SW11 increased to as high as 156 mg/L after Ex-TC Megan due to managed release activities, however these recorded concentrations were well below the SW11 SSTV (1,000 mg/L).

Over the reporting period there were 10 individual exceedances of the SSTVs at SW11. The exceedances were related to:

- dissolved oxygen (DO);
- filtered aluminium (Al_F);
- filtered cobalt (Co_F);
- filtered iron (Fe_F); and
- filtered zinc (Zn_F).

Of these, only Zn_F (a single exceedance) was a notifiable incident under the conditions of the WDL and required further investigation to be submitted to NT DEPWS. The notifiable incident was related to a Zn_F concentration being three times greater than the SW11 SSTV.

Details of the interpretation of this occurrence are provided and summarised as “*Although mine-affected water was draining from Emu Creek at the time, the investigation concluded the sample taken was not representative of fully mixed McArthur River waters at SW11*”. It is noted that the result of the very wet period would have provided a significant amount of dilution for a long period.

The report presents graphical water chemistry monitoring results for stations SW09, SW11, SW12 and SW21, for the period 2008 to 2024, and for the reporting period of 2023 / 24. These stations are used in the report to discuss overall compliance but do not allow easy differentiation of potential NOEF impacts to be considered.

Station SW02 is one of seven ‘potentially impacted’ monitoring stations along Surprise Creek. SW02 is located downstream of the Carpentaria Highway bridge on Surprise Creek, downstream of the TSF and upstream of the NOEF. Data are presented for the monitoring period for creek flow elevation at this station (**Figure 4-48**), which shows an elevation of 33 m AHD was maintained or exceeded for six months of the period. Monitoring bore GW117(D or S) has a range of groundwater elevations over the same period of 30 to 34 m AHD. It would be useful to correlate this data to better understand the conditions where discharge from groundwater near SPROD and along the reach of Surprise Creek, before it merges with the Barney Creek Diversion, may have occurred into the surface drainage and what flows would have occurred in the creek during those periods of ‘groundwater discharge’.

No other stations in close proximity to the NOEF are presented in this report.

Water chemistry of surface waters is presented for each of Surprise Creek, Barney Creek and Emu Creek, however only for two stations on each system, which do not allow for potential impacts from the NOEF to be reasonably extrapolated.

Data and discussion are provided for downstream impacts from TSF Water Management Dam (TSF WMD) releases at SW19/SW20 (Barney Creek Diversion, south of SEPROD). EC levels were typically elevated (up to 9,504 $\mu\text{S}/\text{cm}$) at SW03 and were noted to *immediately reduce to less than 350 $\mu\text{S}/\text{cm}$. WRM (2023) noted “although EC levels were elevated in Barney Creek during the WMD RP releases, the monitoring records demonstrated that release water was rapidly diluted in the McArthur River” and there were no exceedances of the EC SSTV at the SW11 compliance point.* The WMD releases present an additional and short-term transient impact on water quality in the Barney Creek Diversion, and while not related to the operation of the NOEF, provide further justification for the need for site wide consideration of water related impacts.

It is assumed data exist for all stations which were accessible or functional during each of the sampling events. The review of these data with the groundwater records as outlined in **Section 5.2** (Opportunities for Improvement) would assist in improvement in the conceptualisation of the site for future rounds of performance monitoring and / or predictive modelling.

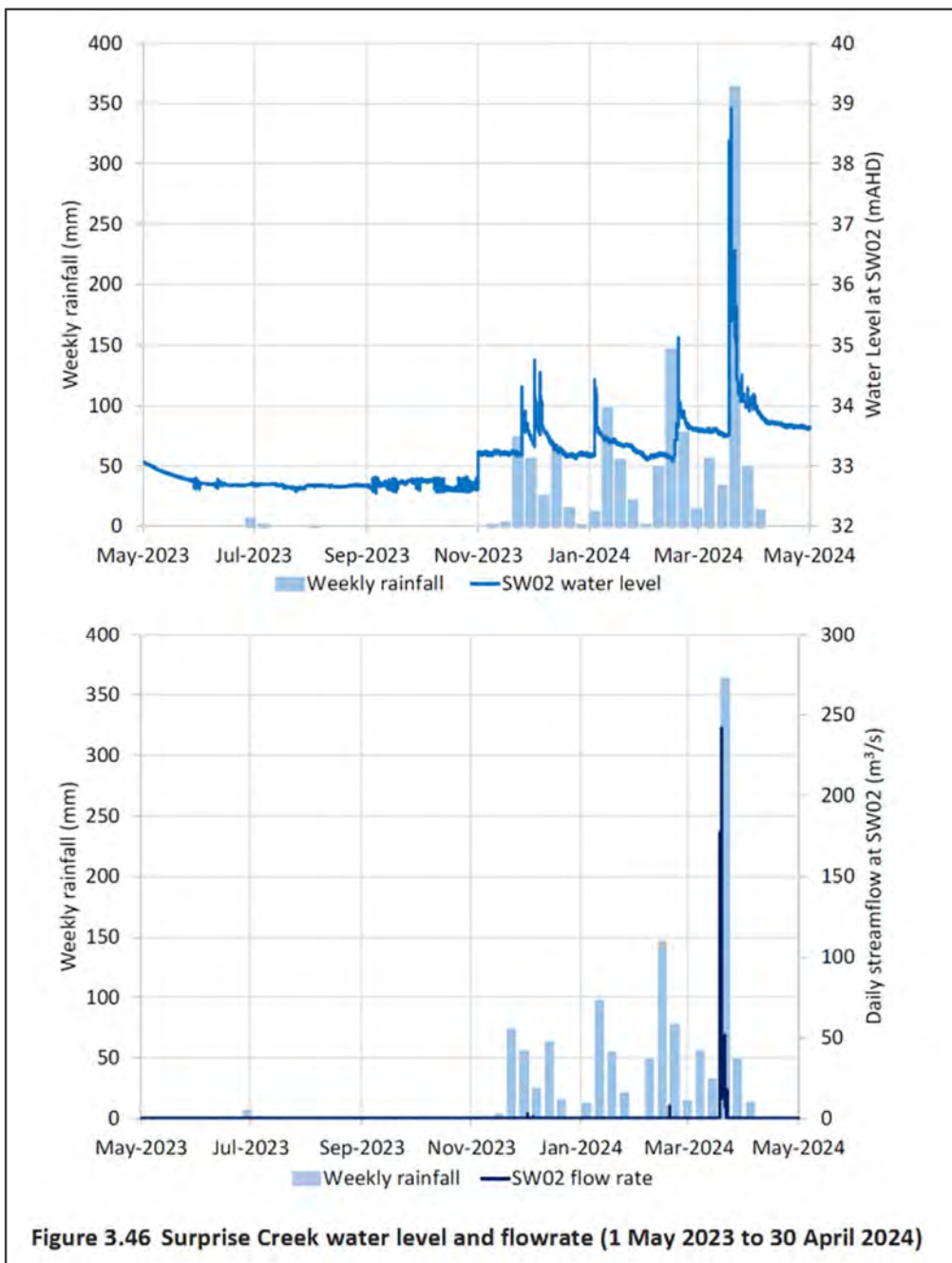


Figure 4-48: Station SW02, Surprise Creek (Carpentaria Highway) 2023 / 24 flow records (WRM, 2024)

4.2.7.2 Verification of Loads to Surface Drainages

The WDL compliance location is SW11, which receives surface water flows from a number of upstream drainages including the McArthur River (and diversions), Barney Creek (and diversions), Surprise Creek, Emu Creek and the Glyde River. The largest potential sources of mine affected chemistry loads with a potential to impact water at the site are the NOEF and the TSF. Both present a potential of groundwater derived seepage discharging into the surface water drainages where groundwater conditions are more elevated than the invert of the drainage, or the base of permeable bedload material these drainages may host. The groundwater monitoring report would be better if the results were to be integrated into the surface water monitoring report.

KCB (2024) applied Darcy’s rule to develop a range of loads reporting to the respective river reaches from the NOEF and other mine infrastructure. These are presented as total loads, with the manually derived values compared to the numerically (groundwater model) derived values in **Figure 4-49**. Good correlation is noted; however, the detail of the analytical approach is not presented explicitly.

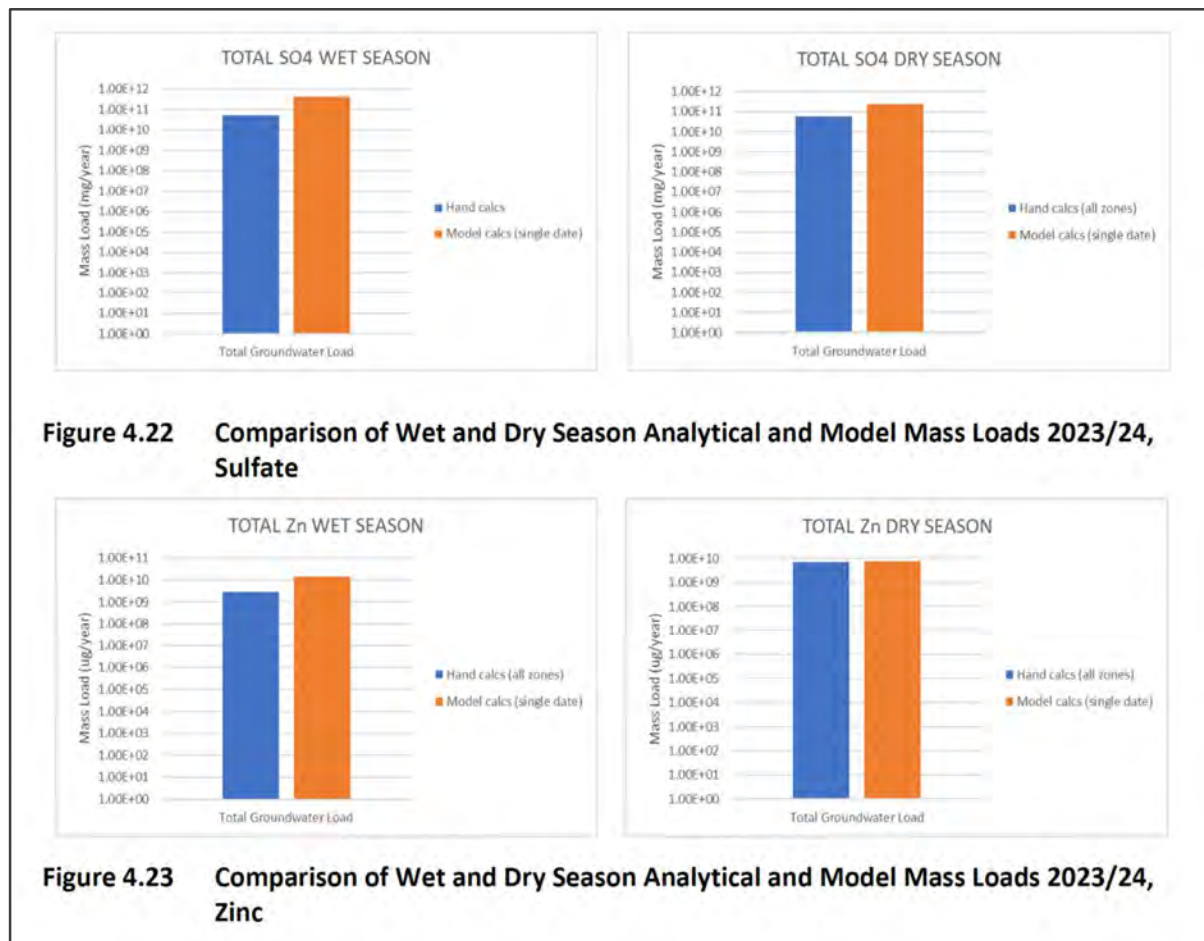


Figure 4-49: Mass load comparison – empirical and numerical estimates (KCB, 2024a)

KCB (2024a) also present a loads assessment for sulfate, lead and zinc. This considered results of the 2023/24 groundwater monitoring program, and model mass loads extracted from the 2017 version of the groundwater model. Loads were calculated for each of the surface water zones using monitoring program data and an analytical approximation for groundwater flow. The period assessed was noted to have below average rainfall, with groundwater loads being lower than prior predictions due to the reduced connectivity of the groundwater with the invert of creeks. The results are provided in **Table 4-10** and generally show good correlation between whole of model domain predicted loads, and whole of mine domain calculated loads. In most cases the model slightly over-estimates load with the exception of dry season modelled lead.

Table 4-10: Annual loads of sulfate, lead and zinc

Total Annual loads	Wet Season		Dry Season	
	Calculated	Modelled	Calculated	Modelled
SO ₄ (mg/year)	5.21E+10	4.43E+11	5.73E+10	2.34E+11
Zn (ug/year)	2.97E+09	1.45E+10	7.18E+09	7.44E+09
Pb (ug/year)	1.97E+07	1.47E+08	4.05E+08	7.00E+07

This version of the load assessment also provides more granular details by creek zone for the manually calculated load assessments, with an example provided below for wet season conditions for sulfate. Creek zone SC 17_2 and Barney Diversion 3 represent the system flowing eastward to the south of the NOEF. Generally, the techniques applied produced slightly lower levels of calculated load in the later data, which is attributed in the report to the construction of the TSF interception trench between the two measured periods (Figure 4-50).

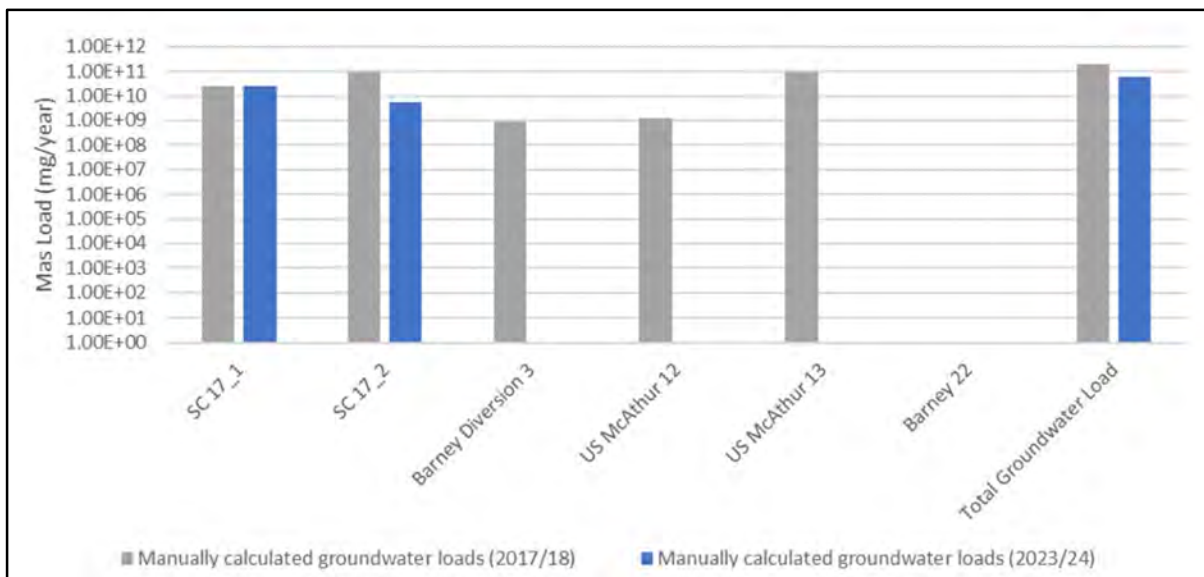


Figure 4-50: Dry Season Analytical and Numerical Sulfate Loads by Creek Zone

The 2023 / 24 surface water monitoring report completed by WRM (2024) presents graphical results of the prior wet period. This data has been compiled and plotted as part of this review for those stations with records between the Carpentaria Highway along Surprise Creek and the Barney Creek Diversion (Figure 4-51). The purpose of this is to understand dry to wet season trends along the drainage alignment closest to the NOEF. Supporting this data is the surface water component of the OMP-EIS (WRM, 2017) “A detailed review of the natural surface water quality data at MRM” was undertaken in January 2015 based on monitoring data collected between 2007 and 2014, a summary from which is provided in Table 4-11.

Observations include:

- From May to late October, EC increases from about 2,000 -4,000 $\mu\text{S}/\text{cm}$ for all stations, then decreases after onset of the wet season to <2,000 $\mu\text{S}/\text{cm}$, and <500 $\mu\text{S}/\text{cm}$ for SW18 and SW19. WRM (2017) report median EC at SW02 as 1,600 $\mu\text{S}/\text{cm}$, below the range apparent in the data presented.
- Sulfate follows a similar seasonal trend from 500 mg/L in the dry period increasing to about 2,000 mg/L prior to the onset of rain, then reducing again over the wet period to (in this case) <500 mg/L. WRM (2017) report median EC at SW02 as 428 mg/L – which is consistent with the end of the plotted period levels along the drainage;
- Filtered arsenic shows a similar although less pronounced trend generally ranging between 1-3 $\mu\text{g}/\text{L}$. Median arsenic (WRM, 2017) was noted at 1.2 $\mu\text{g}/\text{L}$ and the 95th percentile at 2.4 $\mu\text{g}/\text{L}$.
- EC for sites on Surprise Creek upstream of the TSF are limited to two data points at two monitoring stations (SW23 and SW29), and show EC in these areas to be less than 300 $\mu\text{S}/\text{cm}$.

The cyclical nature for the water chemistry of the drainage south of the NOEF reflects the strong seasonality of flow cycle. Data may be available to support a more thorough season by season review of conditions of surface water quality and flow, to construction and operation of the NOEF, and to local groundwater conditions. This will be important in differentiating the impact of the NOEF from impacts across the entire site.

Table 4-11: Parameter ranges for surface water quality, WRM (2017)

Parameter	WDL174-08 SSTV at SW11	Units	SW23		SW02		SW24	
			Median	95% ile	Median	95% ile	Median	95% ile
Sulphate (SO ₄)	341	mg/L	4	9	428	1185	736	2112
Zinc (Zn)	62.68	µg/L	1.2	7.6	4.1	14.0	4.7	20.0
Lead (Pb)	16.6	µg/L	0.10	1.00	0.14	1.00	0.20	1.00
Cadmium (Cd)	1.73	µg/L	0.02	0.10	0.10	0.20	0.10	0.20
Arsenic (As)	24	µg/L	0.5	4.3	1.2	2.4	0.9	1.8
Copper (Cu)	10.97	µg/L	0.33	1.43	0.34	1.56	0.32	1.22
Aluminium (Al)	55	µg/L	62	1756	10	204	10	896
EC	1,000	µS/cm	299	602	1600	2926	1945	4176
Hardness	-	mg/L	98	283	750	1480	1220	2424
pH	<6.0 and >8.5		7.6	8.5	7.6	8.4	7.6	8.1

While graphed data from the 2023 / 24 surface water monitoring report show results for SW23 and SW24 are generally in alignment with data presented in the OMP-EIS (MRM, 2017), recent values recorded at site SW02 (for EC, late dry season), exceed 4,000 µS/cm, about 30 % higher for this water quality indicator than reported in 2017. This is a useful example of why better understanding of potential loads entering surface water drainages may be warranted to support future updates to system conceptualisation and predictive modelling work.

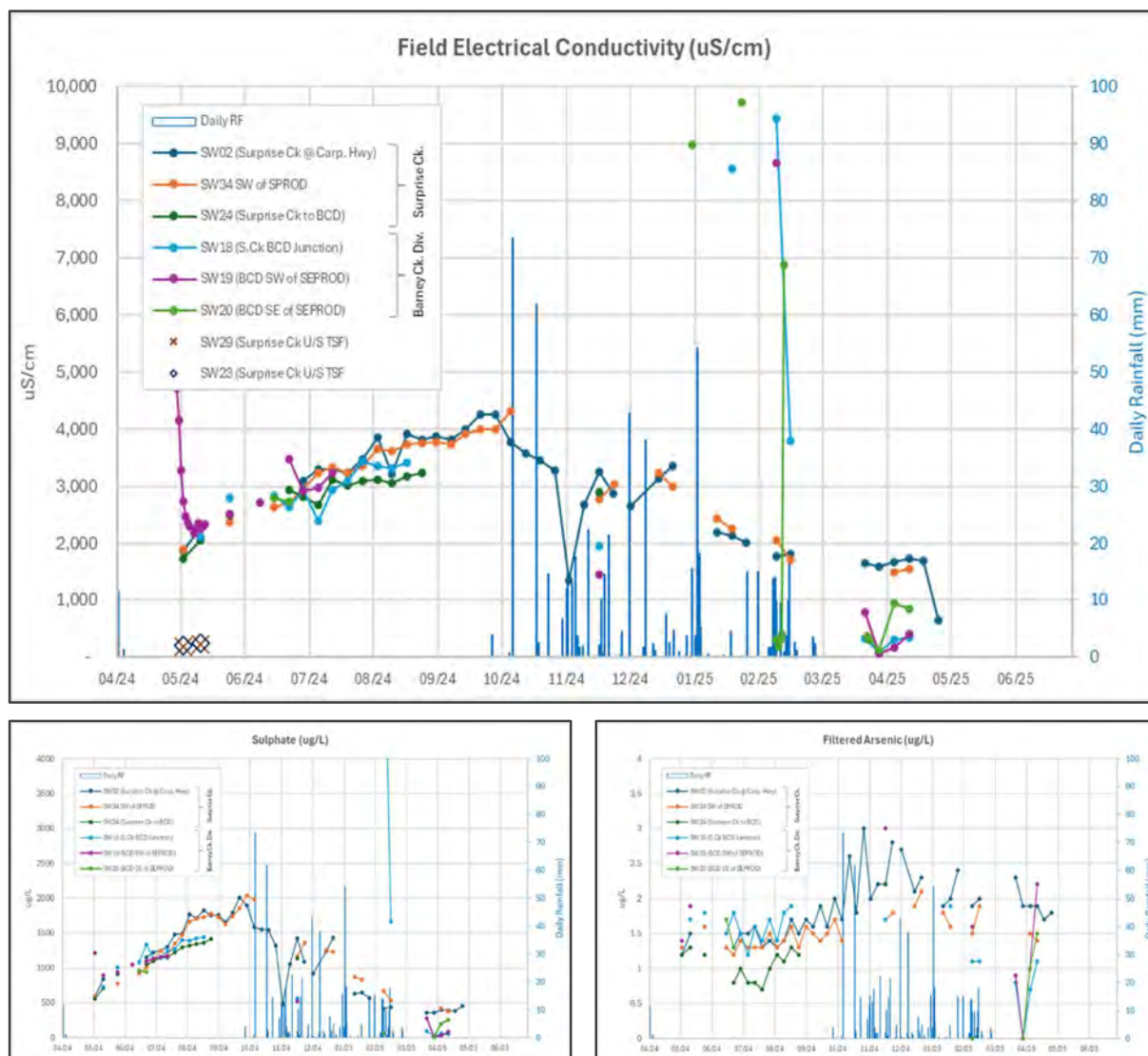


Figure 4-51: Transient monitoring of EC, sulfate and arsenic at surface water monitoring stations compared with rainfall events for the 2024 / 25 season (data extracted from WRM, 2024; KCB, 2024a)

4.2.7.3 Seepage Quantities and Quality (including performance of the NOEF internal drainage system)

It is not possible to physically collect and measure samples of direct basal seepage from the NOEF. Any seepage which exits the NOEF (and in doing so bypasses the internally constructed network of engineered water management), will enter the underlying groundwater system. By the time that water emerges to a location where it can be collected (say) from a bore, or a surface expression of seepage, it has mixed with a potential range of natural and mine affected waters.

As introduced earlier in this report in **Section 4.2.4.3**,

“Evaluation of the performance of a facility such as the NOEF is best served through vigilant performance review, collection and interpretation of a wide range of technical data, conceptualisation updates which constantly challenge and seek to improve the initial site evaluations, progressive improvement in numerical predictive tools which are then used to forecast NOEF performance and to influence future design and construction practices as needed.”

This is particularly relevant in establishing a performance understanding of the water management aspects of the NOEF.

Estimates of basal seepage are currently based on predictions made using the Tough2 simulator. The reasons for the application of this platform are described earlier in this report. **Figure 4-18** of this report shows basal seepage estimates to be a very small component to the NOEF water balance, especially the case post-closure. A water balance approach using PROD storage changes and other measured water movements (pump rates / volumes, etc) may not be suitable to determine losses to basal seepage due to the comparatively high error likely in the total water balance to the small basal seepage rates involved.

The process of evaluating seepage and determining the performance of the NOEF internal drainage must therefore be linked to the predictive tools used in forecasting performance, and the monitoring data used to assess conditions at the NOEF and to update the conceptual understanding of the system.

- The conceptual hydrogeological understanding of the NOEF area is thorough, is well supported with the monitoring network and is routinely challenged and updated.
- The construction methodology of the NOEF and its potential to create seepage during operations and post closure is well understood.
- Simulation tools applied are advanced in their development and application.
 - The Tough2 simulation is noted to be ~10 years old and is due for a review or update, particularly in consideration of design and construction changes which have occurred since construction, and in consideration of monitoring data which is now available to inform the improvement of this tool
 - The regional groundwater flow model captures all mine area potential sources of impact and is transient calibrated in accordance with Australian Modelling Guidelines to head (pressure) and to concentration of sulfate.

Review of model derived results with measured / monitored data is an important aspect to the process of continual improvement as outlined in **Figure 4-18** and is well documented by MRM. The models appear to be producing output which aligns well to observations and conforms to the understanding of the conceptual hydrogeology at the site, at a scale which allows separation of NOEF impacts from other mining landforms, and which enables local zonation of areas of reduced confidence or greater numerical uncertainty to be addressed.

An opportunity identified in this review and described in **Section 4.2.8.2**, is the analysis of monitoring data with the specific intent to assess the effectiveness of design / construction modifications of the NOEF. While this may be built into the model process, it requires an analytical approach to understanding the timing and extent of improvements which a change to construction practices may produce. This is an important value-add to a well-established process already in place.

4.2.8 Summary Observations of Seepage Performance

4.2.8.1 NOEF Design and Construction

Section 4.1 of this report presents in detail the design and construction history of the NOEF, as well as detail of construction oversight rigour, which was observed during the NOEF Panel site visit. The facility is geochemically complex with a precise material balance and construction schedule.

From a seepage management perspective, the NOEF during construction operates as a lined basin with design and construction managing water entering the structure through a complex series of vertical barriers and lateral drainage which ultimately direct water to externally lined PRODs.

This approach to construction water management seeks to minimise the generation of saturated conditions in situ, conditions which would otherwise (i) provide the residence time and waste contact to generate large volumes of poor-quality MAW, and (ii) provide the gradient needed to drive water vertically (as basal seepage) into underlying foundation materials.

The site experiences a vastly contrasting dry and wet season and occasionally must also cope with extreme rainfall events associated with cyclones. These conditions challenge the operational water management strategy with large ranges of potential short term water handling need required.

Closure conditions include the requirement to construct a low permeability cover intended to reduce the future infiltration of water into the NOEF, and to promote the efficient runoff and diversion of non-contact water as much as practical, and before it becomes mine affected. This closure strategy expands the operational strategy

of minimising and the generation of saturated conditions within the NOEF and extends to the reduction of oxygen ingress to support geochemical conditions within the stockpile.

MRM management, design, construction and operation teams show a strong level of commitment to this performance philosophy, and excellent collaboration to assess and rectify excursions of performance from design. The current design of the NOEF and the adaptive approach to its construction and improvement in design is considered leading practice for management of seepage risk.

4.2.8.2 Conceptualization of the Groundwater System

The mine and associated infrastructure are located on floodplains of the McArthur River and its subordinate drainages. These floodplain deposits are the result of a regionally significant topographic ridgeline striking north-south, which constrains drainage and sediment on the upstream side, and diverts all river and creek flow (with exception of Emu Creek) through a single low point in the terrain.

Foundation conditions beneath the NOEF comprise mixed and locally reworked alluvium, weathered rock and fractured and faulted rock of the McArthur River Group. Regional faulting occurs beneath and adjacent to the NOEF and appears well investigated, and karst conditions are mapped nearby to the NOEF. Deeper (fresh rock) groundwater systems are influenced by mining operations and a potentiometric disconnect is apparent from these deeper systems with the shallow groundwater table.

A connected pathway from the NOEF to the compliance location of SW11 requires both groundwater and surface pathways. Understanding shallow hydrogeology and the interaction of groundwater and surface water systems is critical to framing the potential risk of impacts downstream.

The conceptual understanding of the natural setting within which the NOEF is located appears well understood and presented. The concepts of source-pathway-receptor connectivity are being applied to future performance evaluation and to ultimately to design and construction improvement. The hydrogeological conceptualisation is suitable for understanding the performance of and responding to excursion of impacts from the NOEF. Continual updates to the conceptualisation and re-assessment of collected data appear to be a routine and high value aspect of the overall site understanding.

Two areas of future improvement may be considered:

- There may be merit in closer evaluation of transient groundwater levels and groundwater chemistry between SPROD and Surprise Creek prior to and following HDPE lining of SPROD. This evaluation could support the estimation of loads reporting in this case to Surprise Creek but may also assist in understanding the positive impacts of design change to the performance of the NOEF. Such evaluation could also support the understanding of short term impacts from long-term monitoring noted in the comparison of predicted performance to that actually observed.
- Future consideration of rebounding groundwater levels within fresh rock and faults as mining ceases and the interaction of these deeper potentiometric conditions with those of the groundwater table system near the NOEF will be beneficial in determining the potential for significant groundwater flow regimes under longer term changed conditions.

4.2.8.3 Numerical Modelling (Prediction) of Facility Performance

MRM deploys a three-model approach to evaluating NOEF performance and potential seepage risk:

- A Tough2 simulator in 3D format to represent the construction detail and internal saturation and phase conditions of the NOEF and estimates of seepage into foundation materials.
- A GoldSim simulator, coupled with Tough2, to understand the potential range of water quality which may be expected within, and seeping from the NOEF.
- A Modflow model, constructed at the regional scale inclusive of all mine domains and developed to predict groundwater level change and sulfate concentration with time.

This approach is supported for two fundamental reasons (i) the NOEF presents construction, saturation, geochemical and phase complexity at a scale which cannot be reasonably modelled in collaboration with groundwater flow, and (ii), the modelling of groundwater pathways has to be completed at a level of detail and scale which allows pathways to be reasonably represented using a domain which includes all potential sources of water quality that may impact compliance location SW11.

The Tough2 simulator was built and reported in 2017. Considering the rate at which model functionality improves, this simulator may be due for a generation upgrade.

4.2.8.4 Adequacy of the Monitoring Network

The site conceptualisation is well informed with a large monitoring network which collects climatic, hydrological, hydrogeological, geochemical and geological information across the site, and in collaboration with NOEF construction activity. The importance of understanding interactions of groundwater and surface water is well recognised and has influenced the expansion of the monitoring network and the type and frequency of data collected.

Information is routinely reviewed and is duly supported with dedicated technical studies aimed at continually improving the site conceptualisation. There was evidence during the review that modifications to the design and construction of the facility, and to predictions of its performance had been adjusted in line with updated interpretation outcomes.

Continual improvement in data collection, supported with use of well-considered and clearly presented data visualisation tools, is apparent, and is closely integrated with NOEF design and performance.

4.3 NOEF Rehabilitation

The NOEF Panel has reviewed the NOEF MMP (MRM, 2024a) with respect to NOEF rehabilitation matters.

4.3.1 Rehabilitation Trials and Outcomes of Liner Testing

The rehabilitation trials at the pre-2016 areas have utilised BGM as a barrier layer to reduce oxygen ingress and rainfall infiltration into underlying more reactive overburden.

As described in **Section 4.2.2** of this report, all measured temperatures in the pre-2016 area of the NOEF, except those in Bores 32 and 33, remain well below the temperature (>100 °C) required to potentially initiate spontaneous combustion and indicate that the batter geometry and BGM barrier layer is generally minimising oxidation of sulfides. Notwithstanding, elevated temperatures reported for 2024-2025 at Bores 32 and 33 reinforces the need for continued vigilance and targeted management of this original area of the NOEF and emphasises that the originally planned remedial works should be implemented as soon as possible. It may also be prudent to consider covering the BGM with a layer of appropriate NAF overburden material until such time as cultural approvals for the design height of greater than 80 m are in place and the pre-2016 parts of the NOEF can be completed to the “as-designed” height.

The relatively small failure of the BGM layer at the southwest corner of the NOEF in February 2025 may have been due to seams between BGM sheets parting as result of problems with the joining method that was used. It is understood that MRM will optimise the QC / QA associated with the BGM storage and handling, and seam joining process in the next stage of implementation of the BGM cover concept.

It is also possible that ‘bulging’ of the NOEF in this specific area placed tensile strain on the BGM seams, which failed due to the bitumen exhibiting viscous creep in the direct hot sun. The Panel understands that MRM has commissioned a targeted research program into the characteristics of the BGM liner with respect to the field conditions under which it is applied at the NOEF.

Another possibility is that the higher temperatures recorded in this specific part of the NOEF could have been a contributing factor to the failure, noting that softening temperature of the BGM material is approximately 150 °C. During the April 2025 Panel site visit it was noted that some of the rolls of BGM located at the MRM storage area prior to intended use at the NOEF were stored directly on the ground in the open instead of on the metal rollers under cover and this may also have the potential to impact upon the integrity of the applied BGM layer. There is therefore an opportunity to optimise the storage and handling practices for the BGM liner.

It should be noted that one of the main mitigation measures for the pre-2016 parts of the NOEF was to go higher towards the final design height as fast as possible to prevent further wetting up of the material and reduce oxygen ingress from the top, as well as placement of the BGM on the batters. It is therefore possible that no temperature improvement in this specific pre-2016 NOF area will materialise until the NOEF is lifted higher by at least 20 m or an impervious cap is placed on the plateau.

Again these findings can also be related to the current NOEF height restriction of 80 m rather than the design height. Cultural approvals need to be in place before this height restriction can be addressed and the pre-2016 parts of the NOEF built to the planned design. If the design of the NOEF at the pre-2016 areas can be implemented as soon as possible, the Panel expects that the likelihood of potentially higher oxygen ingress and elevated temperature at the southwest quadrant of the pre-2016 areas can be reduced, and consequently, also the potential for any future BGM layer failure in this area.

4.3.2 Rehabilitation Trials and Outcomes of Constructability Test Pads (including outcomes of reactive PAF overburden trials 2018 to 2025)

The reactive PAF overburden trial to emulate at field scale the planned encapsulation strategy for reactive waste in the post-2016 areas of the NOEF was run between 2020 to 2024, when the monitoring instrumentation was destroyed by back flooding of the trial pad due to an extreme rainfall event in April 2024 (OKC, 2024).

It was stated in OKC (2024) that “In general, the field trial performance suggests that reductions in AMD risk are occurring as a result of the waste placement methodology”. This was evidenced by the measured temperatures being well below those required to trigger spontaneous combustion and the greatly reduced concentrations of oxygen gas being measured in the PAF cell.

However, the value of the trial as a simulation of the as-built NOEF was potentially impacted by:

- Substantial infiltration occurring before the first wet season protective cap was in place;
- Problems with the BGM under-liner meant that unfortunately no seepage was able to be collected to quantify seepage solute composition and load; and
- Oxygen ingress into the basal drainage layer allowing for advective transport of oxygen into the base of the PAF (RE) cell.

The trial has now been superseded by monitoring systems being installed in the as-built NOEF, as described in **Section 4.2.4**.

In the post-2016 NOEF areas, oxygen concentration profiles measured in a horizontal monitoring array installed in 2021 show that concentrations in the outer PAF cell located at Central West Charlie (15 m below the batter) are close to 1 %, indicating the halo plus fine-grained advection barrier is effective at reducing oxygen gas advection into the batter.

4.3.3 Knowledge Gaps and Timelines to Completion (including consideration of the appropriate duration of post-closure monitoring)

There are a number of NOEF rehabilitation-related knowledge gaps:

- The current NOEF 80 m height restriction prevents the NOEF design based on greater than 80 m being implemented, noting that the Panel's review conclusions are substantively based on the implementation of the full NOEF design height;
- The performance of the placed BGM barrier layer material after extended exposure to NT climatic conditions on the batter slopes of the pre 2016 NOEF, combined with elevated internal NOEF temperature conditions. It is acknowledged that MRM is working with leading researchers to optimise the use of BGM and the conditions under which it is placed at the NOEF; and
- MRM is currently not making use of ("mining") all of the relevant available surface water, seepage, groundwater and other relevant data as input for ongoing predictive modelling.

4.3.4 Unplanned Closure

As discussed in **Section 4.1.1.8**, materials mass balance consistency with the construction schedule is relevant for the overall mine design if completed according to the current design intent. It is especially relevant for unplanned closure if, for example, the TSF tailings are not reprocessed and remain in situ requiring a cover system. Whilst there is a shortfall of appropriate (LS-NAF) cover material from the main open pit mining stages to complete all the required rehabilitation works, the Woyzbun Quarry has been included and approved as an alternative in the OMP-EIS (MRM, 2017).

The proposed Woyzbun Quarry is a small pit sitting off the southeast of the main pit (Figure 3-12 in *Chapter 3 - Project Description and Justification of the OMP-EIS*) and reproduced as **Figure 4-50**. The small pit targets a known source of benign (LS-NAF) material, southeast of the Woyzbun Fault.

It should be noted there is also abundant topsoil available for rehabilitation purposes, largely because all the topsoil from the pit area was stockpiled and will not be required for pit rehabilitation under any closure scenario.

While the MRM Unplanned Closure Plan (2024b) is currently developed for only a single point in time, every year mining and key rehabilitation activities are scheduled out for the Life of Mine (LOM). This provides the opportunity to look at material balance quantities for unplanned closure at any point in time in the future.

A spreadsheet which shows indicative quantities of LS-NAF required for closure activities for any year from now until the completion of mining (approximately 2040) is provided in **Figure 4-53**.

In summary, the investigation and spreadsheet show that:

- There is insufficient LS-NAF mined from the main pit stages to complete the required rehabilitation works, for:
 - the current Unplanned Closure Plan Scenario;
 - an Unplanned Closure scenario that could occur in future years; and

- the current Planned Closure Scenario.
- The Woyzbun Quarry is indicated to contain up to 54 Mt of LS-NAF.
- The materials balance indicates a maximum of approximately 17.5 Mt of LS-NAF material would be required to be mined from the Woyzbun Quarry to complete closure / rehabilitation works during any future Unplanned Closure scenario.

4.3.5 EOEf

As described in **Section 4.1.2.1**, the highest sulfide (>20 % S) material PAF (HW) will be stockpiled and contained separately to the NOEF. The material is planned to be segregated from both the PAF (HC) and PAF (RE) material because it forms a distinct stratigraphic horizon (located within the Lower Pyritic Shale (LpH) unit and can therefore be selectively mined. It will be handled differently and at the end of mine life will be disposed of sub-aqueously in the mine pit lake, as per the OMP-EIS (MRM, 2017). In the interim it will be stored above grade in a dedicated EOEf, constructed to a similar design specification as for containment of PAF (HC) waste in the NOEF.

This is an important MRM commitment regarding mine rehabilitation and closure as whilst it is acknowledged that there is a firm commitment to follow the material management process and disposal, the consequences of not putting the materials back into the open pit have the potential to be high. Challenges could include scheduling this activity during deposition of reprocessed tailings in the open pit.

If the material management process is not managed well, consequences could include issues such as:

- spontaneous combustion; and
- seepage adversely affecting water quality in the 'pit lake', which has not been modelled in the context of the material at the edge of the pit (only been modelled with that rock in the pit).

4.3.6 Consideration of Seepage Interception at the NOEF

MRM (2015) considered the potential need for a seepage interception trench as part of the NOEF WPROD design "for conveyance of clean surface water and to control peak groundwater levels up-gradient of the dam so that the Carpentaria Highway is not impacted." This report considered the merit of the interception seepage further, "it appears that the aquifer is a thickness (primarily within the dolomite) such that the proposed excavations and liner will not significantly reduce the transmissivity of the aquifer (dolomite is 10 m thick within borehole GW107 with 2 m of clay overburden). Therefore, a monitoring approach at least in the interim appears reasonable." The design presented included a 15 m wide corridor on the downstream toe of the WPROD to accommodate groundwater interception if needed.

Worley Consulting (2024) in their Annual Environmental Performance Audit of the mine, note as an Opportunity for Improvement (OFI-24-DE-AUTH-04**), "DITT to establish the Independent Panel (NOEF), or use an alternative expert review in the interim, to assess requirement for the NOEF seepage interception trench and recovery system."

No designs for an interception trench for the NOEF have been considered during this review. General guidance only is therefore provided.

This report has discussed groundwater and surface hydrology monitoring and their application in developing predictions of the performance of the NOEF. The local NOEF hydrogeology appears well understood, and hydrogeological processes and trends are integrated into forward looking predictive tools. The management of NOEF water, and construction practices of the NOEF are well established, considered leading practice, and have a strong focus on reducing the potential for seepage in the first instance.

While there does not appear to be an immediate or urgent need for an NOEF seepage interception trench and recovery system (SIS), the potential future inclusion of such a system should be considered as the cycle of site understanding and predictive performance is updated. Right now, this would as example be an outcome of the data dive opportunity presented in this review, to determine if there are locations along the Surprise Creek and the Barney Creek Diversion where unacceptable chemical loads are reporting to the surface drainages from the NOEF.

Broadly, a process to evaluate the need for an SIS therefore might comprise.

1. Determine the need for interception of groundwater. Current load estimates are bulked into zones or whole of site, review in more granular detail to frame risk.
2. Define the performance expectations of a NOEF SIS, including timing, load reduction, and challenges that may be present within the local hydrogeological system.
3. Simulate NOEF SIS performance using established tools to determine a suitable design.
4. Consider impacts to design from lease availability, engineering constraints (and potential to impact stability or NOEF performance) and constructability issues:

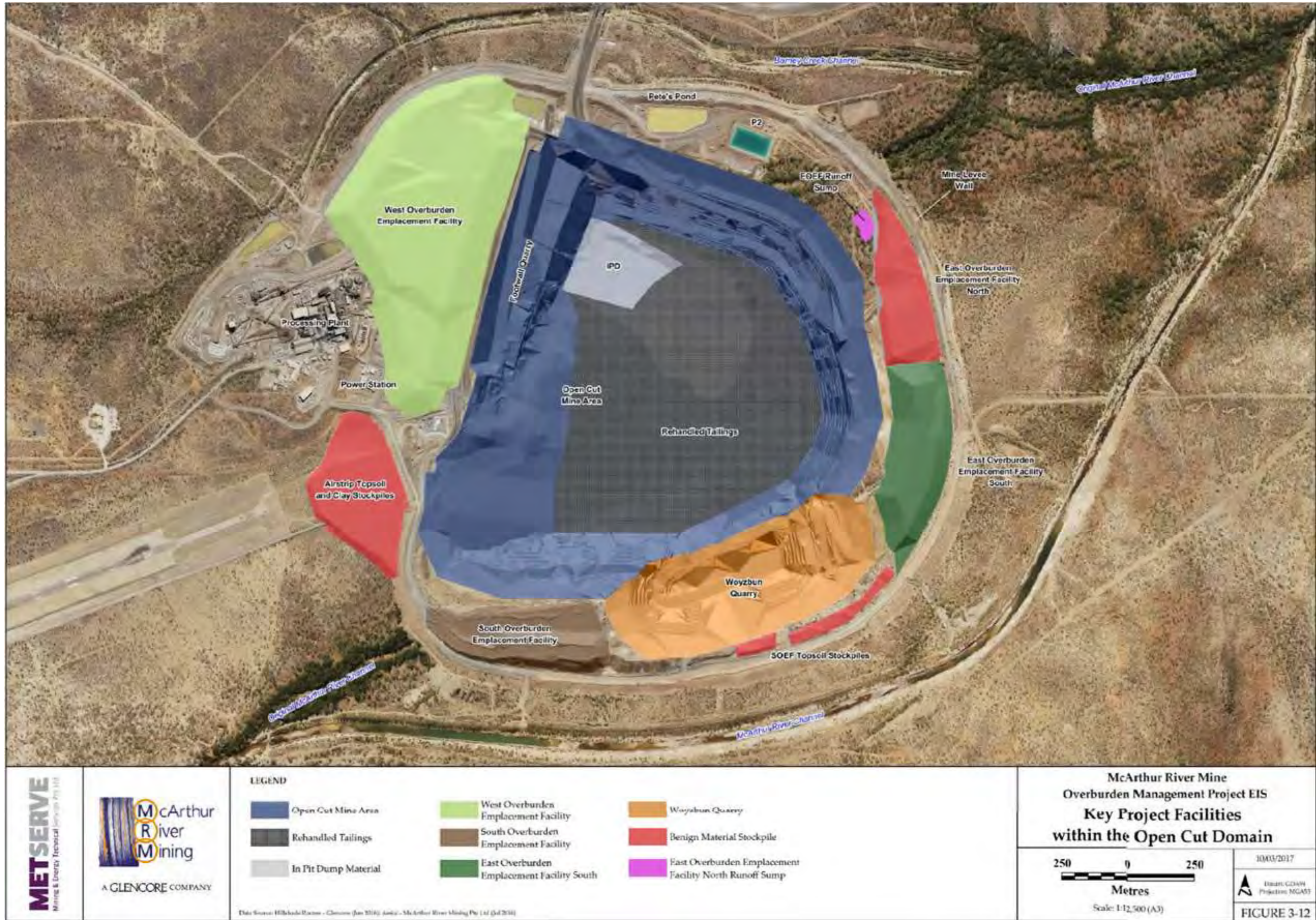


Figure 4-52: Location of Woyzbun Quarry southeast of Main Pit

LS NAF Balance - Unplanned Closure Scenarios			2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040		
<i>Concept NOEF Cover system</i>																				
<i>Requirement LS NAF</i>																				
Plateau (m thickness)	1.5	Operational Demand	NOEF Plateau	m2	32,536															
Batters (m thickness)	1.5		NOEF Batter	m2		75,000	177,500	370,000	400,000	430,256	450,264	306,275	332,804	127,388	52,207	30,820		79,318	94,508	
Density LS-NAF (t/m3)	2.7		NOEF Cover	t	101,363	233,654	552,981	1,152,692	1,246,154	1,340,413	1,402,746	1,326,248	1,036,812	1,193,972	975,011	1,027,195		575,134	797,484	
Swell (inc.compaction)	1.3		TSF Buttress	t	627,232	419,332	488,632	257,632	454,297	390,821	390,821	390,821	390,821	390,821	390,821	390,821	390,821	390,821	390,821	87,192
			Total	t	728,595	652,986	1,041,613	1,410,324	1,700,451	1,731,235	1,793,567	1,717,069	1,427,633	1,584,793	1,365,832	1,418,016	390,821	965,956	1,188,306	87,192
<i>Stockpile balance as of 29/01/2025</i>																				
SW01	5,776,890	Unplanned Closure Demand	NOEF Plateau	m2	2,365,355	2,287,779	2,210,203	2,132,628	2,055,052	1,977,476	1,899,901	1,822,325	1,744,749	1,667,174	1,589,598	1,512,023	1,434,447	1,356,871	1,279,296	1,201,720
NEC	1,465,653		NOEF Batter	m2	1,382,013	1,457,013	1,634,513	2,004,513	2,404,513	2,834,769	3,285,033	3,591,308	3,924,112	4,051,499	4,103,707	4,134,527	4,134,527	4,213,846	4,308,354	4,308,354
2025 Starting SP balance	7,242,543		NOEF Cover	t	11,573,129	11,331,451	11,089,773	10,848,095	10,606,417	10,364,739	10,123,061	9,509,298	9,267,620	8,228,832	7,174,790	6,001,934	5,760,256	5,190,551	4,445,817	4,204,139
			TSF Cover	t	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503	9,346,503
			Total	t	20,919,631	20,677,953	20,436,275	20,194,598	19,952,920	19,711,242	19,469,564	18,855,801	18,614,123	17,575,335	16,521,293	15,348,437	15,106,759	14,537,054	13,792,320	13,550,642
Supply		Expit	t	492,362	162,126	6,037,123	1,004,734	59,714	91,368	123,377			19,734	91,050	98,300	211,791	167,986			
Stockpiling and Borrowing		LS-NAF Stockpile Balance	t	7,006,310	6,515,450	11,510,961	11,105,370	9,464,633	7,824,767	6,154,577	4,437,508	3,009,875	1,444,815	170,034						
		Woyzbun Quarry - Operations	t											78,983	1,247,983	390,821	965,956	1,188,306	87,192	
		Woyzbun Quarry - Unplanned Closure	t	13,913,321	14,162,503	8,925,314	9,089,227	10,488,286	11,886,475	13,314,987	14,418,293	15,604,248	16,130,520	16,351,259	15,348,437	15,106,759	14,537,054	13,792,320	13,550,642	
		Woyzbun Quarry Mined Total	t	13,913,321	14,162,503	8,925,314	9,089,227	10,488,286	11,886,475	13,314,987	14,418,293	15,604,248	16,130,520	16,272,276	16,517,437	16,666,580	17,062,830	17,506,402	17,351,916	

Figure 4-53: Material balance for Woyzbun Quarry located southeast of Main Pit

5 Conclusions and Opportunities for Improvement

5.1 Conclusions

The NOEF Panel has completed an independent technical review of the effectiveness of NOEF management by MRM to achieve secure storage of overburden (waste rock) and protect the health of the McArthur River from mine related impacts. Overall, the NOEF Panel considers that potential risk of the NOEF to the surrounding environment is being managed to an acceptable level and the health of the McArthur River is being protected from mining related impacts from the NOEF.

The technical review work program has been completed to allow benchmarking against the NOEF assessment criteria detailed in **Section 4** of this report. The benchmarks used by the NOEF Panel to evaluate the level to which assessment criteria have been met by MRM are also provided in **Section 4**.

The NOEF Panel has found that:

- The post-2016 construction of the NOEF is consistent with the design intent and is consistent with the design assessed and approved by the Minister. The post-2016 NOEF construction to date exceeds current best practice in the mining industry and can be considered world leading practice for ground up source control.
- The post-2016 design of the NOEF is suited to the particular circumstances of the site and operations, with particular regard to the geochemical and physical characteristics of the materials, climatic conditions and the need to protect the receiving environment including protection of the health of the McArthur River.
- The post-2016 construction of the NOEF is proceeding in accordance with the approved design intent. Remediation measures at the pre-2016 parts of the NOEF indicate improved performance (e.g. reduced internal NOEF temperature). However, the greater than 80 m design height for the NOEF cannot be achieved until cultural approvals are in place and this may have implications for the long-term NOEF performance at the pre-2016 areas which currently cannot be closed out. The pre-2016 construction followed the old design with no compacted clay base nor drainage layer. The final cover system has not been built, with the uncovered surface of the dump continuing to 'wet up' because there is no cover material above the core of the legacy part of the NOEF.
- The post-2016 NOEF construction and previous modelling indicates that the environmental outcomes as indicated by monitoring are expected to be in line with predictions and expectations. However, there is currently insufficient internal NOEF monitoring data associated with parameters such as gas, temperature, and water dynamics to predict if that will continue into the future or not.
- The previous modelling (KCB, 2017) of the NOEF for the OMP-EIS, did not model NOEF construction on a year-by-year basis. The schedule and location of overburden material placement is not as per plan in the pre-2016 areas due to delays in cultural approvals and therefore plan execution. It is therefore not possible to evaluate if environmental outcomes as indicated by monitoring are in line with prediction and expectations because the NOEF construction design sequencing as actually executed was not modelled. Notwithstanding, surface water quality monitoring data from 2023 to 2024 at SW11 indicates that water quality target parameters are met almost all of the time.
- The monitoring network (external to the NOEF) is mature and well distributed, and the site applies a range of visualization and interpretation tools allowing for both continued improvement in the conceptual understanding of the site, and for analysis of exceedance of water qualities (and differentiation of source) which may occur.
- It is important to acknowledge that any exceedance of water quality which might occur at WDL compliance location SW11 would trigger analysis to identify the causes of unacceptable water quality and would be the collective outcome of all flows reaching that location (including those of the Glyde River), and the various potential mine sources of impact. For this reason, the conceptualisation, monitoring network and predictive modelling tools must be capable of understanding this broader issue and must also allow differentiation between potential source of impacts that may be observed.
- The post-2016 NOEF construction and previous modelling suggest that the environmental outcomes, as indicated by monitoring, are expected to be in line with predictions and expectations. However, there is

currently insufficient internal NOEF monitoring data associated with parameters such as gas, temperature and water dynamics to predict if that will continue into the future or not.

- The tri-modelling approach applied to predicting the environmental performance of the NOEF and the manner of integration of predictions with monitoring observations is leading practice (KCB, 2017). The geochemical, phase, temperature and saturation profiles of the NOEF are far too complex to integrate directly with a regional flow simulator. In addition, the flow simulator at the site must be capable of informing MRM of net impacts from a range of mining infrastructure, not limited to the NOEF. The tools applied and their level of complexity is fit-for-purpose, and periodic updates to these simulation tools will continue to assist in design and construction verification.
- Previous modelling of the NOEF for the OMP-EIS (MRM, 2017) did not model NOEF construction on a year-by-year basis. In the pre-2016, the schedule and location of overburden material placement has deviated from the original plan due to delays in cultural approvals for the NOEF design height and therefore plan execution. It is therefore not possible to evaluate if environmental outcomes as indicated by monitoring are in line with prediction and expectations because, the NOEF construction design sequencing actually executed was not modelled. Notwithstanding, surface water quality monitoring data from 2023 to 2024 at SW11 indicate that water quality target parameters are met almost all of the time. In addition, data may exist to support a more detailed review of construction modifications with the intent to improve seepage management for the facility.
- Key environmental risks to air quality related to the NOEF are associated with dust (particulate matter) and sulfur dioxide (SO₂) emissions, however 2023-2024 monitoring data indicates that the risk of impacts from NOEF operations on air quality with respect to community health and the environment remains low.
- The biggest single issue that has the potential to affect environmental performance at the NOEF is the change to the NOEF construction design sequencing at the pre-2016 areas where the schedule and location of overburden material placement is not as per the construction schedule. This is mainly attributable to delays in cultural approvals for the greater than 80 m NOEF height and hence plan execution. Substantial work has been completed by MRM to restrict rainfall ingress and oxygen inflow into PAF materials by covering the pre-2016 areas with benign material. Additionally, a bituminous geomembrane (BGM) has been in place for three years over some areas. However, this part of the NOEF has still not been completed according to the original plan. If the cultural approvals for the NOEF height were in place the planned design could be executed therefore minimising the potential for future negative effects on the environmental performance of the NOEF.

With specific reference to some of the key aspects considered by the NOEF Panel members in their review of the performance of the NOEF against the objective of protecting the health of the McArthur River from mining related impacts, the NOEF Panel has found that:

1. Construction and Engineering

The NOEF is expected to be geotechnically stable and is performing as per the design intent and the design and construction methodology to date are adequate to meet potential ongoing risk.

2. Surface condition

With the exception of the pre-2016 areas, the surface condition of the NOEF is in a condition that supports a stable landform, and the interim covers are adequate at managing potential risks such as erosion and flood protection).

3. Temperature

All measured temperatures within the pre- and post-2016 sections of the NOEF, with the exception of those at depth in Bores 32 and 33 located in the SW quadrant of the pre-2016 NOEF, and at bore 2025-12-Wa located adjacent to the original northern batter are well below the temperature required to potentially initiate spontaneous combustion (>100 °C). This indicates that:

- the batter geometry and alluvial cover regime in the new sections of the NOEF are effective at minimising oxidation of sulfides;
- the rehabilitation works and BGM cover in the pre-2016 section of the NOEF are largely mitigating the potential for oxidation and self-heating. However, Bores 32 and 33 are characterised by a general increase in temperature with depth, reaching a maximum of 100 °C and 92 °C, respectively, at 30 m. This reinforces the need for continued vigilance and targeted management of this part of the pre-

2016 NOEF and emphasises that the originally planned remedial works and NOEF design should be implemented as soon as cultural approvals are in place.

- It is understood that MRM expects the mitigation measures implemented at the pre-2016 NOEF area such as excavation, improved geometry, improved drainage, placement of a wet season cover and clay capping may not yet have resulted in a material reduction in temperature at this specific area and that further controls are being considered.
- overall, the temperature of the NOEF is at a level which indicates that the design and construction methodology implemented as part of the MMP (MRM, 2024a) supports the effective management of oxidation.

4. Internal pore gas composition,

The oxygen concentration profile from the Central West Charlie horizontal array shows that oxygen concentrations in the outer PAF cell (15 m below the batter) are close to 1 %, indicating the halo + fine grained advection barrier is effective at reducing oxygen advection into the batter material.

The gas composition levels within the NOEF appear to be at an acceptable level (as an indicator of managing oxidation) and the controls such as the design and construction of the NOEF methodology as outlined in the NOEF Management Plan support the management of oxidation.

5. Reactions and seepage quantity / quality

Based on the information reviewed, it is concluded that the solute concentrations used as input to the predictive solute load modelling are fit-for-purpose.

MRM can expect to manage from the NOEF, pH-neutral, high sulfate, high magnesium water with varying proportions of other ions. Current and proposed future MRM management practices at the NOEF are expected to protect the health of the McArthur River.

For most metals / metalloids solubility and mobility will be relatively low due to the pH circum-neutral to mildly alkaline water that is predicted to occur.

For the contaminants of potential concern, zinc concentrations are expected in the range of 5 to 10 mg/L over the next 100y (the time limit of the predictive model), while the other metals/metalloids used as indicators are expected to remain similar to current concentrations. the annual loads will drop substantially following the placement of the final infiltration limiting cover system.

The current design of the NOEF and the adaptive approach to its construction and improvement in design is considered leading practice for management of seepage risk. The MRM management, design, construction and operation teams show a strong level of commitment to this performance philosophy, and excellent collaboration and capacity to assess and rectify any excursions of performance from design.

6. Surface runoff and seepage monitoring results,

It is not possible to directly measure seepage emerging from the NOEF (neither quality, nor rate). The prediction of seepage impacts must therefore be a balance of conceptual understanding, monitoring data, and predictive updates. This is a circular process that requires critical and frequent review of the conceptual understanding as underpinned by monitoring data.

Minimisation of environmental impacts from direct surface water losses are currently addressed through design and meticulous construction practices. It is important that monitoring continues to support the evaluation of these processes.

Numerical predictive tools play an important role in the modelling process. Non-uniqueness in these tools should be progressively addressed as each 'generational' update to the model(s) occurs. These updates must not be solely recalibration processes – they should apply the complete cycle of system review for most benefit.

5.2 Opportunities for Improvement

The main opportunities for improvement at the MRM NOEF are associated with:

- Completion of the targeted research program into the characteristics of the BGM liner with respect to the field conditions under which it is applied at the NOEF.

- Ensuring that the QC / QA associated with the BGM storage and handling, and seam joining process is optimised as part of the next stage of implementation of the BGM cover concept.
 - Obtaining cultural approvals for the greater than 80 m NOEF height and consequently plan execution.
 - Until such time as cultural approvals for the greater than 80 m NOEF height are in place and the pre-2016 parts of the NOEF can be completed to the “as-designed” height, it may be prudent to consider covering the BGM with a layer of appropriate NAF overburden material.
 - Completion of the cover system on the pre-2016 NOEF areas (the material over the top of the BGM) as soon as cultural approvals for this action associated with the NOEF height are in place.
 - Interpretation of the complete surface, seepage and groundwater monitoring data sets coupled to other relevant information to essentially “mine that data” to develop an updated model that provides:
 - (i) Higher confidence conceptualisation / understanding of the NOEF, which translates to
 - (ii) Improved predictive modelling capability and reduced non-uniqueness in derived solutions.
- With more comprehensive data sets, it may also be of value to conduct area specific evaluations to determine the degree of improvement which may have occurred from changes in design and construction practices. The HDPE lining of SPROD is a good example of this.
- Improving the current knowledge base regarding the likely performance of the planned final NOEF cover system by developing and monitoring cover system trials against predicted environmental outcomes.

The NOEF Panel, in consultation with MRM and the NT DLPE, considers that there are no other specific matters relating to the NOEF currently requiring attention.

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7 Acronyms and Definitions

%	Percent
°C	Degrees Celsius
µg/L	Micrograms per litre
µS/cm	Micro Siemens per centimetre
AGI	Australian Geosciences Institute
AHD	Australian height datum
Al_F	Filtered aluminium
AMD	Acid and metalliferous drainage
AMIRA	Australian Mineral Industries Research Association Limited
ANC	Acid neutralising capacity
As	Arsenic
ASW	Artificial surface water
BbH	Black bituminous shale
BBLF	Bing Bong Loading Facility
BGM	Bituminous geomembrane
CCL	Compacted clay liner
Cd	Cadmium
Co_F	Filtered cobalt
COA	Commonwealth of Australia
CRD	Cumulative rainfall departure
DAWE	Department of Agriculture, Water and the Environment (Commonwealth)
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DIIS	Department of Industry, Innovation and Science (Commonwealth)
DITR	Department of Industry, Tourism and Resources (Commonwealth)
DO	Dissolved oxygen
DRN	Drains package in MODFLOW
EA	Environmental assessment
EC	Electrical conductivity
EIS	Environmental impact statement
EIS-S	Environmental impact statement - supplementary
EOEF	Eastern overburden emplacement facility
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

EPM	Equivalent porous medium
PROD	Perimeter runoff dam
EPROD	Eastern perimeter runoff dam
ERI	Electrical resistivity imaging
Ex-TC Megan	Ex tropical cyclone Megan
Fe_F	Filtered iron
GCL	Geosynthetic clay liner
GHD	GHD Pty Ltd
GM	Growth medium
GPS	Global positioning system
GWL	Ground water level
ha	Hectares
HDPE	High density polyethylene
HLF	Heap leach facility
ICE	Independent certifying engineer
IM	Independent monitor
IEP	Independent expert panel
INAP	International Network on Acid Prevention
KCB	Klohn Crippen Berger Pty Ltd
k_{fs}	Field saturated hydraulic conductivity
kg	Kilogram
kg/day	Kilograms per day
km	Kilometre
L	Litre
L/s	Litres per second
LDI	Landform Design Institute
LGO	Low-grade ore
LLHQ	Lower left-hand quadrant
LpH	Lower pyritic shale
LRHQ	Lower right-hand quadrant
LS-NAF	Low salinity non-acid forming
LS-NAF (HC)	Low salinity high-capacity non-acid forming
m	Metres
m/s	Metres per second
MAW	Mine affected water

mg	Milligram
mg/L	Milligrams per litre
mg/L/month	Milligrams per litre per month
ML	Megalitres
ML/day	Megalitres per day
ML/month	Megalitres per month
ML/yr	Megalitres per year
mm	Millimetres
mm/yr	Millimetres per year
MMA	Mining Management Act
MDD	Maximum Dry Density
MMP	Mining management plan
MPA	Maximum potential acidity
MRM	McArthur River Mining Pty Ltd
MS-NAF	Metalliferous saline non-acid forming
MS-NAF (HC)	Metalliferous saline high-capacity non-acid forming
MS-NAF (LC)	Metalliferous saline low-capacity non-acid forming
Mt	Million tonnes
NAF	Non-acid forming
NMD	Neutral metalliferous drainage
NOEF	North overburden emplacement facility
NPR	Net potential ratio
NSW	Natural surface water
NT DLPE	Northern Territory Department of Lands, Planning and Environment
NT DEPWS	Northern Territory Department of Environment, Parks and Water Security
NT EPA	Northern Territory Environmental Protection Authority
NT EP Act	Environment Protection Act 2019
NT GS	Northern Territory Geological Survey
OEF	Overburden emplacement facility
OKC	O'Kane Consulting Pty Ltd
OMC	Optimum Moisture Content
OMP EIS	Overburden management plan and environmental impact statement
PAF	Potentially acid forming
PAF (HC)	High capacity potentially acid forming
PAF (HW)	Hanging wall pyrite

PAF (RE)	Reactive potentially acid forming
Pb	Lead
ppm	Parts per million
QA	Quality assurance
QC	Quality control
RFI	Request for information
RGS	RGS Environmental Consultants Pty Ltd
RMS	Root mean squared
S	Sulfur
s	Second
SD	Saline drainage
SPROD	South perimeter runoff dam
SEPROD	South-Eastern perimeter runoff dam
SO ₂	Sulfur dioxide
SO ₄	Sulfate
SPR	Source-pathway-receptor
SPROD	Southern ?
SRMS	Scaled root mean squared
SSTV	Site-specific trigger values
TDS	Total dissolved solids
TOR	Terms of reference
TSF	Tailings storage facility
UD	Underdrain
ULHQ	Upper left-hand quadrant
URHQ	Upper right-hand quadrant
URS	URS Australia Pty Ltd
WDL	Water Discharge Licence
WMP	Water management plan
WPROD	Western perimeter runoff dam
WRD	Waste rock dump
WRM	WRM Water & Environment Pty Ltd
yr	Year
Zn	Zinc
Zn_F	Filtered zinc

8 Attachments

Attachment A **NOEF Independent Expert Panel for MRM - Terms of Reference (NT DLPE, 2022)**

NOEF Independent Panel for McArthur River Mine - Terms of Reference

1. Background

McArthur River Mine is an open pit zinc, lead and silver mining operation in the Northern Territory (NT), located approximately 700 kilometres (km) south-east of Darwin, and approximately 45 km south-west of the township of Borroloola. McArthur River Mining Pty Ltd (MRM) is the authorised operator of McArthur River Mine, and is a wholly owned subsidiary of Glencore Plc.

The North Overburden Emplacement Facility (NOEF) at McArthur River Mine is the principal waste rock dump on the site and represents a geochemical hazard. As a corollary, operation of the NOEF is associated with significant environmental risks. Fundamental to the effective management of the risk is a comprehensive understanding of the geochemical composition of the waste material to ensure management systems effectively minimise, if not eliminate, aspects contributing to the risk.

The environmental objective against which the performance of the NOEF is measured is the protection of the health of the McArthur River along its entire length from mine related impacts¹.

In 2020 MRM submitted to the department for approval under the *Mining Management Act 2001* (MMA) NOEF designs to achieve secure storage of waste rock, reclassified under a robust 5-tier system that recognises the full spectrum of material contributing to the generation of acid and metalliferous drainage (AMD). The documents informing the approved Mining Management Plan presented three crucial actions to address identified risks in relation to:

1. **Management of AMD seepage during operations** with the design and staged construction of a new NOEF. Specific controls to manage and minimise seepage include:
 - a. progressive covering, sealing and rehabilitation of the NOEF
 - b. reducing infiltration by using compacted alluvium on potentially acid forming (PAF) cells, shaped geometrically and staged construction
 - c. installing liners in dams and associated drains from the NOEF
 - d. installing a layer of compacted in-situ clay or a constructed clay liner with a thickness of 0.5 metres (m) as a foundation during construction of new sections of the NOEF.
2. **Management of advection and potential reaction of waste rock.** Specific controls to manage advection include:
 - a. placement of waste rock in specified lift heights dependent on waste classification to limit air permeability, and placement of compacted alluvium as advection barriers on inter-stage faces of the NOEF, with a halo layer comprising non-acid-forming material providing a further barrier to oxygen flow
 - b. excavating, cooling and rehandling actively combusting material
 - c. reconfiguring berms and outer batter slopes of the NOEF to remove preferential air pathways and limit advection of air into the stockpile
 - d. placement of a barrier on the batter and plateau of the NOEF to further reduce bulk air transport into the stockpile.

¹ NT EPA Assessment Report 86, July 2018, Executive Summary page xii accessible at: https://ntepa.nt.gov.au/_data/assets/pdf_file/0004/553081/mrm_overburden_assessment_report.pdf

3. **Management of long-term seepage using a specifically designed cover system** such as a low-permeability surface cover to control long-term net percolation of water through the NOEF.

The NOEF Panel is a requirement of regulatory approvals to which McArthur River Mine is subject under the NT *Mining Management Act 2001*. Other regulatory approvals of relevance to operation of McArthur River Mine have been issued under the NT *Water Act 1992* and *Environment Protection Act 2019*, and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The importance of the NOEF Panel lies in providing external and transparent oversight and reporting, to advise the government on the performance of the NOEF.

2. Purpose

The purpose of the NOEF Panel is to provide the MMA regulator (the Minister for Mining and Industry) with robust, independent advice regarding the effectiveness of NOEF management- i.e. to provide the regulator with a reasonable level of confidence that waste rock is being stored securely and is not impacting the health of the McArthur River.

To achieve this purpose, the NOEF Panel will undertake a triennial technical review (once every three years) focused on the:

1. outcomes of the NOEF management program
2. NOEF seepage monitoring results and the appropriateness of the monitoring program
3. cover trial results, construction quality records, critical controls, stability assessments, cover performance and performance of progressive rehabilitation of the NOEF.

3. Scope

The NOEF Panel is not a decision-making or regulatory body.

The NOEF Panel is an independent advisory body, limited to providing technical assessment and advice regarding the performance of the NOEF.

Aspects of the NOEF for the NOEF Panel to consider in preparing their advice to the regulator are outlined in **Appendix A**.

At completion of each review, the NOEF Panel will submit to MRM and the department a report detailing the findings of their technical review of the performance of the NOEF, addressing at a minimum:

- *the stability, surface condition, internal temperature, reactions and seepage quantity and characteristics of the NOEF to ensure the overarching environmental outcome can be met*
- *runoff and seepage monitoring results, and in particular trends in the contaminant concentrations in groundwater, and loads entering creeks and the McArthur River*
- *cover trial results, construction quality records, critical controls, stability assessments, cover performance and performance of progressive rehabilitation of the NOEF.*²

The NOEF Panel will not undertake any contractual review or reporting regarding MRM operations during the interim period between each triennial review and reporting periods. It is acknowledged that members of the NOEF Panel may engage with the project between reviews for the purpose of

² NT EPA Recommendation 8, as reproduced in Excerpt 1.

maintaining a contemporary understanding of matters of importance. Such interactions will be recorded and provided to the department consistent with the Communication Protocol at Section 9.

Any review by the NOEF Panel of reports or methodology prepared by MRM would take place as part of the NOEF Panel's triennial review and reporting.

The NOEF Panel is to report on whether:

1. the design of the NOEF is consistent with best available practice
2. the design is suited to the particular circumstances of the site and operations
3. construction of the NOEF is proceeding in accordance with the approved design
4. the environmental outcomes as indicated by monitoring are in line with predictions and expectations
5. there are any significant issues affecting performance or future closure
6. the overarching environmental outcome of protecting the health of the McArthur River from mining related impacts attributable to the NOEF continue to be met
7. any other matters relating to the NOEF requiring attention as deemed appropriate by the NOEF Panel in consultation with the regulator.

4. Panel Membership

The NOEF Panel will be chaired by an independent technical expert appointed by the NT Minister for Mining and Industry in consultation with the NT Minister for Environment.

The NOEF Panel will comprise members who are recognised experts in their respective scientific field.

NOEF Panel members will be appointed by the Minister for Mining and Industry for each triennial review. Where appropriate, past panel members may be reappointed. The members appointed will bring a diversity of skills, experience and views from a range of scientific backgrounds of relevance to achieve delivery of the scope. At a minimum, the NOEF Panel will include hydrogeological, geotechnical and water quality data assessment skills and experience.

While membership of the NOEF Panel will be subject to change between three yearly reviews, the panel will be convened triennially for the life of the project, including during any period of care and maintenance.

To ensure independence is maintained, the intention is that members have:

- no pecuniary interest in McArthur River Mine
- had no professional involvement with MRM during the 3 year period under review other than in a peer review capacity.

It is acknowledged there are very few recognised experts with the required specialist knowledge able to fulfil the NOEF Panel requirements.

Should members have any (i.e. past/present/proposed) association with McArthur River Mine, the conflict of interest must be declared and reported to the Chairperson. The Chairperson will then make a recommendation to the department. The department will consider the recommendation and, based on available evidence and natural justice, take appropriate action.

The names and credentials of the NOEF Panel members will be published on an appropriate NT Government website.

5. Role of Chairperson

The Chairperson is to provide leadership to the NOEF Panel, including:

- advising members of their roles and responsibilities as members of the NOEF Panel
- developing the scope, content, assessment criteria and timeline for the review (for approval by the department)
- overseeing the preparation and submission of the draft and final reports
- overseeing the receipt of feedback provided by MRM and the department on the draft report and amendment of the report to the extent required to correct factual inaccuracies
- convening and running meetings as required, including overseeing that appropriate meeting records (e.g. minutes) and correspondence are kept
- arranging information requests and discussions with the department, and with other relevant groups through the department (see Section 6)
- being the point of contact for the NOEF Panel.

The Chairperson is to be a technical expert in their own right, performing the additional functions as outlined above.

6. Reporting Obligations and Process

The NOEF Panel must submit a report to MRM and the department within 12 months of establishment (or otherwise, as agreed with the department); and subsequently on a triennial basis from the date of the first report submission.

The report must detail the review assessment criteria and methodology; and the Panel's conclusions regarding the performance of the NOEF and its effectiveness in achieving the overarching environmental objective.

A draft report is to be submitted to MRM and the department for factual review two months prior to its final submission. The department will coordinate expert advice from relevant agencies as appropriate.

Should the NOEF Panel need to meet with other independent bodies (e.g. the Mine Closure Panel) or government agencies (e.g. the Department of Environment, Parks and Water Security, DEPWS) to discuss findings, this should be arranged in consultation with the department and MRM in accordance with the communication protocol outlined in Section 9, to ensure transparency and accountability.

The department will provide a copy of the final report to other regulators, the Community Reference Group and the Independent Monitor; and publish the report on the department's website.

The relationships between the NOEF Panel and various parties relative to regulatory requirements are depicted in Figure 1.

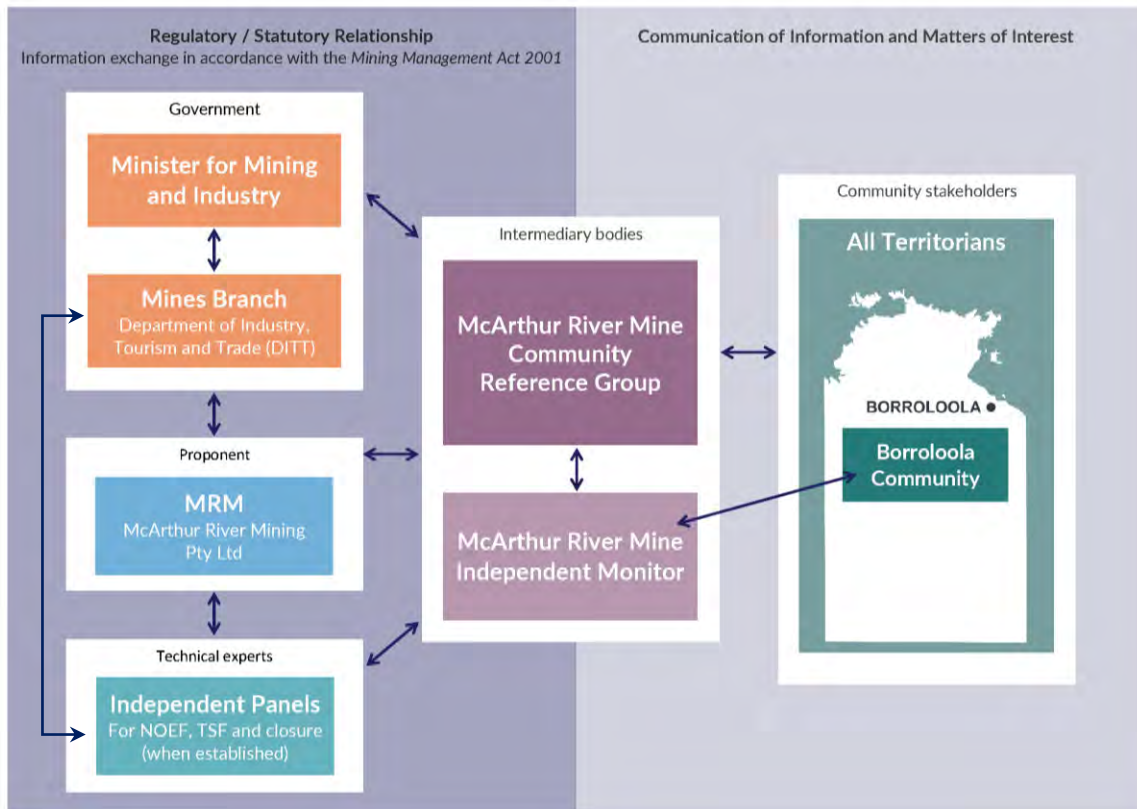


Figure 1: Relationships between governance bodies for McArthur River Mine

7. Period of Review

The structure of the NOEF Panel and its Terms of Reference shall be reviewed every six years³ from the date the Terms of Reference are finalised; or sooner, if required. Reviews are to be conducted by the NT Minister for Mining and Industry, in consultation with the NT Minister for Environment.

If the Chairperson has concerns about the effectiveness of the NOEF Panel, they may refer the matter to the department. The department will consider the concerns raised and determine what action should be taken.

8. Obligations of the Operator

MRM is required to:

1. assist as necessary with the establishment and operation of the NOEF Panel
2. fund reasonable costs for the NOEF Panel
3. organise site visits for the NOEF Panel as required to fulfil its role
4. provide the NOEF Panel with timely, accurate and comprehensive reports (including supporting data relevant to the NOEF) such as the:
 - annual Environmental Mining Report⁴
 - NOEF construction reports and monitoring data

³ NT EPA Recommendation 8, as reproduced in Excerpt 1.

⁴ A requirement under section 37(3)(e) of the *Mining Management Act 2001*.

- approved Mining Management Plan and other relevant plans (including the Adaptive Management Plan).
5. provide the NOEF Panel with timely and accurate monitoring data relevant to NOEF performance (as deemed by the NOEF Panel) as soon as practicable in light of the request made, and in any event no later than 28 days of receiving the request.
 6. respond to questions asked or advice given by the NOEF Panel about MRM’s environmental within 28 days of receiving the request.

9. Communication Protocol

Table 1 outlines a protocol for any communication that takes place between MRM, the NOEF Panel and other relevant bodies. The intent of the communication protocol is to ensure a transparent process is followed and the NOEF Panel can be seen to operate independently.

Table 1: Communication Protocol

Relevant Matter	Approved Communication Method	Other Requirements
Request from Panel for reports and data from MRM	Chairperson to contact MRM directly via email	Copy to be sent to the department
Provision of reports and data from MRM to Panel	MRM to provide directly to Chairperson via email	Copy to be sent to the department
Clarification/discussions	Direct discussion between Panel and MRM to address issues raised by Panel Direct discussion between Panel and the department Department to facilitate discussion between Panel and other agencies, panels and the IM (as required).	The department to be informed of engagement where it relates to report findings/conclusions
Provision of draft reports/findings by Panel	Chairperson to issue directly to MRM	Copy to be sent to the department (and circulated by the department to the Independent Monitor and Community Reference Group as appropriate)
Provision of comments on draft reports/findings by MRM	MRM to issue to Chairperson	Copy to be sent to the department
Provision of final report by Panel	Chairperson to issue to MRM and the department	The department to distribute report to DEPWS, Independent Monitor and Community Reference Group and publish the report on the department’s website
Panel site visits/other meetings	Chairperson to inform the department of proposed site visits/meetings and arrange with MRM directly	The department to be offered opportunity to participate in site visits/meetings

Other communication methods not outlined in this protocol may be used upon endorsement by the department.

Relevant Excerpts

Excerpt 1 – NT EPA Assessment Report 86 Recommendation 8⁵

Approvals and decisions in relation to the Proposal will include conditions required the Proponents⁶ to provide funding to establish and operate a Panel of independent experts to:

- i. review every three years the outcomes of the Proponent's Management program for the NOEF, including the stability, surface condition, internal temperature, reactions and seepage quantity and characteristics of the NOEF to ensure the overarching environmental outcome can be met*
- ii. review NOEF runoff and seepage monitoring results, and in particular trends in the contaminant concentrations in groundwater, and loads entering creeks and the McArthur River*
- iii. review the cover trial results, construction quality records, critical controls, stability assessments, cover performance and performance of progressive rehabilitation of the NOEF.*

The Panel shall provide a report every three years to the relevant regulator and the Independent Monitor and the report made available to the Proponent, government agencies, the Community Reference Group and the public.

The Panel is to be formed:

- iv. with an independent chair, appointed by the responsible Minister in consultation with the Minister for Environment and Natural Resources*
- v. on the advice of the Department of Environment and Natural Resources, the Department of Primary Industry and Resources, and the Proponent.*

Terms of Reference for the Panel shall set out the terms for roles and responsibilities, membership, timeframe for commencement and scope, reporting obligations and transparency and accountability. The Terms of Reference shall be finalised by the responsible Minister, in consultation with the Minister for Environment and Natural Resources acting on advice from the NT EPA, within three months of authorisation of the Proposal.

The structure of the Panel and its Terms of Reference shall be reviewed by the Responsible Minister, in consultation with the Minister for Environment and Natural Resources every six years from the date the Terms of Reference are finalised.

⁵ NT EPA Assessment Report 86, July 2018, Executive Summary page xvi accessible at: https://ntepa.nt.gov.au/__data/assets/pdf_file/0004/553081/mrm_overburden_assessment_report.pdf

⁶ NT EPA documentation refers to the Proponent. Under the *Mining Management Act 2001*, MRM is the operator authorised to undertake the mining activities proposed in the approved Mining Management Plan.

Appendix A: Matters for consideration by the NOEF Panel

Key aspects for consideration by the NOEF Panel in their review of the performance of the NOEF against the objective of protecting the health of the McArthur River from mining related impacts:

1. **Construction:** Review NOEF Management Plan with respect to construction/engineering matters relating attention to:
 - a. structural and internal stability and surface condition by reference to approved designs and construction specifications for:
 - i. foundations including basal compacted clay liner
 - ii. advection barriers
 - iii. potentially acid forming (PAF) reactive (RE) cell
 - iv. internal halo
 - v. covers
 - vi. Independent Certifying Engineer⁷ (ICE) signoff records for hold points
 - vii. materials tracking and placement against Sulfur-block model
 - b. material identification and placement by reference to:
 - i. approved waste classification criteria
 - ii. internal temperatures
 - iii. seepage quantities and quality
 - iv. ICE signoff records for hold points
 - v. materials tracking and placement against Sulfur-block model
 - c. risk management and control
 - i. adequacy of existing controls and requirements of the seepage interception system
 - d. implications for the approved AMP and any requirement for amendment
2. **Performance:** Review of NOEF Performance giving consideration to:
 - a. Runoff and seepage monitoring results
 - b. Status of convective oxidation with respect to:
 - i. advection barriers
 - ii. material placement lift heights
 - iii. internal temperatures
 - iv. seepage quantities
 - v. materials tracking and placement against S-block model
3. **Rehabilitation:** Review of cover system and related works giving consideration to:
 - a. rehabilitation trials and outcomes of liner testing

⁷ Condition 48 of Authorisation 0059

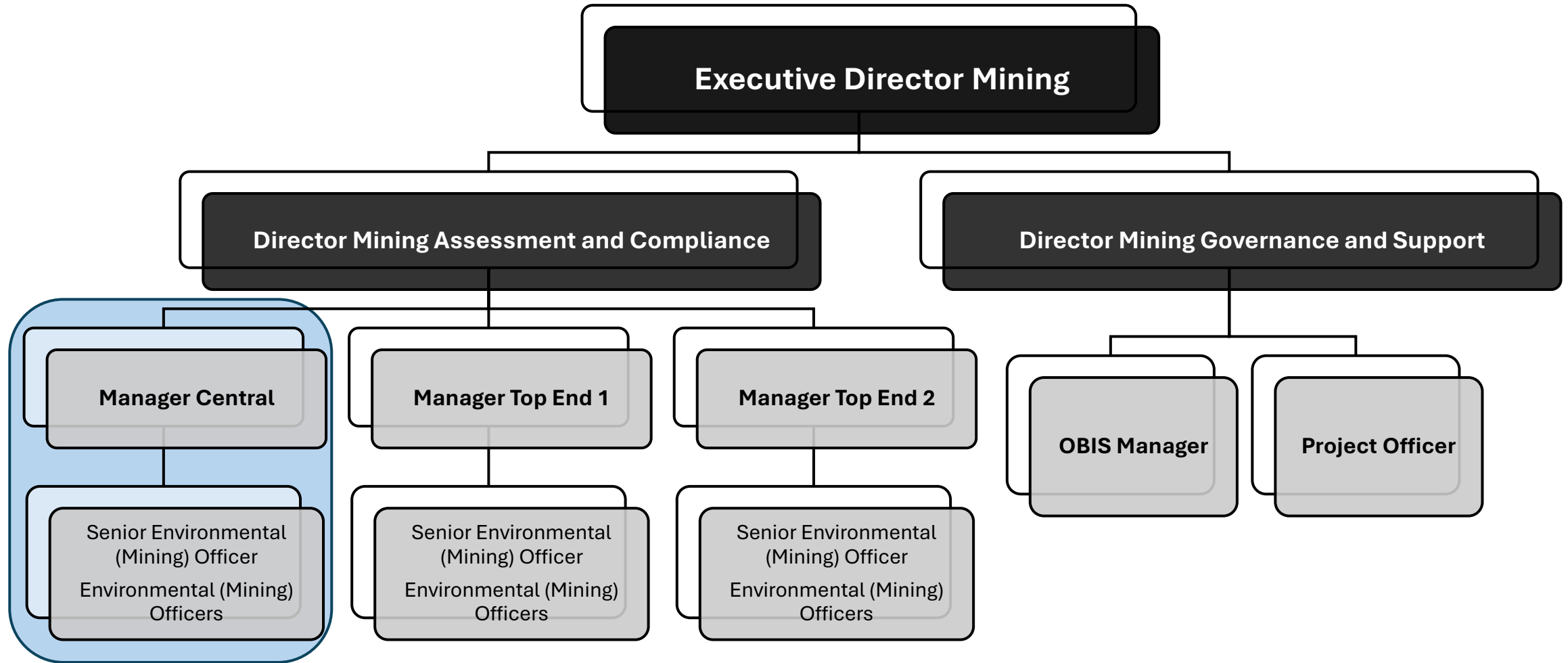
- b. rehabilitation trials and outcomes of constructability test pads
- c. knowledge gaps and timelines to completion.

Attachment B Overview of NT DLPE Governance

Applying for environmental licences



Mining Division Department of Lands, Planning and Environment



Located in Alice Springs

**Attachment C Environmental Mining Licence DML0059-01 Conditions of
Authorisation (NT DLPE, 2024)**

NORTHERN TERRITORY OF AUSTRALIA

Environment Protection Act 2019

Pursuant to section 308 of the *Environment Protection Act 2019*, the application for the grant of an Authorisation must be determined in accordance with the former *Mining Management Act 2001*¹ and granted under the *Environment Protection Act 2019*.

VARIATION OF AUTHORISATION DML0059-01

To: McArthur River Mining Pty Ltd (ACN 008 167 815)
34a Bishop Street
Winnellie NT 0820

Pursuant to section 308 of the *Environment Protection Act 2019*, I, **JOANNE TOWNSEND**, as delegate of the Minister for Environment, Climate Change and Water Security in accordance with section 38(2) of *Mining Management Act 2001* (the Act), after having paid due regard to the matters referred to in section 34 of the Act and being satisfied as to the matters referred to in section 38(3) of the Act, **vary** the Constituent Authorisations as defined in section 4AB(4)(a) and (b) of the *McArthur River Project Agreement Ratification Act 1992* (NT) (the Ratification Act)² for the mining site known as the McArthur River Mine, situated within Mineral Lease Northern (ML N) ML N1121, ML N1122, ML N1123, ML N1124, ML N1125, ML N1126 granted pursuant to section 4A of the Ratification Act, MLN 582 granted pursuant to the *Mining Ordinance 1939* and MA 366, MA 455 and MA 456 granted pursuant to the *Mining Act 1980*, and for the period of those titles, by **omitting** the Schedule to the Authorisation as varied on 17 May 2023, and **inserting** Schedules A, B, C and D attached to this instrument.

This Variation commences on the date this document is signed.



Chief Executive Officer

As delegate of the Minister for Environment, Climate Change and Water Security

23 July 2024

¹ The now repealed *Mining Management Act 2001* (NT) is available here:

https://legislation.nt.gov.au/LegislationPortal/~/_/link.aspx? id=A4297F2822AB4A77B435384C3726DEOA& z=z

² For the purposes of section 4AB(4) of the *McArthur River Project Agreement Ratification Act 1992* (NT), "Authorisation" means the constituent authorisations defined at section 4AB(4)(a) and (b) as "(a) the authorisation under section 36 of the now repealed *Mining Management Act 2001* dated 21 January 2003 and numbered 0059-01; and (b) the further authorisation under section 36 of the now repealed *Mining Management Act 2001*, varying that authorisation, dated 13 October 2006, and numbered 0059-02.

Document history:

Authorisation No.	Grant or variation	Date issued
DML0059-01 V14	Variation	23/07/2024
0059-01 V13	Variation	17/05/2023
0059-01 V12	Variation	05/05/2022
0059-01 V11	Variation	18/06/2021
0059-01 V10	OMP approval	13/11/2020
0059-01 V9	Variation	10/08/2020
0059-01 V8	Variation	15/08/2019
0059-01 V7	Variation	07/06/2019
0059-01 V6	Variation	20/12/2018
0059-01 V5	Variation	12/10/2018
0059-01 V4	Variation	17/07/2018
0059-01 V3	Variation	29/11/2017
0059-01 V2	Variation	01/06/2017
0059-01 V1	Variation	29/01/2014
0059-02	Variation	13/10/2006
0059-01	Grant	21/01/2003

SCHEDULE A - CONDITIONS OF AUTHORISATION

Definitions

1. In this document, unless the contrary intention appears:
 - a. **AAPA** is an acronym for the Aboriginal Areas Protection Authority;
 - b. **Acidic and Metalliferous Drainage** or **AMD** means drainage (which may be generated from sources including waste rock piles, ore stockpiles, tailings storage facilities and tailings dams, processing areas or facilities, roadways and embankments constructed with sulfidic material, open cuts and mine pits, underground mines, heap and dump leach piles, and acid sulfate soils) with the characteristics detailed in Figure 1 of the Preventing Acid and Metalliferous Drainage, Leading Practice Sustainable Development Program for the Mining Industry (DFAT 2016). Acid and Metalliferous drainage includes acidic drainage and pH neutral metalliferous drainage (NMD), and saline drainage (SD), generally caused by the oxidation of sulfide minerals³;
 - c. **Act** means the *Mining Management Act 2001* (NT) as in existence immediately before 1 July 2024⁴ and includes any statutory instruments made under it;
 - d. **Adaptive Management Plan** is defined by the Northern Territory Environment Protection Authority as a plan detailing a systematic process for incrementally improving management practices by learning from the outcomes of past and current practices⁵;
 - e. **AMP** is the acronym for the Adaptive Management Plan;
 - f. **Approved MMP** means the current Mining Management Plan as approved by the Minister in respect of the Site;
 - g. **ARI** is an acronym for annual recurrence interval meaning the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over 72 hours;
 - h. **Authorisation** means this document being Authorisation DML0059-01;
 - i. **CCL** is an acronym for compacted clay liner;
 - j. **Community** means the community of Borroloola in the Northern Territory of Australia, including local businesses and other organisations such as Mawurli and Wirriwangkuma Aboriginal Corporation (ABN 54 878 185 797);
 - k. **CRG** is the acronym for the Community Reference Group;

³ Australian Government Department of Industry Tourism and Resources (2016) Preventing Acid and Metalliferous Drainage, Leading Practice Sustainable Development Program for the Mining Industry. <http://www.industry.gov.au/resource/Documents/LPSDP/LPSDP-AcidHandbook.pdf>, Accessed 27 June 2018.

⁴ The now repealed *Mining Management Act 2001* (NT) is available here: https://legislation.nt.gov.au/LegislationPortal/~/_/link.aspx?id=A4297F2822AB4A77B435384C3726DE0A&z=z

⁵ Northern Territory Environment Protection Authority (2018) *Guidance on Adaptive Management*

- l. **Date of Authorisation** of the Overburden Management Project is 13 November 2020;
- m. **DCCEEW** is the acronym for the Australian Government Department of Climate Change, Energy, the Environment and Water;
- n. **Department** means the Northern Territory of Australia government department or agency that is, from time to time, responsible for the administration of the *Environment Protection Act 2019*, including delegates, officers, employees and other agents of that department;
- o. **Environmental Value** means a feature of, or a use of, the environment or part of the environment;
- p. **EMR** is an acronym for Environmental Mining Report, which has the same meaning as in the Act;
- q. **EOEF** is an acronym for Eastern Overburden Emplacement Facility, being a temporary structure for the management of benign and non-benign waste rock, as defined in the approved MMP;
- r. **Independent**, in relation to a person, means the person has agreed in writing to:
 - i. act independently of the parties with an interest in the person's engagement;
 - ii. act with honesty, reason and with the degree of professional care, skill, knowledge, experience and diligence which may reasonably be expected of the person in carrying out the engagement;
 - iii. treat information received or prepared by the person as part of the engagement:
 - 1. in confidence such that the information is not disclosed to a party other than the parties with an interest in the engagement or the person without the consent of the other parties (unless the disclosure is reasonably required by law, such as the rules of a stock exchange or disclosure to a Minister, Parliament or Legislative Assembly);
 - 2. by freely sharing the information between parties with an interest in the engagement and the person, such that no one of those parties is less informed than another in relation to the engagement.
 - iv. report in writing to the parties with an interest in the engagement at the same time, immediately upon becoming aware of one of the following relevant matters:
 - 1. any potential, perceived or actual conflicts of interest that arise, including any relationship or association, interest in assets, office held, professional or contractual obligation or provision of services relating to the parties with an interest in the engagement which might affect the ability of the person to perform the engagement impartially, diligently or independently;

2. any attempted interference or influence in the performance of the engagement by parties with an interest in the engagement;
 3. any failure to cooperate with the person or unresponsiveness to the person's requests by a party whose cooperation is required for the engagement.
- s. **ICE** is an acronym for the Independent Certifying Engineer as defined in Condition 49;
 - t. **Mine** means the mining site in which mining activities authorised by this document may occur;
 - u. **Mine or Mining Management Plan** has the same meaning as under the Act (to remove all doubt the most recent approved MMP prevails);
 - v. **Mine or Mining Site** means the area of land identified in this Authorisation and the MMP known as McArthur River Mine;
 - w. **Minister** means the Minister responsible for the *Environment Protection Act 2019* or their delegate;
 - x. **MMP** is the acronym for Mining Management Plan;
 - y. **NAF** is an acronym for non-acid forming;
 - z. **NOEF** is an acronym for the Northern Overburden Emplacement Facility, being a Waste Rock dump at the Mine which includes the Waste Rock and all ancillary facilities, infrastructure, areas and things connected to that facility;
 - aa. **NOEF West A, B, C, D, CW, CE, NE, NW and SE** are names for specific areas within the NOEF as identified in the MMP;
 - bb. **NT EPA** means the Northern Territory Environment Protection Authority an independent authority established under the *Northern Territory Environment Protection Authority Act 2012*;
 - cc. **Operator** means McArthur River Mining Pty Ltd ACN 008 167 815;
 - dd. **PAF** is an acronym for potentially acid forming;
 - ee. **Quality Control or QC** means a system of maintaining standards in construction by testing samples of the output against pre-defined specification;
 - ff. **Quality Assurance or QA** means a system for the maintenance of a desired level of quality in construction, especially by means of attention to every stage of the construction process;
 - gg. **Receiving Environment** means any aspect of the environment (within the Mine or outside of the Mine) that has the potential to be impacted by the Mine;
 - hh. **Responsible Representative** means a delegate of the Minister and includes Chief Executive Officer, Executive Director Mines and Director Mining Operations;

- ii. **SOEF** is an acronym for Southern Overburden Emplacement Facility;
- jj. **Tailings** means the residue or waste resulting from the processing of ore, often being a slurry of suspended solid particles and water, but includes both the liquid and solid components;
- kk. **Territory** means the body politic established by the *Northern Territory (Self-Government) Act 1978* (Cth) as the Northern Territory of Australia;
- ll. **Title Holder** means each person that is registered as an owner, on the mineral titles register maintained by the Territory, of a mining interest to which this document relates;
- mm. **TSF** is an acronym for Tailings storage facility;
- nn. **Waste Rock** is:
 - i. Benign Waste Rock if it is classified as **LS-NAF(HC)**; and
 - ii. Non-Benign Waste Rock if it is classified as one of the following:
 - a) **MS-NAF(HC)** – Metalliferous Saline – Non-Acid Forming (High Capacity);
 - b) **MS-NAF(LC)** – Metalliferous Saline – Non-Acid Forming (Low Capacity);
 - c) **PAF(HC)** – Potentially Acid Forming (High Capacity); and
 - d) **PAF(RE)** – Potentially Acid Forming (Reactive) (including **PAF(HW)** – Potentially Acid Forming (Hanging Wall));
- oo. **WDL** is an acronym for the Waste Discharge Licence issued under the *Water Act 1992*;
- pp. **WOEF** is an acronym for Western Overburden Emplacement Facility.

Interpretation

- 2. In this document, unless the contrary intention appears:
 - a. words defined or used in the Act have the same meaning as in the Act;
 - b. a reference to “this document” includes the cover page and Schedules;
 - c. a reference to a document is a reference to that document as in effect from time to time;
 - d. the word “including” is not a word of limitation and is to be interpreted as though it were immediately followed by the words “but not limited to”;
 - e. headings have been included for ease of reference only and do not affect interpretation;

- f. a reference to time is to the time at Darwin in the Northern Territory of Australia; and
- g. monetary references are references to Australian currency.
- h. Where the word “**Completed**” is shown in bold text below a condition, it means the respective condition has been satisfied at the time of issue of this variation of authorisation.

General

- 3. This Authorisation is subject to any conditions contained in the Act⁶, the *Environment Protection Act 2019* and these schedules.
- 4. The Operator must comply with the MMP.⁷
- 5. The Operator may only conduct mining activities identified in the MMP within the Mine subject to any Conditions contained in the Act, this document and the Conditions commitments and systems contained in the MMP.
- 6. The mine site is to be developed and operated in accordance with all relevant Commonwealth and Northern Territory legislation.

Mining management plan and reporting

- 7. The Operator must on 31 August 2021 and on each anniversary of that date (or such other date as nominated by the Operator and approved by the Minister), review the approved MMP. An MMP may be varied in accordance with section 306 of the *Environment Protection Act 2019* (NT), or the Operator may at any time apply for a replacement environmental (mining) licence under section 312 of the *Environment Protection Act 2019*
- 8. The Operator must submit annually all environmental monitoring data⁸ which has been collected since the previous data submission. The data submission must be provided in the approved form (being an MS Excel template that can be provided on request) and include laboratory and field data for the following:
 - a. surface water;
 - b. groundwater;
 - c. dust;
 - d. sediments;
 - e. gas; and

⁶ The now repealed *Mining Management Act 2001* (NT) is available here:

https://legislation.nt.gov.au/LegislationPortal/~/_/link.aspx?id=A4297F2822AB4A77B435384C3726DE0A& z=z

⁷ Section 37(2) of the *Mining Management Act 2001*

⁸ See Schedule D this document in relation to environmental monitoring requirements

- f. water transfers and discharges (including dates, times and volumes).⁹
9. From 13 November 2020 (i.e. the date of authorisation of the Overburden Management Project) the Operator must:
- a. annually submit to the Department, unless otherwise agreed to in writing by the Department, a list of structures scheduled to be constructed in the coming year that will have an “as-constructed” construction report developed subject to Condition 48(g) and in accordance with the approved MMP; and
 - b. submit the “as -constructed” construction reports subject to the above condition for each structure to the Department within 60 days or an alternate date agreed to by the Department in writing, upon construction being finalised.
10. The Operator must submit on or before 31 August 2021 and on each anniversary of that date (or such other date as nominated by the Operator and approved by the Minister), an **EMR** for the previous year in the reporting period as agreed with the Department.

Security and levy

11. The Operator must provide a security of \$494,770,048 in the form of cash or an unconditional bank guarantee to the Minister¹⁰ prior to undertaking any mining activities authorised by this Variation of Authorisations DML0059-01, 0059-01 and 0059-02.¹¹
12. The security provided for under Condition 11 will be reassessed, and may be revised, following the submission, assessment and approval of an:
- a. independent third party assessment of the security by a qualified person approved by the Minister (also refer to Condition 41);
 - b. amended MMP;
 - c. amendment to the Unplanned Closure Plan.
13. The revised security amount to be provided under Condition 11 is to be provided prior to creating the new disturbance, covered under the revised security as per written notification from the Department. For the avoidance of doubt, the Operator must provide the revised security amount in the form of cash or an unconditional bank guarantee to the Minister.
14. Each financial year, the Operator must pay a levy to the Mining Remediation Fund in accordance with section 13 of the *Legacy Mines Remediation Act 2023* (NT).

Overburden Management Project

Explanatory note:

⁹ Section 37(3)(d) of the *Mining Management Act 2001*

¹⁰ Section 43 *Mining Management Act 2001*

¹¹ Section 37(2)(b)(i) of the *Mining Management Act 2001*

The following conditions were introduced in the previous variation, dated 15 August 2019 to reflect the intent of the thirty recommendations made by the NT EPA in the making of their Assessment Report 86 published July 2018.

The NT EPA articulated an overarching environmental objective to be achieved during operation of the Mine: to ensure the health of McArthur River is protected along its whole length at all times from mine related impacts.

The Minister accepted the recommendations as overarching conditions for the life of the project and have been retained to achieve transparency.

15. The Operator must ensure activities related to the McArthur River Overburden Management Project are implemented in accordance with:
 - a. all environmental commitments and safeguards identified in the final Environmental Impact Statement for the McArthur River Mine Overburden Management Project (draft Environmental Impact Statement, Supplement to the draft Environmental Impact Statement and additional information);
 - b. recommendations in the NT EPA Assessment Report 86 where they are approved under an MMP;
 - c. if there is any inconsistency between the above documents, the most recent authorisation shall prevail to the extent of any inconsistency.
16. The Operator must provide written notice to the Minister and NT EPA if it alters or proposes to alter the McArthur River Mine Overburden Management Project and/or commitments, safeguards or mitigation measures in the Environmental Impact Statement in such a manner that the environmental significance of the action may have changed. The referral should be made in accordance with the *Environment Protection Act 2019*.
17. By 13 May 2022 (i.e. within 18 months of the date of authorisation of the Overburden Management Project), unless otherwise agreed in writing by the Department, the Operator must submit a plan to the Department for review, that:
 - a. Enables measurement of total loads of lead and zinc and is consistent with requirements of Condition 28;
 - b. Quantifies and ensures annual loads of lead and zinc discharged to the McArthur River in future years (July to June) do not exceed the loads discharged in 2017-2018 (as per Condition 69(e)) taking into account seasonal variations in rainfall, and subject to future annual load calculations;
 - c. addresses recommendations and outcomes arising from audits of loads by the Independent Monitor;
 - d. include sufficient detail to inform the development of monitoring and management measures (including but not limited to early warning alerts and intervention levels), as part of the site wide AMP (Condition 46);

Completed: 16 (a) to (d) inclusive

- e. once approved by the Department, be implemented by the Operator.

18. By 13 May 2022, the Operator must:

- a. submit a plan to the Department for review, that shall include:
 - i. site-specific trigger values determined in accordance with Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2018 framework, incorporating ANZECC (2000) guidelines, at appropriate monitoring locations, in accordance with Condition 28;
 - ii. a commitment that creeks on the mine site show long-term improving trends in water quality within 20 years after cessation of mining;
 - iii. methodology to calculate contaminant loads and contaminant concentrations entering creeks and the McArthur River using system modelling that must:
 - a. use suitable site-specific data collected as part of Condition 27;
 - b. be subject to review by the relevant independent panel;
 - c. detail specific assumptions to be tested including but are not limited to:
 - i. groundwater flow paths;
 - ii. attenuation of metals from mine-derived wastes;

Completed: 17 (a)

- b. once approved by the Department, implement the plan;
- c. incorporate the relevant findings from the plan into the AMP.

Completed: 17 (c)

19. The Operator must provide a written response to the Department, if an independent technical panel's, required under Condition 22, review of the models and modelling outputs, and the data collection programs that informed the model development at Condition 18(a)(iii) address recommendations for improvements. All relevant outputs must be used to inform and update the AMP.

20. Every three (3) years from the date of authorisation of the Overburden Management Project, an independent environmental audit of the Quality Assurance (QA) and Quality Control (QC) procedures and waste rock identification and handling performance must be undertaken and:

- a. the results of the audit be provided within six (6) weeks to the Department and to the relevant independent panel;
- b. the Operator must provide a written response to the satisfaction of the Department where findings from the audit and review by the relevant panel includes matters that need to be addressed or areas for improvement.

21. From 13 November 2020 (i.e. date of authorisation of the Overburden Management Project), new areas of the NOEF foundation development (i.e. areas at base level) that do not currently contain PAF wastes must include a low permeability liner of 0.5m

thickness and maximum saturated hydraulic conductivity of 1×10^{-9} metres per second above which future PAF, NAF and benign materials are to be stored.

22. The Operator must provide funding and assist the Department to establish and operate an independent panel(s) of experts to advise on matters affecting the environmental performance of the NOEF, TSF and mine closure planning.
23. By 13 November 2021 (i.e. within 12 months of date of authorisation of the Overburden Management Project), the Operator must submit a report to the Department for review, detailing the results of relevant studies undertaken to inform the requirements for implementation (including timelines) of a NOEF groundwater seepage interception and recovery system that:
 - a. controls seepage to the Barney Creek diversion channel and the McArthur River;
 - b. achieves a recovering trend in the Barney Creek diversion channel and the old McArthur River channel (at SW06) water quality within 20 years of cessation of mining;
 - c. facilitates achieving requirements of Conditions 17 and 18.

Completed: 22 (a) to (c) inclusive

24. By 13 November 2022 (i.e. within 24 months of date of authorisation of the Overburden Management Project), the Operator must submit a NOEF geosynthetic liner cover system plan to the Department for review. The plan must:
 - a. outline a process (including timelines) to test and evaluate (i.e. criteria) the constructability and effectiveness of geosynthetic liner cover options including a geosynthetic liner /compacted clay layer combination;
 - b. include implementation of trials on rehabilitated stages of the NOEF;
 - c. identify relevant performance parameters that must be monitored, including but not limited to:
 - i. slope stability during extreme events;
 - ii. cover performance as a result of heat effects;
 - iii. tolerance of the geosynthetic liner to expected differential settlement;
 - iv. veracity of cover longevity predictions;
 - v. likely long-term maintenance requirements.
 - d. Include reporting of trial results and monitoring outcomes:
 - i. within three years from the submission of the plan;
 - ii. every three years thereafter, to the relevant independent panel and the Community Reference Group for review, and shall be audited by the Independent Monitor. The Operator must provide a written response to the Department, if review from the relevant panels and Community Reference Group require matters to be addressed;
 - iii. must be used to inform the AMP and closure planning for the mine.
 - e. The NOEF geosynthetic liner cover system plan, once approved by the Department, must be implemented by the Operator.

25. By 13 November 2025 (i.e. within five (5) years of the date of authorisation of the Overburden Management Project), the Operator must submit a strategy to the Department that details the long-term disposal management of tailings into the mine pit void, submerged under a suitable depth of pit water. The plan must:
- a. include strategies on the tailings reprocessing and assessment of residual chemical contaminants that may likely impact on meeting the requirements of Condition 17;
 - b. be reviewed by the relevant independent panel.
26. Once approved by the Department, the strategy developed in accordance with Condition 25 must be used to develop a plan five (5) years prior to cessation of mining, for approval by the Department. Any requirement to vary the approved disposal strategy or plan must be:
- a. applied for in writing to the Minister;
 - b. based on leading practice and site conditions;
 - c. supported by the relevant independent panel;
 - d. notified to the NT EPA in accordance with Condition 16.
27. By 13 November 2021 (i.e. within 12 months of date of authorisation of the Overburden Management Project), the Operator must review and synthesise all available and relevant information to submit a revised water monitoring plan (surface water and groundwater) to the Department for review, ensuring the plan is capable of identifying and quantifying impacts of mining activities on the environmental values and beneficial uses of the McArthur River.

Completed: 26

28. The plan required under Condition 27 must:
- a. allow for assessment of compliance with Condition 17 and include sufficient detail to inform/develop/update the AMP;
 - b. at a minimum:
 - i. quantify loads of lead and zinc entering the McArthur River each year;
 - ii. quantify impacts to water quality and trends in groundwater to determine that objectives and targets are being met, including the effectiveness of source control to reduce loads to as low as is reasonably practicable;
 - iii. develop appropriate future trigger values for waterways on the mine site and the McArthur River in accordance with the ANZECC Guidelines. In the interim, the trigger values in the most current WDL shall be used;
 - c. be prepared in consultation with the NT EPA;

Completed: 27 (a) to (c) inclusive

- d. be prepared in consultation with the relevant independent panel;
- e. once approved by the Department, be implemented by the Operator;

- f. be subject to consultation with the relevant independent panel in the event that the plan requires updating (e.g. to maintain the currency of the monitoring network);
- g. ensure results of the program:
 - i. are reported annually to the Department;
 - ii. are audited by the Independent Monitor every three years;
 - iii. be published on the Operator's website.

29. By 13 May 2022 (i.e. within 18 months of date of authorisation of the Overburden Management Project), the Operator must submit a research and investigation program to the Department for review that establishes the concentration of mine-derived contaminants at which chronic and acute impacts to biota of relevance to the McArthur River system occur using recognised and accepted eco-toxicological testing, and:

- a. the results of this program must be integrated with other relevant programs, monitoring programs and management plans;

Completed: 28(a)

- b. the plan once approved by the Department must be implemented by the Operator.

30. By 13 May 2022 the Operator must provide to the department a monitoring program that provides improved understanding of aquatic ecosystems in the McArthur River from changing water flows, levels and quality. The program must:

- a) be consistent with the aquatic ecology monitoring and management plan required under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Approval 2014/7210;
- b) include monitoring of relevant parameters at appropriate frequencies to allow for implementation of applicable Trigger Action Response Plans (TARPs) included in the Adaptive Management Plan (AMP);
- c) be implemented by the Operator, once approved by the Department.

31. At all times, the Operator must conduct works consistent with the *Northern Territory Aboriginal Sacred Sites Act 1989* and valid AAPA certificate. All conditions of the AAPA certificate must be complied with (including but not limited to NOEF height restrictions), and evidence produced to demonstrate compliance, when requested by the Minister.

32. The Operator must not disturb or encroach within 5m of archaeological site MRM4, until a design of the NOEF is agreed in writing by the Department. Consultation between the Operator and Minister for Arts, Culture and Heritage must be undertaken prior to seeking endorsement of the design.

33. By 13 May 2021 (i.e. within six months of date of authorisation of the Overburden Management Project), the Operator must provide a report to the Minister, and AAPA

or the Minister for Arts, Culture and Heritage (where relevant) that demonstrates the consultation process undertaken or provide a plan to the Minister that details consultation activities and timeliness to identify and engage with appropriate custodians and traditional owners with an interest in land that would be or may be affected by the Overburden Management Project.

Completed: 32

34. By 13 November 2021 (i.e. within 12 months of date of authorisation of the Overburden Management Project), the Operator must develop or revise and submit to the Department for review an existing air quality monitoring plan that monitors sulfur dioxide emissions at an appropriate location between the NOEF and sensitive receptors determined in consultation with NT EPA.

Completed: 33

35. The air quality monitoring plan required under Condition 34 must include:
- a. objectives, locations, frequency of monitoring, trigger values and reporting commitments to manage and protect any potential air quality risk to human health outside of the mineral lease;
 - b. evidence of consultation with the NT EPA to be provided at the time of the plan submission;

Completed: 34 (a) and (b)

- c. once approved by the Department, be implemented by the Operator.
36. The results of the air quality plan for each reporting frequency must be:
- a. made available on the Operator's website. Initial monitoring results to be reported within 6 months of the plan being accepted by the Department or an alternative timeframe as agreed in writing with the Department;
 - b. incorporated where relevant in the AMP.

37. By 13 November 2022 (i.e. within 24 months of date of authorisation of the Overburden Management Project), the Operator must submit a monitoring and management plan to the Department for review that manages risks of metal toxicity from human consumption of aquatic fauna obtained from the McArthur River. The plan must:

- a. determine if aquatic fauna obtained from any reach of the McArthur River, that may be impacted by the mine's operations, is safe to eat;
- b. include demonstrated evidence of consultation with NT EPA;
- c. detail public reporting of the monitoring results, including at appropriate locations in the Borroloola region;

Completed: 36 (a) to (c) inclusive

- d. include provisions for implementation and maintenance of signage at waterways at the MRM site in accordance with the requirements of Condition 63 until the risk of contamination from consumption of this aquatic fauna is demonstrated to be acceptable by the Department;
 - e. once approved by the Department, be implemented by the Operator.
38. By 13 November 2022 (i.e. within 24 months of date of authorisation of the Overburden Management Project), the Operator must submit a plan to the Department for review that outlines a monitoring program for management of Largetooth Sawfish. The plan must:
- a. include a sampling strategy for Largetooth Sawfish that is non-lethal;
 - b. include details of parameters and criteria, from which the results could be used to define specific (measurable and time-bound) performance indicators to abate a significant decline in Largetooth Sawfish movement;
 - c. include trigger levels for investigation and implementation of management measures;

Completed: 37 (a) to (c) inclusive

- d. once approved by the Department, be implemented by the Operator.
39. Within six months following the establishment of the required panels and groups in accordance with Condition 22, the Operator must:
- a. develop environmental objectives for a Care and Maintenance Plan in consultation with the relevant Independent Panels, CRG, custodians and traditional owners;
 - b. submit this to the Department for review.
40. By 13 November 2025 (i.e. within five years of date of authorisation of the Overburden Management Project), the environmental objectives arising from Condition 39 must be used to develop a Care and Maintenance Plan in consultation with the Department.
41. The Operator must facilitate an independent third-party assessment of the security for rehabilitation of disturbances resulting from authorised activities in the approved MMP that is consistent with requirements under Conditions 11, 12 and 13, to the satisfaction of the Department, and every 3 years thereafter if the security has been re-calculated or adjusted.
42. The Operator, consistent with Condition 41, must:
- a. commission a qualified person to review the security amount whose appointment is accepted by the Minister;
 - b. ensure that the security is reviewed and delivered to the Department within six months of acceptance of the qualified person.

43. For every approved MMP and MMP amendment, the Operator must provide a revised copy of the approved document that removes commercially sensitive information, includes an overview and environmental section, and is suitable for publication on the Department's website, or provide written approval to make the complete documents publicly accessible.
44. The Operator must assist, as required, the Department to establish and operate a Community Reference Group (CRG).
45. By 13 May 2022, (i.e. within 18 months of date of authorisation of the Overburden Management Project), the Operator must undertake a synthesis of all environmental monitoring programs (Condition 27) that assess impacts of mining activities on the environmental values and beneficial uses of the McArthur River, in accordance with NT EPA's overarching environmental outcome. The revised monitoring programs must:
- a. use outputs generated for review and synthesis of water monitoring programs, as part of addressing Condition 27;
 - b. demonstrate how all monitoring data collected under various monitoring programs and management plans were considered and synthesised (e.g. conceptual site models, trend analysis);
 - c. be incorporated in the AMP.

Completed: 44 (a) to (c) inclusive

46. By 13 May 2022, (i.e. within 18 months of date of authorisation of the Overburden Management Project), the Operator must submit an AMP to the Department:
- a. The AMP must include the following key elements:
 - i. clear, measurable environmental objectives for all significant environmental risks and potential impacts;
 - ii. measureable performance indicators to show that objectives are on target to be met;
 - iii. pre-determined triggers to warn of potential for performance indicators to be exceeded, as informed by monitoring;
 - iv. realistic and achievable contingency interventions to maintain performance indicators if triggers are consistently exceeded;
 - v. clearly defined management measures/actions that are capable of being implemented in a timely way to meet performance indicators and environmental objectives;
 - vi. monitoring in accordance with relevant Recommendations in NT EPA Assessment Report 86 to determine whether management measures are effective and to inform the need for adjustments to management measures or need for alternatives;
 - vii. a continual feedback system to inform appropriate actions to be initiated when triggered and environmental objectives are always being met;

- viii. continual development of new management actions as required based on knowledge gained from experience at the site and elsewhere across industry.

Completed: 45 (a) (i) to (viii) inclusive

- b. The AMP must be reviewed by the Independent Monitor or an appropriately qualified, independent third party, and updated with inputs from the CRG (once established under Condition 44);
- c. all review findings and CRG input requirements are to be provided to the Department for approval.

47. Unless agreed otherwise in writing by the Department, the AMP must:

- a. clearly set out the required management objectives and performance indicators;
- b. provide clarity on the triggers for changes to management actions, and responsibility and evidentiary basis for decision-making;
- c. establish the timeframe for initiation of certain actions if triggers are exceeded, including decisions to discontinue an activity and clarify responsibility and evidentiary basis for decision-making;
- d. establish a process for adjusting triggers that includes the regulator;
- e. establish transparent monitoring, reporting and review requirements;
- f. establish processes to achieve transparency and stakeholder engagement in AMP design and implementation that includes NT EPA, DCCEEW and CRG;
- g. set out the mechanism for periodic review by the Independent Monitor, which must not exceed a frequency of every three years;
- h. be provided to the Department for re-approval in the event that any material changes are made to the AMP.

48. The Operator must provide written notice to the Minister and to the NT EPA where trends indicate performance indicators and environmental objectives will not, or are unlikely to be, met by implementing the AMP.

Independent Certifying Engineer (ICE)

49. The Operator must appoint an Independent Certifying Engineer (**ICE**) to:

- a. warrant and accept both the design and construction works;
- b. be present during all phases of construction where required in the approved MMP (including at hold points) and oversee and certify the works that they meet design specifications;
- c. approve re-commencement of construction at defined hold points;
- d. approve any material changes to the design during construction;
- e. verify any monitoring equipment/structure installed or to be installed as part of the construction as specified in the relevant detailed designs remains functional at the conclusion of the construction works;

- i. in the event such equipment becomes non-functional, then replacement or an ICE approved alternative must be implemented by the Operator;
- f. agree in writing, if the Operator wish to appoint an Operator's project manager/resident engineer as an onsite representative, and agree in writing that this does not diminish the ICE's responsibility or liability for the project;
- g. on completion of construction, provide a certified "as-constructed" construction report detailing:
 - i. all the works undertaken;
 - ii. evidence of:
 - a) hold-point sign-offs;
 - b) testing carried out (including but not limited to field tests, laboratory tests and statistical tests);
 - c) acceptance criteria applied and compliance of the test results with the acceptance criteria;
 - d) where deviations to the plan have occurred, justification that demonstrates the design intent and performance of the structure has not been compromised.

50. The Operator must ensure that the ICE holds appropriate public and professional indemnity insurance to cover the scope of works associated with the scope of work certified.

Independent Tailings Review Board (ITRB)

51. The Operator must:

- a. convene an advisory board (Independent Tailings Review Board or **ITRB**);
- b. ensure the ITRB:
 - i. membership includes independent geotechnical, tailings, and groundwater specialists;
 - ii. meets regularly to advise on operation of the TSF and any future modifications to its design;
 - iii. is required to meet within 90 days from commencement of construction to allow sufficient time for review of subsequent modification to the TSF;
- c. provide details of the members of the ITRB panel and meeting frequency to the Department for endorsement by the Department;
- d. together with the ICE, provide a written response to the satisfaction of the Department, in the event that future review of the designs by independent experts require additional matters to be addressed;
- e. ensure ITRB endorses any future modifications to the TSF in writing, with all ITRB review comments appropriately addressed for both construction and future use of the structure. This includes, but is not limited to:

- i. Studies and/or trials to inform future construction and/or operation of the structure;
- ii. The TSF Operations, Maintenance and Surveillance (OMS) manual, including the Trigger, Action and Response Plan (TARP) is updated regularly to accommodate any relevant changes to the structure that may impact on its stability and performance.

Waste Rock Management

52. From the date of authorisation Non-benign Waste is to be permanently placed consistent with the approved MMP:
- a. above the 100 year ARI flood level, unless flood mitigation measures are provided consistent with the approved MMP and relevant Detailed Designs submitted to the Department in accordance with the conditions of this variation of Authorisation, with the exception of PAF(RE);
 - b. on a compacted clay liner (CCL) or low permeability material that satisfies the design objective in Condition 21 that slopes towards a Perimeter Runoff Dam (PROD) or an appropriately lined storage structure, as defined in Condition 59.a;
 - c. PAF is emplaced in lift heights that minimises particle size segregation and creation of chimney structures, and must not exceed 7.5m taking into construction tolerances;
 - d. PAF(RE) is emplaced in dedicated cells in lift heights that minimises particle size segregation and creation of chimney structures, but must not exceed 2m taking into construction tolerances;
 - e. advection barriers of appropriate thickness and moisture condition are emplaced at suitable intervals that disrupt the formation of oxygen convection cycles;
 - f. the ICE verifies the suitability of the PAF placement methodology with respect to particle size segregation and advection barriers;
 - g. construction of the NOEF stages, as defined in Conditions 53 and 54 is undertaken in accordance with a valid AAPA certificate;
 - h. design of the NOEF is flexible to accommodate changes, if required, to comply with archaeological site MRM4 matters under Condition 32;
 - i. in the event that future review of the designs or as-built structure by independent experts require additional matters to be addressed, the Operator together with the ICE must provide a written response to the satisfaction of the Department;
 - j. at mine closure, non-benign waste rock is encapsulated and fully contained within an engineered cover system consistent with the Overburden Management Project, or an alternative cover system endorsed by the relevant independent technical panels to the satisfaction of the Department.

Construction of NOEF

Construction of the NOEF has occurred in stages. Conditions placed on construction of the various stages has been subject to change with the issuing of variations of Authorisation incorporating conditions appropriate for that point in time.

53. From the date of authorisation of the Overburden Management Project, the Operator is approved to construct, operate and maintain the following stages for permanent placement of Waste Rock in the NOEF:
- a. West A, B, C and D;
 - b. CW (alpha, bravo and charlie);
 - c. CE (alpha and bravo);
 - d. SE;
 - e. NW;
 - f. NE.
54. The Operator must develop the NOEF Stages defined in Condition 53 in accordance with Concept designs presented in the approved MMP.
55. During construction of the NOEF, the Operator must ensure:
- a. engagement of the ICE consistent with Condition 49;
 - b. waste rock management requirements comply with Condition 52.

Remaining Waste Rock Management Facilities

56. From the date of authorisation of the Overburden Management Project, temporary placement of non-benign waste is authorised for the following:
- a. EOE (except for PAF(RE));
 - b. stockpiles on NOEF, SOEF and WOE;
 - c. ROM Pad;
 - d. any other location approved by Department in writing.
57. The Operator must ensure that non-benign waste temporarily placed outside of the NOEF:
- a. has suitable water management structures (e.g. drains and sumps) in place to contain and manage poor quality drainage in accordance with the approved MMP;
 - b. has installed water diversion structures that allow segregation of mine-affected drainage from non-mine affected drainage;
 - c. has monitoring and management measures, in accordance with the AMP, implemented to ensure environmental objectives defined in the approved MMP are satisfied;
 - d. is removed and managed at cessation of mining in accordance with the approved MMP;

- e. is removed and managed in accordance with the approved MMP in the event of unplanned closure;
- f. has oversight provided by ICE as per Condition 49.

Ore Processing and Milling

- 58. Surface water management infrastructure associated with the lead filtration facility at the Mine must be suitably designed and constructed to contain a 100 year ARI rainfall event.
- 59. From the date of authorisation of the Overburden Management Project, the Operator is authorised to expand the ore processing and associated milling and storage facilities in accordance with concepts and management systems detailed in the approved MMP including:
 - a. ensuring the structures to be developed are suitably designed and constructed to allow management of poor quality drainage in accordance with the Water Management Plan that is generated from the construction and future operation of the structures;
 - i. construction and development of Gypsum Plant;
 - ii. construction and development of Caustic Facility;
 - iii. construction and development of Reagent Mixing Facility;
 - iv. construction and development of Copper Mud Facility;
 - v. construction and development of Lead Concentrate Storage Facility;
 - vi. expansion of the concentrate storage shed and use of external hardstand area;
 - b. Wastes generated from the operation of the Gypsum Plant must be managed in accordance with Condition 64.

Water management and storage

- 60. Until the AMP (including Environmental Management Plans and sub-plans) is approved by the Department in writing, the Operator must prepare, review and include the following for each MMP and where appropriate each MMP amendment, a Water Management Plan which includes:
 - a. modelling of surface water at and around the Mine;
 - b. a whole of Mine water balance which takes account of the modelling of surface water;
 - c. calibration of the modelling of surface water to confirm its accuracy;
 - d. a written plan detailing how water at the Mine will be managed for the forthcoming wet season;
 - e. a plan of actions which will be undertaken to reduce the risk of any releases from AMD storage structures;

- f. a plan of actions, including engineers' reporting schedules, which will be undertaken to ensure the structural integrity of all AMD storage structures;
- g. a plan of actions which will be undertaken to ensure seepage from AMD storage structures is minimised including, where required, timelines for repairing damaged or installing new seepage management infrastructure.

Completed: 59 (a) to (g) inclusive

61. From 13 November 2020 (i.e. the date of authorisation of the Overburden Management Project), water-related activities involving interfering with waterway and water extraction must be undertaken in accordance with the *Water Act 1992*, and where required, appropriate licenses/approvals are obtained from the responsible agency prior to commencement of the works. The Operator must ensure:
- a. activities involving disturbance must not commence until required studies and/or trials to inform future design, construction and/or operation, as detailed in the approved MMP, are completed;
 - b. works are conducted in accordance with a valid AAPA certificate;
 - c. detailed designs, where nominated in the approved MMP, are developed and implemented in consultation with required experts, including but not limited to ecology, engineering and any other experts as appropriate;
 - d. regular inspections and maintenance are undertaken to ensure design objectives continue to be satisfied.
62. The Operator must complete translocation of the Purple-crown Fairy Wren in accordance with the approved MMP, prior to commencement of works on the Old McArthur River Channel plug.

Completed: 61

63. The Operator must erect and maintain warning signage that:
- a. is permanent and weatherproof;
 - b. contains specific wording agreed to by the Chief Health Officer (CHO) of the Northern Territory;
 - c. is located:
 - i. at appropriate distances and frequency along the waterway;
 - ii. as a minimum at all access points, including but not limited to crossings, vehicle tracks and walking tracks.
 - iii. along the length of:
 - a. Barney Creek downstream to its junction with the McArthur River;
 - b. Barney Creek upstream to a point a short distance upstream of where the Carpentaria Highway crosses Barney Creek;

- c. Surprise Creek to approximately the location of SW29;
 - d. the Bing Bong shipping channel and in the immediate area surrounding the shipping channel and the swing basin, unless otherwise agreed in writing by the CHO and the Department.
64. Wastes generated from operation of the Water Treatment Plant and Gypsum Plant must be disposed of in accordance with concepts and management systems detailed in the approved MMP, ensuring:
- i. trials for the permanent disposal of Gypsum Plant and Water Treatment Plant wastes must be undertaken to inform final material placement;
 - ii. the ITRB or an approved qualified and experienced independent third party endorse the waste disposal strategy, if the wastes are to be placed in the TSF; or
 - iii. the ICE or an approved qualified and experienced independent third party endorse the waste disposal strategy, if the wastes are to be placed in the NOEF.
65. Water storage structures into which the Operator places or directs AMD must be designed, constructed and managed by the Operator to minimise to as low as reasonably practicable contaminants entering the Receiving Environment. In this regard the water storage structures into which the Operator is authorised to place or direct AMD whilst they continue to meet the requirements of this Condition are as follows:
- (a) NOEF Southern Perimeter Runoff Dam (SPROD)
 - (b) NOEF South East Perimeter Runoff Dam (SEPROD)
 - (c) NOEF Western Perimeter Runoff Dam (WPROD)
 - (d) NOEF Eastern Perimeter Runoff Dam (EPROD)
 - (e) Mill Anti-Pollution Pond (Mill APP)
 - (f) Mill Concentrator Runoff Pond (Mill CRP)
 - (g) Open Pit Van Duncan's Dam (OP VDD)
 - (h) Open Pit Pete's Pond (OP PP)
 - (i) Open Pit Lake Archer (OP LA)
 - (j) Mill Old Stores Dam (Mill OSD)
 - (k) Open Pit Pond 2 (OP P2)
 - (l) NOEF West D Sump (WDS)
 - (m) NOEF Mine Infrastructure Area Sump (MIAS)
 - (n) NOEF West A Sump (WAS)

- (o) NOEF North East Alpha Sump (NEAS)
- (p) NOEF North West Sump (NWS)
- (q) NOEF North East Stilling Basin (NESB)
- (r) NOEF Central East Alpha Sump (CEAS)
- (s) NOEF Central East Bravo Sump (CEBS)
- (t) NOEF South Stilling Basin (SSB)
- (u) NOEF South East Alpha Sump (SEAS)
- (v) NOEF North East Bravo Sump
- (w) NOEF North West Stilling Basin
- (x) NOEF South West Stilling Basin
- (y) NOEF Diamond Sump
- (z) Southern Overburden Emplacement Facility Sump (SOEF Sump)
- (aa) East Overburden Emplacement Facility Sump (EOEF Sump)
- (bb) EOEF Low Grade Sump (LGS)
- (cc) Bing Bong Surface Runoff Pond 1 (BBSRP1)
- (dd) Bing Bong Surface Runoff Pond 2 (BBSRP2)
- (ee) Bing Bong Surface Runoff Pond (BBSRP3)
- (ff) Rice Paddies Pond
- (gg) Southern Water Management Dam (SWMD)

Water Transfer and Discharge

66. The Operator must not transfer water to or discharge water from any water storage structure until:
 - a. water quality analysis has been received and interpreted by the Operator;
 - b. results confirm the water is suitable for the destination, having regard to the requirements of this document, the approved MMP and any other relevant restrictions on transfer or discharge of water within or from the Mine.
67. The Operator is authorised to undertake works to release water from WMD to Little Barney Creek in accordance with previous approvals as defined in Schedule B.
68. From the date of authorisation of the Overburden Management Project, water releases are authorised from the following points:

Authorised Release Points	Receiving Water Body	Location Coordinates	
		Latitude	Longitude
WMD	Little Barney Creek	-16.42635	136.0693
Mine Levee Release Point (MLRP)	Barney Creek Diversion	-16.42743	136.1114
South-East Levee 1 Release Point (SEL1 RP)	Barney Creek Diversion	-16.42394	136.1082
McArthur River Diversion Channel Release Point ¹²	McArthur River Diversion	-16.435385	136.120196

69. The Operator must:

- a. ensure all offsite water discharges are undertaken in accordance with a valid WDL;
- b. only release water for offsite discharge from the WDL approved points;
- c. interpret and report all data and results acquired as part of the activity in the Operator's Annual Environmental Mining Report;
- d. evaluate the performance of this activity in terms of its effectiveness as a management tool;
- e. by 30 June 2020, characterise total loads of mine-derived contaminants from all source inputs for the 2017-2018 period consistent with Condition 17.b, unless otherwise agreed in writing by the Department.

Completed: 68(e)

70. The Operator must in relation to the WMD release point to Little Barney Creek undertake:

- a. release activity that minimises localised erosion, and utilises suitable energy dissipation and flow spreader structures (e.g. rock basin) and be monitored daily during release events;
- b. remediation in the event of unacceptable erosion occurring at the Carpentaria Highway culvert system to the satisfaction of the Department of Infrastructure, Planning and Logistics and the Department;
- c. a cross-section profile survey immediately up-stream and down-stream of the Carpentaria Highway crossing, prior to and following each wet season;
- d. each wet season quantification of any significant changes to creek morphology as function of time by documenting at a minimum morphology prior to first water release, and following the last water release. This could be achieved, for example, using a drone survey of the drainage system between the flow outlet and Barney

¹² Subject to approval by the responsible agency

Creek Diversion using a consistent flight path, with the resulting image overlaid on appropriately sized grid (e.g. 2.5 x 2.5 m);

- e. measure and record flow duration, flow rate and volume of all water released from WMD into Little Barney Creek;
- f. ensure all evidence of continuous flow in Little Barney Creek along the length of the drainage system between WMD release outlet and Little Barney Creek Diversion Channel is available for inspection;
- g. ensure the surface water monitoring schedule for the activity includes SW06, which must be assessed for identical parameters as defined for SW03. At monitoring points SW03 and SW06:
 - i. Field parameters must also be measured daily during water release from WMD into Little Barney;
 - ii. The surface water monitoring analytical suite must include thallium, boron and cobalt;
 - iii. The surface water monitoring must be continued for a further two weeks following completion of the release activities for the season or until field parameters have returned to baseline levels;
- h. measure total loads of analytes (including lead and zinc) from all controlled discharge activities entering McArthur River at location SW06 or an alternate location as agreed by the Department; and
- i. interpret the data acquired as part of the activity and its effectiveness and report in the Operator's Annual EMR in accordance with Condition 10.

71. The Operator is authorised to undertake water management trial/s in accordance with:

- a. concepts detailed in the approved MMP, ensuring the trial/s is designed to manage and control all impacted surface water runoff in accordance with the Water Management Plan:
 - i. Irrigation of Treated Water – Open Woodland Irrigation;
 - ii. Irrigation of Treated Water – Phytoremediation;
 - iii. Lowering of surface water elevations – Evapotranspiration;
 - iv. Sulfate Treatment System – Passive engineered wetland;
 - iv. Sulfate Treatment System – Active Bioreactor;
- b. detailed designs, where nominated in the approved MMP, are developed in accordance with the concepts outlined in the approved MMP, and endorsed by a relevant independent third party, prior to construction.

72. At the conclusion of the trials in Condition 71, the Operator must apply in writing to the Department for approval of full-scale implementation.

73. Water management using the Centre Pivot Irrigator is authorised:

- a. within the Mine Levee in accordance with the concept previously approved, as defined in Schedule B;
- b. adjacent to the TSF in accordance with the concept presented in the approved MMP;

- c. to be configured to maximise evaporation and minimise surface spray drift, surface runoff and infiltration into underlying natural soils.

Perimeter Run-Off Dams – SPROD, SEPROD, WPROD and EPROD

74. The Operator is approved to develop SPROD and SEPROD in accordance with relevant documents defined in Schedule B;
75. The Operator is authorised to complete works to construct EPROD and WPROD in accordance with following:
- a. EPROD:
 - i. as previously approved and defined in Schedule B, ensuring that only benign material be used in the construction of the western embankment wall;
 - b. WPROD:
 - i. CWNOEF and NOEF West D Amendment, as defined in Schedule B; and
 - ii. WPROD and Western Surface Water Management Design Update (GHD Memo), as defined in Schedule B.
76. The Operator must:
- (1) Construct EPROD and WPROD informed by the following monitoring regime in the event groundwater dewatering is necessary:
- a. six hourly monitoring of field parameters for the first 24 hours of dewatering. Should parameters not stabilise during the first 24 hours then six hourly monitoring must continue until stabilisation has occurred;
 - b. field parameters must be taken daily following the first 24 hour period. Should parameters change more than 20% then the frequency must increase to every 12 hours until parameters have stabilised;
 - c. field parameters must include pH, specific electrical conductivity (SEC), temperature, REDOX and dissolved oxygen;
 - d. water samples must be taken and analysed at the commencement of dewatering at the end of the first 24 hours, and then weekly sampling and analysis of dewatering water for the remainder of the construction;
 - e. additional sampling and analysis must be undertaken if there is a substantial change in field parameters (approximately 30%);
 - f. analysis must include: specific electrical conductivity (SEC), major ions (Ca, K, Mg, Na, Cl, CO₃, HCO₃ and SO₄), Al, As, Cd, Co, Cu, Fe, Mn, Ni, Pb, Se and Zn;
 - g. field parameters and samples for analysis must be taken from the dewatering source, not the receiving storage;
 - h. if flow meters fail, then dewatering must cease until they are repaired or replaced;
 - i. field water quality parameters, flow meter volumes and laboratory analysis must be submitted to Department on a monthly basis;

- j. any indication of fracturing and/or caverns (Karstification/dissolution features) must be recorded during logging along with water strikes and estimated yields during drilling;
- (2) Prior to use of the structure, submit to the Department construction reports including QA and QC data endorsed by the ICE within 60 days of construction being completed.

Southern Water Management Dam

77. The Operator is authorised to complete works to construct the Southern Water Management Dam in accordance with the MMP, ensuring:
- a. Works are conducted in accordance with a valid AAPA certificate;
 - b. Detailed designs be reviewed by an ICE, consistent with Condition 49 and submitted to the Department for acceptance prior to commencement of construction works;
78. Prior to the use of the Southern Water Management Dam, submit to the Department construction reports including QA and QC data endorsed by the ICE within 60 days of construction being completed.

Tailings storage facility

79. From the date of authorisation of the Overburden Management Project, tailings must be managed in accordance with the following:
- a. be deposited only in Cell 1, Cell 2 or combined Cell 1 and Cell 2;
 - b. any construction of tailings lift, as approved in Condition 82, be reviewed and endorsed by independent oversight requirements in Condition 49 and 51 or an alternative independent qualified and experienced third party approved by the Department in writing;
 - c. construction of the TSF lifts is undertaken in accordance with a valid AAPA certificate;
 - d. the TSF Seepage Interception Trench is fully operational by end of December 2020;
 - e. in the event that future review of the designs or as-built structure by independent experts require additional matters to be addressed, the Operator together with the ICE must provide a written response that justifies the existing design or proposes an alternate design to the satisfaction of the Department.

TSF Cell 1 and 2 Construction

80. From the date of authorisation of the Overburden Management Project, the Operator is approved to develop TSF Cell 1 , Cell 2 and Combined Cell 1 and 2 lifts in accordance with:
- a. McArthur River Mining Pty Ltd, Tailings Storage Facility, Design Development – Life of Mine Plan, May 2017, as defined in Schedule B;

- b. the approved MMP for the following stages:
- i. Cell 1 Raise 4 – 10,056.0 mRL;
 - ii. Cell 1 Raise 5 – 10,059.0 mRL;
 - iii. Cell 2 Raise 6 – 10,061.0 mRL;
 - iv. Cell 2 Raise 7 – 10,061.5 mRL;
 - v. Combined Cell 1 and 2 Raise 1 – 10,062.6 mRL;
 - vi. Combined Cell 1 and 2 Raise 2 – 10,063.8 mRL;
 - vii. Combined Cell 1 and 2 Raise 3 – 10,065.0 mRL;
 - viii. Combined Cell 1 and 2 Raise 4 – 10,066.2 mRL;
 - ix. Combined Cell 1 and 2 Raise 5 – 10,067.4 mRL;
 - x. Combined Cell 1 and 2 Raise 6 – 10,068.6 mRL;
 - xi. Combined Cell 1 and 2 Raise 7 – 10,069.8 mRL;
 - xii. Combined Cell 1 and 2 Raise 8 – 10,071.0 mRL;
 - xiii. Combined Cell 1 and 2 Raise 9 – 10,072.2 mRL;
 - xiv. Combined Cell 1 and 2 Raise 10 – 10,073.4 mRL;
 - xv. Combined Cell 1 and 2 Raise 11 – 10,074.6 mRL;
 - xvi. Combined Cell 1 and 2 Raise 12 – 10,075.8 mRL;
 - xvii. Combined Cell 1 and 2 Raise 13 – 10,077.0 mRL;
 - xviii. Combined Cell 1 and 2 Raise 14 – 10,078.0 mRL.

81. For each lift, the Operator must ensure detailed designs follow the approved McArthur River Mining Pty Ltd Tailings Storage Facility Raising General Specification for Design and Construction; with oversight provided by the ICE consistent with Condition 49.

TSF Management

82. The Operator must operate and maintain the TSF in accordance with the most up-to-date TSF Operations Maintenance and Surveillance manual, ensuring:

- a. no discharge of water into the TSF unless
 - i. it is water contained within the Tailings stream which is at normal operational slurry densities; or
 - ii. It is endorsed by the ITRB;

- b. all Tailings are deposited sub-aerially to allow proper beaching and drying between deposition cycles;
 - c. surface water levels are maintained in the TSF such that they do not come into contact with the embankment internal walls;
 - d. phreatic surface is managed to avoid compromising the integrity of the embankment.
83. The Operator must provide quarterly to the Minister a written status report on the seepage and management of seepage from the TSF, including the following:
- a. water levels in the TSF;
 - b. all monitoring data associated with the seepage (including geotechnical and environmental monitoring);
 - c. flow rate of each seep;
 - d. all actions undertaken during the quarter associated with the seepage and management of Tailings;
 - e. all actions planned for the next quarter associated with seepage and management of Tailings.¹³

Geochemical, Geotechnical and Hydrogeological Assessments and Investigation Drilling

84. The Operator is authorised to undertake Drilling Investigations as outlined in relevant approved plans defined in Schedule B and approved MMP, ensuring adherence to industry best practice:
- i. in order to collect samples for waste rock characterisation and geochemical and geotechnical analyses;
 - ii. to characterise available construction and rehabilitation materials available within the Mine Levee Wall (including the pit) and areas surrounding the TSF and NOEF;
 - iii. to enable geochemical assessment of the overburden emplacement facility and underlying sediments;
 - iv. to obtain hydrogeological information associated with pit inflows, groundwater inputs into the underground void and installation of additional monitoring bores to inform site management.
85. The Operator must ensure the disturbances from the drilling and site investigation activities are rehabilitated consistent with industry best practice.
86. Characterisation data from the drilling must be kept and made available to the Minister on request; and reported in the Operator's EMR or an alternative format as agreed with the Department.
87. All documentation relating to the investigations undertaken is to be made available to the Department on request.

¹³ Section 37(3)(d) of the *Mining Management Act 2001*.

88. On completion of the investigation the disturbances are to be rehabilitated in accordance with the approved MMP and the basis for the proposed adjustment of total security adjustments required under Condition 12, are provided in the annual Unplanned Closure Plan report to the satisfaction of the Department.

Exploration

89. The Operator must ensure that:

- a. works are undertaken in accordance with management systems detailed in the approved MMP;
- b. an environmental management plan is in place that addresses:
 - i. chemical use and storage (e.g. hydrocarbons, drilling fluids);
 - ii. erosion and sediment control;
 - iii. dust;
 - iv. associated risks common for exploration works;
- c. rehabilitation is undertaken for locations not needed for further use;
- d. an exploration rehabilitation report including details regarding the status of disturbance, rehabilitated drill holes and the basis for the proposed adjustment of total security subject to Conditions 11, 12 and 13, be prepared, submitted and implemented to the satisfaction of the Department.

Non-mineral Waste Management

90. The Operator is authorised to complete works to prepare and construct a Centralised Waste Facility (CWF) for management of general, contaminated and putrescible wastes, in accordance with:

- a. concept designs presented in the document entitled *McArthur River Mine Mining Management Plan Amendment, January 2019*, as defined in Schedule B, ensuring:
 - i. detailed designs follow the approved concepts for the facility (including 100 year ARI flood immunity, CCL and protective armour, drainage works and biosecurity control);
 - ii. the structure design and construction is undertaken in accordance with independent oversight consistent with Conditions 49 and 51;
 - iii. detailed designs include allowances for the installation of an adequate number of monitoring bores at suitable locations to monitor the environmental performance of the structure with respect to contaminant seepage. These monitoring locations must be integrated and reported within the site-wide water monitoring requirements.

91. The Operator must ensure the non-mineral waste facility, landfill or equivalent previously in use is rehabilitated following approval by the Department of a rehabilitation plan.

Rehabilitation Trials

92. The Operator is authorised to undertake the following rehabilitation trials, in accordance with concepts defined in relevant documents in Schedule B and the approved MMP:
- a. Construction Test Pads (CTP) on NOEF West stage;
 - b. PAF(RE) Cell and Cover System Performance on NOEF Southeast stage;
 - c. Mine Levee revegetation.
93. The Operator must ensure all contaminated runoff is contained and managed within the water management circuit and as detailed in the Water Management Plan.

Bing Bong Loading Facility

94. Dredging activities at the Bing Bong Port Facility are authorised, subject to:
- a. submission to the department of a Dredging and Dredge Spoil Management Plan;
 - b. approval of the Plan by the Department;
 - c. subsequent provision of any required additional information (including but not limited to detailed designs) and written acceptance by the Department, prior to commencement of dredging.

Environmental Monitoring and Management

95. Environmental monitoring for the McArthur River Mine site (including BBLF) must be undertaken in accordance with requirements in Schedule D and reported as part of Condition 10.

Adaptive Management

96. By 13 November 2021 (i.e. within 12 months of the date of authorisation of the Overburden Management Project), the Operator must submit a revised AMP as required under Conditions 46.

Completed: 93

97. The revised AMP must:
- a. address the comments from the Independent Monitor or independent third party review of the draft AMP and ensuring compliance with Condition 46;
 - b. be consistent with the AMP required under the *Water Act 1992* and *Environment Protection and Biodiversity Conservation Act 1999*;
 - c. be reviewed by a Department approved independent third-party at the discretion of the Minister;
 - d. be approved by the Minister;

e. once approved, be implemented in full.

98. Any material changes to the AMP required by Condition 97 must be re-approved by the Minister.

Mine Closure

99. From the date of authorisation of the Overburden Management Project, the Operator must submit an updated Mine Closure Plan with each Amended MMP that builds upon the closure concepts defined in the Overburden Management Project.

100. The Mine Closure Plan required under Condition 99 must:

- a. detail how key mine domains will be rehabilitated to achieve the Overburden Management Project closure objectives;
- b. address outcomes of the reviews by independent technical and closure panels in accordance with Condition 22 with respect to mine closure;
- c. incorporate relevant outcomes from rehabilitation trials defined in Condition 92.

101. Five years prior to the planned closure of the mine, the Operator must:

- a. finalise the Mine Closure Plan required under Condition 99;
- b. submit to the Department the plan for approval by the Minister;
- c. implement the Mine Closure Plan in full, following its approval.

Unplanned Mine Closure

102. From 13 November 2020 (i.e. the date of authorisation of the Overburden Management Project), the Operator must annually submit to the Department, unless otherwise agreed in writing by the Department, an Unplanned Mine Closure Plan on or before 31 August, starting 2021, that is accompanied by a related security estimate.

Independent monitoring assessment Conditions

103. The Operator must comply with the clauses pertaining to it in SCHEDULE C - INDEPENDENT MONITORING ASSESSMENT CONDITIONS.

SCHEDULE B – PREVIOUSLY APPROVED MMP AND MMP AMENDMENTS

1. Sustainable Development Mining Management Plan 2013-2015 Volumes 1 and 2 dated 3 March 2015 approved by the Minister under the Act on 23 December 2015; and
2. Approved amendments to the Mining Management Plan entitled:
 - a) McArthur River Mining Pty Ltd – Cell 2 Raise 3 Detailed Design Report – Revision 2 April 2015 (GHD Report);
 - b) McArthur River Mining Pty Ltd – Southern PAF Run Off Dam (SPROD) – Dam Lining Upgrade Design Report – August 2016 (GHD Report);
 - c) McArthur River Mining Pty Ltd – TSF Cell 2 – Raise 4 to RL 10057 m Detailed Design Report - February 2017 (GHD Report);
 - d) CWNOEF and NOEF West D Amendment - Construction according to Phase 3 EIS. This MMP Amendments included presentation to officers of the Department, MRM's 2016 - 2018 Waste Plan, Additional information provided by MRM to the Department during February 2016, meeting between MRM and the Department to discuss the amended MMP, presentation to Departmental officers on kinetic testing and waste classification and additional information provided by MRM to the Department during March 2016. This MMP Amendment approval is associated with all of these documents;
 - e) Western PAF Run-Off Dam (WPROD) and Western Surface Water Management Design Update (GHD Memo);
 - f) Design Basis for the Lead Sulphate Filter Plant - Attachment D of Additional Information lodged 01/05/2015);
 - g) McArthur River Mining Pty Ltd – TSF Cell 2 – Raise 5 to RL 10059 m Detailed Design Report - May 2018 (GHD Report);
 - h) McArthur River Mining Pty Ltd – Eastern Perimeter Runoff Dam - Detailed Design Report – March 2018 (GHD Report);
 - i) Letter dated 11 May 2018 from McArthur River Mining Pty Ltd regarding Mining Management Plan Amendment – EPROD and Drilling Investigations;
 - j) Letter dated 12 September 2018 from McArthur River Mining Pty Ltd regarding Mining Management Plan Amendment – Central West Charlie Stage Foundation works. This amendment also includes additional information provided by MRM on 21 September 2018 in relation to groundwater, Central West Charlie Stage Foundation underdrainage and security;
 - k) Letter dated 5 March 2018 from McArthur River Mining Pty Ltd regarding Mining Management Plan Amendment – Additional Water Release. This amendment also includes additional information provided by MRM on 31 October 2018, 26 November 2018 and 14 December 2018;

- l) *McArthur River Mine Mining Management Plan Amendment, January 2019*, including all appendices. This amendment includes:
 - i. additional information provided by MRM on 26 February 2019, 26 March 2019, 28 March 2019, 5 April 2019 and 18 April 2019;
 - ii. McArthur River Mining Pty Ltd – TSF Cell 1 Stage 4 – Raise to RL 10056, Detailed Design Report, March 2018, Revision 1;
 - iii. McArthur River Mining Pty Ltd – Tailings Storage Facility, Design Development – Life of Mine Plan, May 2017, Revision 2;
 - iv. McArthur River Mining Pty Ltd – Tailings Storage Facility Seepage Interception Trench Design, January 2018, Revision 1.

- m) *McArthur River Mine Mining Management Plan Amendment, January 2020, Version 1*, as related to construction of TSF Cell 1, Stage 5 lift only, including information provided to the Department by MRM on 30 July 2020 and 31 July 2020.

SCHEDULE C - INDEPENDENT MONITORING ASSESSMENT CONDITIONS

This Schedule is provided for the purpose of providing both the Operator and the Department with transparent reference to what is known as the “McArthur River Mine – Independent Monitoring Assessment Conditions”. These were introduced in 2006 when the Mine transitioned from underground workings to open pit mining.

1. The purpose of the McArthur River Mine – Independent Monitoring Assessment Conditions” is to establish and set out the operational requirements for an independent monitoring assessment of the environmental performance of the Mine.
2. These Conditions may be cited as the “McArthur River Mine – Independent Monitoring Assessment Conditions”.
3. The purpose of these Conditions is to establish and set out the operational requirements for an independent monitoring assessment of the environmental performance of the Mine.
4. The Department will engage an Independent Monitor to undertake the independent monitoring assessment.
5. The Operator and the Department acknowledge that this independent monitoring assessment is in addition to their respective obligations and statutory responsibilities in relation to the Mine.
6. The Independent Monitor will:
 - a) monitor the environmental performance of the Mine by reviewing:
 - i. environmental assessments and monitoring activities undertaken by the Operator; and
 - ii. environmental assessments and audits undertaken by the Department; and
 - b) report to the Operator and the Department any urgent issues requiring investigation and reporting.
7. The Independent Monitor will not review:
 - a) Mine safety; or
 - b) social issues arising from the operation of the Mine in the McArthur River Region.
8. The Department will engage an Independent Monitor in accordance with its procurement processes.
9. The Independent Monitor may be (in order of preference):
 - a) an environmental or mining agency in another jurisdiction in Australia; or
 - b) a university having the necessary expertise; or
 - c) an environmental consultant that has the necessary expertise, relevant experience and the necessary resources.

10. Prior to advertising a tender seeking to engage an Independent Monitor, the Department must provide the Operator with a copy of the proposed tender documentation, including:
 - a) the Conditions of tendering; and
 - b) the scope of services; and
 - c) the assessment criteria; and
 - d) the Conditions of contract.
11. The Operator may, within 14 days of receiving the proposed tender documentation, provide comment on the proposed documentation to the Department and the Department must consider any comments provided by the Operator on the proposed documentation prior to advertising the tender.
12. The Department must provide the Community with an opportunity to provide submissions on the engagement of the Independent Monitor and the Department must consider any submissions provided by the Community on the engagement of the Independent Monitor prior to advertising the tender.
13. The terms of engagement of the Independent Monitor may include the following:
 - a) a period of engagement between three and five years;
 - b) a statement acknowledging that the Operator is responsible for the costs of the Independent Monitor;
 - c) a warranty by the Independent Monitor that it will:
 - i. act independently of the Department, the Operator, the Minister and any other person; and
 - ii. act honestly, reasonably and with the degree of professional care, knowledge, experience, skill and diligence which may reasonably be expected; and
 - iii. act within the time prescribed under these Conditions, the terms of engagement, or where no time is prescribed, within a reasonable time; and
 - iv. immediately notify the Department in writing upon becoming aware of the existence or possibility of a conflict of interest;
 - d) an obligation on the Independent Monitor to keep all information provided to the Independent Monitor confidential.
14. If the Independent Monitor requires an indemnity, the Operator must enter into a binding agreement providing a reciprocal indemnity to the Department.
15. The Department must notify the Operator of the appointment of the Independent Monitor and must provide the Operator with a copy of the terms of engagement.

16. The Operator and the Department must not interfere or attempt to influence the Independent Monitor in its assessment of environmental performance under these Conditions.
17. The Operator and the Department must each:
 - a) cooperate with the Independent Monitor; and
 - b) provide all necessary information and documents within their possession, custody or control to the Independent Monitor; and
 - c) procure for the Independent Monitor access to such premises owned, leased, or licensed by it as may be reasonably necessary,
 - d) to enable the Independent Monitor to undertake its assessment of environmental performance under these Conditions.
18. The Independent Monitor must engage with the Operator, the Department and the Community in undertaking the independent monitoring assessment.
19. If the Independent Monitor identifies an issue it considers requires urgent investigation and reporting:
 - a) the Independent Monitor must advise the Operator and the Department of the issue as soon as practicable and may include recommendations as to action to be taken; and
 - b) the Operator must consider the advice, and any recommendations, from the Independent Monitor and notify the Department and the Independent Monitor of the action the Operator proposes to take; and
 - c) the Department may, where appropriate, advise the Operator and the Independent Monitor of action the Department proposes to take; and
 - d) the Independent Monitor may provide further advice to the Operator, and where appropriate the Department, regarding the proposed action and the Operator and the Department must consider the further advice; and
 - e) if, after providing further advice, the Independent Monitor is not satisfied with the proposed action, the Independent Monitor may notify the Operator and the Department of the Independent Monitor's intention to undertake its own investigation and report; and
 - f) the Operator and the Department must facilitate the Independent Monitor's investigation and report.
20. The independent monitoring assessment is to be conducted, where practical, in a manner that complements the existing annual environmental assessment and audit processes undertaken by the Operator and the Department.
21. The Independent Monitor must prepare and provide a report:
 - a) annually to the Minister to assist with the review of the Mining Management Plan; and

- b) on request by the Minister.
22. The Minister must provide a report received from the Independent Monitor to the Operator and the Department within 14 days of receiving the report.
 23. The Independent Monitor must prepare an additional report in a form suitable for distribution to the Community.
 24. The Operator and the Department acknowledge that the report from the Independent Monitor will be made publicly available (including publication on an appropriate internet site) and may include data used in the preparation of the report.
 25. Prior to being made publicly available, the Minister must request from the Operator and the Department any comments on the Independent Monitor's report. Such comments must be provided within 28 days of the Minister's request and must be made publicly available with the Independent Monitor's report.
 26. The Operator acknowledges that it is responsible for all costs of the independent monitoring assessment other than those costs directly attributable to those elements of the independent monitoring assessment associated with Condition 21(b)) which are the responsibility of the Department.
 27. The Department may provide to the Operator, from time to time, a notice setting out amounts due and payable under the terms of the engagement of the Independent Monitor.
 28. The Operator must pay an amount notified in accordance with Condition 27 within seven (7) days of receiving such notice.
 29. If the Operator disputes a notice provided by the Department under Condition 27:
 - a) the Operator must pay the amount specified in the notice in accordance with Condition 28; and
 - b) the Operator must notify the Department in writing within 14 days of receiving the notice, setting out the reasons why the Operator disputes the notice; and
 - c) the Chief Executive of the Operator and the Chief Executive of the Department must meet within five (5) working days to resolve the dispute.
 30. If there is a dispute (other than a dispute mentioned in Condition 29) between the Operator and the Department as to any matter or thing arising out of these Conditions (the "Dispute"), the party claiming that a Dispute has arisen must notify the other party to the Dispute and the Chief Executive of the Operator, the Chief Executive of the Department and the Independent Monitor must meet within five (5) working days to resolve the Dispute.
 31. If the Chief Executive of the Operator, the Chief Executive of the Department and the Independent Monitor are unable to resolve a Dispute within ten (10) working days of meeting in accordance with Condition 30, the Operator and the Department may agree to the appointment of an independent party to assist in the resolution of the Dispute.

32. If, within five (5) working days of either the Operator or the Department nominating a person to be the independent party, no agreement is reached as to who is to be appointed as the independent party, either the Operator, the Department or both may refer the matter to the President of the Law Society of the Northern Territory.
33. The President of the Law Society Northern Territory may nominate a person to be the independent party and the parties to the Dispute are bound to accept the appointment of that person.
34. The role of the independent party is to assist in negotiating a resolution of the Dispute and the independent party cannot make a decision that is binding on either the Operator or the Department.
35. The Operator and the Department must make available to the independent party all materials requested by it and must provide the independent party with all other materials relevant to the Dispute.
36. The Operator and the Department must:
 - a) Bear their own costs of resolving the Dispute under this Condition; and
 - b) Bear equally the costs of any independent party engaged.

SCHEDULE D - ENVIRONMENTAL MONITORING AND MANAGEMENT

1. If the Operator establishes a new surface water monitoring location, a written notice of the location (in GDA 94 format) and nature of the monitoring must be given to the Department within 30 days of its establishment.
2. The Operator must maintain continuous monitoring having regard to:
 - a) devices installed at the following locations:
 - i. **SW29** (upstream Surprise Creek outside the zone of influence of TSF);
 - ii. **SCGS** (Surprise Creek gauge station between the TSF and the Mine);
 - iii. **SW30** (upstream Emu Creek);
 - iv. **USGS** (upstream at the McArthur River gauge station);
 - v. **BCGS** (upstream at the Barney Creek gauge station);
 - vi. **SW12** (immediately downstream of the Mine capturing outflow from Emu Creek, Barney Creek, drainage lines from SEPROD, Old McArthur River Channel and the McArthur River diversion channel but before the Glyde River joins the McArthur River channel);
 - b) devices must at a minimum measure electrical conductivity, and may measure additional parameters such as pH;
 - c) the Operator must from 30 August 2017 include data from these devices in data submission under Condition 8 of Schedule A.
3. From the date of authorisation of the Overburden Management Project the Operator is approved to install and manage the following gauging stations at:
 - a) Emu Creek;
 - b) Glyde River.
4. The Operator must ensure groundwater monitoring bores and extraction bores are constructed, maintained and decommissioned in compliance with the document entitled *Minimum construction requirements for water bores in Australia* published by the National Uniform Drillers Licensing Committee (third edition, February 2012 or a current version of the document). In this regard:
 - a) construction logs and bore location coordinates in GDA 94 format must be available to the Minister on request and provided to the Minister annually in the EMR;
 - b) logs of maintenance activities must be kept available to the Minister on request;
 - c) logs of bore decommissioning activities must be kept and made available to the Minister on request and reported in the Operator's Annual EMR or an alternative format as agreed with the Department.

5. The Operator must take appropriate action to reduce the risk to mining operations associated with livestock on the adjoining pastoral property by maintaining an Exclusion Area and managing livestock as appropriate in consultation with the Chief Veterinary Officer.
6. From the date of authorisation of the Overburden Management Project the Operator must undertake monitoring in accordance with the following Environmental Management Plans approved in the MMP:
 - a) Adaptive Management Plan, which includes:
 - i. Water Management Plan
 - ii. Air Quality Management Plan
 - iii. Rehabilitation Management Plan
 - b) Waste Management Plan
 - c) NOEF Management Plan
 - d) BBLF Environment Management Plan
 - e) Unplanned Closure Plan
7. Any required material changes to the Environmental Management Plans mentioned in Condition 6 of this Schedule must be approved by the Department in writing.
8. For the purposes of managing chemicals and flammable or combustible liquids, the Operator must:
 - a) store and handle all hazardous chemicals, toxic substances, gases and dangerous goods associated with the Mine in accordance with the current Australian Standard where such is applicable, and the laws of the Northern Territory;
 - b) include bulk storage tanks and associated infrastructure on a maintenance schedule which conforms with the current Australian Standard where such is applicable, and the laws of the Northern Territory;
 - c) include regular integrity testing to ensure loss of containment or failure of bulk storage tanks does not occur.

**Attachment D Variation of Approval Conditions under EPBC Act, 1999
(then DAWE [now DCCEEW], 2022)**



VARIATION OF CONDITIONS ATTACHED TO APPROVAL

McArthur River Mine Overburden Management Project, Gulf Region, Northern Territory (EPBC 2014/7210)

This decision to vary conditions of approval is made under section 143 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Approved action

Person to whom the approval is granted	McArthur River Mining Pty. Ltd. ACN: 008 167 815
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Approved action	To manage the non-benign overburden and surface water at the McArthur River Mine through the reconfiguration of the Northern Overburden Emplacement Facility, through other Overburden Emplacement Facilities, use of the Tailings Storage Facility or alternative strategies, at the McArthur River Mine, 45 km south-west of Borroloola, Gulf Region, Northern Territory (See EPBC Act referral 2014/7210).
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Variation

Variation of conditions attached to approval	<p>The variation is:</p> <p>Delete conditions 5, 6, 10, 12 and 16 of Part A and replace them with the conditions specified below.</p> <p>Delete condition 10 of Part B and replace it with the condition specified below.</p> <p>Delete the definition for refuge pools and replace it with the definition specified below</p> <p>Add a definition for independent expert.</p>
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Date of effect	This variation has effect on the date the instrument is signed
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Person authorised to make decision

Name and position	Natasha Amerasinghe Acting Assistant Secretary Assessments (Vic, Tas) and Post Approvals Branch
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Signature	
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Date of decision	29 April 2022
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Date of decision	Conditions attached to approval
	Part A - Conditions specific to the action
Original dated 12/6/2019	<p>1. To minimise impacts to EPBC Act listed species, the approval holder must:</p> <ul style="list-style-type: none"> a. Meet the objective of no impact to the health of the McArthur River as a result of the mine. b. Meet the outcome that the action does not cause impacts to the McArthur River that reduce the abundance or population health of EPBC Act listed species. <p>The conditions below describe how both the objective and outcome are to be achieved by the approval holder, including through the establishment of appropriate methodologies, standards and baselines.</p>
Original dated 12/6/2019	<p>2. The Minister may determine that a plan, strategy or program approved by the Northern Territory Government satisfies the requirement for a plan, strategy or program required under these conditions.</p>
Variation dated 18/12/2020	<p>3. To minimise impacts to EPBC Act listed species, the approval holder must not clear more than 7.1 ha of nesting habitat for the Gouldian Finch in the project footprint as part of this action, and the approval holder must:</p> <ul style="list-style-type: none"> a. exclude cattle from at least 452 ha of potential foraging habitat for the Gouldian Finch; and b. establish key food grasses for the Gouldian Finch when rehabilitating the Tailings Storage Facility and Northern Overburden Emplacement Facility.
Original dated 12/6/2019	<p>4. To minimise impacts to EPBC Act listed species, the proposed pit lake, if developed, must remain hydraulically isolated from the McArthur River and its floodplain as there is not sufficient understanding of the potential risks associated with opening the proposed pit lake to the McArthur River. If in the future the pit lake is again proposed to be hydraulically connected to the McArthur River, a referral may be required for a decision to be made by the Minister under the EPBC Act.</p>
As varied on the date this instrument was signed	<p>5. To minimise impacts to EPBC Act listed species, by ensuring that acid and metalliferous drainage from the Northern Overburden Emplacement Facility, Tailings Storage Facility and mine pit does not present an unacceptable risk to the environment, the approval holder must submit the following completed studies to the Department for approval by the Minister:</p> <ul style="list-style-type: none"> a. within 18 months of this approval, a study to determine the capacity for attenuation of metals and acid within the groundwater system. This study must estimate the available attenuation capacity and if, and when, this capacity will be exceeded. The study must have particular regard to the groundwater system beneath and impacted by the Northern Overburden Emplacement Facility and must also include other relevant areas of the site including the mine pit and Tailings Storage Facility. The study must include geochemical modelling that examines the effects on metal concentrations of oxidation of sulfur and depletion of buffering capacity. The study must include an assessment of potential management options that could be implemented if the attenuation capacity is exceeded and identify a suitable management option that will be implemented; b. within 18 months of this approval, a study to identify and characterise any hydraulic connection between the mine pit and the McArthur River. The study must assess how this connectivity could affect water quality in the McArthur River and include an assessment of potential management options to satisfy the requirements of condition 1, including how any material stored within the mine pit should be managed; and c. within 5 years of this approval, a study to determine the long-term (1000 years) stability and performance of the mine pit levee. This study must assess and confirm the stability of the structure in terms of resistance to erosion and must consider the effectiveness of the structure in isolating the mine pit from a 0.1% Annual Exceedance Probability (AEP) event. The study must consider the

Date of decision	Conditions attached to approval
	<p>potential for climate change to increase the magnitude (including the depth of flooding and the velocity of flooding) of a 0.1% AEP event for the life of the project. If the study finds that the current levee may not be effective, the study must be extended to include an assessment of potential management options that could be implemented and identify a management option that will be effective in maintaining the stability and performance of the structure. The report of the study must commit the approval holder to implement the effective option.</p> <p>Upon approval by the Minister, the approval holder must implement any commitments made in an approved study and use the studies to inform the adaptive management plan required by condition 6.</p>
As varied on the date this instrument was signed	<p>6. To minimise impacts to EPBC Act listed species the approval holder must submit an adaptive management plan to the Department for approval by the Minister, within 12 months of the date the study to determine the long-term (1000 years) stability and performance of the mine pit levee required by condition 5(c) is approved by the Minister. The adaptive management plan and its individual component plans must consider all available relevant data (including data from the studies required by condition 5).</p> <p>Upon written request from the Minister, the approval holder must provide the model files for any part of the adaptive management plan for review, either to the Minister or to a third party. The Minister may request revisions to the modelling. If such a revision is requested, the approval holder must revise the modelling and resubmit a report describing the new model run and the results to the Minister within a timeframe specified by the Minister in the written request.</p> <p>If modelling required under condition 6A(a) and 6A(b) shows impacts to water quality are greater than in modelling previously provided to the Minister, within three months of these results being obtained, the approval holder must revise and submit to the Minister for approval relevant plans including the surface water (condition 6B) and groundwater (condition 6C) monitoring and management plans and the adaptive management plan (condition 6) to include mitigation measures that will reduce impacts to levels that will ensure that site-specific guideline values described in condition 7 are not exceeded. The approved adaptive management plan must be implemented during all stages of the project, including care and maintenance.</p> <p>The adaptive management plan must include:</p> <p>A. general requirements</p> <ol style="list-style-type: none"> a. a new conceptual water model for the mine project area and surrounds and update the numerical groundwater, surface water quality and particle tracking models. The models must include all the geological, hydrogeological, geophysical and water quality information and data that has been acquired for, and is referred to in, the Environmental Impact Statement; b. an updated groundwater model, which assesses the impact of hydraulic loading on the groundwater system of the Northern Overburden Emplacement Facility (NOEF); c. reports describing the new and updated models described in condition 6A(a), and 6A(b) and results. The reports must be presented in a form that shows the new results and clearly explains the differences between the results of the updated modelling and the results of modelling presented in the Environmental Impact Statement, and the causes of this difference; d. procedures that ensure that monitoring data is responded to in a timely manner by triggering appropriate actions, responses and changes to planned management and mitigation (i.e. related to water quality objectives and early warning triggers);

Date of decision	Conditions attached to approval
	<ul style="list-style-type: none"> e. procedures that ensure that monitoring plans are regularly reviewed to consider the adequacy of the monitoring locations, frequencies and analytical suite to be measured, and these are improved in a timely manner; f. criteria for monitoring and evaluating the effectiveness of mitigation and management measures and a mechanism for reporting in a timely manner to the Minister when a current adaptive management approach is inadequate and how this will be rectified; g. a commitment to regularly review management options and contingencies (every 2 to 5 years during operations) taking into account recent advances in best practices; h. a commitment to achieve improved water quality and reduced toxicant levels in surface waters within 20 years after the cessation of mining for all monitoring sites for which site-specific guideline values have been developed in accordance with condition 6B(c) for toxicants where baseline levels are above default guideline values; and i. procedures that ensure that water monitoring data is collected for the life of the project including care and maintenance if the project enters this phase. All monitoring data must be provided to the Minister upon request. <p>B. a surface water monitoring and management plan. This plan must:</p> <ul style="list-style-type: none"> a. clearly identify (including on a map) all proposed water quality monitoring sites and flow gauging locations and, for each, justify the purpose/objective and monitoring frequency and timing. The plan must also specify and justify which sites are appropriate downstream monitoring sites (i.e. downstream of mine impacts) for derivation of site-specific guideline values. Water quality monitoring sites must include: <ul style="list-style-type: none"> i. locations on natural waterways (permanent, ephemeral/intermittent and pools); ii. locations within the mine water management system, including all water stores that can discharge (either controlled or uncontrolled) to the environment; iii. locations upstream of any possible mine influence that will be used as control sites; iv. a monitoring location that is upstream of the confluence of the McArthur River and the Glyde River (as locations below the confluence would be diluted by the Glyde River); and v. an additional compliance location, to be located on Emu Creek, that is to be established by 2025 (as at this location and soon after this time, groundwater modelling predicts that sulfate will migrate from the NOEF to the area). b. clearly identify and justify the proposed monitoring frequency, which must be sufficient to capture variability in the system, and locations of monitoring that will be undertaken for all stages of the project (including care and maintenance) and the analyte suite to be measured; c. specify site-specific guideline values for appropriate downstream monitoring sites identified in condition 6B(a). These guideline values must be calculated as specified in condition 7. Guideline values must include, but are not limited to, concentrations of sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium. Default guideline values (as defined in ANZG 2018 or a future relevant ANZG) can be used until the studies required under condition 7 have been completed); d. specify early warning trigger values for water quality at appropriate monitoring sites identified in condition 6B(a). These early warning trigger values must allow

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	<p>early identification of when water or sediment quality could be impacted. Early warning trigger values must include, but are not limited to, concentrations of sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium;</p> <p>e. include a process for reviewing the data collected (at least every three months during operations including one review at the end of the dry season and one review at the end of the wet season and annually during closure), examining trends in water quality and comparing monitoring data with relevant modelling predictions at all monitoring sites required under condition 6B(a). The plan must detail for each monitoring site a robust statistical method for determining whether observations show a statistically significant difference from predictions. The plan must provide for the method to be applied to all data collected at each monitoring site. If the application of this method shows a statistically significant difference, this must be reported to the Minister in accordance with the timeframes required under Part B - condition 8 and a review of the modelling must be undertaken;</p> <p>f. include a trigger action response plan that clearly identifies timeframes and contingencies to be implemented for exceedance for both the site-specific guideline values required under condition 6B(c) or the early warning trigger values under condition 6B(d). The trigger action response plan must also include commitment(s) to implement contingencies in the event that the available capacity of attenuation of metals and acid within the groundwater system, as determined by the study required under condition 5(a), is exceeded;</p> <p>g. include baseline levels of sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium at appropriate sites identified in condition 6B(a) and justify these levels based on existing or, if data are not available, specify a process for collecting suitable data and defining baseline levels.</p> <p>C. a groundwater monitoring and management plan. This plan must:</p> <p>a. clearly identify all monitoring sites (including on a map) and, for each, justify the purpose/objective and the frequency and timing of monitoring. This must include control sites at locations upstream of any possible mine influence;</p> <p>b. clearly identify the proposed timing and frequency of sampling, what monitoring is applicable to all stages of the project (including care and maintenance) and the analyte suite;</p> <p>c. designate some of the monitoring sites identified in condition 6C(a) as appropriate sites for derivation of site-specific guideline values and justify this selection. The plan must specify site-specific guideline values for all of these appropriate monitoring sites. These guideline values must be calculated as specified in condition 7. Guideline values must include, but are not limited to, concentrations of sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium. Default guideline values (as defined in ANZG 2018 or the subsequent currently official Australian Guideline for Fresh and Marine Water Quality) can be used until the studies required under condition 7 have been completed;</p> <p>d. specify site specific early warning trigger values for water quality at appropriate monitoring sites as required under condition 6C(c). These early warning trigger values must allow early identification of when water quality could be impacted. Early warning trigger values must include but are not limited to concentrations for sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium;</p> <p>e. include a process for reviewing the data collected (at least six-monthly during operations including one review at the end of the dry season and one review at the end of the wet season and annually during closure), examining trends in water quality and comparing monitored data with relevant modelling predictions at all monitoring locations. The plan must detail for each monitoring site a robust statistical method for determining whether observations show a statistically significant difference to predictions. The plan must provide for the method to be</p>

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	<p>applied to all data collected at each monitoring site. If the application of this method shows a statistically significant difference, this must be reported to the Minister in accordance with the timeframes required under Part B condition 8 and a review of the modelling must be undertaken;</p> <p>f. include a trigger action response plan with clearly identified timeframes and contingencies to be implemented for exceedances of either the site-specific guideline values in condition 6C(c) or the early warning trigger values in condition 6C(d);</p> <p>g. include locations for additional paired monitoring bores located to the southwest of Barramundi Dreaming and a paired monitoring bore with an associated surface water monitoring location on Emu Creek north of Barramundi Dreaming. Potential impacts arising from hydraulic loading and other groundwater flow changes, including surface and groundwater quality changes, from the Northern Overburden Emplacement Facility must be monitored. These monitoring sites are additional to the monitoring sites required by condition 6C(a); and</p> <p>h. include a definition of baseline water quality that includes concentrations of sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium at appropriate sites identified in condition 6C(a). These concentrations must be justified based on existing data. If data are not available, the plan must specify a process for collecting suitable data and defining baseline water quality within 12 months.</p> <p>D. a sediment monitoring and management plan. This plan must:</p> <p>a. clearly identify (including on a map) all monitoring sites and, for each, justify the objective/purpose and the frequency and timing of monitoring. This must include:</p> <ol style="list-style-type: none"> i. control sites at locations upstream of any possible mine influence; ii. monitoring sites in areas where elevated lead and zinc levels have already been identified; and iii. monitoring sites in soils and sediments around the Tailings Storage Facility, the Northern Overburden Emplacement Facility, the mine pit and within surface water features including the McArthur River and its diversion, Surprise Creek, Barney Creek and its diversion and Emu Creek. <p>b. clearly specify the frequency and timing of sampling for all stages of the project (including care and maintenance) and the analyte suite;</p> <p>c. include site-specific guideline values for appropriate monitoring sites identified as required under condition 6D(a). These values must be calculated as required in condition 7. Guideline values must include, but are not limited to, concentrations of sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium. Interim values can be used until the studies required under condition 7 have been completed;</p> <p>d. include a process for reviewing the data collected, examining trends in water quality and comparing monitored data with relevant modelling predictions at all monitoring sites identified as required under condition 6D(a). A statistically robust criteria for determining if observations are significantly different to predictions must be determined for each monitoring site. If any of these criteria are exceeded this must be reported to the Minister in accordance with the timeframes specified in Part B condition 8 and a review of the modelling undertaken;</p> <p>e. include a trigger action response plan with clearly identified timeframes and contingencies to be implemented for exceedances of either the site-specific</p>

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	<p>guideline values required under condition 6D(c) or the early warning trigger values required under condition 6D(d); and</p> <p>f. include a plan for monitoring and managing the impacts of lead rich dust on the Gouldian Finch. The plan must include a commitment to monitor the composition and density of key food grasses for the Gouldian Finch in the project footprint and manage the impacts of lead and zinc on foraging habitat and nesting habitat for the Gouldian Finch.</p> <p>E. a synthesis of all environmental monitoring and management plans required under conditions 6B, 6C and 6D that describes the interconnections between these plans. This synthesis must identify:</p> <p>a. how all monitoring data collected under the various environmental monitoring and management plans will be considered in order to assess the effectiveness of the mitigation, management and contingency measures; and</p> <p>b. how all monitoring data collected under the various environmental monitoring and management plans will be integrated to identify trends in water quality and inform the adaptive management plan in condition 6.</p>
<p>Variation dated 18/12/2020</p>	<p>7. To minimise impacts to EPBC Act listed species, the site-specific guideline values required under conditions 6B, 6C and 6D must be developed in accordance with ANZG (2018) (or the subsequent currently official Australian Guideline for Fresh and Marine Water Quality) by a suitably qualified person.</p> <p>A. Guideline values must:</p> <p>a. include values for the following toxicants and physico-chemical parameters as a minimum:</p> <p>i. Toxicants: for all surface water, ground water and sediment monitoring sites: sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium.</p> <p>ii. Physico-chemical parameters: For all surface water, ground water and sediment monitoring sites: pH and electrical conductivity. Where relevant, values should also be adjusted for water hardness, measured as milliequivalents per litre</p> <p>b. include parameters capable of detecting potential threats to terrestrial and aquatic species, determined from a food web of the terrestrial and aquatic areas that are relevant to EPBC Act listed species. This food web must inform the likely bioaccumulation rates and risks of metals to EPBC Act listed species; and</p> <p>c. be developed to address possible risks to EPBC Act listed species, including the Gouldian Finch and the Large-tooth Sawfish.</p> <p>B. The approval holder must:</p> <p>a. ensure that 95% of samples of water and sediment quality do not exceed site-specific guideline values at monitoring sites determined in accordance with conditions 6B, 6C and 6D; and</p> <p>b. ensure that 95% of sediment samples (measured in accordance with condition 6D) do not exceed site-specific guideline values at monitoring sites that address mine-related impacts for the following metals: sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium within four years of the date of approval and at all monitoring events for the life of the project thereafter. The site-specific guideline values for sediments must be developed from a source approved by the Minister.</p>
<p>Original dated 12/6/2019</p>	<p>8. To minimise impacts to EPBC Act listed species, within 12 months of the date of approval the approval holder must develop and implement standard operating procedures for the collection and processing of all surface water, groundwater, soil, and</p>

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	<p>sediment samples required under conditions 6B, 6C and 6D. The standard operating procedures must:</p> <ol style="list-style-type: none"> a. prescribe all collection, handling and sample processing steps to be undertaken prior to samples being delivered to a suitable qualified laboratory for analysis. This includes explicit instructions for cleaning of sampling and processing equipment; b. prescribe quality assurance and quality control procedures in the field and laboratory. This must include, but is not limited to, collection and analysis of field and laboratory duplicate and blank samples; c. include a program for reviewing the standard operating procedures. This will include regular auditing, quality control and quality assurance procedures to ensure that the standard operating procedures are being correctly implemented and are effective; and d. be submitted to the Minister for approval at least three months prior to the proposed date of commencement of surface water, groundwater and sediment sampling required under conditions 6B, 6C and 6D.
Original dated 12/6/2019	<p>9. If the Minister concludes from the results of the study required by Condition 5a that buffering capacity of the groundwater system is insufficient to enable the approval holder to meet the outcomes of condition 1, the approval holder must submit a plan for approval by the Minister the implementation of which will prevent any increase in water contamination by metals in the McArthur River arising from the project. If the Minister or the approval holder determines that sufficient mitigation is not possible then the approval holder must submit within 2 years a plan that will ensure that the outcomes of condition 1 are met by the approval holder. The approved plan must be implemented.</p>
As varied on the date this instrument was signed	<p>10. To minimise impacts to EPBC Act listed species, by ensuring protection of the environment from potential contamination and failure of the proposed Northern Overburden Emplacement Facility the approval holder must:</p> <ol style="list-style-type: none"> a. within 4 years of the date of this approval, develop a geotechnical plan for the Northern Overburden Emplacement Facility. The plan must include measures to limit erosion (including cavitation), supported by erosion modelling. The plan must be written by a geotechnical engineer. The plan must be completed to the satisfaction of the Department and submitted to the Department for the Minister's approval. The approval holder must not change the structure of the Northern Overburden Emplacement Facility unless a revised version of the geotechnical plan for the Northern Overburden Emplacement Facility that addresses the proposed change is approved by the Minister. The approved plan must be implemented; b. within 4 years of the date of this approval, develop and submit to the Department for approval by the Minister, a geosynthetic liner testing plan. The plan must be developed by an expert with at least 5 years relevant experience. The plan must outline a process to test the effectiveness of geosynthetic liner cover options for the Northern Overburden Emplacement Facility, including a geosynthetic liner /compacted clay layer combination. The testing must be designed to demonstrate the performance of the geosynthetic liner over the long term (1000 years). This must include accelerated aging testing. Testing must also be performed on rehabilitated areas of the Northern Overburden Emplacement Facility. All relevant performance parameters must be monitored, including: <ol style="list-style-type: none"> i. slope stability during extreme events; ii. cover performance as a result of heat effects; iii. cover performance if erosion exposes the liner at the surface, including the effects of (acidic tropical) rainfall and sunlight;

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	<ul style="list-style-type: none"> iv. effects of plant, including tree, roots on the integrity of the cover; v. resistance of the cover to burrowing animals; vi. tolerance of the geosynthetic liner to expected differential settlement; vii. veracity of cover longevity predictions; viii. likely long-term maintenance requirements; and ix. tolerance of the geosynthetic liner for the chemistry of water to which it may be exposed. This must include acidic leachate from unneutralised acidic drainage. <p>The approved plan must be implemented within 5 years of the date of this approval. The approval holder must report results of all tests and monitoring to the Minister every three years.</p> <p>c. If requested by the Department, develop a plan which details what other mitigation measures can be implemented if the geosynthetic liner option for the Northern Overburden Emplacement Facility proves unsuccessful. The plan must be submitted to the Minister for approval within one year of the date of this request. The approved plan must be implemented.</p> <ul style="list-style-type: none"> i. If other mitigation measures are not demonstrated to be effective to the satisfaction of the Minister, then the approval holder must submit a variation to its current mining management plan that allows all mine derived wastes to be stored in the mine pit within 6 months of the geosynthetic liner option being proven to be unsuccessful. The varied approved plan must be implemented. ii. The approval holder must not store mine derived wastes in the mine pit unless the Minister has approved new surface water and ground water models not based on rapid filling of the pit lake and ground water level recovery.
Original dated 12/6/2019	<p>11. To minimise impacts to EPBC Act listed species, in areas where the Northern Overburden Emplacement Facility is to be expanded as part of this action the basal layer of the Northern Overburden Emplacement Facility foundation must be constructed with a maximum saturated hydraulic conductivity of 10^{-9} metres per second to limit seepage to groundwater.</p>
As varied on the date this instrument was signed	<p>12. Within 12 months of the date of the approval the approval holder must submit to the Minister for approval, a report that includes:</p> <ul style="list-style-type: none"> a. the results of further detailed design studies for the groundwater interception scheme to be implemented adjacent the Northern Overburden Emplacement Facility; b. the results of further studies undertaken to characterise any preferential flow paths that may exist in the geological formations through which contaminated water is modelled to flow that contain dolomite rock, including an analysis of how any flow paths could reduce the effectiveness of the interception scheme; c. the components of the proposed interception scheme and a plan for implementing the scheme within 2 years of the date of the approval; d. a detailed plan for the operation and monitoring of the interception scheme for the life of the project including during any care and maintenance. This plan must clearly detail how monitoring will demonstrate effectiveness of the interception scheme; and e. the predicted improvements to water quality expected as a result of implementing the interception scheme.

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	<p>The reviewed report, following approval by the Minister, must be used to inform the adaptive management plan required by condition 6 and the geotechnical plan for the Northern Overburden Emplacement Facility required by condition 10.</p>
Original dated 12/6/2019	<p>13. Within five years of the date of the approval the approval holder must submit a management plan for the management of the Tailings Storage Facility after mining ceases to the Department for approval by the Minister. This plan must include:</p> <ul style="list-style-type: none"> a. a commitment to reprocess all material within the Tailings Storage Facility within 15 years of the end of mining; b. a commitment to undertake geochemical analysis of the material (including bore water) within 50 m of the Tailings Storage Facility footprint. The plan will determine disposal options for contaminated materials commensurate with the type and level of contamination, including disposal within the mine pit; and c. a program for geochemical analysis of the reprocessed waste material to identify the level and type of contamination that would likely impact on meeting the requirements of condition 1(b). The plan must include, but may not be limited to, the option of encapsulating waste material before deposition within the mine pit. <p>The approved management plan must be implemented.</p>
Variation dated 18/12/2020	<p>14. Within 24 months of the date of the approval the approval holder must submit an aquatic ecology monitoring and management plan to the Department for approval by the Minister. The plan must:</p> <ul style="list-style-type: none"> a. clearly identify the locations of all monitoring sites (including providing a map) and for each monitoring site specify the frequency, timing and types of monitoring that will be undertaken and its purpose/objectives. This must include control sites at locations upstream of any possible mine influence; b. include modelling of the extent and duration of drawdown on refuge pools in the dry season during operations; c. include monitoring of refuge pools including for water quality and water level; d. include a plan to monitor the health of the surface waters; e. include a non-lethal monitoring program to measure the presence and abundance of Largetooth Sawfish; f. develop the triggers and corrective actions that will be implemented in the event that the monitoring required under condition 14c indicates that drawdown of refuge pools may impact on the Largetooth Sawfish and its habitat; g. identify where supplementary water will be sourced, how sourced water will match the baseline water quality determined by implementing the requirements of condition 8, and describe a process for quality control if the corrective actions identified in condition 14f include supplementary watering of refuge pools; and h. demonstrate how the translocation is consistent with the Department's EPBC Act Policy Statement on Translocation of Listed Threatened Species if the corrective actions required under 14f include translocation of the Largetooth Sawfish. <p>The approved aquatic ecology monitoring and management plan must be implemented.</p>
Variation dated 18/12/2020	<p>15. To minimise the impact of weeds on foraging habitat and nesting habitat for the Gouldian Finch in the project footprint, the approval holder must implement the weed management plan provided to the Department as Appendix S of the Supplement to the Environmental Impact Statement from the commencement of the action.</p>
As varied on the date this instrument was signed	<p>16. All plans required under this approval to be submitted for approval by the Minister must:</p> <ul style="list-style-type: none"> a. include:

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	<ul style="list-style-type: none"> i. an independent expert review that has been conducted according to terms of reference agreed by the Department in writing; and ii. contain advice on how the independent expert review findings have been addressed in the submitted plans. <p>b. address findings of the independent expert review to the satisfaction of the Minister.</p>
	Part B - Standard administrative conditions
Original dated 12/6/2019	Notification of date of commencement of the action 1. The approval holder must notify the Department in writing of the date of commencement of the action within 10 business days after the date of commencement of the action .
Original dated 12/6/2019	2. If the commencement of the action does not occur within 5 years from the date of this approval, then the approval holder must not commence the action without the prior written agreement of the Minister .
Original dated 12/6/2019	Compliance records 3. The approval holder must maintain accurate and complete compliance records .
Original dated 12/6/2019	4. If the Department makes a request in writing, the approval holder must provide electronic copies of compliance records to the Department within the timeframe specified in the request. Note: Compliance records may be subject to audit by the Department or an independent auditor in accordance with section 458 of the EPBC Act , and or used to verify compliance with the conditions. Summaries of the result of an audit may be published on the Department's website or through the general media.
Original dated 12/6/2019	Submission and publication of plans 5. The approval holder must: <ul style="list-style-type: none"> a. submit plans electronically to the Department for approval by the Minister; b. publish each plan on the website within 20 business days of the date the plan is approved by the Minister or of the date a revised action management plan is submitted to the Minister, unless otherwise agreed to in writing by the Minister; c. exclude or redact sensitive data or information from plans published on the website or provided to a member of the public; and d. keep plans published on the website until the end date of this approval.
Original dated 12/6/2019	6. The approval holder must ensure that any monitoring data (including sensitive data or information), surveys, maps, and other spatial and metadata required under the conditions of this approval , is prepared in accordance with the Department's Guidelines for biological survey and mapped data (2018) and submitted electronically to the Department in accordance with the requirements of conditions.
Original dated 12/6/2019	Annual compliance reporting 7. The approval holder must prepare a compliance report for each 12 month period following the date of commencement of the action , or as otherwise agreed to in writing by the Minister . The approval holder must: <ul style="list-style-type: none"> a. publish each compliance report on the website within 60 business days following the relevant 12 month period and remain published for the life of the project; b. notify the Department by email that a compliance report has been published on the website within five business days of the date of publication;

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	<p>c. keep all compliance reports publicly available on the website until this approval expires;</p> <p>d. exclude or redact sensitive data or information from compliance reports published on the website; and</p> <p>e. where any sensitive data or information has been excluded from the version published, submit the full compliance report to the Department within 5 business days of publication.</p> <p>f. include monitoring information for the relevant period in accordance with Part B condition 6. The proponent must also submit to the Minister all monitoring data (in spreadsheet format) for the relevant period in accordance with Part B Condition 6 to accompany the compliance report.</p> <p>Note: Compliance reports may be published on the Department's website. The first compliance report may report a period less than 12 months so that it and subsequent compliance reports aligns with the similar requirement under state approval.</p>
Original dated 12/6/2019	<p>Reporting non-compliance</p> <p>8. The approval holder must notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in plans. The notification must be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance. The notification must specify:</p> <p>a. the condition which is or may be in breach; and</p> <p>b. a short description of the incident and/or non-compliance.</p>
Original dated 12/6/2019	<p>9. The approval holder must provide to the Department the details of any incident or non-compliance with the conditions or commitments made in plans as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying:</p> <p>a. any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future;</p> <p>b. the potential impacts of the incident or non-compliance; and</p> <p>c. the method and timing of any remedial action that will be undertaken by the approval holder.</p>
As varied on the date this instrument was signed	<p>10. The approval holder must ensure that independent audits of compliance with the conditions are conducted for the first 12 month period from the commencement of the action, and subsequently as requested in writing by the Minister.</p>
Original dated 12/6/2019	<p>11. For each independent audit, the approval holder must:</p> <p>a. provide the name and qualifications of the independent auditor and the draft audit criteria to the Department;</p> <p>b. only commence the independent audit once the audit criteria have been approved in writing by the Department; and</p> <p>c. submit an audit report to the Department within the timeframe specified in the approved audit criteria.</p>
Original dated 12/6/2019	<p>12. The approval holder must publish the audit report on the website within 10 business days of receiving the Department's approval of the audit report and keep the audit report published on the website until the end date of this approval.</p>
Original dated 12/6/2019	<p>13. The approval holder may, at any time, apply to the Minister for a variation to an action management plan approved by the Minister under Part B conditions 6, 7 and 13 or as subsequently revised in accordance with these conditions, by submitting an application in accordance with the requirements of section 143A of the EPBC Act. If the Minister approves a revised action management plan (RAMP) then, from the date</p>

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	specified, the approval holder must implement the RAMP in place of the previous action management plan.
Original dated 12/6/2019	14. The approval holder may choose to revise an action management plan approved by the Minister under Part B conditions 6, 7 and 13 or as subsequently revised in accordance with these conditions, without submitting it for approval under section 143A of the EPBC Act , if the taking of the action in accordance with the RAMP would not be likely to have a new or increased impact .
Original dated 12/6/2019	<p>15. If the approval holder makes the choice under Part B condition 14 to revise an action management plan without submitting it for approval, the approval holder must:</p> <ul style="list-style-type: none"> a. notify the Department in writing that the approved action management plan has been revised and provide the Department with: <ul style="list-style-type: none"> 1. an electronic copy of the RAMP; 2. an electronic copy of the RAMP marked up with track changes to show the differences between the approved action management plan and the RAMP; 3. an explanation of the differences between the approved action management plan and the RAMP; 4. the reasons the approval holder considers that taking the action in accordance with the RAMP would not be likely to have a new or increased impact; and 5. written notice of the date on which the approval holder will implement the RAMP (RAMP implementation date), being at least 20 business days after the date of providing notice of the revision of the action management plan, or a date agreed to in writing with the Department. b. subject to condition 14, implement the RAMP from the RAMP implementation date.
Original dated 12/6/2019	16. The approval holder may revoke its choice to implement a RAMP under Part B condition 15 at any time by giving written notice to the Department . If the approval holder revokes the choice under Part B condition 15, the approval holder must implement the previous action management plan approved by the Minister .
Original dated 12/6/2019	<p>17. If the Minister gives a notice to the approval holder that the Minister is satisfied that the taking of the action in accordance with the RAMP would be likely to have a new or increased impact, then:</p> <ul style="list-style-type: none"> a. Part B condition 15 does not apply, or ceases to apply, in relation to the RAMP; and b. the approval holder must implement the action management plan specified by the Minister in the notice. <p>18. At the time of giving the notice under Part B condition 17, the Minister may also notify that for a specified period of time, Part B condition 15 does not apply for one or more specified action management plans.</p> <p>Note: Part B conditions 13, 14, 15, 16, 17 and 18 are not intended to limit the operation of section 143A of the EPBC Act which allows the approval holder to submit a revised action management plan, at any time, to the Minister for approval.</p>
Original dated 12/6/2019	19. All management plans required under this approval should be prepared in line with the Department's Environmental Management Plan Guidelines.
Original dated 12/6/2019	20. Within 30 days after the completion of the action , the approval holder must notify the Department in writing and provide completion data .

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Original dated 12/6/2019	Abundance or population health is as described in the Environmental Impact Statement .
Original dated 12/6/2019	Acid includes pH, and should be less than 6 pH.
Original dated 12/6/2019	All stages of the project includes: <ul style="list-style-type: none"> a. Stage 1: Commencement of proposal (estimated 2019) b. Stage 2: Open Cut Mining Operations (estimated 2019 to 2037) c. Stage 3: Tailings Reprocessing Phase (estimated 2038 to 2047) d. Stage 4: Closure Phase (estimated 2048 to 3019)
Original dated 12/6/2019	ANZG (2018) means the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments. Canberra ACT, Australia.
Original dated 12/6/2019	Approval means this approval to take the action under section 133 of the EPBC Act as noted in the date of decision section of this approval.
Original dated 12/6/2019	Approval holder means the name of the person to whom the approval is granted.
Original dated 12/6/2019	Barney Creek means Barney Creek identified in Figure 2.
Original dated 12/6/2019	Barramundi Dreaming means Barramundi Dreaming identified in Figure 2.
Original dated 12/6/2019	Baseline means data collected from 1 July 2017 to 30 June 2019, except for sites where data were not collected during this period. For those sites, Baseline means data for the earliest 24 months for which data is available.
Original dated 12/6/2019	Business day means a day that is not a Saturday, a Sunday or a public holiday in the state or territory of the action.
Original dated 12/6/2019	Clear and Clearing means the cutting down, felling, thinning, logging, removing, killing, destroying, poisoning, ringbarking, uprooting or burning of vegetation (but not including weeds – see the <i>Australian weeds strategy 2017 to 2027</i> for further guidance).
Original dated 12/6/2019	Commencement of the action means any preparatory works required to be undertaken including clearing vegetation, the erection of any onsite temporary structures and the use of heavy duty equipment for the purpose of breaking the ground for buildings or infrastructure; excluding the installation of fences and signage.
Original dated 12/6/2019	Completion data means an environmental report and spatial data information clearly detailing how the conditions of this approval have been met. The Department's preferred spatial data format is shapefile.
Original dated 12/6/2019	Completion of the action means that all stages of the project have permanently ceased.
Original dated 12/6/2019	Compliance location means a monitoring point at which the site-specific or generic guideline values are not to be exceeded.
Original dated 12/6/2019	Compliance records means all documentation or other material in whatever form required to demonstrate compliance with the conditions of approval in the approval holder's possession or that are within the approval holder's power to obtain lawfully;
Original dated 12/6/2019	Compliance reports means written reports: <ul style="list-style-type: none"> a. providing accurate and complete details of compliance, incidents, and non-compliance with the conditions and the plans; b. consistent with the Department's Annual Compliance Report Guidelines (2014);

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	<p>c. include a shapefile of any clearance of any protected matters, or their habitat, undertaken within the relevant 12-month period; and</p> <p>d. annexing a schedule of all plans prepared and in existence in relation to the conditions during the relevant 12 month period.</p>
Variation dated 18/12/2020	Construction means the erection of a building or structure that is or is to be fixed to the ground and wholly or partially fabricated on-site; the alteration, maintenance, repair or demolition of any building or structure; preliminary site preparation work which involves breaking of the ground (including pile driving); the laying of pipes and other prefabricated materials in the ground, and any associated excavation work; but excluding the installation of fences and signage.
Original dated 12/6/2019	Current levee means the levee as described in the Environmental Impact Statement .
Original dated 12/6/2019	Department means the Australian Government agency responsible for administering the EPBC Act .
Original dated 12/6/2019	Department's EPBC Act Policy Statement on Translocation of Listed Threatened Species means the <i>Department's EPBC Act Policy Statement on Translocation of Listed Threatened Species</i> available on Department's website at http://www.environment.gov.au/resource/epbc-act-policy-statement-translocation-listed-threatened-species-assessment-under-chapter
Original dated 12/6/2019	Dry season means the period from 1 May until 31 October each year.
Original dated 12/6/2019	Emu Creek means Emu Creek identified in Figure 2.
Variation dated 18/12/2020	Environmental impact statement means the environmental impact statement McArthur River Mining Pty Ltd (March 2017) and supplementary environmental impact statement McArthur River Mining Pty Ltd (March 2018) (available online at https://ntepa.nt.gov.au/your-business/public-registers/environmental-impact-assessments-register/completed-assessments/register/mcarthur-river-mine-overburden).
Original dated 12/6/2019	EPBC Act means the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .
Original dated 12/6/2019	EPBC Act listed species means the EPBC Act listed Gouldian Finch (<i>Erythrura gouldiae</i>) and Large-tooth Sawfish (<i>Pristis pristis</i>).
Original dated 12/6/2019	EPBC Regulations means the <i>Environment Protection and Biodiversity Conservation Regulations 2000</i> .
Original dated 12/6/2019	Footprint means the maximum proposed footprint described in Figure 1.
Original dated 12/6/2019	Foraging habitat for the EPBC Act listed Gouldian Finch includes annual grasses including <i>Sorghum intrans</i> , <i>Sorghum stipoideum</i> , <i>Sorghum timorense</i> and <i>Schizachyrium</i> species in the dry season and perennial grasses including <i>Chrysopogon fallax</i> , <i>Alloteropsis semialata</i> and <i>Triodia</i> species in the wet season.
Original dated 12/6/2019	Geosynthetic liner option means the geosynthetic liner option proposed in the Environmental Impact Statement .
Original dated 12/6/2019	Gouldian Finch means the EPBC Act listed Gouldian Finch (<i>Erythrura gouldiae</i>).
Original dated 12/6/2019	Incident means any event which has the potential to, or does, impact on protected matter(s) .
Original dated 12/6/2019	Independent audit: means an audit conducted by an independent and suitably qualified person as detailed in the <i>Environment Protection and Biodiversity Conservation Act 1999 Independent Audit and Audit Report Guidelines</i> (2015).

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As varied on the date this instrument was signed	<p>Independent expert means a person or persons approved by the Department as possessing the professional qualifications, training, skills and/or experience related to the nominated subject matter, and demonstrating independence by not having:</p> <ul style="list-style-type: none"> i. conflicting or competing interests with the approval holder, the approval holder's staff, representatives or associated persons, or the project; and ii. any individual, employment or family affiliation to the approval holder, the approval holder's staff, representatives or associated persons, other than as relevant to performing and receiving payment for the performance of duties required by these conditions of approval. <p>Note: points i. and ii. above may be satisfied by submission of a signed Declaration of Independence accepted by the Department.</p>
Original dated 12/6/2019	Isolated means that water from the pit lake must not be able to enter the McArthur River or its floodplain by any means.
Variation dated 18/12/2020	Key food grasses for the Gouldian Finch include <i>Triodia</i> species, <i>Sorghum</i> species, <i>Chrysopogon fallax</i> , <i>Alloteropsis semialata</i> and <i>Heteropogon triticeus</i> .
Original dated 12/6/2019	Large-tooth Sawfish means the EPBC Act listed species <i>Pristis pristis</i> .
Original dated 12/6/2019	Life of the project means from the date of approval to the end of the period for which the approval has effect.
Original dated 12/6/2019	Locations upstream of any possible mine influence means locations on natural waterways upstream of the footprint of the action as defined in the Environmental Impact Statement .
Variation dated 18/12/2020	Metals includes sulfate, zinc, lead, cadmium, arsenic, cobalt, manganese, nickel and thallium.
Original dated 12/6/2019	Mine pit means the open cut identified in Figure 1.
Original dated 12/6/2019	Mine project area and surrounds includes the mine pit, Northern Overburden Emplacement Facility, Tailings Storage Facility to Emu Creek and the Djirrinmini Waterhole.
Original dated 12/6/2019	Mine water management system means the mine water management system as described in the Environmental Impact Statement .
Original dated 12/6/2019	Minister means the Australian Government Minister administering the EPBC Act including any delegate thereof.
Original dated 12/6/2019	Monitoring data means the data required to be recorded under the conditions of this approval.
Original dated 12/6/2019	Natural waterways includes but may not be limited to, the McArthur River and associated tributaries (including Barney Creek, Little Barney Creek, Emu Creek, Surprise Creek), waterholes (Djirrinmini Waterhole, Eight Mile Waterhole, Wurrini Waterhole and Nanbadini Waterhole) and diversion channels.
Variation dated 18/12/2020	Nesting habitat for the EPBC Act listed Gouldian Finch includes hollow-bearing smooth-barked gums, including Eastern Snappy Gum (<i>Eucalyptus leucophloia</i>), on low to mid-high open woodland on hillslopes, scarp-foot slopes, plateau and hillcrests.
Original dated 12/6/2019	New or increased impact a new or increased environmental impact or risk relating to any protected matter , when compared to the likely impact of implementing the action management plan that has been approved by the Minister under Part B conditions 13, 14, 15, 16, 17 and 18, including any subsequent revisions approved by the Minister , as

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	outlined in the <i>Guidance on 'New or Increased Impact' relating to changes to approved management plans under EPBC Act environmental approvals (2017)</i> .
Original dated 12/6/2019	Northern Territory Assessment Report 86 means the Northern Territory Environment Protection Authority (2018). <i>McArthur River Mine Overburden Mine Overburden Management Project</i> . Available online at https://ntepa.nt.gov.au/_data/assets/pdf_file/0004/553081/mrm_overburden_assessment_report.pdf .
Original dated 12/6/2019	Northern Overburden Emplacement Facility means the Northern Overburden Emplacement Facility identified in Figure 1.
Original dated 12/6/2019	Plan(s) means any of the documents required to be prepared, approved by the Minister , and/or implemented by the approval holder and published on the website in accordance with these conditions (includes action management plans and/or strategies);
Variation dated 18/12/2020	Project footprint means the areas enclosed by the blue lines designated as 'Indicative Overburden Management Project Footprint' in <u>Figure 1</u>
Original dated 12/6/2019	Protected matter means a matter protected under a controlling provision in Part 3 of the EPBC Act for which this approval has effect.
As varied on the date this instrument was signed	Refuge pools includes water holes within the McArthur River including, but not limited to, the Djirrinmini Waterhole, Eight Mile Waterhole and Wurrini Waterhole.
Original dated 12/6/2019	Sensitive ecological data means data as defined in the Australian Government Department of the Environment (2016) <i>Sensitive Ecological Data – Access and Management Policy V1.0</i> .
Original dated 12/6/2019	Stage 4 of the proposal is as defined under all stages of the project .
Original dated 12/6/2019	Suitably qualified person means a person who has sufficient professional qualifications, training, skills and/or experience related to the nominated subject matter and can give authoritative independent assessment, advice and analysis on performance relative to the subject matter using the relevant protocols, standards, methods and/or literature and is approved by the Department in writing.
Original dated 12/6/2019	Surface waters includes, but is not limited to, the McArthur River and associated tributaries (including Barney Creek, Little Barney Creek, Emu Creek, Surprise Creek) and waterholes (Djirrinmini Waterhole, Eight Mile Waterhole, Wurrini Waterhole and Nanbadini Waterhole).
Original dated 12/6/2019	Surprise Creek means Surprise Creek identified in <u>Figure 2</u> .
Original dated 12/6/2019	SW 12 means the surface water monitoring site SW 12 identified in the Environmental Impact Statement .
Original dated 12/6/2019	Tailings Storage Facility means the Tailings Storage Facility identified in <u>Figure 1</u> .
Original dated 12/6/2019	Terrestrial and aquatic areas means the McArthur River Mine Overburden Management Project envelope and surface waters .
Original dated 12/6/2019	Toxicant means a substance capable of producing an adverse response (effect) in a biological system, and which may, at sufficiently high concentration, seriously injure structure or function or produce death (ANZG (2018)).
Original dated 12/6/2019	Water quality and health is as defined under condition 8(e) (i.e. 95 per cent of samples of water and sediment quality must not exceed site-specific guidelines values at appropriate monitoring sites determined in accordance with conditions 7A, 7B and 7C).
Original dated 12/6/2019	Website means a set of related web pages located under a single domain name attributed to the approval holder and available to the public.

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Original dated 12/6/2019	Weeds includes, but is not limited to, Mission Grass (<i>Cenchrus pedicellatum</i>), Devil's Claw (<i>Martynia annua</i>), Horehound (<i>Hyptis suaveolens</i>), Bellyache Bush (<i>Jatropha gossypifolia</i>), Parkinsonia (<i>Parkinsonia aculeate</i>) and Noogoora Burr (<i>Xanthium strumarium</i>).
Original dated 12/6/2019	Wet season means November to April.

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Variation dated 18/12/2020	Figure 1 – Maximum Project Footprint showing Gouldian Finch nesting habitat (based on Fig 6-18 from Supplementary EIS)
Original dated 12/6/2019	Figure 2 – Surface Water Features – Local Drainage Network and Selected Cultural Features