# WASTE ROCK MANAGEMENT PLAN

Document No: ARMS-0000-H-PLN-N-0008 Rev 1

Project Name: Nolans Rare Earth Project

# REVISION HISTORY

| Date | Description | Prepared | Reviewed | Approved | 3rd Party Approval |
|---|---|---|---|---|---|
| July 2022 | Rev 1<br>Issued to DITT | Michael Robinson, ESG Manager | Michael Robinson, ESG Manager | Stewart Watkins, GM Projects | |
| 29/10/2021 | Rev 0 | Michael Robinson, ESG Manager | Brian Fowler, GM NT & Sustainability | Stewart Watkins, GM Projects | |

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# 1.0 INTRODUCTION

## 1.1 Background

The Nolans Rare Earths Project (the Project) is located approximately 135 km north north-west of Alice Springs, in the Northern Territory. The Project targets the Nolans Bore mineral deposit for rare earth elements. Activities will focus on construction, mining, processing, rehabilitation and decommissioning of an open-cut, rare earth mine, and its associated infrastructure.

The Project involves several processes where the use of hazardous substances is required including mineral processing and non-mineral process activities. The use of chemicals (herein referred to as hazardous substances) has the potential to impact upon site personnel and/or the surrounding environment. Hazardous substances are chemicals or other materials that can cause acute or chronic harm to health and environmental impact; in general they are any substance, mixture or article that satisfies the criteria of one or more hazard classes in the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), as modified by Schedule 6 of the Work, Health and Safety (WHS) Regulations.

## 1.2 Purpose

This Waste Rock Management Plan (WRMP) provides guidance on the management of waste rock produced during the development and operation of the Nolans rare earth mine, to further minimise the inherent low risk of environmental impacts from runoff or leachate from stockpiled, stored or otherwise disturbed waste rock and in-situ material exposed within the mine or drained in the areas immediately surrounding the mine. It does not cover the management of tailings or other process residue or general mine waste, which are covered in other documents.

This WRMP (Plan) is based on previous geochemical investigations completed on representative material in the Darwin warehouse complex, a large database of assay data and the assessment of the risk of acid, metalliferous or saline drainage, and block models of the amount of sulfur and naturally occurring radioactive materials (NORM) in the planned mined waste rock.

For the purpose of this plan the term acid and metalliferous drainage (AMD) is inclusive of acid, neutral and saline drainage.

Key documents that should be read by users of this Plan include:

- Acid & Metalliferous Drainage (AMD) Assessment and Management Plan. Nolans Bore EIS Appendix L (GHD, 2016).
- Barrel Leach Report (GHD, 2021).
- Resource Evaluation - ARU Report 17/002, (Arafura, 2017).

### 1.3 Objectives

Objectives relevant to waste rock management include:

- Minimising the potential for adverse environmental impacts due to handling, storage and management of Naturally Occurring Radioactive Material (NORM) waste and the minor amounts of Potentially Acid Forming (PAF) waste rock.
- Minimising the potential for inappropriate material placement through accurate identification of NORM or PAF waste during construction and mining operations.
- Managing NORM or PAF rock so that the potential for environmental harm is minimised.
- Developing project personnel awareness of the WRMP, and its objectives and management, particularly those aspects relevant to the individual.

### 1.4 Assumptions

The following assumptions have been made:

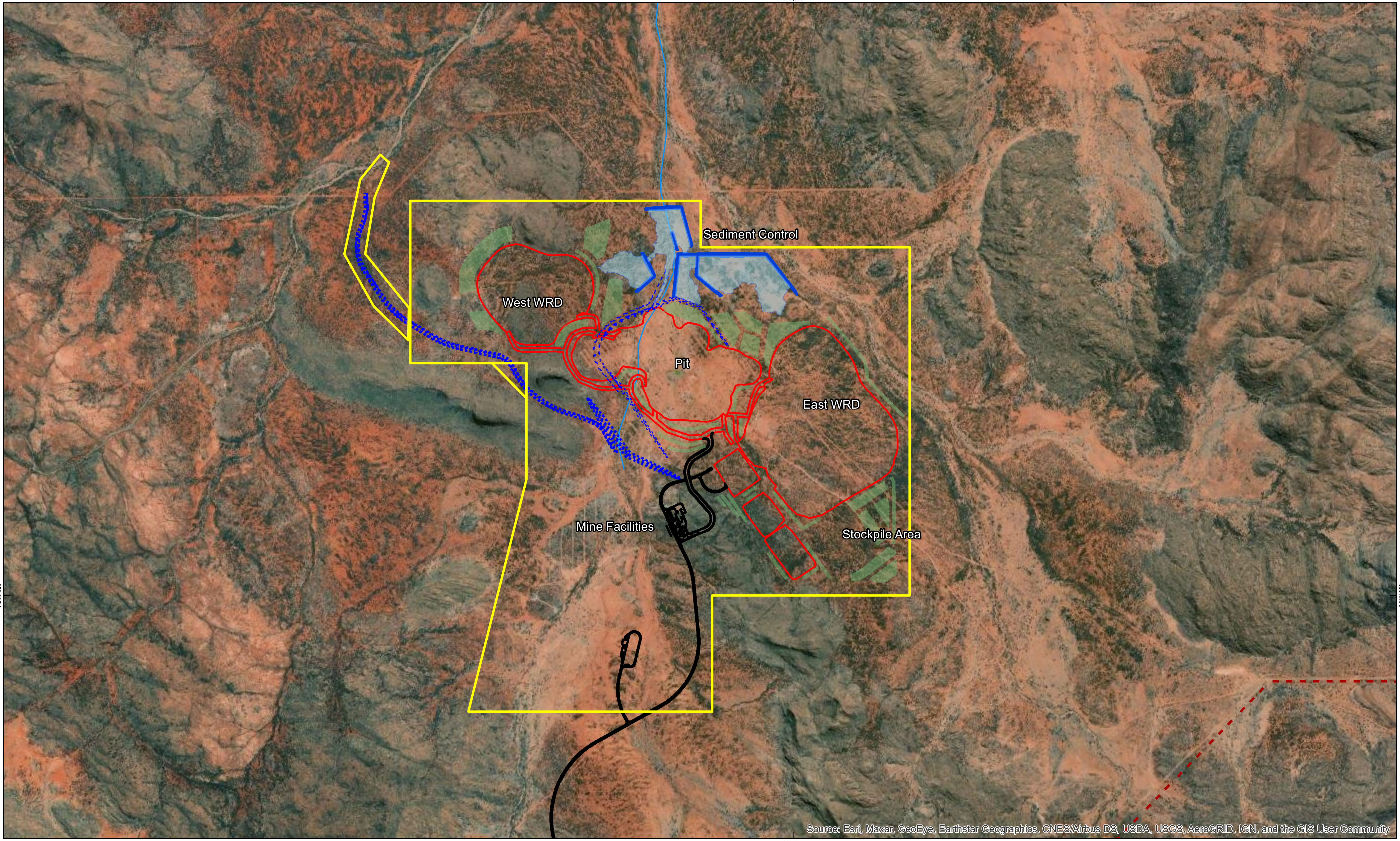
- Historical assay data are approximately proportional to the total volume of ore and waste rock to be disturbed.
- The block model provides an estimate of the amount and the composition of the ore and waste.
- The Site Geologist(s) to supervise and where necessary improve the ore and waste classification/grade control process as mining continues.
- The process of logging and sampling blastholes for waste classification is to be guided by the waste rock units in the block model and future revisions due to ongoing geological definition and, where necessary, given the same importance as ore classification/grade control.
- The cut off grades for ore are geologically defined and determined as part of the mine plan and project economics but are not detailed in this document.
- Ongoing studies of blasthole sampling analysis occur to optimise representative material classification.
- The methodology and equipment for drilling, blasting, and mining have been identified.
- Check analysis of selected samples, other than field XRF or gamma-ray spectrometer scans, or other tests designated as field tests, is to be conducted via an accredited NATA laboratory if doubt exists.

### 1.5 Previous Investigations / Data Sources

The following key data sources were used in this assessment:

- Site-specific climate and hydrological data.
- Assay data for metals: Al, Ba, Be, Bi, Cd, Ce, Co, Cs, Cu, Fe, Ga, Ge,Hf, In, K ,La, Li, Mg, Mn, Mo, Na, Nb, Ni, Pb, Rb, Re, S, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, Ti, Tl, U, W, Y, Zn and Zr.
- Stage 1 Static AMD testing of potential ore and waste rock material for Total Metals by ICPMS; Net Acid Producing Potential (NAPP); Net Acid Generation (NAG); and 1:5 EC and pH.

- Stage 2 Waste rock static NAG, NAPP and total metals; kinetic NAG and Acid Buffering Characteristics Curve; and Australian Standard Leachate Procedure analyses.
- Life of mine (LOM) plan and potential options relative to the above features.
- Hydrogeological (including geological and geotechnical) documents, reports and borehole logs.




1:30,000 @ A3

0 250 500 750 1,000

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Project Areas
- Topsoil Stockpile
- Predicted Water Surface
- Mine Infrastructure
- Mine Access Roads
- Diversion Channel Stage 1
- Diversion Channel Stage 2
- Sediment Control
- Waterways
- Gas Pipeline

Arafura Resources Limited
Mine Management Plan

Mine Site

| | |
|---|---|
| Job Number | 12515982 |
| Revision | B |
| Date | 28 Jul 2021 |

Figure 1-1

2 Salamanca Square, Hobart Tasmania 7000 Australia T 61 3 6210 0600 E hbamail@ghd.com W www.ghd.com

G:\43\12515982\GIS\Maps\Deliverables\MMP\MMP report mxd files\12515982_1-11_MineSite_GWLocations_RevB.mxd



Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:tdcoates

# 2.0 WASTE ROCK SUMMARY

## 2.1 NORM

All mined material that is classified as NORM will be managed by simple and well understood management practices.

Table 2—1: Waste Quantities for Mining Campaign 1 and 2 quantifies the estimated benign and NORM waste volumes, in bulk cubic metres (BCM), expected for the first two mining campaigns.

**Table 2—1: Waste Quantities for Mining Campaign 1 and 2**

| Waste Material | Unit | Pre-production | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | Yr6 | Yr7 |
|---|---|---|---|---|---|---|---|---|---|
| Benign | M BCM | 0.5 | 0.9 | 0.0 | 1.0 | 1.0 | 1.0 | 0.8 | 0.0 |
| NORM | M BCM | 0.2 | 0.7 | 0.0 | 0.7 | 0.8 | 0.9 | 1.0 | 0.1 |

LOM benign and NORM waste volumes will be considered in waste rock dump layouts and designs on an ongoing basis throughout the project.

## 2.2 Sulphide Mineralogy

Arafura geologists (Hussey pers. com., 2020) provided the following summary of the site mineralogy. Sulfur mostly occurs as sulfate, substituting for phosphate in apatite (i.e. already oxidised) with some barite (barium sulfate) as a trace mineral in thin section. Trace sulfides are observed in the amphibole- and epidote-rich alteration/mineralisation. Commonly, pyrite is partially or completely oxidised and converted Fe oxides. A maximum of 5% $SO_3$ (i.e. 2% S) was detected in a 1-metre interval (epidote-amphibole-apatite-pyrite) from the Central Zone. The neighbouring 1-metre core sample interval also had 1.96% $SO_3$ (<1% S). This interval was targeted because it is the most pyrite enriched interval of mineralised core observed on the site. Pyrite is visible in numerous samples from this zone but is a disseminated trace mineral everywhere else in the mineralisation and waste lithologies. Pyrite is observed in the country rocks that host the mineralisation but it is rare. Of the 807 country rocks that have been assayed for sulfur, only three exceed 0.3% S with a maximum of 0.56% S.

## 2.3 Acid -base accounting

Previous static and initial kinetic geochemical testing have been detailed in GHD (2016) and barrel leach tests in GHD (2021).

The results of static NAG testing indicate that greater than 99% of the material is non-reactive and non-acid-forming (NAF), with a median NAPP value of -18.2 kg/t $H_2SO_4$. Kinetic NAG pH showed that single addition NAG pH is suitable for identifying PAF and that reaction times are relatively slow, with a very low risk of acid generation either during short-term storage of ore, or long-term storage of waste rock.

Given the abundance of pyrite, NAF and Acid Consuming Material (ACM), a PAF cut-off of 0.3 %S or 10 kg/t $H_2SO_4$ has been selected as a conservative trigger value for our waste rock. As the one recorded PAF sample had a relatively low Maximum Potential Acidity coupled with a low Acid Neutralising Capacity, confirmatory field NAG testing could be carried out on samples with a sulfur content of greater than 0.2%. It is planned that further testing will be done during operations to confirm an appropriate cut-off, triggering any requirement for further investigation.

## 2.4 Leachability

Batch (ASLP) leachate testing indicated that the vast majority of the waste rock was non-sulfidic and relatively benign, with only minor amounts of material with slightly elevated sulfur, most of which is in the form of non-acid generating sulfate. Although neutralised by the excess acid-neutralising capacity, the material may contain metals that may form soluble forms when their sulfide forms are oxidised and neutralised.

Barrel Leach testing (GHD, 2021) was run over 98 weeks on 12 samples covering each major rock type. None of the drinking water, livestock or irrigation guidelines are exceeded for any metal or major ion by more than 10x, meaning that with minor dilution of the leachate, concentrations in potential receiving waters, both surface and groundwater, are likely to be below the guidelines. The Freshwater Aquatic Ecosystem 80% guideline for aluminium was exceeded by more than a factor of 10 in one sample on one occasion, and was considered likely to be due to colloidal, rather than dissolved aluminium. The materials of highest concern were oxidised gneiss and schist. The general trend with exceedances was an initial "first flush" after which concentrations dropped below the guidelines and decreased steadily or stabilised. Leachate concentrations for some analytes were higher than in local groundwater whereas some were lower. Over time leachate produced lower concentrations compared to maximum groundwater for the majority of analytes.

Leachate from waste rock is unlikely to degrade the useability of the groundwater. It is unlikely that leachate from the waste rock dumps will affect existing poor-quality groundwater or ephemeral surface water quality when typical dilution factors are considered. It will be important, however, to ensure leachate (or ambient groundwater) is not allowed to discharge to the surrounding creeks and concentrate through evaporation.

Based on the overall geochemistry of the waste rock and ore, the risk of acid, metalliferous or saline drainage is very low and the material can generally be managed as non-acid-forming (NAF), non-metalliferous and non-saline waste, although the management plan should have a contingency for management of, nominally, 1 % of material being PAF.

Radiation risk has been addressed in Appendix X-J of GHD (GHD, 2016). The report notes Arafura has conducted extensive waste rock NORM characterisation, which identified some rock containing more than 1Bq/g (based on a weighted combination of uranium and thorium content). The material will be managed by placing it within the broader waste rock dumps and covering it with benign waste rock. Testwork indicates that one metre of benign material is more than adequate to encapsulate and shield radioactive material within the waste rock stockpiles.

## 2.5 Sulfur Distribution

To assess the amount of potentially PAF waste rock requiring special management, Arafura interrogated the mine block model focusing on Sulfur grades, using the 2020 Ore Reserve pit shell, assuming that all classified resources > 1% TREO are ore and would eventually be processed, and hence waste comprises material with <1%TREO; below shows the Grade Tonnage Curve for sulfur blocks. The data show the following key points on sulfur content and tonnage:

- ~180 Mt **(99.5%)** < 800 ppm S (0.08%S).
- 826 kt (0.5%) >1000 ppm S (0.1%S).
- 31 kt >2000 ppm S (0.2%S).
- 16 kt >2500 ppm S (0.25%S.
- 6 kt >3000 ppm S (equivalent to the PAF cutoff grade of 0.3%S or 10 kg $H_2SO_4$ /t ).
- 0 kt > 3300 ppm S (0.3%S).

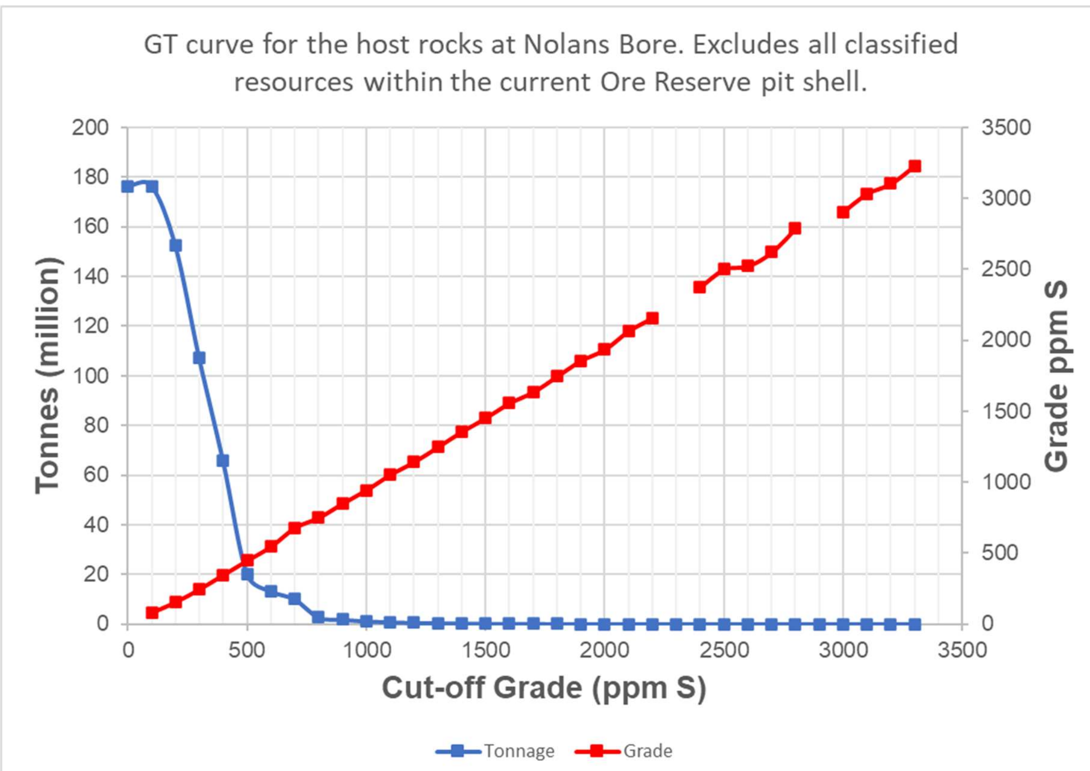



**Figure 2—1 Grade tonnage curve for sulfur**

## 2.6 Conclusion

Based on the data available to date, the risk of potentially acid-forming or PAF material is extremely low, but the WRD design will allow for some PAF designated storage areas. There is a very low risk of leachate or run-off from the WRD exceeding some water quality guidelines as the site is a controlled area. Discharge to groundwater is unlikely to change the current useability of local groundwater, given current groundwater chemistry and groundwater in rocks outside the orebody is extremely limited. The mine site design has incorporated surface water diversion for all potential sites where contaminants may be present, and this drainage will report to surface ponds for settlement and assessment before reuse or release dependant on results.

Concentrations of NORM in some material will require management to prevent the direct exposure of waste rock at the surface post-closure and to minimise dust generation during operations.

The overall risk and appropriate mitigation measures are the focus of this WRMP and the following sections.

# 3.0 AMD AND NORM RISK ASSESSMENT

NORM risk is addressed in the Radiation Management Plan (ARMS-0000-H-PLN-N-0010 RADIATION MANAGEMENT PLAN).

The following AMD ecological and human health risk assessment was undertaken to determine the AMD risk associated with the material identified at the Nolans Bore deposit. It is based on the risk assessment presented in GHD (2016) and updated to reflect subsequent additional testing.

It has been undertaken within the context of, and considering:

- PAF material identified during the geochemical assessment.
- Metal (including radioactive metals such as thorium and uranium) leaching potential of the excavated material.
- The mine plan and schedule.
- Baseline environment and any sensitive receptors as identified in GHD (2016).

The AMD risk assessment is a source-focused risk assessment in that it is not an exhaustive study of downstream impacts. It has been completed to provide a high-level understanding of AMD source risk on a greenfield mine site within the context of the mine plan, such that any potential impacts from mismanaging the mine wastes may be identified based on the geochemical information as reported above. In that regard, it uses INAP's (2011) source→pathway→receptor model as shown on Figure 3—1.

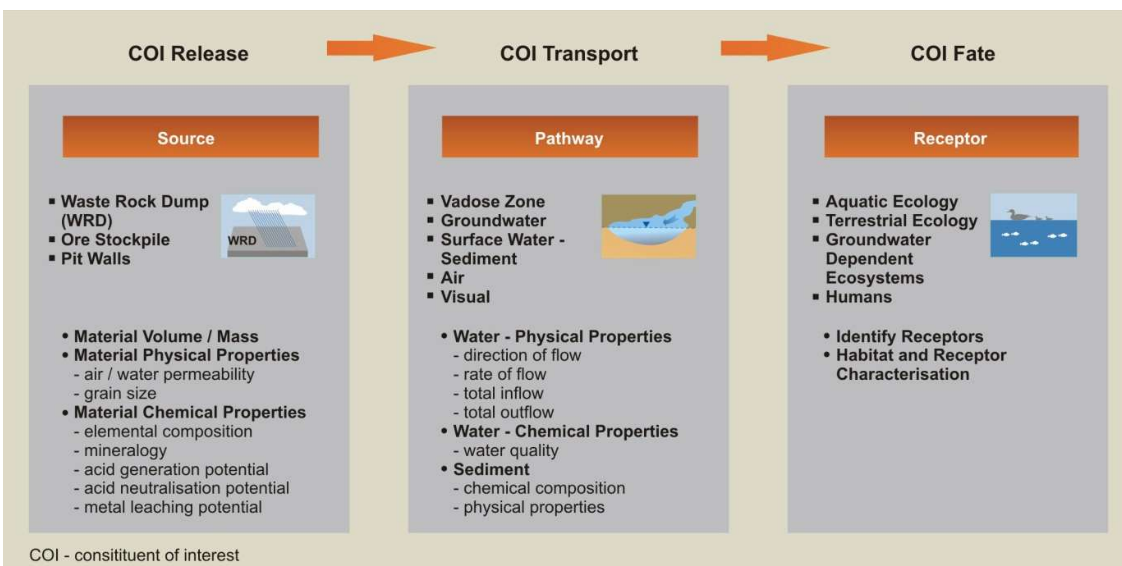



**Figure 3—1 The AMD Source→Pathway→Receptor Model (INAP, 2011)**

The general approach to the risk assessment followed standards and leading practice guidelines including:

- AS/NZS 4360:2004 Risk Management.
- AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines.
- Managing Acid and Metalliferous Drainage (DITR, 2007).
- The Global Acid Rock Drainage Guide (INAP, 2011).

The outcomes of the AMD risk assessment have informed the AMD management strategy and Plan.

## 3.1 AMD and NORM Risk Assessment & Management Process

### 3.1.1 Introduction

NORM risk is addressed in the Radiation Management Plan (ARMS-0000-H-PLN-N-0010 RADIATION MANAGEMENT PLAN).

INAP (2011) notes that the geochemistry and risk assessment techniques related to AMD for a new mining development are not calibrated for all situations. There will therefore remain a degree of uncertainty in terms of the confidence in the data collected and the reliability of the analysis and output. For this reason, a precautionary approach and contingency planning is an integral part of this AMD risk assessment, as it informs the WRMP.

The risk assessment recognises the limitations of the input data. However, the use of the large resource - database including site sulfur (samples), metal assay/gamma spectrometry dataset (>30,000 samples), kinetic ABA testing and barrel leach testing has provided a suitably sized input for the stated purposes of assessing AMD risk, and developing high level management strategies for site implementation throughout the operational mine stage, and into closure.

The risk assessment has also acted as a gap analysis, with any data gaps proposed to be filled by the collection of additional geochemical samples when triggered, with subsequent analysis throughout the operational stages. Additional data collected in the future will be fed back into the WRMP to better inform the process such that AMD management strategies may be fine-tuned as required.

INAP (2011) notes that the level of acceptable risk will vary from the local, regional, and national communities. In addition, the level of acceptable risk will change over time. Acceptable risks today may not be acceptable in the future, therefore, this risk assessment should be revised commensurate with updates to the WRMP.

### 3.1.2 Geochemical Conceptual Site Model

The following Nolans Project conceptual site model (Figure 3—2) considers INAP's (2011) source→pathway→receptor model as shown in Figure 3—1. The source material risk has been assessed in the geochemical assessment, and the receptors are drawn from the EIS (GHD, 2016). It considers the overall AMD and NORM risk based on the life of mine for the Nolans project.

| Conceptual AMD Site Model – Nolans project | | |
|---|---|---|
| **Source** | *In situ* sulfides | *Ex situ* sulfides |
| | Pit walls. Only trace elevated sulfide is expected in pit walls. | Mined and placed PAF on ROM Pad or WRDs. Low risk as only trace PAF identified in pit and only minor non-PAF waste stored outside pit. Small volumes stored in stockpiles. |
| | Metals and NORM: Some elevated metals in whole rock assays using the geochemical abundance index method. | |
| | Metals and NORM leaching: Low . | |
| | Sulfate/salinity leaching: Low. | |

| | | | | |
|---|---|---|---|---|
| **Pathway** | Groundwater | Surface water | Sediment | Windborne Dust |

| | |
|---|---|
| **Receptors** | Terrestrial flora and fauna.<br>Aquatic flora and fauna in ephemeral surface waters.<br>Potential springs and Groundwater Dependent Ecosystems (e.g. riparian vegetation).<br>Potential future groundwater users. |

**Figure 3—2 Nolans Bore AMD and NORM Conceptual Site Model**

### 3.1.3 Key Activities and Impacts

Key activities and impacts associated to AMD are provided in Table 3—1. NORM associated activities and impacts are addressed in the Radiation Management Plan (ARMS-0000-H-PLN-N-0010 RADIATION MANAGEMENT PLAN).

**Table 3—1: Key Activities and Impacts**

| ID No | Activity | Potential Environmental Impact | Risk |
|---|---|---|---|
| 1 | Uncontrolled AMD seepage from in-pit and ex-pit AMD material at Mine Site, ROM pad or storage. | Contamination of a groundwater resource by acidity, salinity or metals. | Low |
| 2 | Waste rock dump cover material and/or design allowing for erosion and exposure of waste rock and excessive leachate generation. | Contamination of a groundwater resource by acidity, salinity or metals. | Low |
| | | Rainwater comes in contact with encapsulated radioactive material resulting in mobilisation of radionuclides and their movement into the ecosystem. | Low |
| 3 | 'First flush' surge of stored oxidation products (AMD) generated in mine storage facilities at Mine site (Waste Rock Dump, Long Term Stockpile, ROM Pad etc ) over extended dry period, discharging downstream. | Contamination of ephemeral waterways and subsequently groundwater from uncontrolled release resulting in impact on ecosystem health and/or public water supply. | Low |
| | | Release to groundwater of leachate (elevated levels of radioactive material).<br>Contamination of a significant groundwater resource.<br>Impact on Ti Tree groundwater basin and consequential impacts to water supply (domestic, agricultural). | Low<br>Low<br>Low |
| 4 | Rehabilitation activities or constructed landforms not conforming or performing to design. | Environmental damage caused during rehabilitation works and delays to effective rehabilitation, with un remediated Project site-potential acting as source of ongoing environmental hazard. | Low |

### 3.1.4 Mitigation Measures

Mitigation measure associated to AMD are provided in Table 3—2. NORM associated mitigation measures are addressed in the Radiation Management Plan (ARMS-0000-H-PLN-N-0010 RADIATION MANAGEMENT PLAN).

**Table 3—2: Mitigation Measures**

| Mitigation Measure | Timing | Responsibility |
|---|---|---|
| **Waste Rock General (Risk Activity 2 and 4)** | | |
| Appropriate compaction of construction material and waste rock<br>Selective materials handling and placement using mine schedule and geochemical model | All project times | Mine Manager and Mine Geologist |
| **Ground and Surface Water (Risk Activity 1 - 4)** | | |
| Clean, dirty and contaminated water drainage systems<br>Surface water management basins<br>Controlled and managed site drainage and release<br>Dumps and fill areas profiled to shed and capture runoff | All project times | Environmental Staff |
| Sediment and erosion control plan<br>Sediment control ponds | | |
| Waste rock management plan, with regular reviews. Including ongoing AMD sampling and analysis<br>Testing to confirm chemical properties.<br>Addition of ACM to PAF to neutralise leachate/runoff<br>PAF designated storage areas within ex-pit WRDs<br>Compaction of PAF waste in cell limiting infiltration | | |
| **Mine Closure and Rehabilitation (Risk Activity 4)** | | |
| Develop detailed designs and tender documents for closure activities during operations and prior to closure works<br>Prepare preliminary mine closure plan<br>Prepare Decommissioning and Rehabilitation plan<br>Undertake inspections and monitoring | Mine closure | Mine Manager and Environmental Staff |

#### 3.1.5 Waste Rock Risk Assessment Conclusions

Concentrations of NORM in some material will require management to prevent direct exposure of waste rock at surface post closure and minimise dust generation during operation.

Given the low sulfur content, generally low metal toxicant content and low metal and salt leachability of waste rock, the primary (pre-management) risk level is currently low. Taking into consideration the proposed WRMP (Section 4.0), including separate storage of all separable PAF material, blending of any minor PAF with NAF and ACM, and encapsulation of radioactive material, the residual (managed) risk becomes low.

The risk assessment was informed by the geochemical assessment provided in GHD's *Acid & Metalliferous Drainage (AMD) Assessment and Management Plan* (GHD, 2016) and A*rafura Rare Earth Project Barrel Leach Test Results* (GHD, 2021) and the proposed project mine Plan and schedule. The geochemical assessment provided information pertaining to AMD risk by waste/ore stream and by geological unit.

The AMD risk assessment as informed by the geochemical assessment also acted as an information gap analysis. This gap analysis has shown that the laboratory acid-base accounting data set and the metals leaching data set are appropriate, given the low risk posed by a low sulfur ore body and waste rock and low leachability of metal and metalloid toxicants and NORM. Additional confidence is provided by the large assay dataset, which enabled additional MPA assessment, which also indicated a low risk of acid generation.

To improve confidence in these data sets, additional sampling and analysis will be completed where justified. The results will be used to validate AMD management strategies in subsequent revisions of this document.

In addition to the laboratory ABA / NAG and metals leaching data sets, exploration data and laboratory metal and sulfur analyses were used to inform the AMD risk assessment. The laboratory data set showed that there was only minor PAF material present within the proposed pit area, and if encountered during mining, PAF within the current pit shell can be managed with encapsulation within a large body of NAF within the main WRD.

The AMD risk assessment presented in Section 3.0 shows that with appropriate design and operational control measures, the residual AMD risk on site is low. This residual risk would be monitored (WRMP below) to confirm that the design and operational control measures are effective.

# 4.0 WASTE ROCK MANAGEMENT

## 4.1 Waste rock management summary

The waste rock management process is summarised below.

## 4.2 AMD Risk

The static and kinetic AMD and geochemical testing indicates that the proposed waste rock and ore material has a low risk of generating acidic, metalliferous, NORM or saline leachate.

Although the AMD risk is therefore considered low, based on the data assessed, the management plan has taken the highest risk material into account.

## 4.3 NORM Risk

NORM risk is addressed in the Radiation Management Plan (ARMS-0000-H-PLN-N-0010 RADIATION MANAGEMENT PLAN). Disturbed waste material with a radioactivity of greater than a 1 Bq/g gamma threshold, will be classified as NORM. Concentrations of NORM in some material will require management.

## 4.4 Waste Rock Classification

For this management strategy, PAF refers to waste rock or in-situ rock with potential to form acidic leachate. The sulfur (S) cut-off for classifying PAF waste rock material at Nolans Bore is 0.30%, unless otherwise confirmed as NAF by subsequent future testing. NAF is anything that is neither PAF nor NORM. This conservative sulfur cut-off figure will be assessed on an ongoing basis. All analysis results of 0.30 % S and above in waste rock material will be reviewed, and materials assessed to determine quantities and representativeness. Additional further testing using static testing (NAG and NAPP) where warranted will be completed on selected samples to satisfy AMD classification of negative NAPP, NAG pH of greater than 4.5 and a NAGpH7 of less than 10 kg/t $H_2SO_4$. If NAG and NAPP results are contradictory, classifying the material as uncertain, additional KNAG and ABCC testing may be performed to clarify classification.

# 5.0 RESPONSIBILITIES

**Mine Manager**

- Review and monitor environmental performance at regular worksite meetings.
- Be the primary contact for notification of any major environmental incidents and review the management procedures in place to deal with such occurrences.
- Monitor non-compliance and review management procedures if problems persist.
- Ensure that appropriate and adequate resources are allocated to allow for effective implementation and maintenance of the WRMP (including mine personnel to undertake the verification and field testing, if required).
- Manage remediation actions to correct incidents of environmental non-compliance.

**Mine Geologist**

- Monitor exploration samples, blast hole cuttings and excavated material, as detailed in section 8.0 for any indicators of NORM and AMD or variations in the material from that detailed in the site AMD assessment report (it should be noted that all personnel onsite are responsible for monitoring for visual indicators of AMD and reporting any issues to the Mine's Environmental Officer).
- Carry out verification sampling and field testing - of drill cuttings and excavated waste rock and submit samples for verification analysis.
- Update the mine r block model as new data become available and whenever the ore block model is updated. Note that it must include sulfur content in waste rock.
- Report unexpected material variations re NORM or AMD indicators to the Radiation Safety Officer (RSO) and Environmental Officer immediately.
- Facilitate the reporting of incidents that may impact on the surrounding environment.

**Mine Environmental Officer**

This person will be an experienced environmental professional with an understanding of NORM and AMD issues. Should conditions onsite be different to those detailed in the report on which this WRMP is based, the Mine Environmental Officer must be available to assist in recommending an appropriate solution. All advice shall be made professionally and in the best interest of the environment and all parties involved. Any issues identified through site audits or inspections shall be communicated immediately to Arafura and the Mine Manager at the time of inspection.

- Provide guidance and advice to staff regarding NORM and AMD management requirements.
- Ensure that all staff are aware of and understand their responsibilities under the WRMP.
- Identify any environmental training requirements.
- Monitor statutory requirements and ensure compliance.

- Where necessary, coordinate and/or assist in the response to environmental incidents.
- Monitor excavated material for any indicators of NORM exceedances or AMD or variations in the material from that detailed in the site AMD assessment report (applicable to all site personnel).
- Monitor runoff and leachate (discharging to surface and in underdrain lysimeters) from any waste rock dumps, tailings storage facilities and the like.
- Maintain records of disposal and treatment, including verification testing of treated soils.

# 6.0 AMD SAMPLING AND ANALYSIS

## 6.1 Blast hole sampling and analysis

### 6.1.1 Blast Hole Spacing

Based on the current mine design, blasting will be typically carried out on 5m benches with areas consisting of bulk waste material potentially accommodating 10m blasts. A variety of down the hole hammer and top hammer drill rigs will be used to drill varying blast hole diameters dependant on the material types to be drilled, and design powder factors required. All drill rigs will be fitted with a cyclone and splitter to facilitate blast hole sampling requirements.

The mine plan currently proposes drill patterns averaging 4.5m by 5.0m spacings.

### 6.1.2 Sampling

Sampling of blast holes will be done during blasthole drilling for each blast pattern to determine the classification of ore and waste rock.

The drilling method, and hence capture of drill cuttings, will determine the sample collection methodology. A representative sample will be collected for assay and material type assessment.

### 6.1.3 Waste rock sample analysis

Waste rock will be sampled using blast holes samples to determine the classification of waste rock. Hand held XRF will indicate if more detailed analysis is required. Where required, external NAG, NAPP, KNAG, and ABCC analyses will be caried out at a NATA-certified external laboratory until such time as an on-site laboratory becomes operational. The monitoring program is to be reviewed annually.

# 7.0 MATERIAL MANAGEMENT

The analysis results of the blasthole samples in conjunction with geological mapping, dump truck gamma radiation detection technology, and the mining block model will aid in determining the destination of the NORM waste material. To ensure the appropriate material management, the following summarised process will be followed:

- Blast the material based on grade / material classification to minimise heave and mixing.
- Mine the material blocks accordingly, based on assigned material classification.
- Ensure the correct material is dumped at the correct destination. Visible spotting and mark up Site Geologist of material types may be required.
- Potential acid forming (PAF) material if found will be contained and encapsulated within benign waste in designated areas of the WRD along with NORM classified waste material.

## 7.1 Waste rock management methodology

The following processes will be used to effectively evaluate both NORM and PAF during the grade control process

- Samples from a number of blastholes based on geological assessment will be analysed for ore / waste determination as well as a standard suite of analytes material type classification will be done.
- Factors that will be considered (but are not limited to) include:
    - blasthole diameter.
    - blasthole spacing
    - block model re mineralisation/waste, sulfur and the level of radioactivity.
    - acceptable errors of chosen sampling methods and analysis.
    - size of material classification blocks for optimum mining.
- Review against the block model to validate with in-pit sampling.
- Reconciliation of the mining model, blast hole sampling, stockpiles and process plant outputs and results.

## 7.2 Material Management

Areas will be designated with the waste dumps for the placement of PAF material when found and for the placement of norm waste rock material. The mining fleet will be guided to the required dump locations using installed tracking equipment.

## 7.3 Waste rock destinations

The general waste classifications are summarised in Table 7—1 and the management process summarised in Section 4.2.4 in the MMP . It is planned that S, U and Th will be a standard part of the analysis completed on blast hole samples to determine their classification and therefore destination within the waste rock dump.

**Table 7—1: Waste Rock Classifications and Fate**

| Material | Code | Final location |
|---|---|---|
| Non-acid-forming and non-NORM rock | NAF | Outer areas of waste rock dumps |
| Uncertain | UC | Treated as PAF unless otherwise demonstrated as NAF |
| Potentially acid-forming waste rock | PAF | Designated inner area of waste rock dumps |
| Naturally occurring radioactive material | NORM | Inner area of waste rock dumps |

## 7.4 Waste Rock storage

The proposed waste rock dump design is outlined in Section 4.2.4 of the MMP.

## 7.5 Closure

Planning for closure is a fundamental component of mine planning (INAP, 2011) (DFAT, 2016) Wherever practical PAF or NORM material will be identified in the mine plan and schedules. This will be validated by in situ checks in the pit prior to mining. To that end, the detail designs and operational controls minimise forward closure risks; particularly over the closure or care and maintenance period.

# 8.0 ONGOING GEOCHEMICAL INVESTIGATIONS

## 8.1 Geochemical analyses

Additional geochemical data requirements identified under the geochemical assessment, as described below, will be part of ongoing operational monitoring and management. The sampling will include sulfur and a standard suite of analytes including radioactivity (gamma).

### 8.1.1 Static geochemical testing

As required on selected samples, sulfur content and species and neutralising capacity will be done to validate a simple sulfur-based PAF cut-off. This will be achieved by having sulfate sulfur analysed in conjunction with additional NAG and NAPP testing, to enable correction for non-acid-forming oxidised sulfur.

### 8.1.2 Leachable contaminant testing

Ongoing monitoring of waste rock and pit wall leachate and runoff is required for pH, EC, and a suite of analytes., to add confidence to the observation of low total and leachable concentrations during mining.

### 8.1.3 Block Model Review

Block models will be updated before mining new pits and on an as required basis to assist with reconciliation or resolution of grade control.

# 9.0 SURFACE AND GROUNDWATER MONITORING

Surface water and groundwater monitoring will be completed as per the Surface Water Management Plan (ARMS-0000-H-PRO-N-0002 Rev 0) and Groundwater Monitoring Procedure (ARMS-0000-H-PRO-N-001).

Analytes with specific reference to AMD monitoring include pH, EC, acidity and alkalinity, fluoride, sulfate and selected metals. Baseline water quality data is also included in the monitoring plan.

Decreasing alkalinity is generally a good early indicator of deteriorating conditions in leachate from a WRD containing PAF material and can therefore be tracked as a trigger mechanism. Metals concentrations and declining pH values generally lag behind declining alkalinity; therefore, corrective actions can be implemented early should alkalinity decline.

Other trends that highlight the onset of possible AMD include increasing sulfate, increasing sulfate to alkalinity and sulfate to chloride ratios, decreasing pH values and an increase in soluble metals. Monitoring of the existing groundwater and surface water monitoring network around the Nolans mine area will continue, to provide additional baseline data prior to commencement of mining. An increased network of monitoring bores will be established around the footprint of the planned waste dumps and open pit.  Monitoring of these bores and continue periodically throughout the life of mine.

# 10.0 RECORD KEEPING / QA/QC

Record keeping and QA/QC initiatives required are shown in Table 10-1.

QA/QC initiatives have been discussed throughout this procedure and are critical to ensure data integrity, and to therefore drive continuous improvement opportunities based on data validation.

In general, data QA/QC validation protocols should follow the Precision Accuracy Representativeness Completeness Comparability (PARCC) process as described below.

## 10.1 Document control and reporting

It is intended that information gathered will to be saved in both hard and electronic form:

- The XRF, gamma ray spectrometer calibration sheet from the supplier.
- A copy of the signed CoC of analysis external to site.
- The completed field data/observation sheet for any validation / verification monitoring round.
- The laboratory results including laboratory QA/QC report.
- Daily production reports including handling and or placement inventory notes.

A range of performance data will be reported as required to demonstrate compliance with regulatory requirements. Parameters that may be reported include:

- Changes in disturbed areas.
- Inventory summary.
- Major incidents.
- Changes to management strategies.
- Concerns raised by regulators or other external stakeholders.

## 10.2 Audit, review and reporting

- It is planned that reviews, audits and reports will be completed on a regular schedule as required by Arafura's Resources planned Integrated Management System (ARMS) which will include this management plan.

**Table 10-1: QA/QC and record keeping**

| Mineral waste | Validation / verification | Method | Daily report | Materials handling and placement inventory | Equipment Calibration record | Field observation sheet | Reagent concentration | 1:10 blind duplicate | NATA laboratory QA/QC | Chain of custody / sample receipt / holding time |
|---|---|---|---|---|---|---|---|---|---|---|
| Waste Rock | Validation | Visual | √ | √ | | √ | | | | |
| | | Semi-quantitative | | | √ | √ | √ | | | |
| | | Analytical | | | | √ | | | √ | √ |
| | Verification | Visual | | | | √ | | | | |
| | | Analytical | | | √ | √ | | √ | √ | √ |
| Tailings | Validation | Visual | | √ | | √ | | | | |
| | | Semi-quantitative | | | √ | √ | √ | | | |
| | | Analytical | | | | √ | | | √ | √ |
| | Verification | Visual | | | | √ | | | | |
| | | Analytical | | | √ | √ | | √ | √ | √ |

# 11.0 PERFORMANCE REVIEW

## 11.1 Targets & Performance Indicators

The targets and performance indicators that are relevant to management of waste rock include:

- Ensuring that all waste rock has been appropriately classified. Where material excavated differs from that described in the geochemical assessment reports (GHD, 2016) (GHD, 2021), and displays characteristics of PAF or NORM, the material shall be assessed by an experienced person, prior to treatment or disposal. Assessment will include total sulfur and metals content by XRF analysis and radiation by gamma spectrometer, and regular validation sampling or analysis of material with a total S content of greater than 0.3% sulfur using NAG and NAPP testing. In the case of samples classified as uncertain (UC), due to conflicting NAG and NAPP testing, as well as randomly selected validation samples, they will be subjected to kinetic testing such as Kinetic NAG (KNAG) and Acid buffering Characteristic Curve (ABCC) testing (AMIRA 2000). Samples with field XRF Uranium and Thorium concentrations corresponding to NORM classifications (yet to be determined) will be subjected to confirmatory laboratory testing for NORM classification.
- Ensuring that excavations and/or deposition occurs only in areas where disturbance is necessary.
- Ensuring that no residual sulfide acidity is present allowing for full oxidation of disturbed PAF (i.e. appropriate treatment of excavated PAF confirmed through verification sampling).
- During and after construction, the physical characteristics (i.e. pH) of any surface or ground waters encountered in excavation or disposal areas are to be maintained within 0.5 pH units of the values encountered at the start of the project or within the acceptable (range for the receiving environment.
- Ensuring that all personnel involved in the project are appropriately trained.

## 11.2 AMD and NORM Risk

Based on the low sulfur and low to moderate leachable metal content, it is unlikely that there would be significant quantities of AMD material within the waste rock or drained formations around the proposed Nolans pit. The geochemical analyses indicated very low sulfur and low leachable metals and salt content, with an apparent potential for self- neutralisation, based on the predominantly negative NAPP values and NAG/KNAG pH above 4.5.

Significant volumes of waste rock will be classified as naturally occurring radioactive material (NORM). The WRDs are divided into discrete zones and scheduled on a 10 m lift-by-lift basis to ensure encapsulation of the NORM waste is achieved using benign waste material mined during the life of the project. NORM material is centrally within each dump stage and lift with benign waste layer used at the waste dump extremities to provide encapsulation requirements.

Based on the geology, geochemistry and overall environment, the primary risk of environmental or human health damage from AMD or NORM is deemed low. With the inclusion of the nominated mining and waste management process set out in this document, the key component of which is on-going assessment and encapsulation of NORM and any minor PAF material, and the management of mine inflow and runoff, the residual risk is deemed to be low.

To further refine the waste rock management process and to validate the testing to date and address identified data gaps, additional testing is being carried out as part of the pre-production and detailed design process, and this WRMP will be amended as appropriate.

## 11.3 Proposed Waste Rock Management

Although the geochemistry indicates a low risk of AMD, this management plan takes into consideration the highest AMD risk material observed. PAF material, currently defined as waste rock with greater than 0.3% sulfur, includes material with potential to leach metals and will be interred, encapsulated or blended, within the core of the WRD. A key aspect of the management plan is early identification of PAF material through additional field testing and laboratory analyses, and encapsulation or blending of all PAF material within the WRD.

Similarly, the larger volumes of NORM will be managed by encapsulation with NAF material to provide a physical barrier to radiation.

## 11.4 Additional AMD and NORM Assessment Work Proposed

The sulfur and NORM estimates within the mining block models will be updated on as need basis to support the mining operation. Additional static and kinetic AMD testing, including XRF and gamma spectrometer scan, total metals and sulfur analyses will continue throughout mining.

Runoff and leachate from WRD and pit walls will be monitored as part of the surface and groundwater program to confirm the water chemistry is consistent with current data.

# 12.0 REFERENCES

## 12.1 Arafura Documents

| Ref No. | Title | Document Number |
|---|---|---|
| A1 | Arafura (2017) Resource Evaluation ARU Report 17/002, dated June 2017. | |

## 12.2 Third Party Documents


| Ref No. | Title | Document Number |
|---|---|---|
| C1. | DFAT. (2016). Preventing Acid and Metalliferous Drainage. Manual in the Leading Practice Sustainable Development Program for the Mining Industry series. Canberra: Department of Foreign Industry and Trade. | |
| C2. | GHD. (2016). Arafura Resources Nolans Bore EIS Appendix L: Acid & Metalliferous Drainage (AMD) Assessment and Management Plan. Hobart: GHD Pty Ltd. | |
| C3. | GHD. (2021). Arafura Rare Earth Project Barrel Leach Test Results. Hobart: GHD Pty Ltd. | |
| C4. | INAP. (2011). Global Acid Rock Drainage Guide (GARD Guide). (The International Network for Acid Prevention.) Retrieved from http://www.inap.com.au/GARDGuide.htm | |