

# Daunia Mine Progressive Rehabilitation and Closure Plan

*Environmental Geochemical Characterisation  
and Risk Assessment of Mineral Waste*

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**Daunia Mine**  
**Progressive Rehabilitation and Closure Plan V3**  
*Environmental Geochemical Characterisation and Risk Assessment of Mineral Waste*

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## EXECUTIVE SUMMARY

Mine Waste Management Pty Ltd (MWM) has prepared this report for Whitehaven Daunia Pty Ltd (WHD) to document and discuss the environmental geochemical characteristics of mineral waste materials associated with Daunia Mine (DNM), as supporting information for the progressive rehabilitation and closure plan (PRCP<sup>1</sup>) for DNM.

DNM has two main types of mineral waste, and the geochemical characteristics and potential hazards associated with the mineral waste materials on site are discussed by type:

- Spoil (overburden and interburden) currently comprises approximately 98.5% of all mineral waste at DNM and includes weathered (Tertiary and Permian-age) and fresh (unweathered, Permian-age) wastes. Approximately 52% of spoil is fresh and the remaining (approximately 48%) is weathered/oxidised. Spoil comprises several subtypes of material, the most relevant subtypes from an environmental geochemical perspective being carbonaceous spoil (approximately 6% of all present and likely future spoil) and non-carbonaceous spoil (approximately 94% of all present and likely future spoil) subgroups. For the geochemical assessment, spoil samples have been sourced from drillholes (primarily as drillcore).
- Coal rejects: Coal rejects are generated (and disposed) as mixed plant rejects (MPR) which comprises approximately 80% coarse rejects (rejects) and 20% fine rejects (tailings) mixed together at coal handling and preparation plant (CHPP). Coal rejects comprises approximately 1.5% of all mineral waste at DNM - with this approximated proportion expected for the remaining life-of-asset mine plan.
- Coal is generally not considered mineral waste, with the exception of small quantities of sub-economic coal that may report to the spoil dumps, and remnant coal exposed on residual void highwalls and/or floor.

Mineral waste (and coal) samples have undergone environmental geochemical characterisation and assessment with regard to their potential to generate acid and metalliferous drainage (AMD), which comprises acid drainage (AD), neutral and metalliferous drainage (NMD) and/or saline drainage (SD) [salinity due to sulphate derived from sulfide oxidation]. Additionally, samples have been assessed with regard to their potential to generate salinity (non-oxidative) and, for spoil materials, their sodicity and dispersion potential. With respect to AD, each sample has been broadly characterised as either non-acid forming (NAF) or potentially acid forming (PAF).

Mine domains representing potential sources of AMD/salinity at DNM, and having a direct relevance to mineral waste characterisation and management at DNM at closure, are pits (and their corresponding residual voids post-closure) and spoil dumps (and rehabilitated final spoil landform post-closure). DNM does not have tailings storage facilities, such as tailings dams or similar facilities where tailings slurry is disposed.

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<sup>1</sup> Version 3 of the PRCP.

## Geochemical Assessment Approach

The geochemical characteristics of each waste type have been assessed with respect to their ability to generate AMD by leveraging on historical geochemical data (2008 and 2009), augmented with a significant data acquisition program undertaken between 2020 and 2022 designed to close identified knowledge gaps to assist with mineral waste management and closure planning. Overall, the geochemical data available to assess the geochemical properties of key mineral waste types and associated landform include:

- 710 drill-hole samples that had, as a minimum total sulfur (S) data available. These comprise 83 drill-chip samples collected during 2008 and 2009 and 627 drill-core samples collected from 2020 to 2022.
- 199 coal processing waste samples, comprising 86 MPR samples, 61 tailings samples (fine rejects), 52 rejects (coarse rejects samples) collected from the CHPP. For the purposes of this assessment, we have differentiated between tailings, rejects, and MPR where the data allowed, in order to better understand the characteristics and influence of each material sub-type. However, MPR samples (being comprised of mixed tailings and rejects samples) are considered to be representative of coal processing waste generated and disposed at DNM in the past, present, and future.

The environmental testing protocol included a variety of analytical techniques that are consistent with industry and regulatory accepted guidelines (e.g., GARD Guide [INAP, 2009]). The overburden/interburden samples were selected from drill cores that are representative of the vertical and lateral geological (stratigraphic) variability encountered at DNM.

## Geochemical Assessment of Mineral Waste

The test work results were used to understand the geochemical properties of each individual material type (source) and assign a geochemical classification. These data (and AMD classifications) were then used to infer the geochemical hazard posed by each mineral waste type in their relative proportions within the final spoil landform. The key findings from the geochemical assessment are:

- Coal Processing Waste:
  - Classification: 92% of the 61 tailings samples were classified as NAF, with only one sample identified as PAF-Low Capacity (PAF-LC), 4 samples as NAF-S<sup>2</sup> and none as PAF or UC(PAF)<sup>3</sup>. All 52 rejects samples were NAF. Similarly, 94% of the 86 MPR samples were NAF, with three PAF-LC and one sample classified as UC(PAF).
  - Elemental Enrichment: Two out of 28 rejects samples and two out of 22 tailings samples were significantly enriched in S [GAI ≥ 3], consistent with acid base accounting (ABA) data for these samples. No other tailings/rejects/MPR samples were significantly enriched in any of the elements tested.

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<sup>2</sup> NAF-S – NAF sample with S > 1%.

<sup>3</sup> UC(PAF) – Uncertain but expected to be PAF.

- Solubility: All samples were generally non-saline (median electrical conductivity [EC]<sub>1:5</sub>: 292–331 µS/cm). The pH distribution of all coal processing waste samples indicate that, as bulk materials, they are expected to generate alkaline to highly alkaline contact water (runoff and seepage). Leachate under freshwater and saline water leaching conditions produced low soluble metal concentrations at near-neutral to alkaline pH. Under acidic leaching conditions, peroxide leach tests indicated elevated metal/metalloid loads but not elevated sulfate or salinity. However, the presence of organic acids in highly carbonaceous materials (such as coal processing waste) may influence water quality for these materials.
- AMD Potential: Overall, approximately 94% of coal processing waste samples were assessed as having low AMD potential (AD/NMD/SD), while around 6% have moderate to high AMD potential. As a bulk material, coal rejects (MPR) present a low overall risk for AMD generation.
- Spoil (overburden/interburden): Spoil represents over 98% of all mineral waste at DNM and over 98% of 633 spoil samples were classified as NAF, with very low total S concentration and moderate to high acid neutralising capacity (ANC). As such, bulk spoil represented by these samples is clearly NAF and has a very low (negligible) potential to generate AMD. Less than 2% of spoil samples were classified as 'PAF' of some type with some potential to generate low-level AD and/or NMD and/or SD. However, the very small proportion of 'PAF' spoil is broadly distributed and mixed amongst the bulk NAF material.
  - Elemental Enrichment: Only one of 91 non-carbonaceous spoil samples showed significant (GAI ≥ 3) enrichment for arsenic (As). No carbonaceous spoil samples showed significant enrichment.
  - Solubility: Overall spoil is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), which is typical for sedimentary materials in the Bowen Basin, including materials from the Rangal Coal Measures. Soluble metal and metalloid concentrations from both non-carbonaceous and carbonaceous spoil types were generally low. A few samples showed slightly elevated soluble metals concentrations (aluminium [Al], As, manganese [Mn], molybdenum [Mo], antimony [Sb], selenium [Se]), but results remain low overall. Peroxide leach tests (n=2 samples; one carbonaceous and one non-carbonaceous) indicate weakly acidic behaviour under oxidising conditions, but metal concentrations remain low.
  - AMD Potential: Spoil is essentially dominated by NAF material with very low total S concentrations. A small proportion of this material type has some potential to generate low-level AD and/or NMD and/or SD, however, is distributed amongst the bulk NAF material. Therefore, as a bulk material, spoil represents a low risk for AMD generation.
- Coal: Coal is not regarded as waste because ROM coal remains on-site for a relatively short period of time. However, some minor coal may report directly to spoil as waste, while remnant coal (seams) will be exposed on the highwalls and floors of residual voids at closure. The assessment has shown that coal samples have variable geochemical properties, with approximately 44% of coal samples conservatively classed as 'PAF' of some type. Similar to

other source material tested, coal samples at potential for AMD can release moderate concentrations of metals and metalloids in contact with water, under controlled laboratory conditions. Based on the geochemical properties and samples assessed for this report, it is expected that as a bulk source material, coal has been conservatively assessed as having a moderate capacity to generate AMD.

### **Geochemical Risk of Final Landform**

Of relevance to mineral waste, final closure domains comprise of rehabilitated spoil dumps (Main spoil landform is located north of the Pandora void; whereas two smaller landforms, referred to as the Pandora landform and Out-of-Pit-Dump [OOPD] landform, are located at the south and west of the Pandora void respectively), and four residual voids. The final Main spoil landform is comprised of approximately 98.5% spoil with the remaining 1.5% being coal rejects with very minor waste coal. Pandora and OOPD landforms will consist mainly of mined spoil (~99%) with an assumed 1% waste coal; no coal rejects will be placed within the landform.

In particular, based on operational practices and life of asset waste management, at closure it is expected that:

- Main spoil landform will comprise spoil (overburden, interburden) and rejects. Pandora and OOPD landforms will comprise of spoil only (no coal rejects).
- Highwalls will comprise overburden, interburden and coal seams (including seam roof, partings and floor).
- Pit floors may comprise coal (conservative assumption).

A geochemical source hazard assessment was conducted on the source material types comprising carbonaceous and non-carbonaceous spoil, coal rejects and coal (where relevant). The source hazard score is a formula devised by the authors that leverages on the geochemical test work results to estimate the propensity (ability) to generate AMD, the AMD capacity (severity) and the quantity (volume/tonnage/%) of material that could produce AMD within each landform. The AMD score for each landform was then used to estimate the likelihood of each landform to generate AMD.

The potential environmental risk posed by the landforms (containing variable proportions of each mineral waste type) was determined using a source-pathway-receptor (SPR) approach. With this approach, the environmental geochemical risk is determined by taking into account the geochemical source hazard of each landform, the plausible environmental and human health receptors of AMD and salinity from the landform and the plausible pathways between the source (landform) and the receptor. The outcome of this assessment informed development of appropriate management and rehabilitation measures for the landform at closure.

Potential pathways and receptors for AMD and salinity have been identified for landforms at DNM. Details on the identification of pathways and receptors are found in Section 7.2. For the purpose of this SPR assessment, the following mechanisms for AMD and salinity to enter plausible pathways and report to plausible receptors have been identified:

- Source: Final spoil landforms (Main, Pandora and OOPD landforms)

- Surface water run-off (pathway) from the final spoil landform reports to a nominated creek/river (receptor).
- Seepage from the final spoil landform enters a shallow permeable strata (pathway) and reports to a nominated creek/river (receptor).
- Seepage from the final spoil landform enters groundwater (pathway) and reports to a nominated residual void (receptor).
- Source: Highwall and floor of residual voids
  - Run off from highwall of residual void (pathway) reports to nominated residual void (receptor).

The outcomes of the SPR are summarised below:

- Spoil landforms: with respect to AMD, the overall SPR risk rating from the final spoil landforms at DNM is **Low**. With respect to non-oxidative salinity the overall SPR risk from the final spoil landforms is rated **as Low**.
- Residual voids: The final receptors for seepage from the final spoil landforms and run-off from the highwall (of each void) are the four residual voids. The AMD assessment has found that it's unlikely that undiluted salinity or AMD from a flooded post-closure residual void floor (of any of the voids) would impact on residual void water quality to any significant degree, as other processes such as evapo-concentration are the key drivers of void lake water quality. Therefore, the AMD SPR risk rating on the overall water quality of the residual voids is **Low** for each void.

Groundwater or surface water reporting to residual voids is expected to remain within the residual voids (excluding evaporative loss). Modelling undertaken by SLR (2026) shows that seepage from the pit lake (of each void) into groundwater, if any, would be limited.

### **Management and Rehabilitation Measures**

The geochemical characterisation, SPR, and residual risk assessment conducted in support of this PRCP informed the following mineral waste management and rehabilitation measures with regards to AMD and salinity management:

1. Residual Voids: Titan North void, Titan Central void, Titan East void and Pandora void.
2. Spoil dumps: will be reshaped, covered with soil and seeded.
3. Coal rejects: Managed during operations (disposed as MPR within spoil) and progressively covered by spoil. No specific AMD management measures are proposed for the rejects (at closure). The optimal thickness of spoil cover to manage the AMD hazard of rejects will be determined following further assessment prior to covering.

## Glossary of terms

Key terms and definitions as used in this report are listed below:

<b>Acid</b>	A measure of hydrogen ion (H <sup>+</sup> ) concentration in water; generally expressed as pH.
<b>Acidity</b>	A measure of hydrogen concentration and latent acidity generated by metal hydroxylation, expressed as mg/L CaCO <sub>3</sub> equivalent.
<b>Acid-Base</b>	Evaluation of the balance between acid generation and acid neutralisation processes.
<b>Account (ABA)</b>	Generally determined by the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below. See also ANC and MPA.
<b>AMD</b>	Acid and metalliferous drainage. AMD encompasses 3 drainage types: acid drainage (AD), pH- neutral and metalliferous drainage (NMD) and/or sulfide-derived saline drainage (SD) – and/or any combination of these, all generated by sulfide oxidation processes +/- neutralisation reactions.
<b>ANC</b>	Acid neutralising capacity, expressed as kg H <sub>2</sub> SO <sub>4</sub> per tonne of rock/material. A measure of a sample's maximum potential ability to neutralise acid.
<b>ANC/MPA ratio</b>	Ratio of the acid neutralising capacity (ANC) to the maximum potential acidity (MPA) of a sample. Used to assess the risk of a sample generating acid conditions. See also ANC and MPA.
<b>CHPP</b>	Coal handling and preparation plant.
<b>Co-Disposal</b>	The practice of disposing different waste types together. For example, MPR is the co-disposal of coarse rejects and fine rejects.
<b>Coal rejects</b>	Also called Rejects. The general term given to fine rejects, coarse rejects and mixed plant rejects (MPR), produced during the processing of coal from the CHPP.
<b>Coarse rejects</b>	Coarse sand to cobble-sized rock material produced during coal processing. Coarse reject is typically associated with the roof, floor and partings of coal seams and is separated from ROM coal in the CHPP. Coarse rejects produced at DNM are co-disposed with fine rejects as mixed plant rejects (MPR). Coarse reject also includes a small proportion of what is called 'mid rejects', which is coarse to very coarse sand and fine gravel and is combined with coarse rejects prior to disposal.
<b>DNM</b>	Daunia Mine. The name of the site subject to this PRCP.
<b>EC</b>	Electrical conductivity, expressed as µS/cm.
<b>Fine rejects</b>	Very fine to medium grained sand, silt and clay-sized material, which is commonly coaly and carbonaceous, produced during coal washing. Fine rejects is associated

with coal seams and is separated from ROM coal in the CHPP. Fine rejects produced at DNM is co-disposed with coarse reject as mixed plant rejects (MPR).

<b>Interburden</b>	Potential spoil material located between mined coal seams. See also Overburden, Mineral waste and Spoil.
<b>Kinetic test</b>	Procedure used to measure the geochemical/weathering behaviour of a sample of mine material over time.
<b>Mineral waste</b>	Material comprising mine spoil, ± rejects, ± waste coal. Sometimes called 'mine waste' or 'mining waste'.
<b>MPR</b>	Mixed Plant Rejects. A mixture of approximately 80% coarse rejects and 20% fine rejects disposed within spoil.
<b>MPA</b>	Maximum potential acidity. Calculated by multiplying the total sulfur (S) content of a sample by 30.6 (stoichiometric factor) and expressed as kg H <sub>2</sub> SO <sub>4</sub> per tonne of rock/material (kg H <sub>2</sub> SO <sub>4</sub> /t). Assumes all sulfur is present as sulfide and will oxidise to generate acid.
<b>NAF</b>	Non-acid forming. Geochemical classification criterion for a sample that is unlikely to be acid generating. These samples have excess acid neutralising capacity compared to their acid generating capacity. NAF material are generally inert, but may still develop NMD and/or SD, depending on sulfur concentration.
<b>NAG</b>	Net acid generating test. A pulp sample is reacted with hydrogen peroxide to encourage rapid oxidation. Any acid generated through oxidation may be consumed by neutralising components in the sample. Any remaining acidity (after neutralising material is consumed) is measured and expressed as kg H <sub>2</sub> SO <sub>4</sub> /t. Following a NAG test, the solution can be measured for soluble parameters (e.g. metals, sulfate) to understand their solubility under acidic or low pH conditions.
<b>NAPP</b>	Net acid producing potential, expressed as kg H <sub>2</sub> SO <sub>4</sub> per tonne of rock/material (kg H <sub>2</sub> SO <sub>4</sub> /t). Calculated by subtracting the ANC from the MPA.
<b>NMD</b>	Neutral and metalliferous drainage. A component of AMD, NMD occurs where drainage is pH-neutral or higher yet contains elevated trace metals and metalloids in solution.
<b>Org S</b>	Organic sulfur.
<b>Overburden</b>	Mineral (mining) waste located above (overburden proper) or between (interburden) coal seams and reports to spoils dumps. Typically comprises non-coaly and non-carbonaceous material, such as sandstone, siltstone and claystone/mudstone, but also includes a small percentage of carbonaceous material (e.g. carbonaceous siltstone) and sub-economic waste coal.
<b>OxCon</b>	Oxygen consumption test. A type of kinetic (dynamic) test for estimating the sulfide oxidation rates, acidity generation rates and carbonate neutralisation rates for sulfidic geological materials.

<b>PAF</b>	Potentially acid forming. Geochemical classification criterion for a sample that has the potential to generate acid conditions. A sample classified as PAF has an acid generating potential (MPA) that exceeds the inherent acid neutralising capacity (ANC) of the material. This means that such a material is likely to generate acidic drainage (AD) if exposed to atmospheric conditions. See also PAF-LC.
<b>PAF-LC</b>	Potentially acid forming (low capacity). Geochemical classification criterion for a sample that has the potential to generate relatively low-level AD.
<b>PRCP</b>	Progressive rehabilitation and closure plan.
<b>Product coal</b>	Coal produced from the CHPP after being washed/processed. Coal that is ready for sale.
<b>ROM</b>	Run-of-Mine. The term given to mined coal before being processed at the CHPP.
<b>ROM pad</b>	Location where ROM coal is temporarily stored pending processing at the CHPP.
<b>S</b>	Sulfur.
<b>Scr</b>	Chromium reducible sulfur. Analytical procedure to determine the sulfide-sulfur concentration in a sample. This typically represents the proportion of sulfur associated with sulfide (reactive) minerals.
<b>SD</b>	Saline drainage. A component of AMD, SD occurs where drainage is saline due to elevated sulfate as a result of sulfide oxidation and neutralisation reactions.
<b>SO<sub>4</sub></b>	Sulfate.
<b>Spoil</b>	Rock material overlying and between 'target' coal seams, which will report as waste. Waste rock overlying a coal seam is called overburden. Waste rock between mined coal seams is called interburden. See also Overburden and Interburden.
<b>Spoil dump</b>	In-pit or out-of-pit landform containing mineral waste.
<b>SPR</b>	Source-pathway-receptor.
<b>Static test</b>	Procedure for characterising the geochemical nature of a sample at one point in time. Static tests may include measurements of mineral and chemical composition of a sample and the Acid-Base Account.
<b>Tailings</b>	Fine rejects prior to being dewatered at the CHPP. See Fine rejects.
<b>Uncertain</b>	In the context of classifying a material (sample) as NAF or PAF. An 'Uncertain' (UC) classification applies when there is an apparent conflict in results such that neither NAF nor PAF classification can be given, or there is insufficient information to unequivocally classify as

NAF or PAF. UC samples are sometimes given a tentative sub-classification, such as UC(NAF) or UC(PAF) where preliminary data suggests the sample may be NAF or PAF, respectively.

**Waste coal**

Sub-economical coal that reports directly to the spoil dumps as waste (i.e. not ROM coal). Waste coal can be fresh or weathered (oxidised). All weathered/oxidised and coked (cindered) coal is waste.

**Water extract**

A method to determine the water-soluble parameters in soil. Solid samples undergo a bottle leach method where 10 g of pulped solid (85% passing 75 µm) is combined with 20 grams or 50 grams of water (leaching fluid) into a glass bottle. Depending on the type of leaching undertaken the leaching fluid may be deionised water (DI water extract) or saline water (saline water extract). The 1:2 or 1:5 solution (1 part solid to 2 or 5 parts water) is tumbled end-over-end for one hour. Solutes are leached from the soil by the continuous suspension and agitation. The water extract solution is measured for pH and electrical conductivity (EC) prior to filtering for solute analysis (e.g. metals/metalloids and major ions).

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## 1 INTRODUCTION

This report serves to document and discuss the environmental geochemical characteristics of mineral waste materials associated with Daunia Mine (DNM), as defined under the current Environmental Authority (EA) EPML00561913, held by Whitehaven Daunia Pty Ltd (WHD). WHD is a subsidiary of Whitehaven Coal Limited (WHC). In this report the term 'mineral waste' refers to all geologic material generated by or associated with DNM during the course of mining, handling and processing coal.

It is a requirement of a Progressive Rehabilitation and Closure Plan (PRCP) that mineral waste is adequately characterised (as relevant to mine rehabilitation and closure) such that appropriate rehabilitation strategies can be selected and implemented. The PRCP guidance document: "Guideline – Progressive Rehabilitation and Closure Plans" (DESI, 2024) outlines the requirements and considerations for producing a PRCP, including documenting the relevant aspects of mineral waste characterisation for the purposes of PRCPs.

### 1.1 Approach

The general approach to mineral waste characterisation and assessment includes the following key steps:

- Briefly describe the current/existing background information for DNM of relevance to the generation and ultimate storage/disposal of mineral waste materials;
- Document the methodology used to characterise mineral waste materials (samples);
- Present and discuss the geochemical results;
- Describe the potential environmental geochemical hazards with respect to mineral waste materials;
- Present the conceptual site model (CSM), which illustrates the relationship between AMD and salinity sources, potential environmental and human health receptors and plausible pathways between the AMD and salinity sources and the receptors (Source-Pathway-Receptor [SPR]) at closure;
- Present the acid and metalliferous drainage (AMD) and salinity SPR risk assessment undertaken on the mineral waste materials;
- Outline the AMD specific management and rehabilitation measures proposed for mineral waste materials; and
- Outline a future work plan to address any gaps identified from the assessment.

### 1.2 Objective

The objective of the assessment is to evaluate the geochemical nature of mineral waste currently at DNM and mineral waste likely to be present at closure, and identify relevant environmental issues/opportunities that may be associated with mining, handling and storing mineral waste to inform appropriate rehabilitation and management strategies.

## 2 BACKGROUND

### 2.1 Site Overview

DNM is an open cut coal mine located approximately 20 km east of the town of Moranbah in the Bowen Basin, Central Queensland. DNM commenced operations in 2013 and is located close to many other coal mines and coal mining development projects. The nearest mines and projects include: Poitrel Mine and Red Mountain Infrastructure (coal processing facility) to the west, Millennium Mine to the north-west, Moorvale Mine to the north-east, proposed Winchester South project to the south-west and proposed Moorvale South Extension Project to the south-east.

DNM comprises typical open-pit coal mining facilities, such as open pits, waste rock (spoil) piles, stockpiles, coal processing facilities, rail loadout facilities, process water and raw water dams, surface water drains and administration areas. The key facilities and natural features at DNM of relevance to this waste characterisation report are shown on Figure 1 are geochemical sampling locations and the locations of geological sections along and across each pit.

Activities of relevance to this waste characterisation report comprise:

- Current and future disposal of spoil to in-pit spoil dumps behind the active mining face (in-pit low-wall spoil disposal);
- Future disposal of spoil to an out-of-pit dump (OOPD) to be located west of Pandora pit;
- Short-term storage of run of mine (ROM) coal on the ROM Pad;
- ROM coal processing at the coal handling and preparation plant (CHPP), which produces one main mineral waste type for disposal: MPR (mixed plant rejects), which is trucked to designated disposal areas and buried within spoil. MPR is comprised of two waste materials:
  - Fine rejects. Combined with coarse rejects in the CHPP to form MPR (see above). Fine rejects are mostly disposed as a component of MPR, however are sometimes disposed as monofill to meet operational requirements.
  - Coarse rejects. Combined with fine rejects in the CHPP to form MPR (see above). Coarse rejects are mostly disposed as a component of MPR, however are sometimes disposed as monofill to meet operational requirements.
- Short-term storage of product coal on the product Coal Stockpile, awaiting off-site transport by rail;
- The operation of raw water and process water dams and sediment control structures as stipulated in the environmental authority (EA).

An overview of the proposed mineral waste management and rehabilitation activities of relevance to this waste characterisation report are outlined in Section 8 (Management and Rehabilitation Measures). Refer to the main volume of the PRCP for detailed management and rehabilitation information.

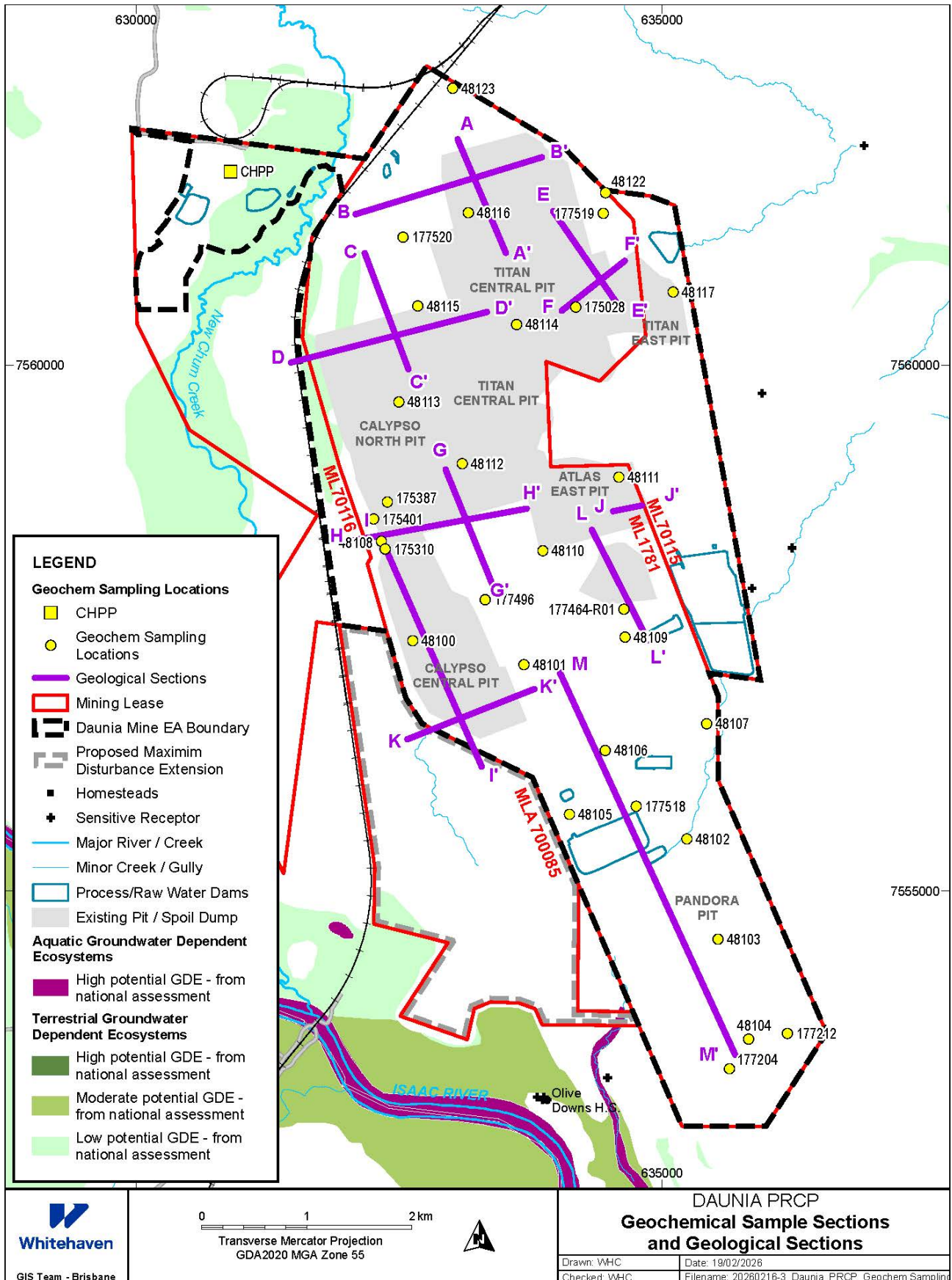


Figure 1: Project layout, geochemical sample locations and locations of geological sections.

## 2.2 Mine Domains

The mine domains of direct relevance to mineral waste characterisation and management at DNM are:

- Residual voids: Titan East, Titan North, Titan Central and Pandora.
- Spoil dumps: Titan East dump, Titan North dump, Titan Central dump, Pandora dump and OOPD.
- Coal stockpiles: ROM coal pad and stockpile; and Product coal pad and stockpile.

DNM has no tailings storage facility (TSF). Tailings are dewatered at the CHPP to produce fine rejects, which is mostly co-disposed (into spoil) with coarse rejects as MPR or periodically disposed into spoil directly as fine rejects (i.e. not co-disposed with coarse rejects). Tailings liquor from the dewatering process is recycled for use within the CHPP.

### 2.2.1 Material Types and Quantities

DNM has two main types of mineral waste:

- Spoil (overburden and interburden) currently comprises approximately 98.5% of all mineral waste at DNM and includes weathered waste (Tertiary and Permian-age – in approximately equal proportions) and fresh (unweathered) waste (all Permian-age). Approximately 52% of spoil is fresh and the remainder (approximately 48%) is weathered/oxidised.
  - Spoil is comprised of approximately 94% non-carbonaceous material (93.6% of all spoil) and 6% carbonaceous material (i.e. 6.4% of all spoil).
- Coal rejects are generated at the CHPP. Coal rejects currently comprises less than 1.5% of all mineral waste at DNM.
  - Coal rejects is primarily generated (and disposed) as MPR, which comprises approximately 80% coarse rejects and 20% fine rejects mixed together at the CHPP.

In consideration that the proportion of spoil and rejects are not expected to materially change over the life of asset, we have assumed that spoil comprises 98.5% of mineral waste and rejects comprises 1.5% of mineral waste at DNM (on average), now and into the future.

Coal is also included in the assessment; however, it is understood that coal is generally not considered mineral waste. Coal is primarily representative of ROM coal, however is also representative of potential waste coal from sub-economic seams and remnant coal exposed on pit highwalls or pit floors (such as in residual voids).

## 2.3 Baseline Information

### 2.3.1 Topography

The regional topography of the Bowen Basin is dominated by flat to gently sloping landforms and low rolling hills. DNM lies within the north-eastern areas of the Bowen Basin. Topography across DNM is generally of low relief and dominated by flat to gently undulating rural plains. DNM lies between an elevation of approximately 240 mAHD in the north down to approximately 190 mAHD in the south, with a slope typically between 1 and 2%, except in the southern portion where there is a broad drainage floor that has more gentle slopes.

At a catchment scale, the mine site lies within a sub catchment of the Fitzroy Basin, which includes the major tributaries of the Isaac, Connors, and Comet rivers. The catchment is flanked by the Denham and Peak Downs Ranges in the west and the Connor Ranges in the east. These ranges form the prominent topographic features in an otherwise low-relief landscape.

### 2.3.2 *Climate*

DNM is located within Queensland's semi-arid climatic zone, which is characterised by high summer temperatures, warm dry winters and a distinct wet and dry season. Weather data was collected at the Moranbah Water Treatment Plant (Station No. 034038) between 1972 and 2012 and since 2012 it has been collected at the Moranbah Airport (Station No. 034035). The Moranbah Airport weather station is located about 25 km west of DNM. The Moranbah Water Treatment Plant is located about 35 km west of DNM.

Maximum temperatures range from 24°C in June/July to 35°C in December/January, with minimum temperatures ranging from 9°C in July to 22°C in January<sup>4,5</sup>. Rainfall occurs in any month, though it is more prevalent in the summer months of December, January and February. The average annual rainfall (and averaged between the two weather stations) is approximately 570 mm per year. The evaporation rate is highest in the summer months - mean daily rate of 8.2 mm in January, and lowest in the cooler months - mean daily rate of 3.6 mm in June. The mean monthly rate of evaporation is 78 mm. The annual average rate of evaporation is 2,373 mm, which greatly exceeds the annual rainfall, a characteristic of semi-arid environments. Rainfall events are often associated with thunderstorms, which are typically short-lived, intense and have variable coverage. Sustained rainfall over a large landscape area is experienced when tropical lows with cyclonic activity occur in coastal area. However, periods of prolonged drought do occur within the region.

### 2.3.3 *Geology*

DNM is located on the western limb of the northern Bowen Basin. The Bowen Basin (at DNM) is characterised by a relatively thin accumulation of sediments, gentle easterly dips and minor to moderate deformation. DNM lies near the western boundary of one of the sedimentary troughs, the Taroom Trough, which was filled by a thick accumulation of mainly terrestrial sediments during the Permo-Triassic period. DNM occurs within a shallow basinal structure immediately east of the New Chum Fault, which separates DNM from Poitrel deposit to the west. New Chum Creek, which flows from north to south between DNM and Poitrel Mine, broadly follows New Chum Fault.

The coal bearing sequences at DNM are the late Permian-age Rangal Coal Measures (RCM) and the very upper seam of the Fort Cooper Coal Measures (FCCM), comprising the following seam groups in stratigraphic order, from youngest to oldest:

- Leichhardt Seam (RCM): L1, L2 and L3 plys (when combined L1 and L3 plys together are referred as L13 ply).
- Lower Leichhardt Seam (RCM): L4 ply.
- Upper Vermont Seam (RCM): V1, V2 and V3 plys (when combined V2 and V3 plys together are referred as V23 ply. V23 is sub-economic and not mined).
- Lower Vermont Seam (FCCM): VL ply (not mined).

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<sup>4</sup> Accessed from the Bureau of Meteorology (1972-2012)

<sup>5</sup> Accessed from [www.willyweather.com.au](http://www.willyweather.com.au) (2012-2020)

Non-coal Permian sediments consist of moderately weak to strong sandstones, siltstones, minor mudstones and carbonaceous mudstones. Sandstone units are commonly greater than 2 m thick. Interbedded and interlaminated siltstone occurs within some sandstone units. The Yarrabee Tuff 'marker horizon' is widespread throughout the RCM and marks the top of the FCCM. At DNM the Yarrabee Tuff is located immediately below the V3/V23 ply and immediately above the VLL ply (i.e., between the V3/V23 and the VL plys).

An indicative stratigraphic column showing the seam groups is provided at Figure 2, which also includes the number of geochemical samples collected from each overburden, interburden and seam zone (refer to Section 4.2 for information regarding sample collection). Geological long-sections (indicatively north-south) along Titan North pit, Titan Central pit and Titan East pit high-wall are provided at Figure 3 and Figure 5. Geological cross-sections (indicatively west-east) through Titan North pit, Titan Central pit and Titan East pit are provided in Figure 7 and Figure 9. Refer to Figure 1 for section locations. The seam groups are shown in the geological sections.

In coal environments (i.e. at coal mines) fresh carbonaceous materials typically have higher sulfide concentrations compared with fresh non-carbonaceous materials and, as such, typically pose a greater environmental geochemical hazard compared with fresh non-carbonaceous material. Comparatively, non-carbonaceous lithologies are essentially void of (or have negligible) carbonaceous material and thus have low or nil sulfide mineral concentration.

The location of weathered zone shown in the stratigraphic column (Figure 2) has ranged from above the Leichhardt seam at the start of mining operations to the current location (at the highwall) above the Vermont seam in Titan North pit, Titan Central pit and Titan East pit (refer to the geological long-sections in Figure 3 to Figure 6 and cross-sections in Figure 7 to Figure 8 respectively).

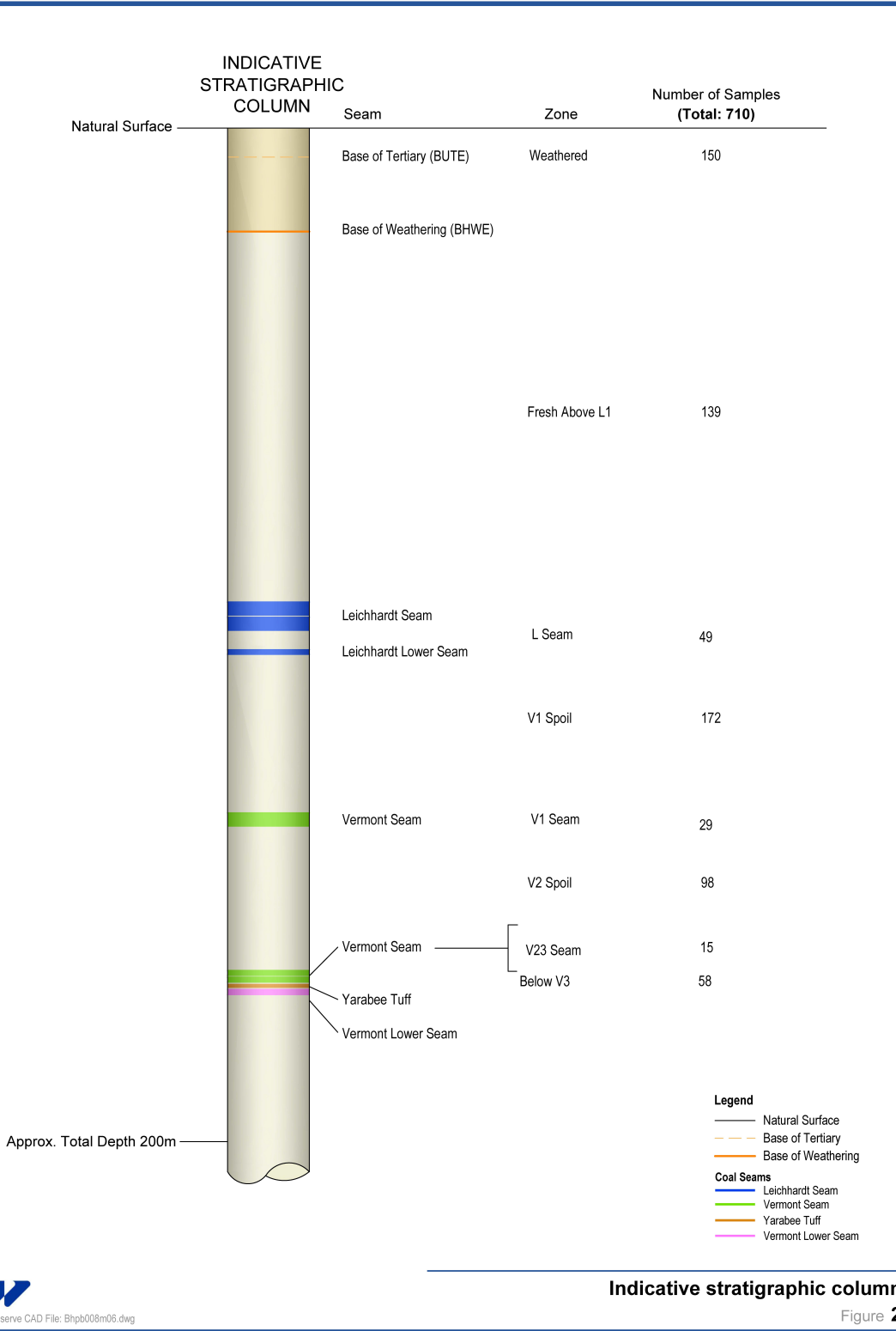


Figure 2: Indicative stratigraphic column (WHD 2025).

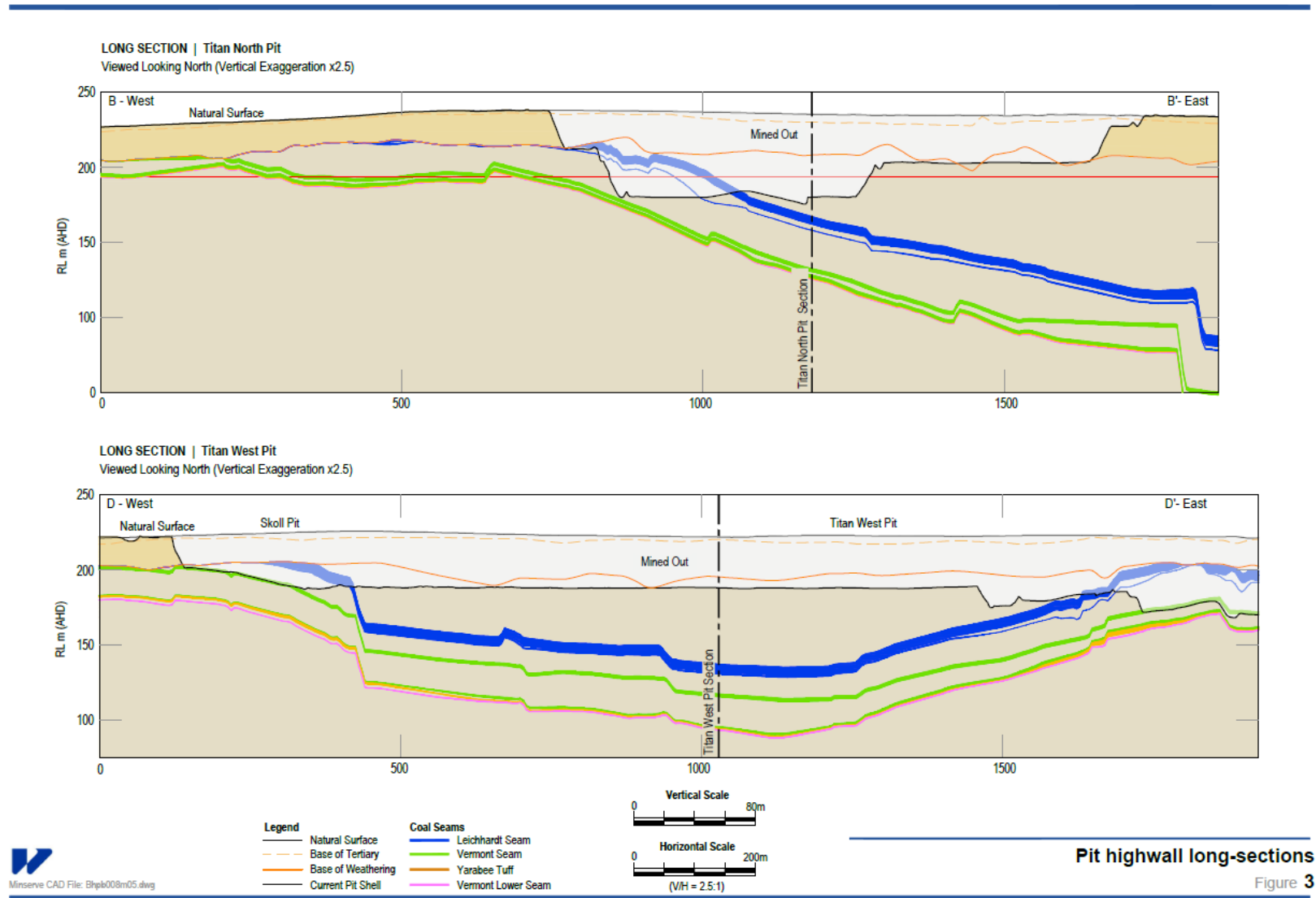


Figure 3: Pit highwall long-sections for Titan North and Titan Central pits (WHD, 2025).

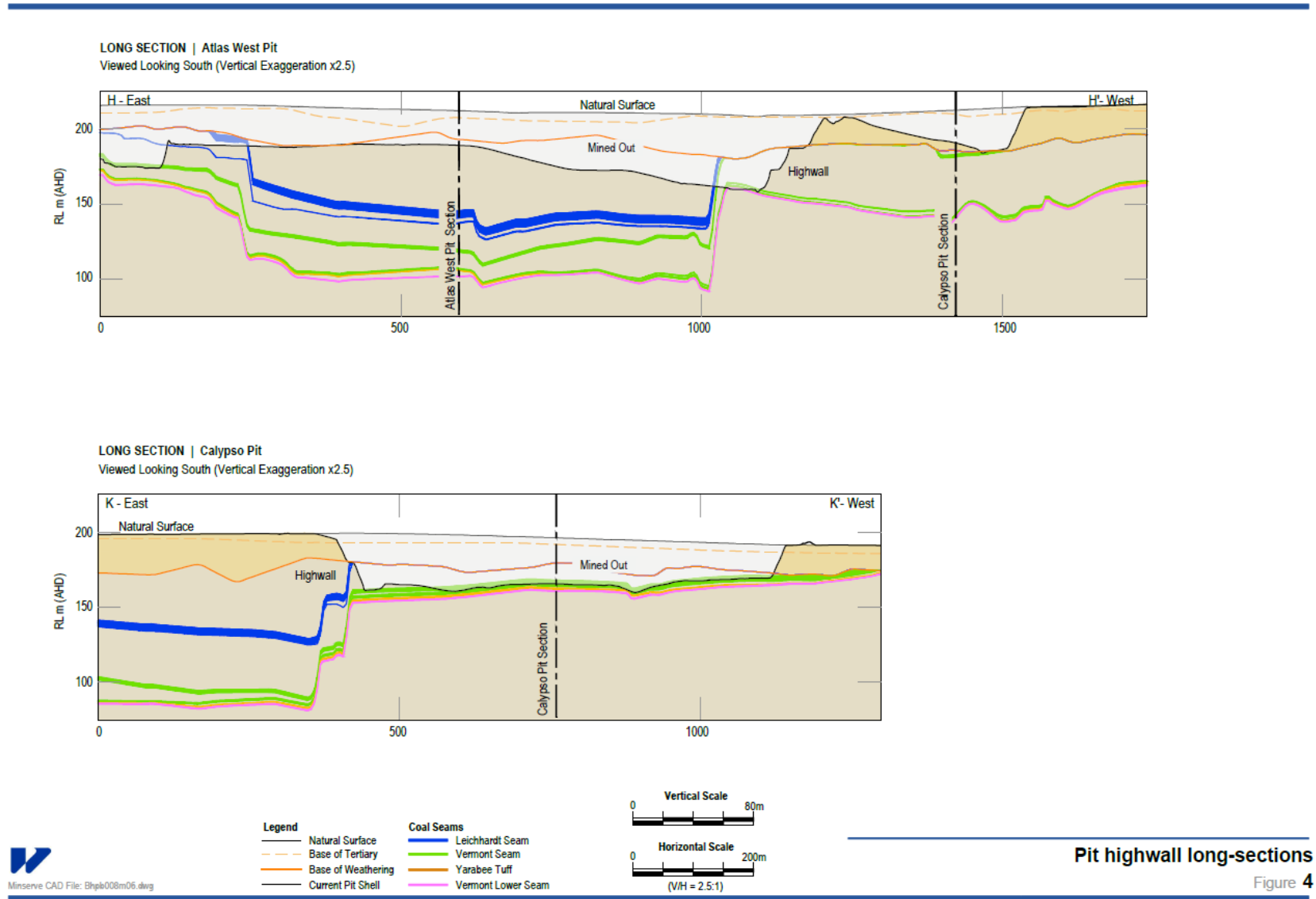
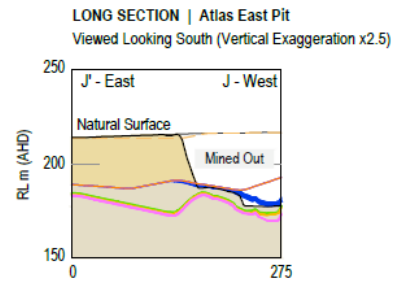
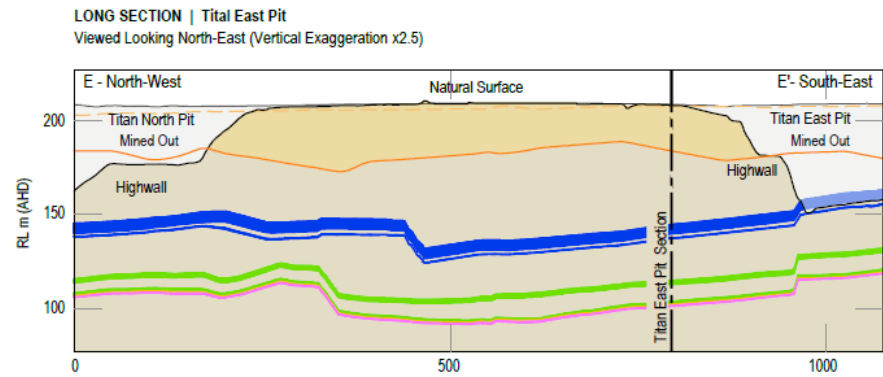
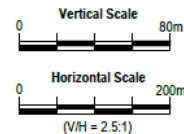


Figure 4: Pit highwall long sections for Atlas West and Calypso pits (WHD, 2025).



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- |                        |                      |
|------------------------|----------------------|
| <b>Legend</b>          | <b>Coal Seams</b>    |
| — Natural Surface      | — Leichhardt Seam    |
| - - - Base of Tertiary | — Vermont Seam       |
| — Base of Weathering   | — Yarabee Tuff       |
| — Current Pit Shell    | — Vermont Lower Seam |



**Pit highwall long-sections**

Figure 5

Figure 5: Pit highwall long sections for Titan East and Atlas East pits (WHD, 2025).

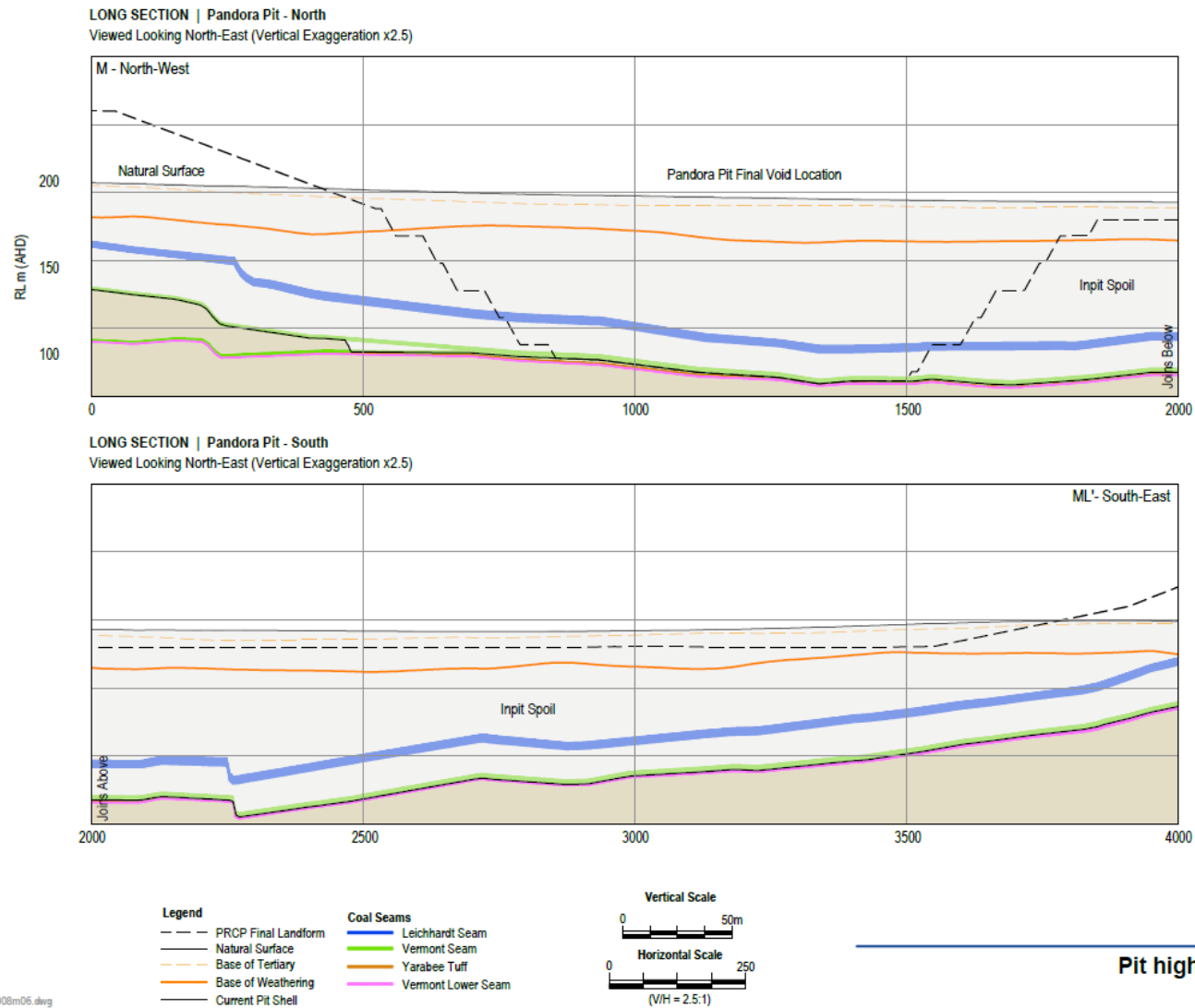


Figure 6: Pit highwall long sections for Pandora pit (WHD, 2025).

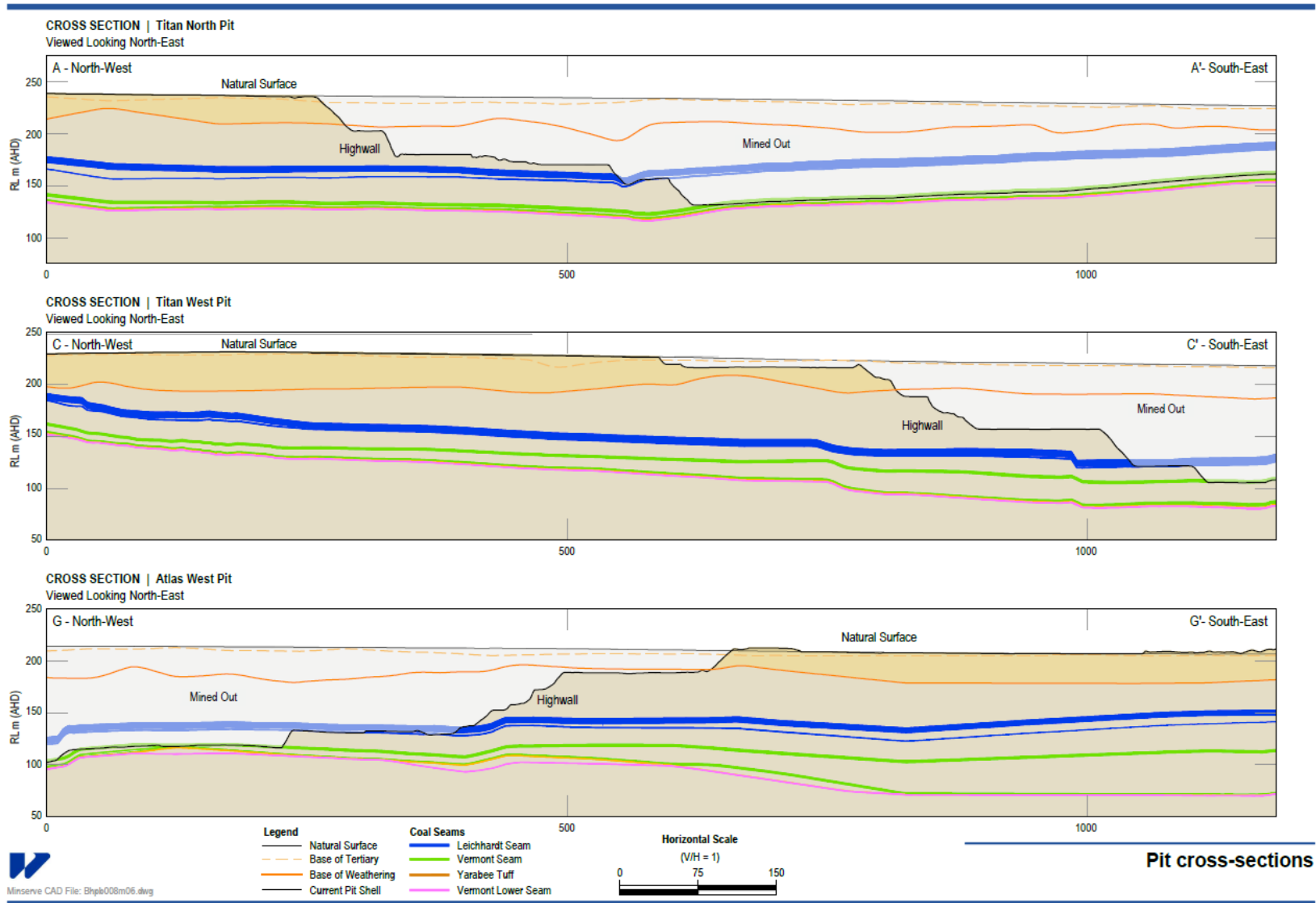


Figure 7: Cross-sections for Titan North, Titan West and Atlas West Pits.

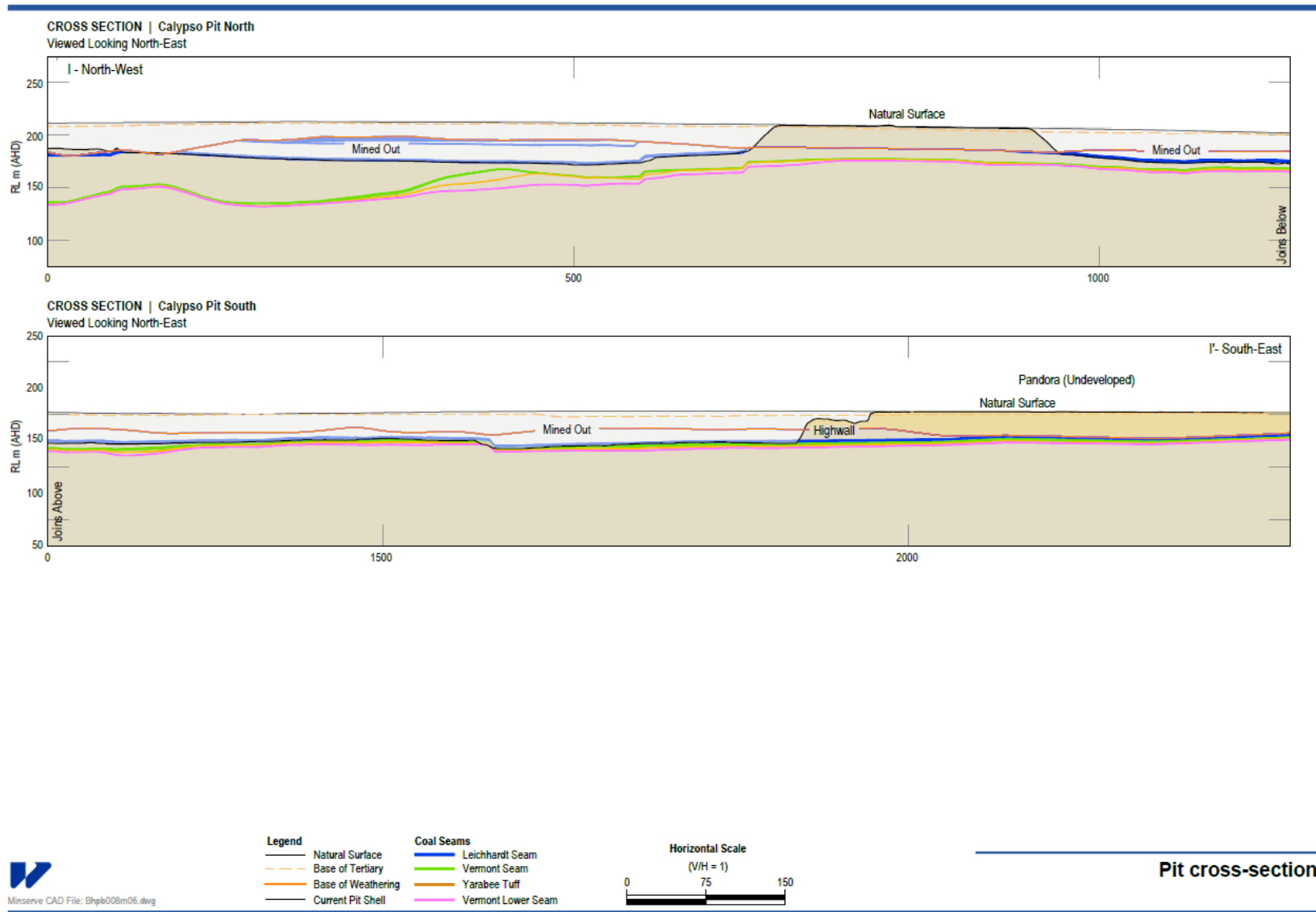


Figure 8: Cross-sections for Calypso North and South Pits.

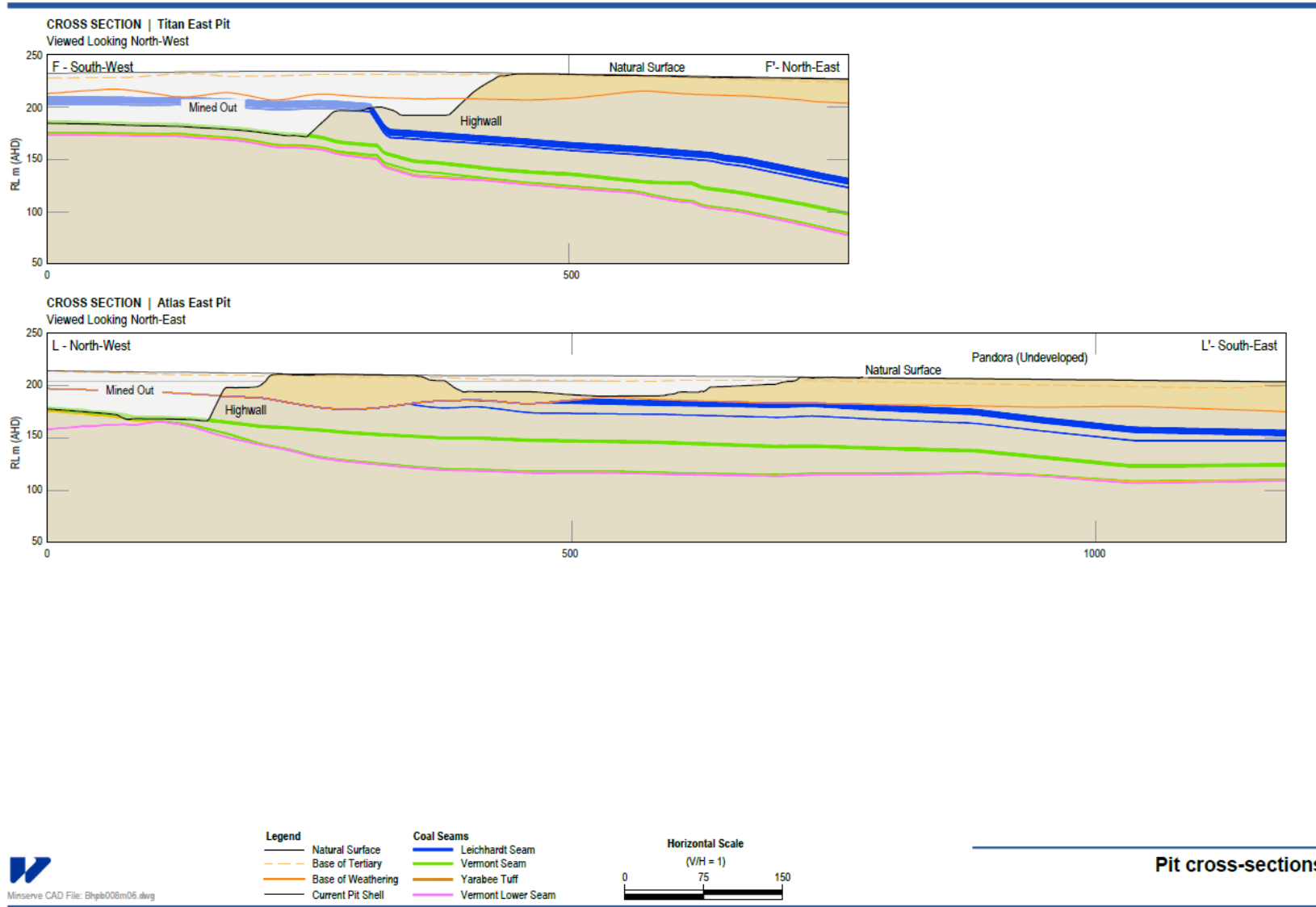


Figure 9: Cross-sections for Titan East and Atlas East pits.

### 2.3.4 Surface Water / Hydrology

The following information about surface water / hydrology is general and provided for broad context. Refer to the main volume of the PRCP for detailed information about surface water environment at DNM.

DNM is located in the Upper Isaac surface water catchments of the Isaac River Sub-Basin, and DNM shares these catchments with several mines. The topography of the DNM gradually slopes from northeast to southwest towards Isaac River, with elevations ranging from approximately 210 mAHD to 240 mAHD. All water courses and tributaries within DNM are ephemeral and only flow briefly after rainfall.

The key surface water features are shown on Figure 1 and include:

- Isaac River (Upstream of DNM).
- New Chum Creek (west of DNM, between DNM and Poitrel Mine).
- Un-named drainage feature (west of DNM).
- North Creek (east of DNM).
- Three un-named drainage features (east of DNM).

The Isaac River is the major drainage feature of the region and flows from north-west to south-east in the vicinity of DNM (Figure 1). The New Chum Creek, a tributary of Isaac River, traverses north-east to south-west across the northern section of mining lease, before running south adjacent to Poitrel Mine to the west of the ML70116 (Figure 1). An un-named drainage feature runs parallel to the western boundary of ML1781 before forming a minor tributary to Isaac River approximately 4 km south-east at DNM (Figure 1). There are three un-named drainage feature approximately 1 km from ML70115 that drains into North Creek which is approximately 3.5 km east of DNM and flows south, before joining the Isaac River approximately 7.5 km downstream at DNM. In summary, surface water from DNM flows south towards the Isaac River.

All creeks in DNM are ephemeral with no semi-permanent or permanent waterholes and generally dominated by sandy substrate, with gravel bars dispersed throughout New Chum Creek. No creeks within DNM have a permanent groundwater baseflow. The only significant waterway within the vicinity of DNM is the Isaac River, which is also an ephemeral water course.

### 2.3.5 Groundwater / Hydrogeology

The following information about groundwater / hydrogeology is general and provided for broad context. Refer to the main volume of the PRCP for detailed information about hydrogeology at DNM.

Two distinct aquifers occur in the proximity of DNM. Namely, a Quaternary age alluvium unit and a Permian age unit. The Quaternary age alluvium consists of clay, silt, sand and gravel and is located in receiving environments in the proximity of Isaac River and North Creek. Quaternary alluvium has not been identified within the DNM lease areas. Where present, these sediments act as an unconfined (water table) aquifer. The Rewan Group and Rangal Coal Measures also act together as a minor fractured rock aquifer. The formations consist of sandstone, siltstone, mudstone, shale and coal. The permeability of this aquifer is highly variable and dependent on the size and degree of interconnectivity between the fractures within the aquifer. Given the large impermeable nature of the Permian age

sandstone/siltstone occurring between, above and below the coal seams, the aquifer constituting the coal seam unit is considered confined to semi-confined.

The main factors influencing natural groundwater levels are groundwater recharge, evapo-transpiration and regional flow patterns. Recharge of the aquifers in the region occurs predominantly in the topographically higher areas and along creek beds during and immediately following rainfall events. Recharge to the Quaternary age alluvium unit occurs in the areas of thin soil cover or along creek beds (i.e. the Isaac River) where surface water can readily permeate into the aquifer during and following rainfall events. The Permian age RCM will recharge via leakage from the overlying alluvium units or via direct rainwater infiltration in regions where the formation outcrops or sub-crops. Groundwater flow in the Permian Coal Measures are shown to follow a general northwest to southeast trend, with local modifications in the vicinity of the active mine pit voids. Local groundwater flow is therefore towards active mine voids, whilst regional flow remains towards the southeast (SLR, 2026).

The physico-chemical results from groundwater sampling at DNM indicate the water chemistry is typically pH-neutral for all geological formations. Groundwater associated with alluvium and coal seams have variable salinity levels [measured as electrical conductivity (EC)], ranging from fresh to highly saline (SLR, 2026). The metal concentrations for all parameters analysed in DNM bores were either below the laboratory detection limit or below the ANZG (2018) guideline level for most elements (SLR, 2026).

The hydrogeological units at DNM are outlined in Table 1.

Table 1. Hydrogeological units at DNM.

AGE	GROUP	GEOLOGICAL UNIT	AQUIFER
Quaternary	Undifferentiated alluvium and colluvium	Alluvium (mainly clay, silt, sand and gravels)	Sand and gravel deposits associated with the Isaac River and North Creek form an unconfined aquifer. Quaternary alluvium has not been identified within the DNM tenements.
Tertiary	Undifferentiated sediments	Soil, alluvium, gravel, scree, sand	Unconfined and largely unsaturated unit bordering alluvium.
Permian	Rewan Group	Siltstone, sandstone, calcareous and carbonaceous shale	The low permeability sedimentary rocks and clays typically with aquitard properties.
	Blackwater Group	Rangal Coal Measures (Sandstone, siltstone, mudstone, coal, tuff, conglomerate)	The Leichardt and Upper Vermont coal seams are identified as a semi-confined to confined minor aquifers within the coal measures; the sandstone/siltstone of the interburden/overburden have low permeability.
		Sandstone, conglomerate, mudstone, carbonaceous shale, coal, cherty tuff	Low permeability with aquitard properties and is typically dry or very low yielding.

### 2.3.6 Potential Environmental and Human Health Receptors

A conceptual environmental geochemical model (source-pathway-receptor (SPR) model) for DNM identified the potential environmental and human health receptors and is discussed within this report. Of relevance to this assessment (i.e. hazards and risks posed by AMD), the following potential receptors are noted:

### 2.3.6.1 Potential surface water receptors

The primary surface water feature is the Isaac River and flows from western to southern boundary of DNM and comes within 1 km of ML boundary. The New Chum Creek flows from northeast to southwest in the vicinity of DNM (~1km east from ML boundary) and drains into the Isaac River. An un-named drainage feature traversing parallel to western boundary of DNM and joining Isaac River approximately 4 km southeast of DNM was considered as potential surface water receptor. Due to its distance from the DNM (approximately 3.5 km), North Creek was not identified as a potential surface water receptor. DNM shares the Isaac River Catchment with several other coal mines upstream and downstream.

### 2.3.6.2 Potential groundwater receptors

Aquatic and terrestrial groundwater dependent ecosystems (from national assessment) are shown in Figure 1.

### 2.3.6.3 Potential domestic (human) receptors

Consideration was also made to people living in the homesteads near DNM, of which the closest is 'Olive Downs' located approximately 1 km west of the ML boundary at the far southern end of the site. Other unlabelled homesteads seen in Figure 1 are considered implausible receptors.

### 2.3.7 *Acid and Metalliferous Drainage*

Environmental geochemical information with regard to AMD from mineral waste materials at DNM has been sourced from the WHD DNM Coal Geochemical Database (hereafter called 'the geochemical database') and is presented and discussed within this report.

### 2.3.8 *Salinity, Sodidity and Dispersion*

Environmental geochemical information with regard to salinity, sodicity and dispersion of mineral waste materials at DNM has been sourced from the geochemical database and is presented and discussed within this report. Refer to the main volume of the PRCP for detailed information about soils and rehabilitation of spoil dumps at DNM.

### **3 POTENTIAL ENVIRONMENTAL GEOCHEMICAL HAZARDS**

#### **3.1 Acid and Metalliferous Drainage**

The term 'AMD' is used to describe low-quality seepage or drainage (from soil and rock) that has been affected by the oxidation of sulfide minerals (primarily pyrite and marcasite) and/or by the dissolution of acid generating sulfate minerals (primarily alunite and jarosite) and associated neutralisation reactions, if any. The term AMD is used to describe any drainage type affected by this process.

AMD may be produced when sulfide minerals are exposed to oxygen and water. Oxidation of sulfide minerals may result in the production of acid(ity), sulfate (SO<sub>4</sub>) and, depending on mineralogy, the release of metals and salinity. AMD comprises three key components, which are defined below as per recognised Australian and international guidelines (INAP, 2009; DIIS, 2016). MWM and WHD has adopted these recognised definitions:

- Acid drainage (AD): where contact water is acidic and, in most cases, also contains 'elevated' concentrations of metals and metalloids. This drainage type is generated when the acid generating capacity exceeds the acid neutralisation capacity of a sample.
- Neutral and metalliferous drainage (NMD): where contact water is pH-neutral/alkaline and contains 'elevated' concentrations of metals and metalloids. This drainage type is generated when the acid neutralising capacity exceeds the acid generating capacity of a sample.
- Saline drainage (SD): where contact water contains elevated sulfate concentration due to oxidation of sulfide minerals, and very low metal/metalloid concentration. This drainage type is generated when the acid neutralising capacity vastly exceeds the acid generating capacity of a sample with high sulfide concentration.

Whether contact water is impacted by AD, NMD and/or SD largely depends on the relative proportion of acid generating minerals (sulfide / sulfate) and acid neutralising minerals (carbonate) in the source materials.

#### **3.2 Salinity, Sodicity and Dispersion**

An assessment of salinity characteristics of mineral waste materials has been undertaken on materials using available EC data from the geochemical database. An assessment of sodicity and dispersion characteristics of potential final landform materials has also been undertaken using exchangeable cation and Emerson Class data from overburden/interburden samples (data obtained from the geochemical database). Salinity released from the dissolution of geogenic salts (non-oxidative) is a separate and distinct process from SD associated with sulfide oxidation / leaching of acid sulfate salts.

## 4 ASSESSMENT METHODOLOGY

This section provides the methodology used for the geochemical characterisation and assessment of spoil and coal rejects (mineral wastes) and coal at DNM.

### 4.1 Information Review

Sampling and laboratory test-work was undertaken by BHP<sup>6</sup>, WHD and consultants throughout the development and operation of DNM. The geochemical database contains all available geochemical data for mineral waste samples. All data has been compiled and reviewed specifically to support the PRCP, to provide a unified and consistent interpretation of all available data. Past characterisation and assessment reports are superseded by this review and assessment undertaken to support the PRCP.

### 4.2 Sample Collection

#### 4.2.1 *Drill-hole Samples – representing soil, ROM coal, pit walls and pit floor*

All data used to assess spoil and ROM coal (and pit walls and floor) has been derived from drill-hole sampling. The geochemical database contains drill-hole sample data collected from 31 drill-holes located throughout DNM, dating from exploration drilling undertaken in 2008/2009 during pre-feasibility of the project (i.e. before operations commenced and during early stage construction) through drill-hole samples collected in 2022.

The drill-hole samples that have undergone test-work are representative of the geology/stratigraphy at DNM from existing mining (disturbance) areas. The DNM coal resource model provides an estimate of coal resources from current pit highwall (at each pit) through to the final extent of the mine (where residual voids will be located). The resource model indicates that - at closure - the proportion of coal versus non-coal in the highwall of the residual voids is broadly consistent with the current proportions on the relevant pit highwalls. The model also shows that the proportion of each seam group is expected to be broadly similar to current seam group proportions on the highwall of the current pits (as relevant to the voids remaining at closure). As such, it is reasonable to assume that the mineral waste types assessed, and their relative proportions, are representative of the mineral waste types and proportions likely to be mined through closure.

Geochemical data is available for 710 drill-hole samples that had, at minimum, total S data. These comprise 83 drill-chip samples collected during 2008 to 2009 and 627 drill-core samples collected between 2020 to 2022.

Geochemical samples collected and tested to date were sourced from the following key mineral waste domains:

- Weathered, non-carbonaceous spoil. 139 samples.
- Weathered, carbonaceous spoil, including weathered coal. 11 samples (all Permian age).
- Fresh, non-carbonaceous spoil. 391 samples (all Permian-age).
- Fresh, carbonaceous spoil. 92 samples (all Permian age). These samples typically include carbonaceous (carb) siltstone, (carb) sandstone, (carb) mudstone and coaly shale, but also

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<sup>6</sup> BHP owned and operated the site prior to its sale in 2024 to WHD.

includes similar coaly and carbonaceous materials other than coal. A large proportion of this material is typically associated with coal seams as roof, parting and floor.

- Fresh, coal. 77 samples (all Permian age).

Drill-chip samples were typically collected at set intervals (e.g. every 1 or 2 m) or within targeted sampling zones. Drill-core samples were collected as discrete samples – typically a 15-25 cm interval of core within targeted sampling zones. Drill-core samples were collected semi-continuously across the entire stratigraphic sequence, with greater emphasis placed on those stratigraphy's posing a greater AMD hazard (i.e. carbonaceous spoil, roof/parting/floor, and coal).

It is understood that most fresh coal will report to ROM coal and be processed. A small fraction of coal may be mined as spoil (waste) due to coal quality and mining considerations, and a small proportion of coal will remain exposed in seams on pit walls and potentially in pit floors at closure. The coal samples discussed herein represent 'pure' coal and do not include associated roof, parting and floor samples that would ordinarily be mined with the seam as ROM coal. Carbonaceous roof, parting or floor samples are included in the 'fresh, carbonaceous' sample group, although a significant proportion of this type of material are likely to report to the CHPP as rejects/MPR.

The geochemical sampling locations are shown on Figure 1 (site layout) and the number of drill-hole samples from each stratigraphic zone is shown on Figure 2 (indicative stratigraphic column).

#### 4.2.2 Coal Rejects Samples – representing process waste

Geochemical data is available (within the geochemical Database) for 199 coal rejects samples, comprising 61 tailings samples (fine rejects) and 52 rejects (coarse rejects samples) collected from the CHPP prior to being mixed into MPR; and 86 MPR<sup>7</sup> samples also collected from the CHPP. For the purposes of this study, we have differentiated between tailings, rejects, and MPR where data were available, in order to better understand the characteristics and influence of each material type. However, MPR samples are assumed to be representative of all coal processing waste generated at DNM in the past, present, and future.

### 4.3 Sample Characterisation

The aim of the environmental geochemical test-work is to understand the geochemical characteristics of the mineral waste materials with respect to AMD, geogenic salinity, erosion and dispersion potential; and to inform management and closure options for these materials.

A phased approach was implemented to define the geochemical behaviour of the key material types generated at DNM, as discussed below.

#### 4.3.1 Solid Sample – Static Tests

Coal rejects and overburden (spoil) samples have generally undergone similar test-work methods. Test-work was generally undertaken in stages, with most samples being subjected to 'screening' tests followed by more detailed test-work undertaken on selected samples.

The vast majority of the samples have undergone 'screening' tests (stage 1 tests) for:

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<sup>7</sup> Coal rejects are primarily generated and disposed as MPR, which comprises approximately 80% coarse rejects and 20% fine rejects mixed together at the CHPP.

- pH and electrical conductivity (EC) on 1:5 w:v water extracts (on pulps, with minimum 85% passing 75 microns);
- Net acid producing potential (NAPP) test, which comprises total S and ANC determination. The NAPP test provides the fundamental information about the theoretical maximum amount of acid-producing and acid-neutralising material that a sample could produce;

Based on the results of the screening tests, selected samples were subjected to some or all of the following tests:

- Total carbon (total C), and organic carbon (C-org).
- Total sulfate (SO<sub>4</sub>);
- Sulfide (chromium reducible sulfur – Scr) - a test to determine the proportion of total S present as sulfide;
- Acid buffering characterisation curve (ABCC) - a test to determine the proportion of ANC that's in a readily-available form and to provide an indication of the carbonate mineralogy of the neutralising material;
- Net Acid Generation (NAG) [single addition] - a test that encourages the oxidation of a sample to determine if acid can be produced, and how much acid could be produced;
- Sequential net acid generation test (S-NAG) - a refinement of the single addition NAG test to resolve potential issues associated with incomplete oxidation of samples with high sulfide concentrations;
- Extended boil net acid generation test (NAG Extended) - a refinement of the NAG test to resolve uncertainty due to potential organic acid interference (where non-acid generating organic acids can provide false positive results in the NAG test);
- Total metals and metalloids by 4-acid (mixed) or 2-acid (aqua regia) digest with analysis by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and/or Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) and Flow Injection Mercury System (FIMS);
- Quantitative x-ray diffraction (QXRD) - to determine the mineralogical composition;
- Short-term leaching tests, including:
  - Deionised water extract leach procedure - a 1 hour end-over-end bottle leach at 1:5 w:v (solid:water) ratio using de-ionised water, with filtered leachate analysed for:
    - § Major and minor ions [calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), SO<sub>4</sub>, chloride (Cl) and fluoride (F)];
    - § Alkalinity [total alkalinity, bicarbonate (HCO<sub>3</sub>) and carbonate (CO<sub>3</sub>)] and Acidity (pH dependent);
    - § Soluble metals and metalloids [approximately 28 elements by ICP-MS, ICP-AES and FIMS].

- Saline water extract leach procedure - a 1 hour end-over-end bottle leach at 1:5 w:v (solid:water) ratio using saline water (2 g/L NaCl), with filtered leachate analysed for the soluble analytes listed above.
- Peroxide (NAG) leach - analysis of the solution on completion of the NAG or NAG Extended test, with filtered leachate analysed for the same (or similar) suite of soluble analytes as listed above.
- Exchangeable cations (Calcium [Ca], Magnesium [Mg], Sodium [Na], Potassium [K]) (with pre-treatment for salinity, if required). Results were used to calculate the cation exchange capacity (CEC);
- Emerson Aggregate Class testing.

For most samples, excluding some historical samples/data, laboratory test work was undertaken by ALS Environmental (ALS) Brisbane, using National Association of Testing Authorities (NATA) accredited methods (where such accreditation exists). Mineralogical analysis (QXRD) was undertaken by a university (research) mineralogical laboratory in Melbourne (via Earth Systems Consulting).

#### 4.3.2 Solid Samples – Kinetic OxCon Tests

Oxygen consumption and carbon dioxide (CO<sub>2</sub>) generation (OxCon) test-work was undertaken by Earth Systems (Melbourne) on two samples (one coal and one spoil). The sample were selected on the basis of earlier static geochemical test results.

OxCon is a laboratory-scale kinetic geochemical test for the estimation of sulfide oxidation rates, acidity generation rates and carbonate neutralisation rates for sulfidic geological materials.

Prior to the OxCon test the sample is 'washed' to remove any pre-existing salts and oxidation rates, acidity generation rates and carbonate neutralisation rates for sulfidic geological minerals. Test-work then involves isolating a known mass of sulfide-bearing material in a known volume of oxygen inside a sealed vessel and allowing pyrite oxidation to proceed. Once the test is initiated, oxygen in the vessel is consumed via sulfide oxidation. Oxygen consumption is measured directly on an hourly basis and logged over the test-work period (1-8 weeks, depending upon the sample). Carbon dioxide generation is measured hourly and logged for estimation of the extent of acid neutralisation by carbonate minerals or the rate of biological organic carbon oxidation, if any, during testing.

At the conclusion of OxCon test, the solid undergoes a bottle leaching procedure at a 1:2 solid:water ratio and the leachate was analysed to determine the pH, acidity/alkalinity and concentration of soluble metals/metalloids and salts.

#### 4.4 Geochemical Source Hazard Assessment

Geochemical data was assessed with regard to the samples potential to generate AMD. Only after making such an assessment to understand the potential AMD hazard can appropriate AMD specific management measures be formulated to adequately mitigate the risks, as required.

#### 4.4.1 AMD Classification

The Acid-Base Account (ABA) method was used to assess the acid-neutralising and acid-generating characteristics of the samples in order to determine an acid (AD) classification for the mineral waste materials.

The maximum potential acidity (MPA) and acid neutralising capacity (ANC) represent each side of the acid-base account. MPA is calculated from total S and is the theoretical maximum potential acidity that can be generated if all of the S, assumed to be associated entirely with pyritic sulfide, is able to oxidise and generate acid (H<sub>2</sub>SO<sub>4</sub>). ANC represents the theoretical maximum amount of acid-neutralising capacity of a sample assuming all neutralising material is in a readily available form. The net acid producing potential (NAPP) is the difference between the MPA and the ANC. In simple terms, a negative NAPP indicates an excess of ANC and the sample is likely to be non-acid forming (NAF) and a positive NAPP indicates an excess of MPA and the sample is likely to be potentially acid forming (PAF) – though there can be exceptions to this simplified interpretation. Note that NAF samples have the potential to generate NMD and SD, depending on the sulfur concentration.

Sample classification of mineral waste material follows some general rules. Samples were initially classified using Total S, NAPP and ANC/MPA ratio (and NAG data, where available), into three broad categories:

- **NAF** Non-acid Forming;
- **PAF** Potentially Acid Forming;
- **Uncertain** Those samples with inconclusive results, leading to a degree of uncertainty about their ability to generate acid.

Where available, additional geochemical information such as Scr, ABCC, NAG extended and NAG sequential results were used to resolve acid classification uncertainties. The general approach was to build in a level of conservatism in the preliminary classification, as shown in Table 2.

Table 2. Preliminary AMD classification criteria.

PRELIMINARY CLASSIFICATION	SULFUR %	NAPP kg H <sub>2</sub> SO <sub>4</sub> /t	ANC/MPA RATIO	NAGpH (IF DATA AVAILABLE)
NAF	≤0.01	-	-	-
	≤ 1	< 0	≥ 2	-
	≤ 1	< 0	-	≥ 4.5
NAF-Sulfur (NAF-S)	> 1	< 0	≥ 2	-
	> 1	< 0	-	≥ 4.5
PAF – Low Capacity (PAF-LC)	≤ 1	≥ 0 and < 10	< 2	-
	-	≥ 0 and < 10	-	< 4.5
PAF	-	≥ 10	< 2	-
	-	≥ 10	-	< 4.5
Uncertain	Any result outside of the above criteria, or results that appear to significantly conflict with the expected result based on lithology or mineralogy			

Total S data was unavailable for 1 drill-core sample, which means that the MPA and NAPP cannot be calculated. This sample was classified using ANC and NAGpH data only, adopting a conservative classification as shown in Table 3.

Table 3. Preliminary AMD classification criteria for samples without total sulfur data.

PRELIMINARY CLASSIFICATION	ANC kg H <sub>2</sub> SO <sub>4</sub> /t	NAGpH	NAG CAPACITY kg H <sub>2</sub> SO <sub>4</sub> /t
NAF (weathered samples)	-	≥ 4.5	< 0.5
NAF (fresh samples)	≥ 10	≥ 4.5	< 0.5
Uncertain-NAF UC(NAF)	≥ 10	≥ 4.5 and < 7	< 0.5
	< 10	≥ 7	< 0.5
Uncertain-PAF UC(PAF)	< 10	≥ 4.5 and < 7	-
PAF	-	< 4.5	-

#### 4.4.2 Sulfur Category

To ensure a consistent approach to describe the samples geochemical characteristics, specific total S cut-off values were used to discuss sulfur data, as shown in Table 4.

Table 4. Sulfur category and associated cut-off.

SULFUR CATEGORY	TOTAL S WT. %
Very low	< 0.1
Low	0.1 – 0.5
Low-moderate	0.5 – 1.0
Moderate	1.0 – 1.5
High	> 1.5

#### 4.4.3 ANC Category

To ensure a consistent approach to describe the samples geochemical characteristics, specific ANC cut-off values were used to discuss ANC data as shown in Table 5.

Table 5. ANC category and associated cut-off.

ANC CATEGORY	ANC kg H <sub>2</sub> SO <sub>4</sub> /t
Very low	< 5
Low	5 - 15
Moderate	15 - 30
High	30 - 50
Very high	> 50

#### 4.4.4 Soil Salinity

The term 'soil' salinity (and 'soil' pH – refer below) is an industry-adopted term to refer to the salinity and pH measured on any solid geologic matrix, such as soil, spoil, rock, sediment, tailings, rejects, etc.

That is, in this context, the term 'soil' applies to all solid samples, not just shallow surface (root zone) material.

Classifying whether a sample/material is non-saline, highly saline, or somewhere in between will depend upon the methods used to measure soil salinity. Soil salinity data is obtained from a 1:5 (w:v) [and 1:2 w:v] water extract procedure typically on pulp samples (pulping the sample minimises the potential to underestimate salinity on sandy samples/materials). The soil salinity classes shown in Table 6 are expressed in units of microSiemens per centimeter ( $\mu\text{S}/\text{cm}$ ) and are based on a 1:5 w:v method. These soil salinity classes are used as an indicative guide. The classes are broadly based on soil salinity classes reported by DME (1995).

Table 6. Soil salinity classification.

SOIL SALINITY CLASSIFICATION	EC1:5 $\mu\text{S}/\text{CM}$
Non-saline	< 450
Slightly saline	450 - 900
Moderately saline	900 - 2000
Saline	2000 - 4000
Strongly saline	> 4000

#### 4.4.5 Soil pH type

Classifying whether a sample/material is acid, pH-neutral or alkaline or somewhere in between will depend upon the methods used to measure soil pH. Soil pH data is obtained from a 1:5 (w:v) water extract procedure typically on pulp samples. The soil pH types shown in Table 7 are based on a 1:5 w:v method. These soil pH types are used as an indicative guide.

Table 7. Soil pH type and associated cut-off.

SOIL pH TYPE	pH1:5
Highly acid	< 3.0
Moderately acid	3.0 – 4.5
Weakly acid	4.5 – 6.0
Near neutral	6.0 – 7.5
Alkaline	7.5 – 9.0
Highly alkaline	> 9.0

#### 4.4.6 Mineralogy

Mineralogical data (QXRD) provides supporting information for the geochemical data, particularly with regard to sulfide and carbonate mineralogy of a sample, showing results for mineralogical forms (e.g. what sulfide or carbonate minerals are present) and their concentrations (reported in weight %). These data are also used to validate the results from ABCC test-work and assist with interpretation of the ABA data.

#### 4.4.7 Element Enrichment

The total concentration for each element were compared to average element abundance in soil in the earth's crust (Bowen, 1979) to measure how the total elemental concentrations in the samples compare

against average elemental concentrations in unmineralised soil (worldwide). Such a comparison is undertaken to identify samples that contain what may be regarded as 'elevated' concentrations of metals and metalloids to identify potential element of concern. However, enrichment in any metals/metalloids in the solids, does not translate to enhanced leachability or mobilization and/or bioavailability of that specific element.

From the comparison with average crustal abundance in rocks a geochemical abundance index (GAI) was calculated. The GAI quantifies an assay result for a particular element in terms of the average abundance for that element (in sedimentary rocks). The index, based on a log 2 scale, is expressed in seven integer increments (0 to 6), which correspond to enrichment factors from 0 to over 96 times average crustal abundance, as shown in Table 8.

Table 8. Geochemical abundance index (GAI).

GAI	ENRICHMENT FACTOR	GAI	ENRICHMENT FACTOR
0	Less than 3-fold enrichment	4	24 to 48-fold enrichment
1	3 to 6-fold enrichment	5	48 to 96-fold enrichment
2	6 to 12-fold enrichment	6	Greater than 96-fold enrichment
3	12 to 24-fold enrichment		

As a general rule, a GAI greater than or equal to three indicates enrichment compared to unmineralised soil that may warrant further investigation to assess their mobility under laboratory conditions.

Elements identified as enriched may not necessarily be a concern for revegetation and rehabilitation, human and animal health or drainage water quality. Similarly, if an element is not enriched it does not mean it would not be mobilised, because under some conditions (e.g. low pH, reducing conditions) the geochemical behaviour of metals/metalloids such as Al, As, Cu, Cd and Zn can change (i.e. become less or more mobile).

#### 4.4.8 Solubility

Metal/metalloid mobility from samples has been assessed using deionised water, saline water and peroxide (NAG) leaching methods. The deionised water and saline water leaches assess the initial solubility under fresh water and saline water conditions, whereas the peroxide water leach assesses the solubility after the samples have been oxidised. The objective of the saline leaching procedure is to mimic the brackish to moderately saline water commonly used in CHPP to process ROM coal.

The solubility data from bottle leaching provides an indication of likely solubility/release of salt and metals/metalloids under field pH and redox (oxidation) conditions (and/or saline or low-pH conditions, where applicable). Peroxide (NAG) leachate data provides an indication of potential acidity and concentrations of metals and metalloids that could be released from samples that are fully and rapidly oxidized. This test provides an assumed 'worst case' scenario in term of metal/metalloid mobility. Solubility data from OxCon testing provides an indication of likely solubility/release of salt and metals/metalloids when the samples are oxidised and can be used to estimate release rates.

To ensure a consistent approach to describe the samples geochemical characteristics, specific concentration cut-off values were used to discuss leachate composition as shown in Table 9.

Table 9. Soluble trace element concentration category and associated cut-off.

CLASSIFICATION	TRACE ELEMENT SOLUBLE CONCENTRATION mg/L
Close to detection	≤ 0.001
Very low	> 0.001 – 0.05
Low	> 0.05 – 0.1
Moderate	> 0.1 – 1.0
High	> 1.0 – 10
Very high	> 10

A classification scheme initially developed by Ficklin et al. (1992) has been adapted to summarise major attributes of the solubility data by plotting pH against soluble metal and metalloid concentrations for groups of elements, with the classification scheme shown in Figure 10. The soluble metal and metalloid concentrations are shown as the sum of soluble metal concentrations for base metals (Cd + Co + Cu + Ni + Pb + Zn) and/or the sum of soluble As + Mn + Mo + Se. These two groups of elements are chosen because they remain in solution across a wide range of pH and are not only associated with AD conditions, but also with NMD/SD conditions.

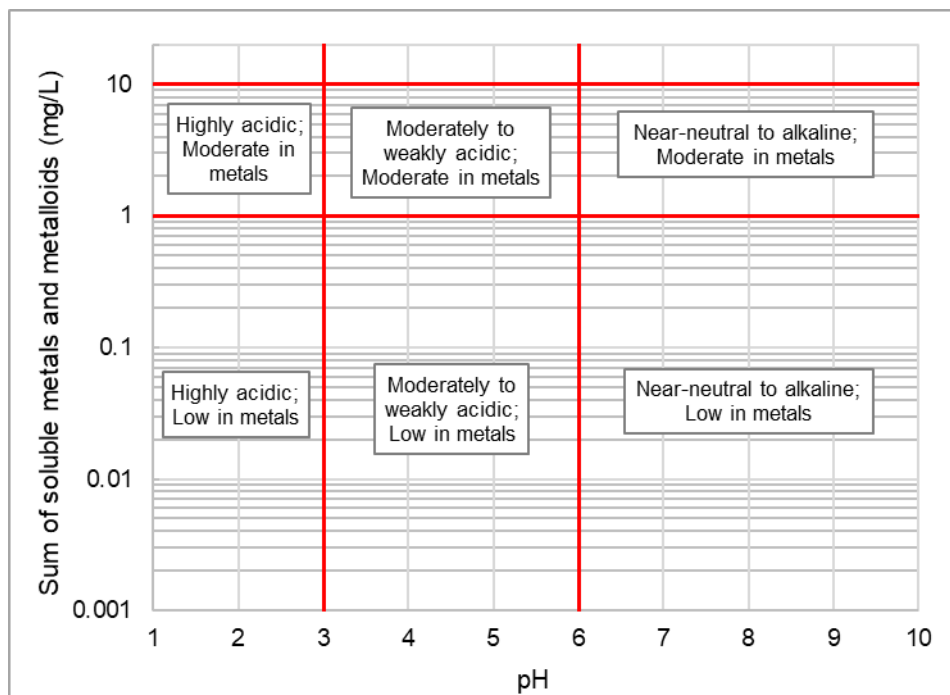


Figure 10. Classification of soluble metals and metalloids as a function of pH.

No comparison is made between leachate results and water quality guideline values, such as ANZG (2018), as such a comparison is inappropriate. The guideline values provided in ANZG (2018) are for receiving water environments (e.g. creeks), whereas the soluble element data in this assessment is ‘point source’ obtained from a finely pulped sample subjected to rigorous and artificial extraction to obtain a concentration approaching ‘near maximum’. Furthermore, contact water will undergo a number of geochemical reactions along a pathway from source to receptor, including: retardation, adsorption and precipitation – and also likely dilution, which will attenuate the concentration as seepage/contact water migrates from the source. These processes are not accounted for in a laboratory setting.

#### 4.4.9 Sodicity and Dispersion

Potential spoil samples (representing material that is likely to report to final landform surface) are broadly classified with respect to sodicity on the basis of the exchangeable sodium percentage (ESP) value, as shown in Table 10 (after Northcote and Skene, 1972; Isbell, 2002):

Table 10. Sodicity classification.

SODICITY CLASSIFICATION	ESP %
Non-sodic	≤ 6
Sodic	6 – 14
Strongly sodic	> 14

The sodicity will depend upon a range of factors, such as clay mineralogy, soil sodium concentration, soil salinity and irrigation water (rainwater) chemistry, which may enhance or limit that potential for soil to be sodic or become sodic over time. Therefore, values of 6% ESP and 14% ESP to represent soils as being sodic or strongly sodic are used as a general guide only and should not be taken as definitive. Sodidity assessments only apply to materials likely to report to final landform surfaces, such as overburden/interburden (i.e. not coal rejects or waste coal).

Sodidity information is broadly used to understand potential revegetation and dispersion aspects, and is supported by Emerson Aggregate Class test information, which provides a direct measure of soil slaking and dispersion based on the Standards Australia (2017) classification. Soils are divided into classes on the basis of their coherence in water and presence (or absence) of calcium-rich minerals (Table 11).

Slaking occurs when dry soil crumbs, after being immersed in deionised water, break up and run along the bottom of the beaker into a flat pile. Most dry soil crumbs slake when immersed in deionised water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in deionised water. Materials are generally regarded as being dispersive (or prone to dispersion) if they have an Emerson Class number of three or less.

Table 11. Emerson classifications.

CLASS	DESCRIPTION	CLASS	DESCRIPTION
1	Slaking and complete dispersion	5	<i>No calcite or gypsum present; dispersion</i>
2	Slaking and some dispersion	6	<i>No calcite or gypsum present; flocculation</i>
3	Dispersion [remoulded]	7	<i>Non-slaking and swelling</i>
4	<i>Calcite or gypsum present; no dispersion</i>	8	<i>Non-slaking and non-swelling</i>

#### 4.4.10 Using Coal Quality Data for AMD Classification

Coal quality data has been used to aid in the assessment of AMD hazard associated with coal seams. In particular, the WHD coal quality database was used to supplement the geochemical database and provide additional understanding of the AMD potential of potential ROM coal, remnant coal, waste coal and rejects. Coal plys were grouped into their respective seam groups on a per-pit basis, such as Leichhardt seam group and Upper Vermont seam group for DNM.

Total S concentrations can be used conservatively to assess the AMD hazard for any given sample; thus, statistical analyses were conducted on total S as a function of seam group and for all seams combined to define the AMD hazard of coal.

The data were used to understand the sulfur grade range for each seam group to gain an understanding of the potential AMD hazard posed by each coal seam group (and by inference, potential rejects materials). The results were then compared with detailed geochemical data available for coal and rejects to 'calibrate' the coal quality total sulfur data.

Coal samples from less than 20 m depth were assumed to be completely or predominantly oxidised and were assigned as 'weathered carbonaceous spoil' and, therefore, excluded from the assessment of potential ROM coal. For context, of the 26,798 m of drill-hole data available from the coal quality database, approximately 58 m were assigned as 'weathered coal'. Acid producing sulfate minerals, such as jarosite, may be present within the weathered coal and carbonaceous material, however, mineralogical data available from DNM suggests that jarosite is likely an insignificant mineral.

#### *4.4.11 Residual Void Highwall Assessment*

An assessment of the AMD hazard associated with exposures of all lithological materials, such as remnant coal, weathered materials, fresh non-carbonaceous and carbonaceous overburden was undertaken.

The frequency of occurrence of relevant material types within each pit was determined from the stratigraphic distribution within representative drill holes under the assumption that the frequency of distribution of each material type is broadly indicative of their respective surface exposures on current highwalls. For example, if Leichhardt seam group had a frequency of occurrence of 5% in the drill-hole data set, then the assumption is that the same coal seam group would represent approximately 5% of the surface exposure on the highwall. This method – whilst being relatively simple – provides an acceptable approximation with regard to which seam groups or mineral waste types are most likely to be significantly present in pit walls versus those material types present in relatively minor and less significant proportions.

The following method was used for estimating the proportion of key material domains on the highwalls in each pit:

Exploration drill-holes in proximity to the current/recent highwall/s were selected for each pit or pit group. The holes extended to depths approximating future pit floor depths. Titan North and Titan Central voids were assessed together and utilised data from 146 drillholes, Titan East void used data from 97 drillholes and Pandora void used data from 59 drillholes.

Stratigraphy, age, weathering, location with respect to the water table, and major stratigraphic horizons (as recorded in the coal geology database) were used to assign individual (discrete) lithological units to a material domain as follows:

- Weathered, non-carbonaceous;
- Weathered, carbonaceous (includes weathered coal);
- Fresh, non-carbonaceous;
- Fresh, carbonaceous;
- Fresh, coal.

Coal plies were grouped into their respective seam groups, such as Leichhardt seam group, Vermont seam group etc.

For each pit highwall, a statistical assessment was conducted on each drill-hole sub-set (as applicable to each pit) to summarise the frequency of occurrence of drill core intervals as a function of each of the material groups listed above.

The inherent AMD hazard of each material group listed above was inferred from the environmental geochemical database and coal quality database for similar material types. The combined AMD hazard for the material groups likely to be exposed on the highwall was then used to estimate the AMD hazard of the highwall at each pit.

The pit highwall AMD hazard assessment is based on data being representative of current and near-future mining (indicatively now to 10 years). The DNM coal resource model was used to estimate coal resources and overburden/interburden proportions from current pit highwall through to the expected highwall position of the pit at closure. Note that some current pits will be backfilled as mining—therefore the pit highwall assessment has only been undertaken on those pits that remain as residual voids at closure. The resource model indicates that—at closure—the proportion of coal versus non-coal in the highwall of all pits is broadly consistent with the current proportions on the pit highwalls. The model also shows that the proportion of each seam group is expected to be similar to current seam group proportions on the pit highwall of all pits. As such, the proportions of the various mineral waste types on the pit highwall and floor for all pits will not change significantly from those shown.

Therefore, the overall AMD hazard posed by the pit highwall and floor of the residual voids at end of mining is expected to be similar to that shown in the current highwalls and pits.

#### *4.4.12 Residual Void Floor Assessment*

An assessment of the AMD hazard associated with exposures of remnant coal on the pit floor was undertaken.

As explained in Section 4, coal quality data was assessed to understand the potential AMD hazard associated with coal. For the task of assessing the AMD hazard specific to pit floors (on a per pit basis), only the coal quality data from the seam group likely to form the pit floors at a given pit was assessed. At DNM, the base of mineable coal is the V3 ply (base of the Vermont Upper V2/3 seam group) and therefore forms the floor of residual voids (Figure 2).

It is acknowledged that there are generally minor geochemical differences between the various plies of any given seam group. Also, the AMD hazard of the floor of a pit may change depending on whether a significant proportion of the pit floor resides on coal(ly) or non-carbonaceous material. Furthermore, the AMD hazard of any pit floor is not just associated with its surface exposure, but more so with the composition of the sub-drill zone, which represents an extensively fractured coal / interburden comprising the upper sections of a pit floor. For this assessment, the AMD hazard was estimated only for assumed surface exposures of coal / plies.

In practice, mining takes all coal to the bottom of the seam (at the bottom of a pit), therefore very little coal would be expected to remain on the floor of the voids. As such, the assessment has adopted a highly conservative position assuming the floor of each void is all coal, and the coal floor is completely exposed.

#### 4.4.13 AMD Hazard Scoring

Estimating the AMD hazard is the first step in estimating the geochemical risk associated with potential sulfide oxidation of mineral wastes. MWM assisted with the development of a procedure to standardise the AMD hazard assessment to maintain consistency across all BHP coal sites and material domains within similar geological environments. The process is described below.

AMD hazard scoring and the AMD geochemical likelihood ranking describe the Geochemical Hazard. The former describes the hazard for AMD generation and the latter describes the likelihood of an AMD event to occur.

A source material is a distinct material type (e.g. non-carbonaceous spoil or rejects), whereas a landform is a domain comprising one or more source material types (e.g. rejects disposed within non-carbonaceous and carbonaceous spoil). AMD hazard scorings are assigned using individual source materials reporting to a landform as well as to landform domain properties as a whole.

The likelihood of a landform developing AMD was determined based on the AMD hazard scoring of a landform. AMD hazard scores are estimated by analysing three key components, which are used to describe the geochemical hazard of a source material/landform:

- Geochemical propensity to generate AMD;
- AMD capacity; and
- AMD quantity.

In undertaking the AMD hazard assessment, the assumption is that the source materials (within the landforms) will predominantly be dry or moist, but not wet or saturated. That is, the landforms will be unsaturated. This assumption is realistic, since most spoil landforms are generally unsaturated. This assumption is also conservative, since the potential for oxidation (to some degree) is assumed.

Table 12. AMD hazard scoring matrix.

COMPONENT	RATING	CATEGORY	DEFINITION
Propensity for AMD generation All material types/domains - Non-carb. - Coaly & carb. - Rejects  Per spoil landform	1	Implausible	Geochemical properties suggest that the vast majority of the material has a negligible potential for AMD generation (less than 5% of the samples identified at potential for AMD in the samples set)
	5	Plausible	Geochemical properties suggest that significant proportion of the material may have potential for AMD generation (5-40% of the samples identified at potential for AMD in the samples set)
	7	Expected	Geochemical properties strongly suggest that the material has a high potential for AMD generation but has not yet been observed in the field (due to lag time) -(>40% of the samples identified at potential for AMD in the samples set)
	15	Certain	AMD issues have been observed in the field
AMD <u>Capacity</u> All material types/domains - Non-carb. - Coaly & carb. - Rejects  Per spoil landform	1	Low	Source has a negligible potential for AMD generation with 75 <sup>th</sup> percentile total S less than 0.1%
	3	Moderate-Low (NMD)	Dominant AMD sources contain material that will likely generate NMD and/or SD (related to sulfide oxidation). Assumed to be bulk NAF but sulfide bearing, with NAF samples having 75 <sup>th</sup> percentile total S greater than 1%
	5	Moderate	Dominant AMD sources with 75 <sup>th</sup> percentile total S concentration ranging 0.2-0.5% and with potential to generate AD.
	7	Moderate-High	Dominant AMD sources with 75 <sup>th</sup> percentile total S ranging 0.5-1% and with potential to generate AD.
	10	High	Dominant potential AMD sources with 75 <sup>th</sup> percentile total S >1% and with potential to generate AD.
AMD <u>Quantity</u> All material types/domains : - Non-carb. - Coaly & carb. - Rejects  Per spoil landform	1	Low	All material rated LOW for AMD capacity; or less than 5% of waste is rated MODERATE-LOW for AMD Capacity
	3	Moderate-Low	Less than 5% of mineral waste rated as MODERATE for AMD capacity
	5	Moderate	Greater than 5% of mineral waste rated as MODERATE or MODERATE-LOW for AMD capacity
	7	Moderate-High	Less than 5% of mineral waste rated as MODERATE-HIGH or HIGH for AMD capacity
	10	High	Greater than 5% of mineral waste rated as MODERATE-HIGH or HIGH for AMD capacity
AMD <u>Quantity</u> Residual void (pit) highwall & floor  Per residual void	1	Low	Less than 10% of drill-hole meters (or less than 10% of pit floor exposure) are classified as PAF
	3	Moderate-Low	Between 10% and 30% of drill-hole meters (or 10-30% of pit floor exposure) are classified as PAF
	7	Moderate-High	Greater than 30% of drill-hole meters (or greater than 30% of pit floor exposure) are classified as PAF
	10	High	Observed AMD on highwall or pit floor or AMD affected water in pit

**AMD Propensity** is the geochemical propensity of a given material type to generate AMD. The propensity to generate AMD is determined based on the proportion of samples that have expressed potential for AMD as determined from laboratory test-work and the subsequent assessment—the higher the percentage of materials that can generate AMD within a sample set, the greater the AMD propensity.

**AMD Capacity** represents the ‘severity’ of AMD generation, with total S concentrations used as a proxy for scoring this component, which represents a conservative approach as some sulfur is associated with non-acid generating minerals. For example, the higher the total S concentration in materials with potential for AMD, the higher the hazard, the higher the score. Furthermore, the AMD capacity also takes into account the type of drainage a source material can produce, i.e. AD, NMD and/or SD, where discrimination or prediction is possible. The various drainage types should be differentiated (where the data allows) to reflect the difference in impact severity and difficulty to manage or treat. For example, on an equal quantity basis, AD is likely going to cause more severe impacts than NMD or SD and therefore is assigned a higher score.

As a first approximation the AMD Capacity of each material type is estimated based on 75<sup>th</sup> percentile value of the total S concentration for the samples classified as PAF. This is a conservative assumption, as not all total S is associated with reactive minerals and choosing the 75<sup>th</sup> percentile total S value of PAF and NAF-S samples to assess the AMD Capacity will attract a higher AMD Capacity scoring. For example, if two material types had the same proportion of samples with the same propensity for AMD, but one has a higher total S concentration associated with PAF and NAF-S materials, then this sample would receive a higher AMD Capacity score.

**AMD Quantity** is the amount of material (tonnages) that has the potential to generate AMD. The greater the tonnage of AMD generating material the greater the hazard scoring. The AMD Quantity scores are assigned to material types for each landform.

#### 4.4.14 AMD Likelihood Ranking

The likelihood of a landform generating AMD is estimated by analysing two key components:

- Source material AMD hazard score; and
- Landform AMD hazard score.

**Source material AMD hazard score:** Describes the likelihood for AMD generation by the respective material type. It is estimated from the weighted combined scores of each component used to describe the AMD source hazard:

- Propensity to generate AMD. Assigned a 50% weighting (weighting = 1);
- AMD capacity. Assigned a 25% weighting (weighting = 0.5); and
- AMD quantity. Assigned a 25% weighting (weighting = 0.5)

**Landform AMD hazard score:** Describes the likelihood for AMD generation by landform domain. It is estimated from the AMD source material hazard scores for each material type assumed to be present within that specific landform. At closure, DNM has four residual void domains which will form a single spoil landform as outlined in Section 2.1.

- Spoil landform: the AMD landform score estimated using the weighted average of the AMD source material scores and the PAF and NAF-S quantities (as a proportion of total waste within the landform) likely to report to the landform from each material type. Note that only one sample

(out of 1046 samples in total) was classified as NAF-S. As such, the proportion of NAF-S samples in spoil dumps is insignificant relative to PAF samples and other NAF samples.

- Residual voids: the AMD landform score estimated from the average of the AMD source material hazard scores for each material type likely to be exposed on the highwalls or floor of each residual void.

To support the assessment of the AMD closure risks, the landform AMD hazard score is assigned a likelihood score (Table 13), which is broadly aligned with ISO 31000. ISO 31000 is a family of standards relating to risk management codified by the International Organization for Standardization. For landform and residual voids with AMD hazard score between 10 and 20 a preliminary likelihood of 'Probable/Likely' is assigned unless/until kinetic data are available to provide a time frame for AMD generation. The likelihood can be revised as more data, such as kinetic or field data, becomes available.

Table 13. AMD hazard ranking and landform AMD likelihood ranking.

AMD HAZARD RANKING	LANDFORM AMD LIKELIHOOD RANKING
0 - 5	Highly Unlikely: Highly unusual; may occur in extreme circumstances
5 - 10	Unlikely: Known to occur, but only rarely
10 - 15	Probable: May occur
15 - 20	Likely: Could easily occur
>20	Highly Likely: Expected to occur

For landforms domains (including voids) with AMD hazard ranking greater than 10, a conservative likelihood ranking of 'Likely' should initially be assigned, if no kinetic data are available to provide a time frame for AMD generation. This likelihood ranking can be revised as more data becomes available, such as kinetic or field data becomes available.

## 5 RESULTS

Environmental geochemical data sufficient to enable a sample to be classified with respect to AMD hazard (e.g., NAF, PAF, or a sub-classification) is available for 909 samples (as defined in Section 4.2), which have undergone a range of environmental geochemical and mineralogical tests. The environmental geochemical and mineralogical test-work results for all samples are presented and discussed.

### 5.1 Mineralogy

Data is available for 10 potential spoil samples, 1 coal sample, 2 tailings samples, 2 rejects samples, and 4 MPR samples that underwent mineralogical analysis by Quantitative X-Ray Diffraction (QXRD).

The spoil samples were selected to cover a broad range of spoil types - weathered non-carbonaceous (3 samples), fresh non-carbonaceous (5 samples) and fresh carbonaceous (2 samples). Results, summarised in Figure 11, show that most samples (of all types, but especially the spoil samples) are dominated by silicate group minerals - predominantly quartz and clay minerals, with variable contributions of other silicate minerals and carbonate.

Amorphous (non-crystalline) material was detected in all samples - with a wide range of concentration from 0.2% to 54.3% - but generally present in greater proportions in the coal rejects, MPR, tailings and carbonaceous spoil samples compared to the non-carbonaceous samples. The nature of the noncrystalline material is largely unknown, although for coal rejects, tailings, MPR and similar carbonaceous waste it is most likely associated with organic carbon.

All samples have low sulfide mineral proportions, with the highest concentrations being in the rejects, tailings and coal samples. Sulfide is present mostly as pyrite with minor marcasite (marcasite is another form of  $\text{FeS}_2$ , similar to pyrite). All samples have low (negligible) sulfate concentrations.

Carbonate group minerals predominantly comprise ankerite (Fe-dolomite), calcite and siderite in variable proportions. ABCC data for these samples indicated that iron-dolomite (+/- minor dolomite) and siderite were the likely dominant carbonate minerals, which is broadly consistent with the mineralogy data.

Water quality data is available for liquor (supernatant) associated with tailings production (with the liquor recycled back into the CHPP). The data shows that liquor generally has a low alkalinity, therefore water from the CHPP is not likely to be a significant contributor to the carbonate present in rejects and tailings from the CHPP.

In summary the key acid generating mineral is pyrite (+/- marcasite), and the key acid neutralising minerals are iron-dolomite and calcite. Although siderite is a carbonate, it provides no net acid neutralising capacity.

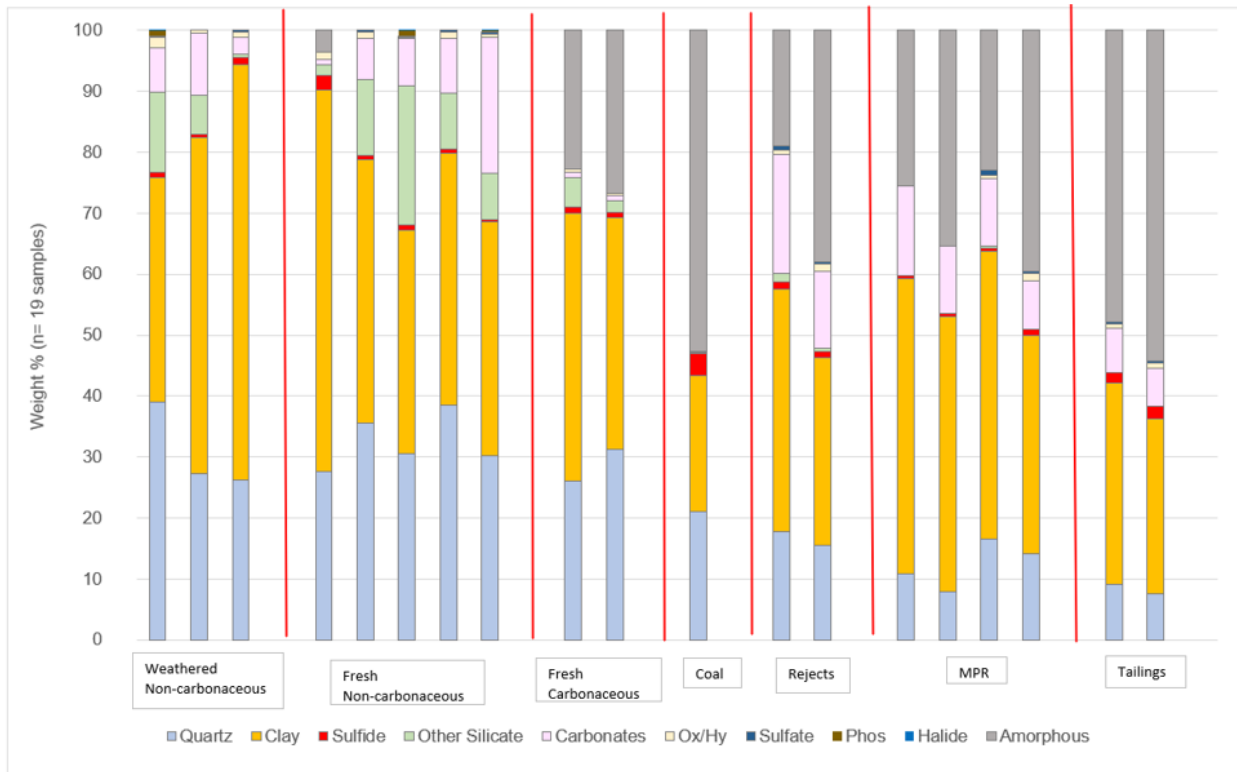


Figure 11: Mineral distribution within spoil and rejects samples.

### 5.2 Acid-Base Accounting (Potential for AMD)

Acid-base accounting (ABA) is a theoretical balance between the potential for a sample to generate acid and neutralise acid, and is expressed in units of kilograms of sulfuric acid per tonne of sample (kg H<sub>2</sub>SO<sub>4</sub>/t). The ABA results for the samples that underwent geochemical characterisation are statistically summarised in Table 14 (spoil) and Table 15 (coal, tailings, rejects, and MPR) and discussed in the following sections.

Table 14: ABA results statistics for spoil materials.

		TOTAL S <sup>1</sup>	SCR <sup>2</sup> (S)	ANC	MPA <sup>3</sup>	NAPP	ANC/MPA	NAGpH <sup>4</sup>
		%			Kg H <sub>2</sub> SO <sub>4</sub> /T		RATIO	pH
Potential Spoil Weathered, non- carbonaceous.	Count (n)	139	3	136	139	136	136	1
	Maximum	0.42	0.1	225	13	1	1469	8.0
	95 <sup>th</sup> percentile	0.03	0.09	124	0.9	-4	583	-
	75 <sup>th</sup> percentile	0.01	0.06	57	0.3	-9	234	-
	Median	<0.01	0.01	22	<0.3	-21	101	-
	25 <sup>th</sup> percentile	<0.01	0.01	10	<0.3	-56	46	-
	5 <sup>th</sup> percentile	<0.01	0.01	6	<0.3	-123	11	-
	Minimum	<0.01	<0.01	<0.5	<0.3	-225	2	-
Potential Spoil Weathered, carbonaceous.	Count (n)	11	5	11	11	11	11	1
	Maximum	0.20	0.08	30	6	-3	20	5.1
	95 <sup>th</sup> percentile	0.18	0.07	27	5	-3	20	-
	75 <sup>th</sup> percentile	0.09	0.03	13	3	-4	15	-
	Median	0.07	0.01	10	2	-6	11	-
	25 <sup>th</sup> percentile	0.01	0.01	6	0.3	-10	4	-
	5 <sup>th</sup> percentile	0.01	0.01	4	0.3	-24	2	-
	Minimum	<0.01	<0.01	3	0.3	-28	2	-
Potential Spoil Fresh, non- carbonaceous.	Count (n)	391	59	369	391	369	369	13
	Maximum	0.76	0.73	490	23	19	3200	9.3
	95 <sup>th</sup> percentile	0.11	0.18	135	3	1	431	9.0
	75 <sup>th</sup> percentile	0.04	0.08	63	1	-16	122	8.2
	Median	0.02	0.04	32	0.6	-29	53	7.0
	25 <sup>th</sup> percentile	0.01	0.01	19	0.3	-59	22	5.8
	5 <sup>th</sup> percentile	<0.01	0.01	9	<0.3	-133	5	2.6
	Minimum	<0.01	<0.01	<0.5	<0.3	-490	0.06	2.5
Potential Spoil Fresh, carbonaceous.	Count (n)	92	29	93	92	92	93	14
	Maximum	0.91	0.87	66	28	15	82	9.7
	95 <sup>th</sup> percentile	0.24	0.28	38	7	0.4	41	9.3
	75 <sup>th</sup> percentile	0.11	0.11	18	3	-4.5	18	7.1
	Median	0.04	0.11	13	1	-10	8	6.3
	25 <sup>th</sup> percentile	0.03	0.04	8	0.8	-16	3	4.2
	5 <sup>th</sup> percentile	0.02	0.02	3	0.5	-37	0.9	2.8
	Minimum	<0.01	<0.01	<0.5	<0.3	-62	0.1	2.3
All Potential Spoil	Count (n)	633	96	609	633	609	609	29
	Maximum	0.91	0.87	490	28	19	3200	9.7
	95 <sup>th</sup> percentile	0.14	0.19	120	4	0	469	9.2
	75 <sup>th</sup> percentile	0.04	0.09	55	1	-11	123	7.8
	Median	0.02	0.04	24	0.6	-23	44	6.6
	25 <sup>th</sup> percentile	0.01	0.02	13	0.3	-52	17	4.7
	5 <sup>th</sup> percentile	<0.01	0.01	5	0.2	-112	3	2.5
	Minimum	<0.01	<0.01	<0.5	<0.3	-490	0.1	2.3

<sup>1</sup>Total S values less than laboratory limit of reporting (LOR) were assigned a value of 0.5xLOR for statistical calculations.

<sup>2</sup>Scr was generally measured on potential spoil samples with total S greater than 0.1%. Scr values less than laboratory limit of reporting (LOR) were assigned a value of 0.5xLOR for statistical calculations.

MPA calculated from total S.

<sup>4</sup>NAGpH is final pH as NAG single addition and/or NAG extended.

Table 15: ABA results statistics for coal and tailings, rejects, and MPR materials.

		TOTAL S <sup>1</sup>	SCR <sup>2</sup> (S)	ANC	MPA <sup>3</sup>	NAPP	ANC/MPA	NAGpH <sup>4</sup>
		%			Kg H <sub>2</sub> SO <sub>4</sub> /T		RATIO	pH UNITS
Coal	Count (n)	77	76	78	77	77	78	1
	Maximum	2.21	1.8	114	68	66	27	2.4
	95 <sup>th</sup>	0.52	0.26	54	16	14	10	-
	75 <sup>th</sup>	0.29	0.11	14	9	5	2	-
	Median	0.24	0.06	9	7	-2	1	-
	25 <sup>th</sup>	0.18	0.03	3	6	-7	0.3	-
	5 <sup>th</sup> percentile	0.12	0.02	0.3	3.6	-48	0.0	-
	Minimum	0.04	0.01	<0.5	1.2	-110	0.0	-
Rejects	Count (n)	52	43	52	52	52	52	49
	Maximum	1.00	0.84	222	31	-4	33	11.0
	95 <sup>th</sup>	0.80	0.60	150	25	-15	23	10.3
	75 <sup>th</sup>	0.61	0.46	103	19	-37	8	9.0
	Median	0.49	0.32	68	15	-57	5	8.5
	25 <sup>th</sup>	0.34	0.23	52	10	-87	3	8.1
	5 <sup>th</sup> percentile	0.17	0.12	27	5.2	-144	2	6.8
	Minimum	0.13	0.08	20	4.0	-206	1	2.9
MPR	Count (n)	86	77	86	86	86	0	0
	Maximum	1.24	0.86	182	38	17	27	10.6
	95 <sup>th</sup>	0.76	0.59	117	23	1	14	10.0
	75 <sup>th</sup>	0.56	0.37	71	17	-15	6	9.1
	Median	0.38	0.27	43	11	-30	4	8.3
	25 <sup>th</sup>	0.27	0.16	28	8	-57	2	7.8
	5 <sup>th</sup> percentile	0.14	0.05	14	4	-105	1	5.5
	Minimum	0.08	0.02	10	2	-175	0.4	2.5
Tailings	Count (n)	61	52	61	61	61	61	58
	Maximum	1.59	1.34	86	49	5	9	10.6
	95 <sup>th</sup>	1.06	0.82	78	32	0	7	9.8
	75 <sup>th</sup>	0.82	0.58	57	25	-15	3	8.9
	Median	0.63	0.41	48	19	-25	2	8.2
	25 <sup>th</sup>	0.49	0.32	33	15	-35	2	7.7
	5 <sup>th</sup> percentile	0.30	0.17	19	9	-57	1.0	3.7
	Minimum	0.18	0.13	13	6	-72	0.7	2.9

1 Total S values less than laboratory limit of reporting (LOR) were assigned a value of 0.5xLOR for statistical calculations.

2 Scr was generally measured on all coal samples (except one) and on about 86% of tailings/rejects/MPR samples..

3 MPA calculated from total S.

4 NAGpH is final pH as NAG single addition and/or NAG extended.

### 5.2.1 Sulfur and Sulfide

The total sulfur (total S) concentration of spoil samples was generally very low to low - with a very low median value of 0.02% and low 95<sup>th</sup> percentile value of 0.14% (Figure 12).

The total S distribution in MPR samples was higher than potential spoil samples and ranged from 0.08% to 1.24%, with a low median value of 0.38% and a low-moderate 95<sup>th</sup> percentile value of 0.76% (Figure 12). Similarly, rejects samples also showed higher total S concentration than potential spoil samples

and ranged from 0.13% to 1.00%, with a low-moderate median value of 0.49% and a low-moderate 95<sup>th</sup> percentile value of 0.80% (Figure 12).

Tailing samples reported the highest total S concentration with values ranging from 0.18% to 1.59%, with a low-moderate median value of 0.63% and a low-moderate 95<sup>th</sup> percentile value of 1.06% (Figure 13).

Coal samples had relatively low total S median value and a high 95<sup>th</sup> percentile value of 0.24% and 0.52%, respectively. For comparison, total S data is available within the WHD coal quality database for 1499 coal (seam) samples from DNM, had median and 90<sup>th</sup> percentile total S values of 0.39% and 0.53%, respectively. The total S distribution in coal from the smaller geochemical dataset (n=112) is comparable to the total S distribution in coal from the much larger coal quality dataset (n=1499).

As evident in Figure 12, the total S concentrations were higher in the coaly and carbonaceous materials compared to the non-carbonaceous materials, however, with the exception of the tailings samples, were still generally low.

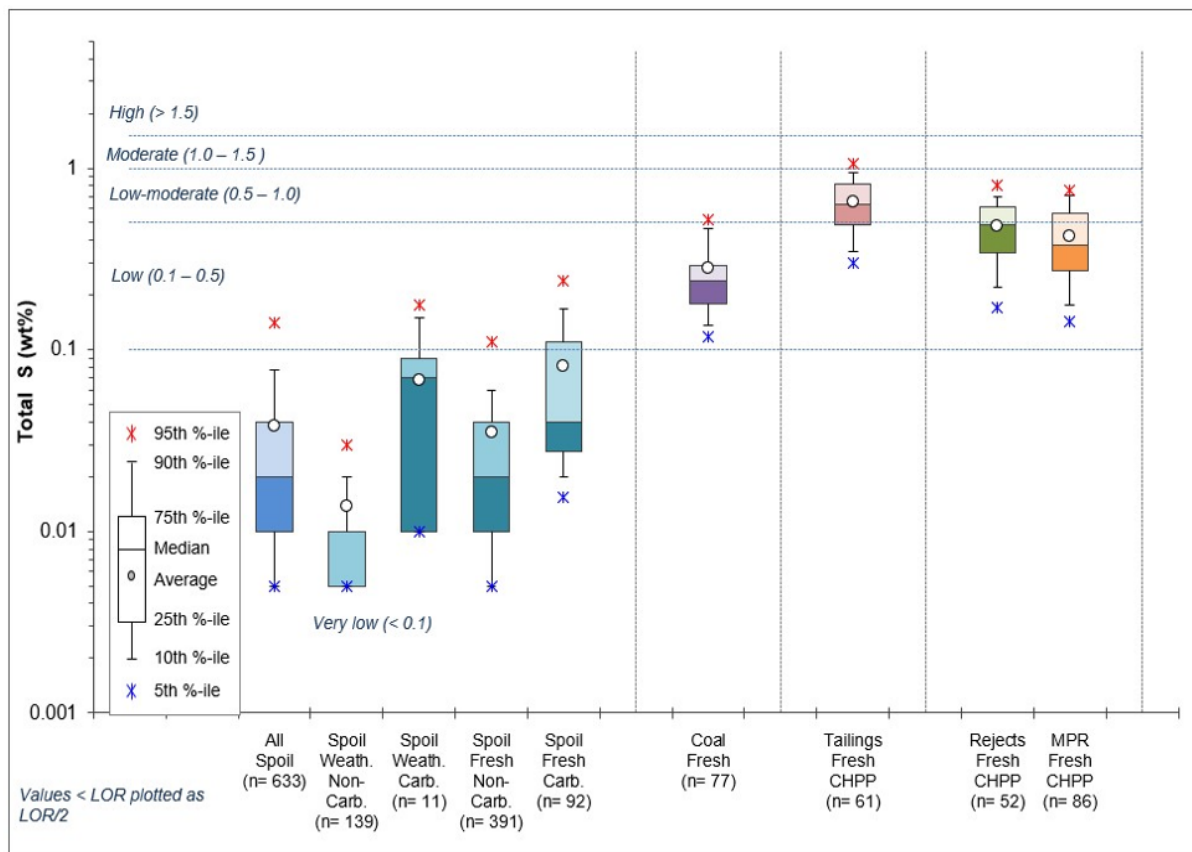


Figure 12: Sulfur (S) distribution [all samples].

Note: The 'Spoil Weath. Non-Carb.' boxplot has a minimum value of 0.005 up to 0.1 at the 75th percentile. Hence, only the range from the median to the 75th percentile shows due to overlap.

Chromium reducible sulfur (Scr) data is available for 344 samples (96 potential spoil samples, 76 coal samples, 52 tailing samples, 43 reject samples, and 77 mixed plant rejects samples). For the spoil and coal samples, Scr was generally measured on samples with total S values greater than 0.1%, therefore the Scr distribution is skewed slightly higher for spoil and coal samples generally. Where sulfide was measured in weathered samples, this was generally only in those samples described as being 'slightly' weathered.

For rejects, tailings and MPR samples, Scr data is available for 86% of the combined samples. The decision to analyse for Src was not based on a total S value like it was for the spoil samples.

The total S and Scr distributions are shown in Figure 13 and Figure 14. Scr values in most spoil samples were generally very low - consistent with the generally low total S values, with median and 95<sup>th</sup> percentile values of 0.11% and 0.34%, respectively (Figure 13). Similarly, Scr values in all coal samples were also generally very low - consistent with the low total S values, with median and 95<sup>th</sup> percentile values of 0.06% and 0.26%, respectively.

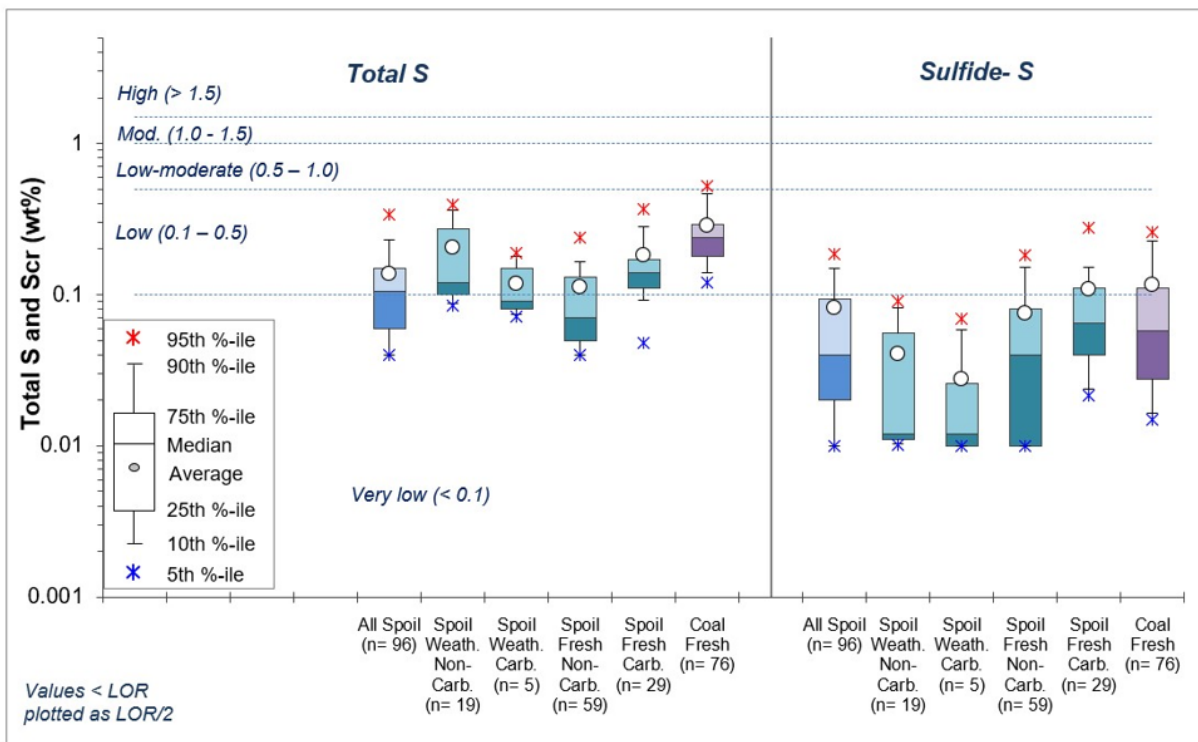


Figure 13: Sulfur (S) and sulfide (Scr) distribution for spoil [for samples where Scr data is available].

Scr values in tailings, rejects, and MPR samples were generally low to low-moderate, consistent with their respective total S concentrations. Tailings exhibited the highest Scr values, with median and 95<sup>th</sup> percentile values of 0.64% and 1.03%, respectively, followed by rejects (0.50% and 0.83%) and MPR (0.64% and 1.03%) (Figure 13). Overall, tailings had the highest mean and median total S and Scr values, followed by rejects and then MPR.

As a proportion of total S, Scr accounts for 69% (median value) in MPR samples; 65% in tailings samples; 64% in rejects samples; 57% in non-carbonaceous spoil samples; 45% in carbonaceous spoil samples and 24% in coal samples. This means that the proportion of acid generating sulfur is generally highest in MPR samples and lowest in coal samples - the lower Scr proportions in coal samples is likely due to coal containing a greater proportion of organic sulfur compared to MPR/rejects/tailings. These results indicate that the maximum potential acidity (MPA) that could be generated by all material domains is generally very low to low and that using total S as an indication of AMD hazard – particularly for the coal and highly carbonaceous materials - will result in a conservative outcome. The relationship between Scr and total S (for samples where Scr data is available) is shown in Figure 15 and Figure 16.

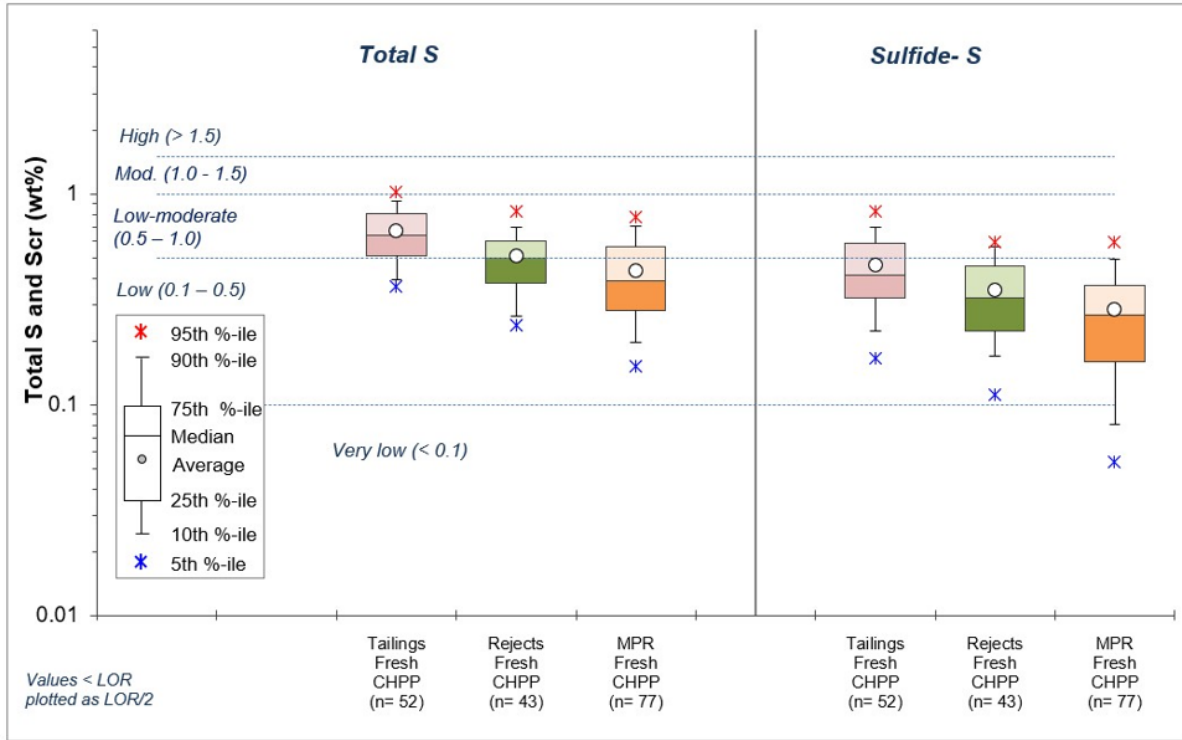


Figure 14: Sulfur and sulfide (Scr) distribution for tailings, rejects, and MPR [for samples where Scr data.

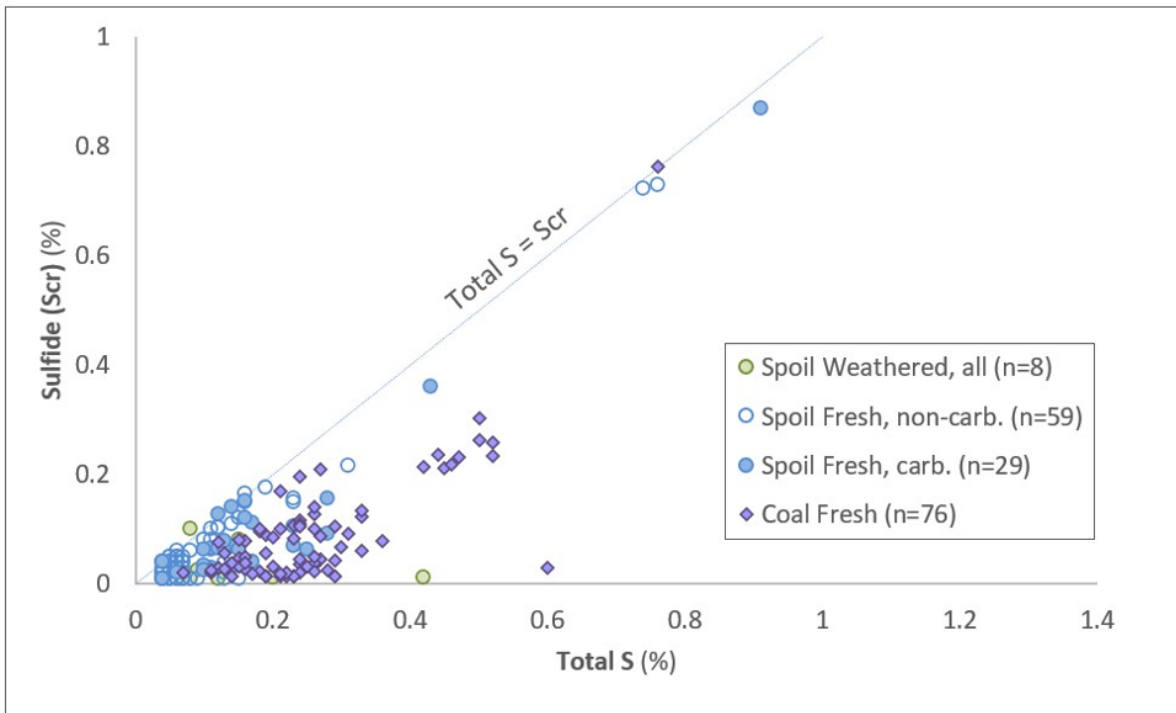


Figure 15: Sulfide (Scr) versus sulfur (S) for spoil and coal [for samples where Scr data is available].

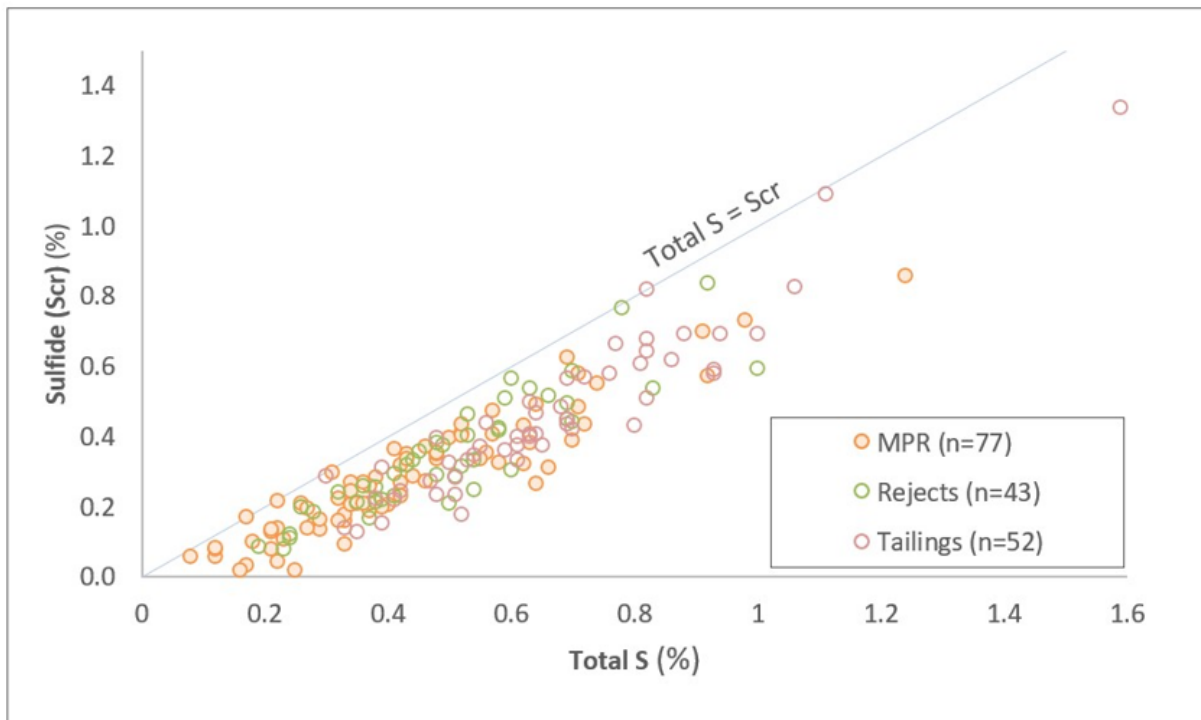


Figure 16: Sulfide (Scr) versus sulfur (S) for tailings, rejects and mixed plant rejects [for samples where Scr data is available].

### 5.2.2 Maximum Potential Acidity

MPA is calculated from total S, therefore the MPA distribution for each material type mimics the total S distribution for the same samples (refer to Figure 12). Due to the generally very low to low total S (and Scr) values for carbonaceous and non-carbonaceous samples (representing spoil), the MPA for these samples was correspondingly low, with a 95<sup>th</sup> percentile MPA of 4 kg H<sub>2</sub>SO<sub>4</sub>/t. As such, spoil represented by these samples, is expected to have negligible potential to generate acid/acidity and negligible potential to release sulfate-derived salinity from sulfide oxidation.

MPR, tailings and rejects samples had higher (but still relatively low) total S and Scr values compared to potential spoil samples. As a result, these materials also had higher MPA values (MPA calculated from total S), with median and 95<sup>th</sup> percentile MPA values of 11 and 23 kg H<sub>2</sub>SO<sub>4</sub>/t for MPR; 19 and 32 kg H<sub>2</sub>SO<sub>4</sub>/t, for tailings; and 15 and 25 kg H<sub>2</sub>SO<sub>4</sub>/t for rejects.

Coal samples produced MPA values somewhere between the MPA of spoil and the higher values observed for MPR, tailings and rejects samples. The median and 95<sup>th</sup> percentile MPA values for coal samples were relatively low, at 7 and 16 kg H<sub>2</sub>SO<sub>4</sub>/t. As discussed above, the proportion of total S associated with sulfide minerals is low, with most sulfur in coaly samples likely associated with organic sulfur. Therefore, MPA values calculated from total S for coal samples is very conservative. For comparison, the 95<sup>th</sup> percentile MPA value for coal samples (n=76) calculated from Scr is 8 kg H<sub>2</sub>SO<sub>4</sub>/t—i.e. about half of the 95<sup>th</sup> percentile MPA value calculated from total S.

### 5.2.3 Acid Neutralising Capacity

The ANC distribution for all samples is presented in Figure 17. The ANC values of spoil samples are typically well in excess of the MPA values and span a very large range, from less than 0.1 to 490 kg H<sub>2</sub>SO<sub>4</sub>/t, with a moderate median ANC value for spoil samples of 24 kg H<sub>2</sub>SO<sub>4</sub>/t and a 5<sup>th</sup> percentile value of 5 kg H<sub>2</sub>SO<sub>4</sub>/t, respectively. In other words, 95% of spoil samples have an ANC greater than 5

kg H<sub>2</sub>SO<sub>4</sub>/t which, if all ANC was readily available, would neutralise the acidity generated by material containing 0.16 wt% S.

The ANC for MPR, tailings and rejects samples ranged from moderate to very high, with rejects generally showing slightly higher values than tailings, and MPR falling in between (Figure 17). For tailings samples (n=61), ANC values ranged from 13 to 86 kg H<sub>2</sub>SO<sub>4</sub>/t, with high median and moderate 5th percentile values of 48 and 19 kg H<sub>2</sub>SO<sub>4</sub>/t, respectively. For rejects samples (n=52), ANC values ranged from 20 to 222 kg H<sub>2</sub>SO<sub>4</sub>/t, with very high median and high 5th percentile values of 68 and 27 kg H<sub>2</sub>SO<sub>4</sub>/t, respectively. For MPR samples (n=86), ANC values ranged from 10 to 182 kg H<sub>2</sub>SO<sub>4</sub>/t, with high median and moderate 5th percentile values of 43 and 14 kg H<sub>2</sub>SO<sub>4</sub>/t, respectively.

Coal samples had ANC values in the range of very low to low, with a low median (9.2 kg H<sub>2</sub>SO<sub>4</sub>/t) and 5th percentile (0.3 kg H<sub>2</sub>SO<sub>4</sub>/t) that were the lowest of all sample types, indicating very limited acidneutralising capacity compared to spoil, tailings, rejects, and MPR samples.

As evident in Figure 17, the weathered carbonaceous samples (n=11), which comprises a very small proportion of mineral waste [and coal, which is generally not waste as it reports to ROM], have the lowest median ANC values and the fresh non-carbonaceous samples (n=369), which is the dominant spoil type, has the highest median ANC values of all spoils, with rejects and MPR being the material type with the highest ANC (n=138). In summary, spoil has generally moderate to high ANC, MPR/tailings/rejects have generally high to very high ANC and coal has generally very low to low ANC.

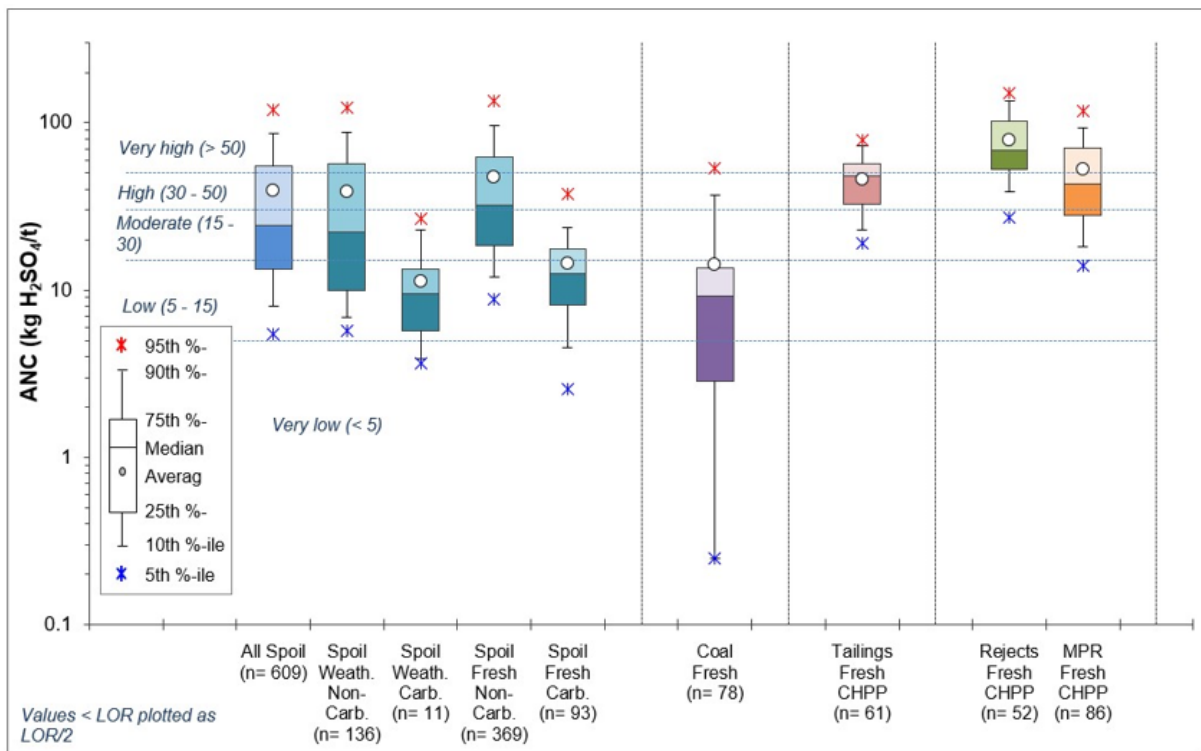


Figure 17: The ANC for MPR, tailings and rejects samples ranged from moderate to very high, with rejects.

5.2.4 Available Acid Neutralising Capacity.

The availability of neutralising material is generally determined by the mineralogy of the sample – with calcite and iron-dolomite (carbonate minerals) being more readily-available to neutralise acidity compared with, for example, silicates. Siderite, although a carbonate, has no net acid neutralising

capacity. However, routine ANC tests assumes that all ANC measured is readily available to neutralise acid, when in the field is rarely the case. Hence, acid buffering characterisation curve (ABCC) (and mineralogical) test-work is undertaken to better understand the likely effective (readily available) ANC.

ABCC tests were undertaken on 50 spoil samples, 13 tailings samples, 11 rejects samples, 10 MPR samples to assess the proportion of ANC that may be 'readily available' (i.e. short-acting) in these materials under field conditions and provide some indication of what carbonate minerals are providing the ANC. 'Readily availability' is regarded as the proportion of ANC that is available for buffering reaction at pH 4.5. The results are summarised in Figure 18 for spoil MPR, tailings, and rejects samples, respectively.

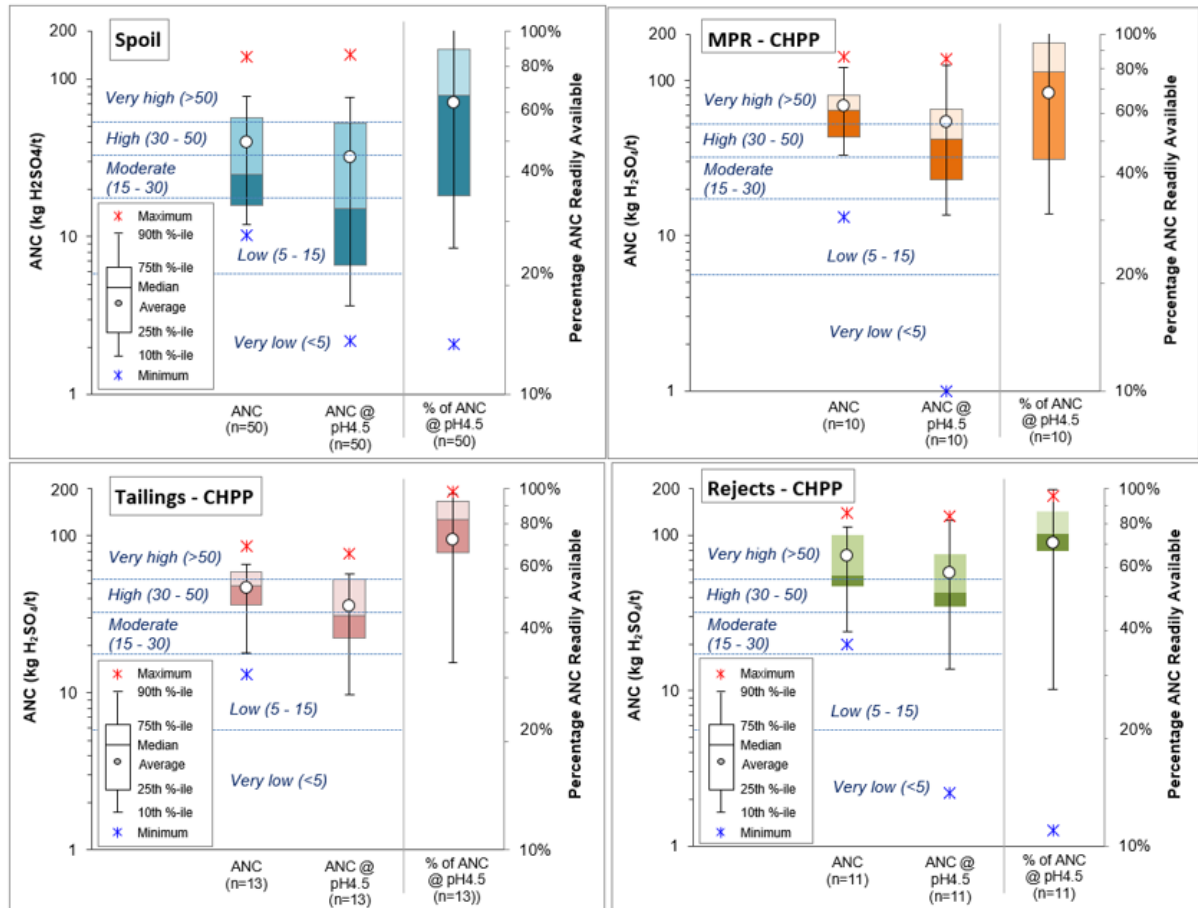


Figure 18: Distribution of acid neutralising capacity (ANC) [total], ANC at pH 4.5 and proportion (%) of ANC expected to be readily available.

For the 50 spoil samples where ABCC data is available, the results showed that the proportion of ANC likely available under field conditions ranged from 14% to nominally 100% of the ANC, with a median of approximately 67%. The proportion of ANC likely available under field conditions was generally high across all coal processing waste materials, with medians of ~82% for tailings (n=13), ~75% for rejects (n=11), and ~79% for MPR (n=10).

The relationship between ANC @ pH 4.5 [i.e. ABCC ANC] and ANC [total] (for samples where ABCC data is available) is shown in Figure 19 and Figure 20.

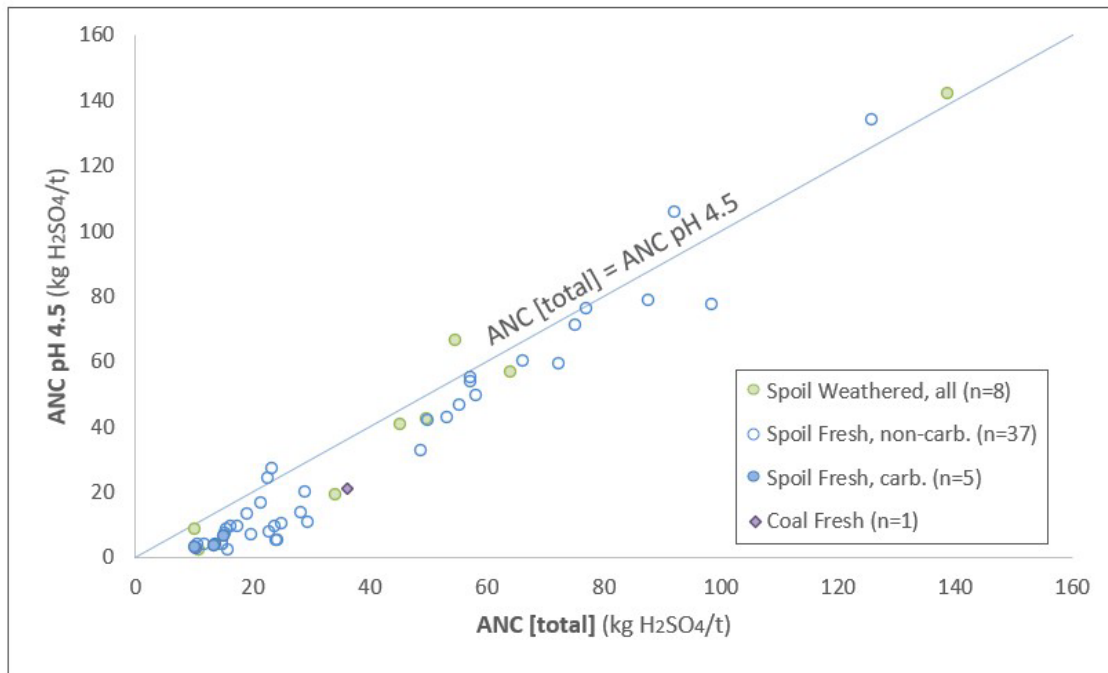


Figure 19: ABCC ANC [ANC @ pH 4.5] versus ANC [for spoil samples where ABCC data is available].

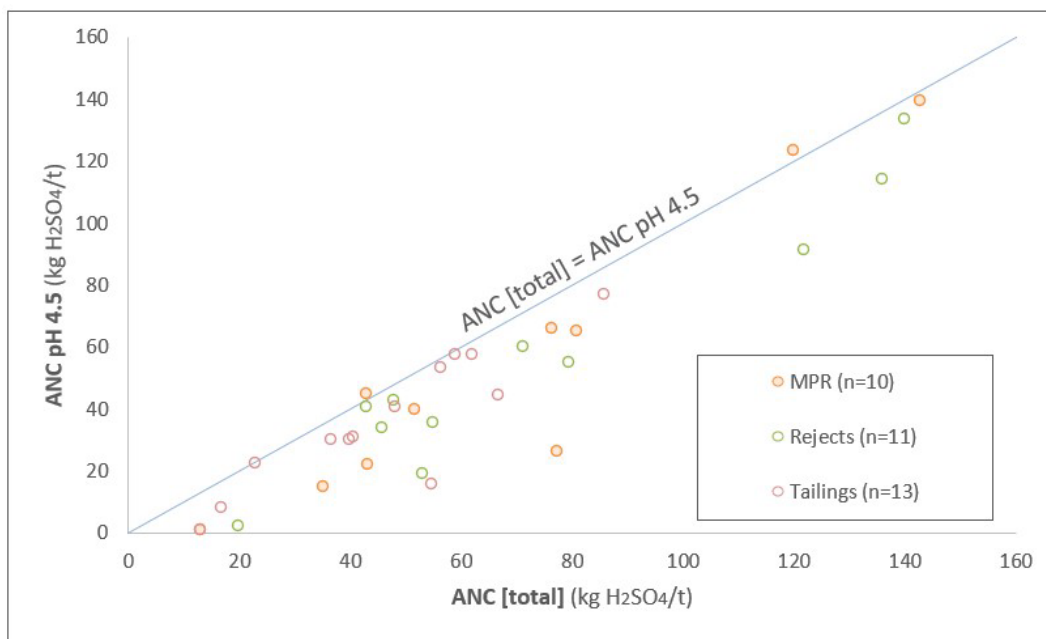


Figure 20: ABCC ANC [ANC @ pH 4.5] versus ANC [for MPR, rejects, and tailings where ABCC data is available].

The shape of the ABCC curves (the reaction rate) can also be used to infer likely carbonate mineralogy based on standard curves/data for different carbonate minerals at varying ANC values. For all samples, iron dolomite (Fe-dolomite) appears to be the dominant carbonate mineral (based on the ABCC curves), with minor siderite. Siderite is fairly common throughout the Permian sediments of the Bowen Basin, albeit in generally relatively small amounts. Several samples appear to have trace amounts of dolomite or calcite.

Based on the above, and supported by the QXRD data (Section 5.1), the carbonate mineral in bulk spoil is likely to be Fe-dolomite +/- siderite with varying influence from dolomite and calcite.

5.2.5 ANC / MPA Ratio

Generally, those samples with an ANC/MPA ratio greater than two are considered to have a negligible/low risk of acid generation (DIIS, 2016; INAP, 2009), especially where sulfide concentrations are very low and reactive ANC is moderate to high - as is the case with the potential spoil samples. The results, illustrated in Figure 21, show that 585 of the 609 spoil samples (96% of spoil samples) have an ANC/MPA ratio greater than two. Approximately 14% of fresh carbonaceous samples (13 out of 93 samples) have an ANC/MPA ratio less than two.

Only 30% (23 out of 77 samples) of coal samples had an ANC/MPA ratio greater than two. In addition, the percentage of tailings, rejects, and MPR that had an ANC/MPA ratio greater than two were 66% (40 out of 61 samples), 90% (47 out of 52 samples), and 83% (71 out of 86 samples) respectively. Comparatively, ANC/MPA values calculated from Scr reveals that 66% of coal samples had ANC/MPA ratios greater than two, as was the case with 81% of tailings samples, 95% of rejects samples, and 88% of MPR.

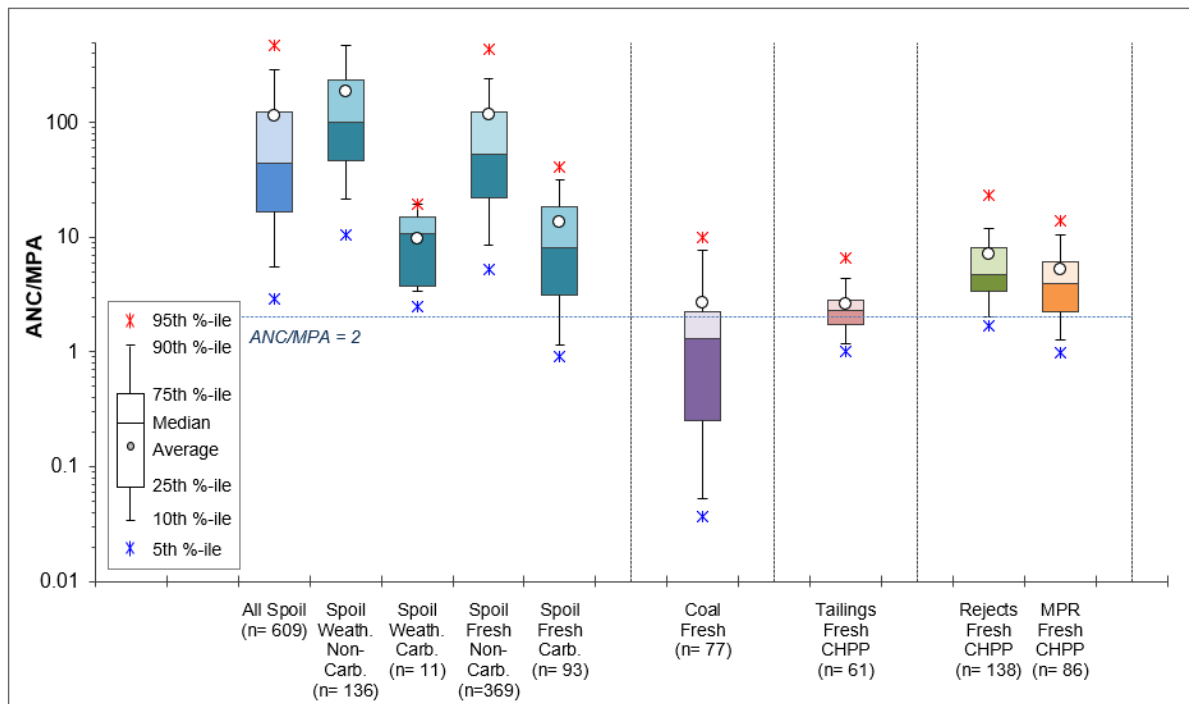


Figure 21: Distribution of ANC/MPA ratio.

5.2.6 Net Acid Producing Potential and Net Acid Generation Capacity.

Based on the generally low MPA and higher ANC values (relative to the MPA), the calculated NAPP values are negative for about 95% of the spoil samples and also about 95% of the tailings, rejects and MPR samples (Figure 22). Comparatively, approximately 40% of coal samples (31 out of 77) have low positive NAPP values. The results indicate that, overall, there is significantly excess neutralising capacity (ANC) compared to potential acidity (MPA) for spoil and rejects samples (mineral waste materials).

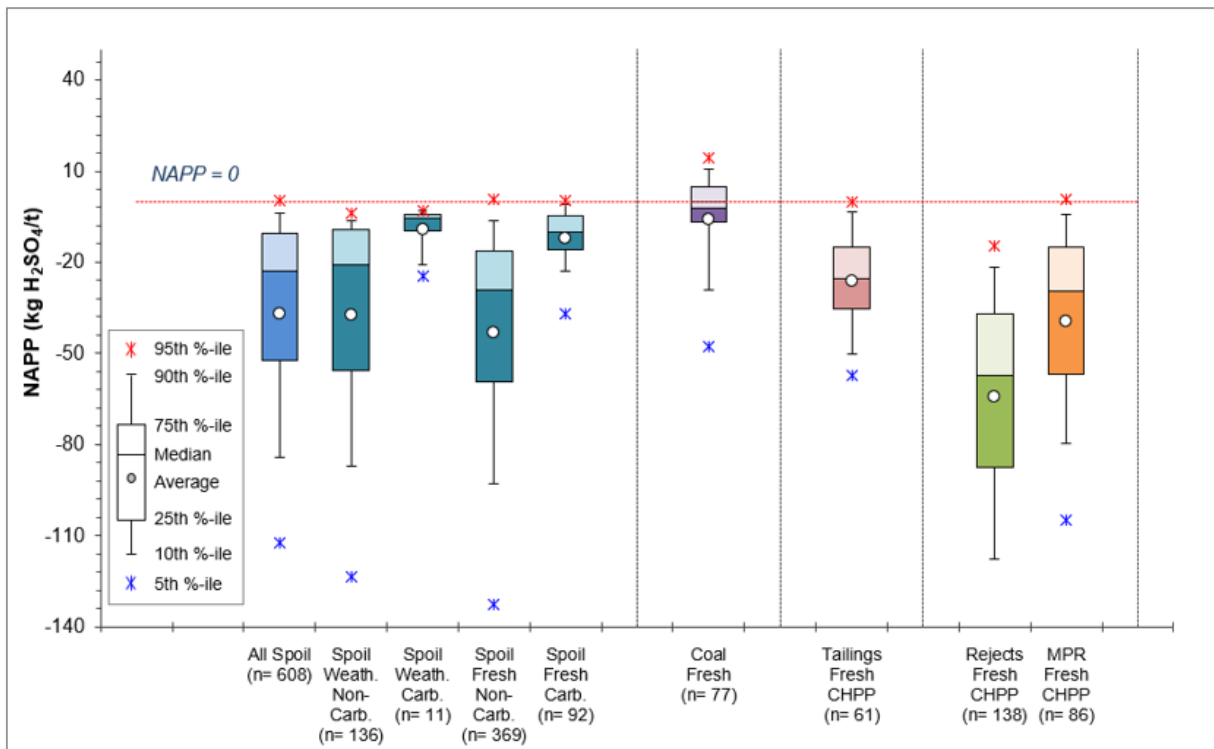


Figure 22: Distribution of net acid production potential.

NAG test results are used in conjunction with NAPP values in determining the AMD classification of samples. The calculated NAPP value assumes that all sulfur (present as sulfide) will oxidise to generate acid (MPA) and that all neutralising material in a sample is in a readily available form to neutralise any acid that could be generated (ANC). Unlike the theoretical basis of the NAPP test, in a NAG test, a sample is encouraged to oxidise by reacting with hydrogen peroxide and any acid generated through oxidation may be consumed by neutralising components in the sample. Any remaining acidity is measured and expressed as kg H<sub>2</sub>SO<sub>4</sub>/t.

Samples with NAGpH values greater than pH 4.5 are considered to be NAF. Samples with NAGpH values less than or equal to pH 4.5 (i.e. acid-generating) would also be expected to have measurable NAG capacity (i.e. NAG capacity greater than 0.1 kg H<sub>2</sub>SO<sub>4</sub>/t). As a guide, NAG capacity values between 0.1 and 5 kg H<sub>2</sub>SO<sub>4</sub>/t are considered 'low capacity' (AMIRA, 2002).

NAG test data is available for 31 potential spoil samples, 54 coal samples, 58 tailings samples, 49 rejects samples, and 83 MPR samples with the NAGpH distribution shown in Figure 23. Among the spoil samples, 74% had NAGpH values above pH 4.5. For tailings, 98% of samples were above pH 4.5, while all rejects samples exceeded pH 4.5. For MPR samples, 95% recorded NAGpH values above pH 4.5.

In coal and highly carbonaceous samples with appreciable organic sulfur concentrations, the NAG test can be influenced by organic acid (i.e. organic acid can produce NAGpH between approximately pH 4 to 4.5, thus providing a 'false positive' for sulfuric acid). To circumvent this issue and clarify the uncertainty associated with the 'single addition' NAG test for coal and highly carbonaceous samples, two carbonaceous samples (one weathered and one fresh), one MPR sample, 53 coal samples, 4 tailings samples and 2 rejects samples underwent an Extended Boil NAG method (NAG Extended). Twenty-six of these 62 samples (or 42% of samples) returned Extended NAGpH values greater than pH 4.5, thus indicating that the NAG results for these coaly and highly carbonaceous samples were likely influenced by organic acid.

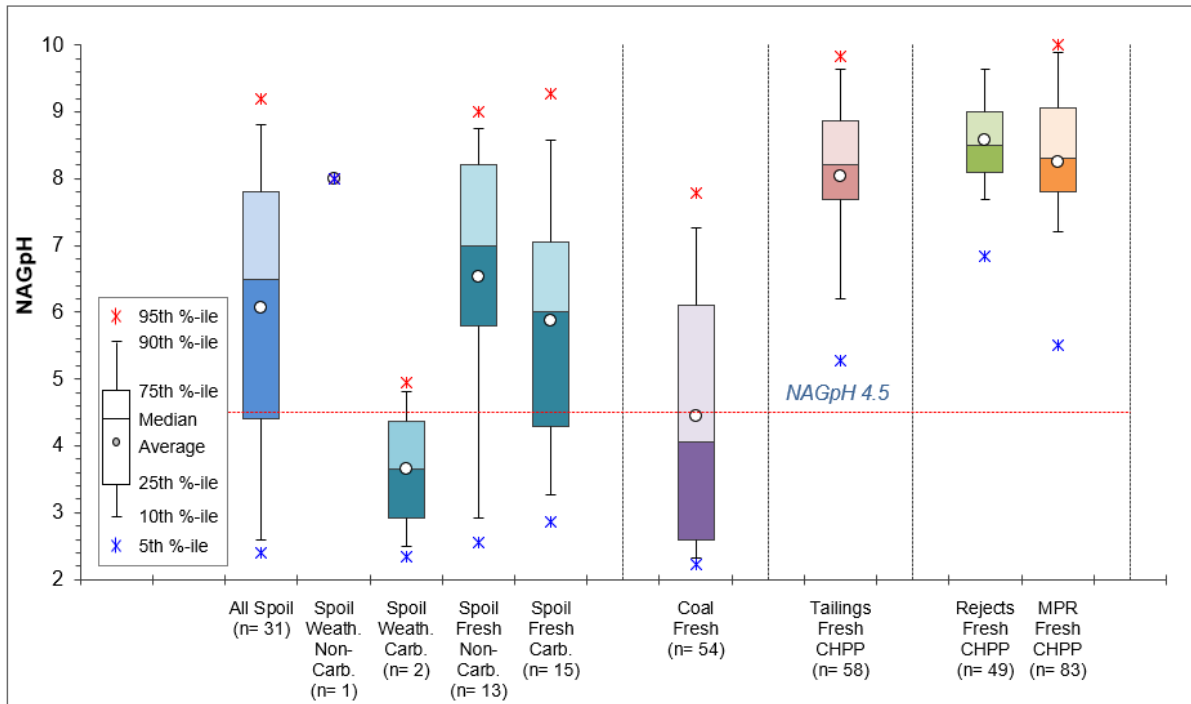


Figure 23: Distribution of net acid generation pH (NAGpH single or NAG Extended).

5.2.7 AMD Classification

The ABA results presented in this section have been used to classify the acid forming nature of the samples following the classification criteria outlined in Section 4.4. Additional relevant data, such as ABCC and Extended NAG test results were used to aid in the classification of samples where there was uncertainty following the preliminary AMD classification. The acid forming nature of these samples is summarised in Table 16.

Table 16: Geochemical classification of samples.

	NAF	UC(NAF)	NAF-S	UC(PAF)	PAF-LC	PAF
<b>MATERIAL TYPE</b>	<b>NUMBER AND (%) OF SAMPLES</b>					
Weathered non-carbonaceous spoil (n=139)	137 (99%)	2 (1%)	0	0	0	0
Weathered carbonaceous spoil (n=11)	10 (91%)	0	0	0	1 (9%)	0
Fresh non-carbonaceous spoil (n=390)	364 (93%)	23 (6%)	0	1 (<1%)	0	2 (<1%)
Fresh carbonaceous spoil (n=93)	82 (88%)	5 (5%)	0	4 (4%)	1 (1%)	1 (1%)
Spoil [all] (n=633)	593 (94%)	30 (5%)	0	5 (<1%)	2 (<1%)	3 (<1%)
		623 (98%)			10 (2%)	
Coal (n=77)	33 (43%)	10 (13%)	0	5 (6%)	21 (27%)	8 (10%)

	NAF	UC(NAF)	NAF-S	UC(PAF)	PAF-LC	PAF
MATERIAL TYPE	NUMBER AND (%) OF SAMPLES					
	43 (56%)			34 (44%)		
Tailings (n=61)	56 (92%)	0	4 (6%)	0	1 (2%)	0
	56 (92%)			5 (8%)		
Rejects (n=52)	52 (100%)	0	0	0	0	0
	52 (100%)			0		
MPR (n=86)	81 (94%)	0	1 (1%)	1 (1%)	3 (4%)	0
	81 (94%)			5 (6%)		

#### 5.2.7.1 Spoil

The classifications in Table 16 show that approximately 94% of spoil samples (n=593) were classified as NAF, and approximately 5% were expected to be NAF (and have been classified as UC(NAF)). These spoil samples (and spoil material represented by these samples) have very low sulfur concentration, significant excess ANC (relative to the MPA) and clearly have negligible capacity to generate AMD. One percent (10 out of 633) of spoil samples were classified as PAF, PAF-LC or UC(PAF). Out of the 10 PAF, PAF-LC or UC(PAF) samples, seven samples were carbonaceous. No spoil samples were classified as NAF-S.

Data show that potential spoil, as a bulk material, would be overwhelmingly NAF. Furthermore, the very low sulfur concentrations in spoil indicates that the sulfate concentration that could be generated in spoil from sulfide oxidation (in addition to any salinity unrelated to sulfide oxidation) would also be very low.

#### 5.2.7.2 Coal

Coal samples had higher total S values and lower ANC compared to spoil, thus resulting in 44% of coal samples classified as PAF, PAF-LC or UC(PAF). No coal samples were classified as NAF-S. The proportion of PAF, PAF-LC and UC(PAF) samples is comparable across all coal seam groups being mined at DNM. It is worth noting that 25 of the 34 coal samples classified as some form of 'PAF' showed limited capacity to generate acidity, suggesting that 'PAF' coal is unlikely to generate significant acid(ity).

Approximately 56% of coal samples tested (43 out of 77 samples) were classified as NAF or UC(NAF), and seam material represented by these samples has very low sulfur values, excess ANC (relative to the MPA) and clearly has no capacity to generate acidity or release significant sulfate from sulfide oxidation.

These results suggest that coal represented by these samples and stored on a ROM pad, located within pit walls and un-economic coal seam material reporting as spoil (mixed with non-coal spoil) would likely be bulk NAF. A small proportion of coal from all seam groups poses a greater, but relatively low AMD source hazard.

### 5.2.7.3 Tailings, Rejects and MPR

Of the 61 tailings samples, 4 samples were classified as NAF-S and one as PAF-LC, no other samples were classified as either PAF or UC(PAF). From an acid generating perspective tailings, as a bulk material, do not pose a potential hazard with respect to AD and/or NMD/SD. All rejects samples (n=52) were classified as NAF (n=52). From an acid generating perspective rejects, as a bulk material, do not pose a potential hazard with respect to AD and/or NMD/SD.

For MPR samples (n=86), results show that 94% (81 out of 86) were classified as NAF or UC(NAF). None of the 86 MPR samples were classified as 'PAF', one sample was classified as 'UC(PAF)', one sample was classified as NAF-S and a further 3 samples (4%) were classified as 'PAF-LC'. From an acid generating perspective rejects, as a bulk material, do not pose a potential hazard with respect to AD and/or NMD/SD.

## 5.3 Total Metals and Metalloids

Multi-element (metal and metalloid) data is available for 107 potential spoil samples [33 weathered non-carbonaceous, 58 fresh non-carbonaceous, 3 weathered carbonaceous, and 13 fresh carbonaceous]. In addition, 194 spoil samples had limited data for As, Cr, Cu, Hg, Mn, Mo, Ni, Se, and Zn. Multi-element data is also available for 17 coal samples, 22 tailings samples, and 28 reject samples.

The degree of enrichment with respect to elements potentially of environmental interest is shown in Figure 24 for spoil and coal samples and in Figure 25 for tailings and rejects samples.

The GAI values show that only one spoil sample was significantly enriched [ $GAI \geq 3$ ] with regards to arsenic (As) and is not cause of concern.

Two out of 28 rejects samples, 2 out of 22 tailings samples and one out of 17 coal samples were significantly enriched [ $GAI \geq 3$ ] with S which are consistent with ABA data for these samples.

The GAI values also show that a considerable number of samples tested (of all material types) had minor enrichment ( $GAI = 1$  or  $2$ ) with regard to one or more of the following, i.e., silver (Ag), As, Ba, Co, Cr, mercury (Hg), Mo, nickel (Ni), S, antimony (Sb), uranium (U) and zinc (Zn). The level of S enrichment in these samples is consistent with ABA data for these samples

Overall, the results suggest that bulk mineral waste materials have generally low metals assay concentration (low levels of metal and metalloid enrichment), which is consistent with Permian-age coal measures throughout eastern Australia.

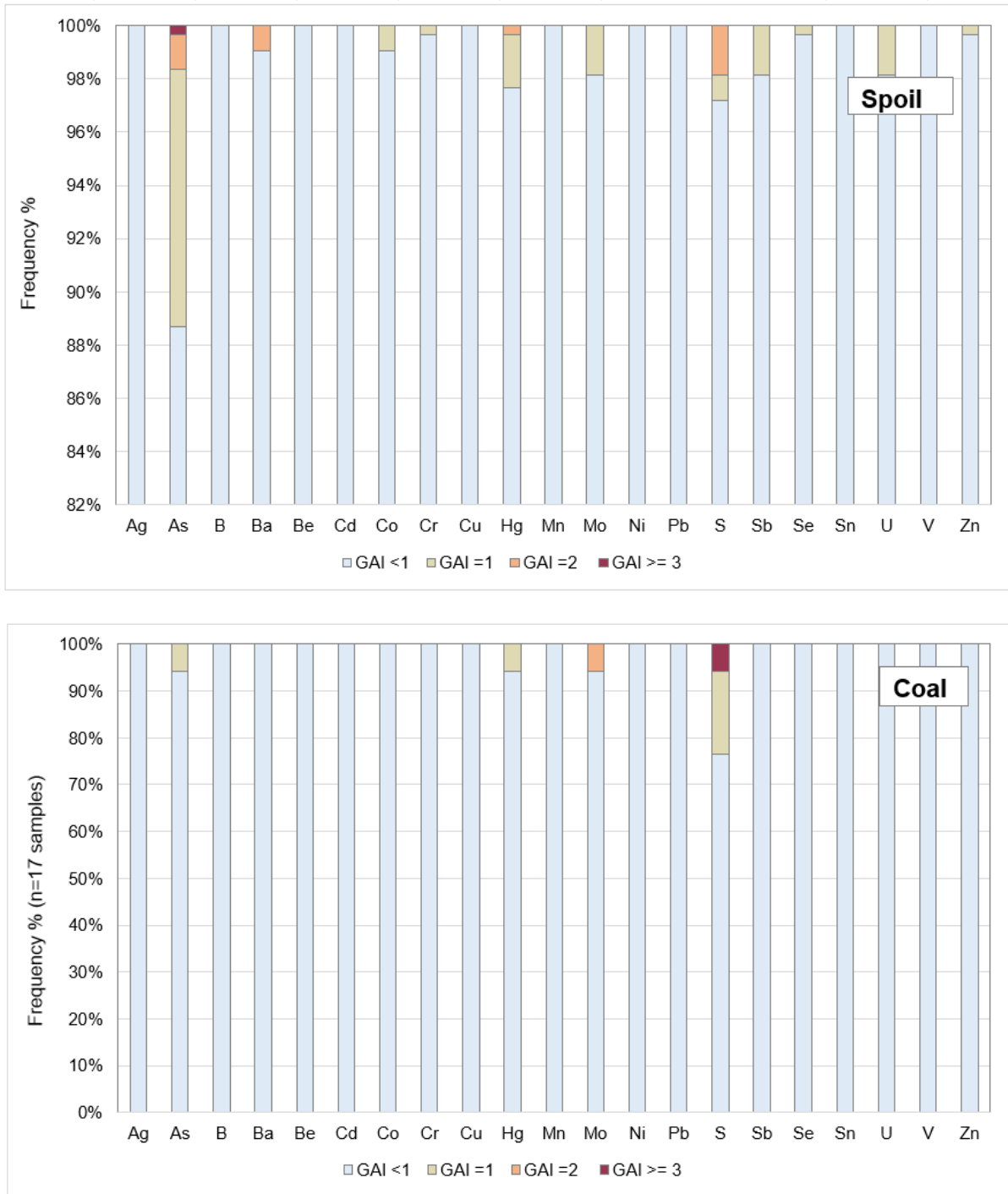


Figure 24: Frequency distribution of geochemical abundance indices (GAI) of selected elements in spoil and coal.

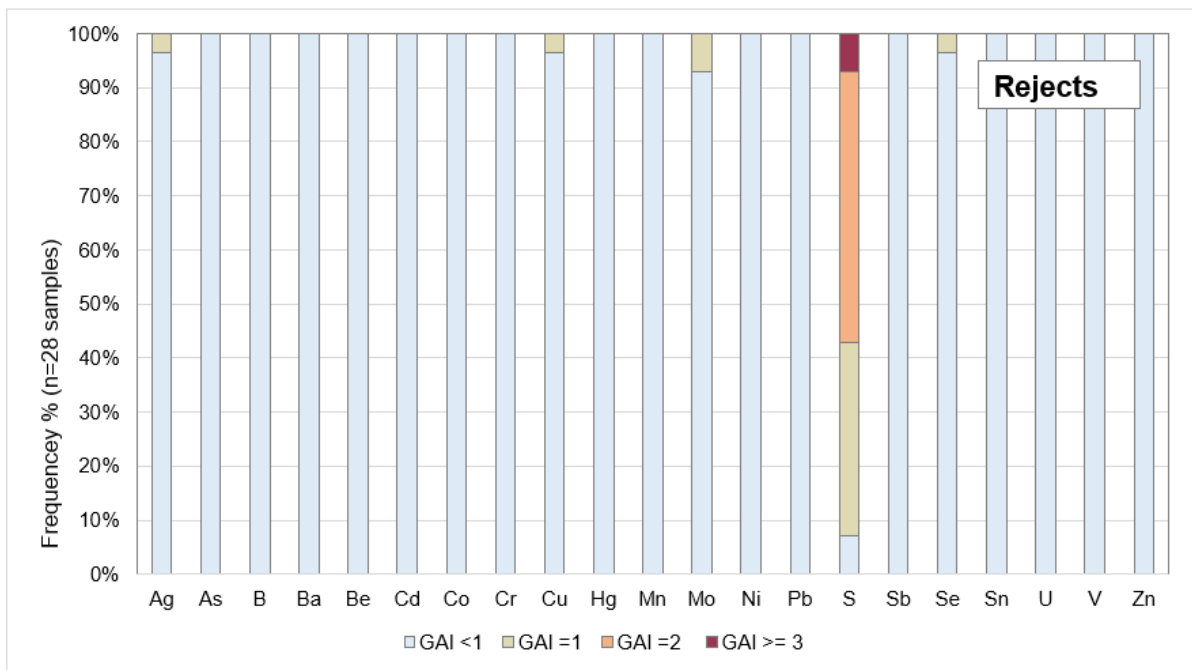
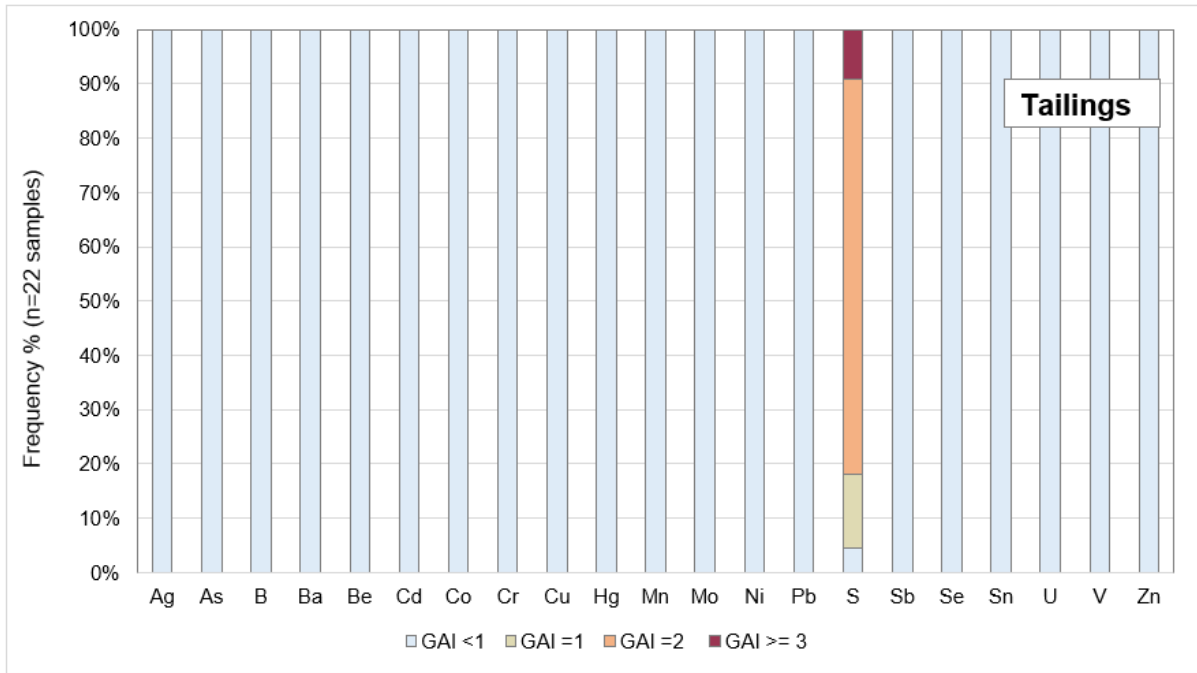


Figure 25: Frequency distribution of geochemical abundance indices (GAI) of selected elements in tailings and rejects.

**5.4 Initial Solubility and Deionised Water**

Water extract test results are available for a wide range of samples, as outlined in Table 17. Therefore, a relatively large dataset is available to assess the potential for leaching of salt and environmentally important elements from mineral waste at DNM. Water extract tests provide a preliminary indication of the elements that may be readily mobilised from any given material type.

The samples underwent a 1:5 w:v (solid:water) deionised water bottle leach procedure on fine pulps. Note that the use of fine pulped materials in water extract tests will enable a high level of reaction and

dissolution. The results from these tests are summarised and discussed below. Tabulated results can be provided on request.

Table 17: Samples subjected to deionised water solubility tests.

MATERIAL TYPE	EC	pH	SOLUBLE METALS AND METALLOIDS
Number of samples			
Spoil	623	623	107
Coal	89	89	18
Tailings	57	57	18
Rejects	52	52	14
MPR	86	86	14

The test-work has found that the mineral wastes are pH-alkaline, generally slightly to moderately saline and have very low concentrations of soluble (dissolved) metals and metalloid concentrations - within the range typical for Permian sedimentary materials in Queensland. For most samples, the soluble metals and metalloids are at concentrations below or marginally above the laboratory limit of reporting (LOR).

#### 5.4.1 Electrical Conductivity (EC) and pH

EC and pH data is available for 1070 samples at 1:5 w:v on pulp (Figure 26). The EC<sub>1:5</sub> of 623 spoil samples spanned a large range from 58 to 1460  $\mu\text{S}/\text{cm}$ , with median, 75<sup>th</sup> and 90<sup>th</sup> percentile EC<sub>1:5</sub> values of 284, 375 and 478  $\mu\text{S}/\text{cm}$ , respectively. As evident in Figure 26, bulk spoil is generally non-saline to slightly saline. These EC<sub>1:5</sub> results are common (if not typical) for Bowen Basin Permian and Tertiary material in the region.

Coal samples (n=89) are non-saline to slightly saline with median EC<sub>1:5</sub> values of 119  $\mu\text{S}/\text{cm}$ . Tailings (n=57), rejects (n=52) and MPR (n=86) samples were generally non-saline with values similar to spoil samples and slightly higher than coal samples. The median EC<sub>1:5</sub> values for tailings, rejects and MPR samples were 292, 331 and 281  $\mu\text{S}/\text{cm}$ , respectively.

The pH distribution by material type (Figure 26) shows the samples to be generally alkaline to highly alkaline indicating no readily soluble acidity from these samples. These pH results are common (if not typical) for Bowen Basin Permian and Tertiary material in the region.

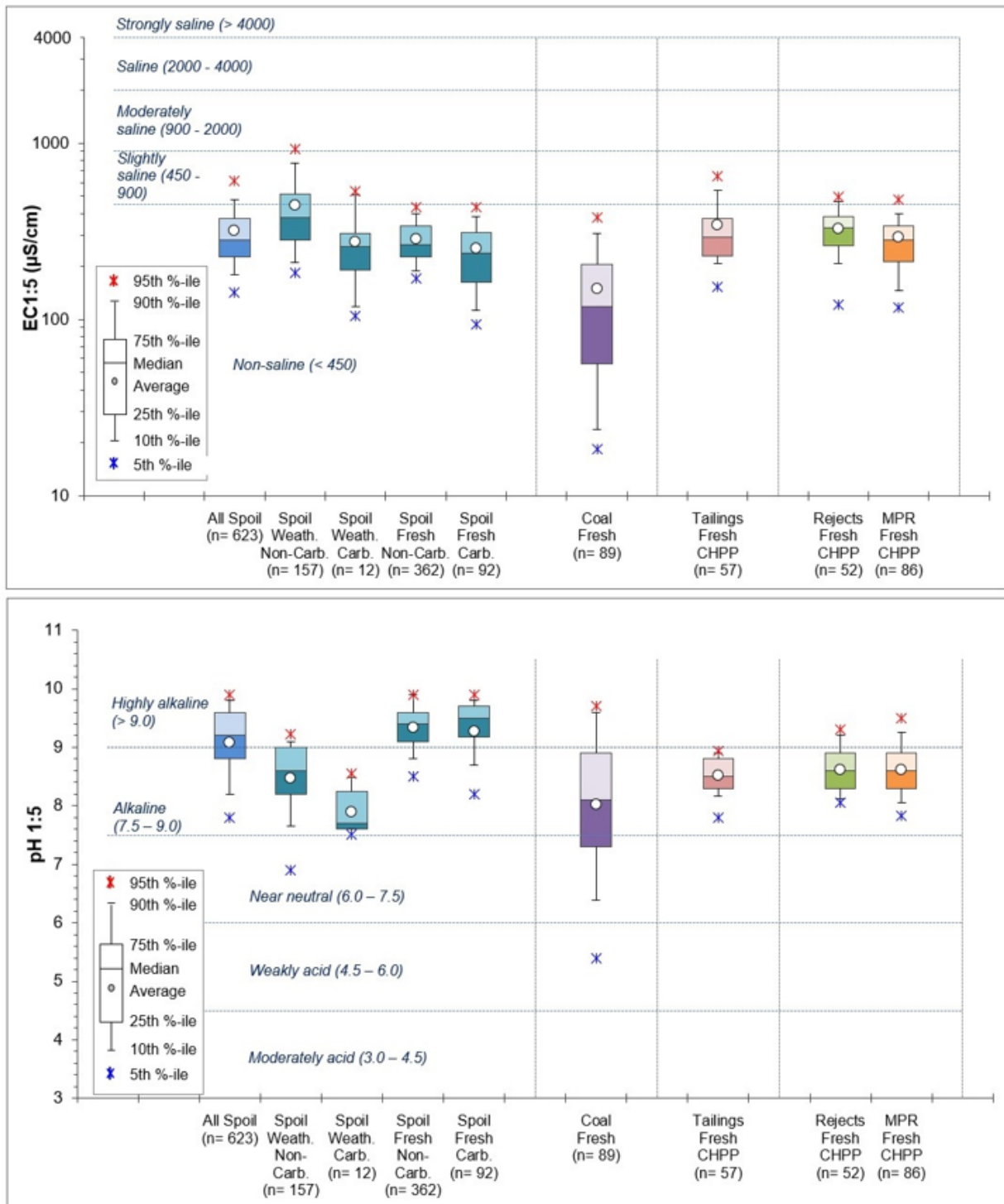


Figure 26: Electrical conductivity (EC) and pH distribution.

5.4.2 Soluble Metals and Metalloids

Deionised water extract (leaching) data for major ions and metals/metalloids is available for 107 spoil samples, 18 coal samples, 18 tailings samples, 14 rejects samples and 14 MPR samples. All samples underwent a 1:5 w:v (solid:water) water extract procedure on pulps. The sum of 16 environmentally important elements are plotted as a function of pH in Figure 27, in a modified version of what is referred to as a Ficklin plot (after Ficklin et al., 1992). The 16 selected metals/metalloids comprise: aluminium (Al), Sb, As, cadmium (Cd), Co, chromium (Cr), copper (Cu), lead (Pb), Hg, manganese (Mn), Mo, Ni, selenium (Se), U, V and Zn.

As evident in Figure 27, all tailings, rejects and MPR samples, almost all spoil samples, and most coal samples produced low soluble metals concentrations under near-neutral to alkaline pH. Five spoil samples and three coal samples produced low to moderate soluble metals concentrations under weakly acidic to pH-alkaline conditions.

In pH-neutral to alkaline waters, many metals/metalloids cannot remain in solution and, thus, trace metal/metalloid concentrations are generally low. Comparatively, in acid(ic) waters, many metals/metalloids are highly soluble and remain in solution and, thus, trace metal/metalloid concentrations are generally high. Notable exceptions to these general rules include elements such as As, Mn, Sb and Se, which remain soluble through a wide pH range. Other trace metals that are somewhat soluble under pH-neutral to alkaline conditions include Cd, Cr, Mo and Zn. As such, under the pH-alkaline conditions of the leach, the mobility of these elements would not be inhibited.

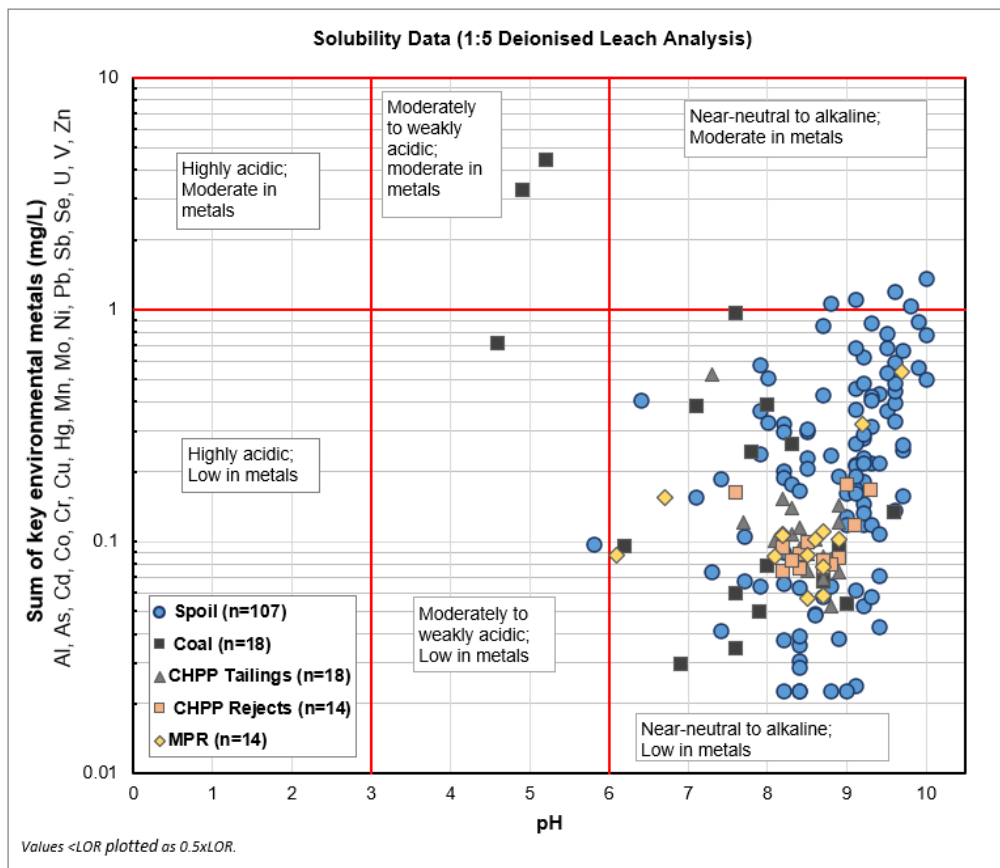


Figure 27: Sum of key environmental metals versus pH in deionised water extracts.

The median concentrations of major ions and environmentally important metals/metalloids in deionised water extracts are shown in Table 18.

Table 18: Median concentrations of major ions and selected elements in deionised water extracts.

MEDIAN CONCENTRATION mg/L	SPOIL (n=107)	COAL (n=18)	MPR, TAILINGS AND REJECTS (n=46)
≤ 0.0001	Cd, Hg	Cd, Hg	Hg
≤ 0.001	Ag, Be, Bi, Co, Cr, Cu, Mn, Ni, Pb, Sn, Th, Tl, U, W	Ag, As, Be, Bi, Cd, Co, Cr, Cu, Ni, Pb, Sb, Sn, Th, Tl, U, V, Zn	Ag, Be, Bi, Cd, Co, Cr, Cu, Hg, Ni, Pb, Th, Tl, U, V, Zn

MEDIAN CONCENTRATION mg/L	SPOIL (n=107)	COAL (n=18)	MPR, TAILINGS AND REJECTS (n=46)
≤ 0.01	Sb, Se, Ti, V, Zn, Zr	Mn, Mo, Se, Ti, V, Zn, Zr	Al, As, Mn, Sb, Se, Sn, Ti, V, Zn, Zr
≤ 0.1	Al, As, B, Ba, Fe, Mo, Sr	Al, B, Ba, Fe	B, Ba, Mo, Fe
≤ 1.0	F, P	F, P, Sr	P, Sr
≤ 10	Ca, Mg, K, Cl	Ca, Mg, K, Cl	Mg, K, Cl
≤ 100	SO <sub>4</sub> , Na	SO <sub>4</sub> , Na	Ca, Na, SO <sub>4</sub>

### 5.5 'Saline' Water Solubility of MPR, Tailings and Rejects

Thirty-five samples comprising of 11 MPR, 12 rejects and 12 tailings samples underwent a 1:5 w:v (solid:water) mildly saline (brackish) water extract procedures on pulps using a 2 g/L sodium chloride (NaCl) leaching solution. This leach was undertaken to determine the solubility of metals and metalloids under 'brackish' conditions, which better simulate the normal (brackish) water quality of the CHPP process water. Note that the salinity of CHPP process water varies from fresh to brackish on a day-to-day basis depending upon the source of the water from within the mine water management system.

The results from these tests found that the soluble metals and metalloid concentrations were very low and very similar to the concentrations from the de-ionised water (freshwater) leaching tests for these same samples.

Soluble barium (Ba) and strontium (Sr) concentrations were higher in the 'brackish' leachate solution compared to the freshwater leachate for the same samples - a trend that has been observed in similar 'brackish' and 'saline' leaches of tailings solutions from other Permian coal mines in the Bowen Basin. For the other elements there was little difference between the soluble concentrations in the 'brackish' leachate compared to the freshwater leachate.

Overall, the results have shown that the solubility of MPR, tailings and rejects is low under 'brackish' leaching conditions.

### 5.6 Characteristics of Tailings Liquor (Water)

Water quality data for tailings liquor is available for 18 tailings slurry samples collected from the CHPP (at the thickener underflow). Results showed all samples to produce low soluble metals concentrations associated with alkaline pH conditions.

### 5.7 Peroxide Leachate Solutions

Peroxide leachate (NAG leach) data is available for:

- One fresh non-carbonaceous spoil sample classified as NAF and one fresh carbonaceous sample classified as UC(NAF).
- Three coal samples classified as PAF-LC and one as UC(PAF).
- One MPR sample classified as PAF, one rejects sample classified as NAF and one tailings sample classified as NAF.

- Peroxide leachate is the solution remaining from the NAG test after the sample has been oxidised with peroxide to encourage oxidation and neutralising reactions, if ANC is available. The test encourages complete and rapid oxidation, with the resulting leach representing and assumed 'worse case' scenario in term of metal/metalloid mobility. The purpose of this test is to understand what metals/metalloids can be mobilised following full oxidation. The samples submitted for this test were selected to assess the hazard of similar waste type or to assist clarifying borderline geochemical properties.
- The peroxide leachate of the all the samples (n=9) was measured after undertaking a single addition (standard) NAG test. The fresh non-carbonaceous sample—having little to no carbonaceous material—would not be expected to be influenced by organic acids. However, the 'acidity' of the carbonaceous, coal, tailings, rejects and MPR samples may be influenced to varying degrees by organic acids potentially producing acidity and corresponding elevated soluble metals concentrations unrelated to AMD. As such, the result for these samples should be interpreted with this in mind.
- Three PAF-LC coal samples produced low NAG leachate pH values of 2.42, 3.73 and 2.59 respectively confirming their AD classifications. One UC(PAF) coal sample produced weakly acid pH value of 4.78. Spoil samples produced NAG leachate pH of 5.92 (for carbonaceous spoil) and 6.55 (for non-carbonaceous spoil). Both NAF rejects and tailings samples produced NAG leachate pH of 3.40 and 3.79 respectively. MPR sample that was classified as PAF reported NAG leachate pH of 2.73.
- The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the peroxide leachate solution in Figure 28. The 16 selected metals/metalloids are the same elements as per the 1:5 deionised water leach.
- As evident in Figure 28 both spoil samples have low soluble metals concentrations. All four coal, one rejects, one tailings and one MPR samples reported high soluble metal concentrations, which may be due to organic acids producing acidity and correspondingly elevated soluble metals concentrations unrelated to AMD.

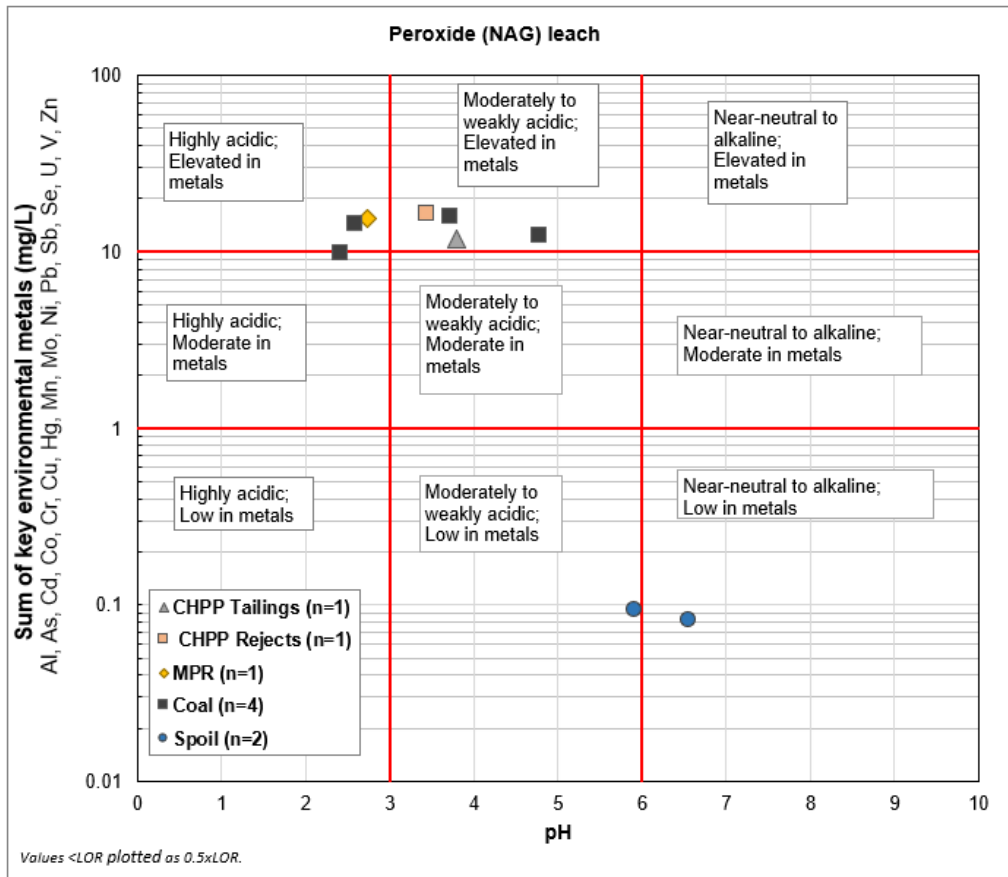


Figure 28: Sum of key environmental metals versus pH in peroxide (NAG) leachate solution.

Compared to the 1:5 deionised water extract solutions, the median concentration of several metals and metalloids in the peroxide leach is higher, notably Al, Cu, Fe, Mn and Ni, however the concentrations of all other elements, and major ions, are comparable to the deionised water solubility concentrations.

The results suggest that coal, tailings, rejects and MPR samples under acidic conditions are capable of generating elevated metal and metalloid loads, however the SO<sub>4</sub> (and salinity) loads are not expected to be elevated – due to generally low to low-moderate total S concentrations. Furthermore, the majority of coal samples gets shipped off site therefore they are not of concern. Additionally, the water quality associated with coal, tailings, rejects and MPR samples are likely to be affected by organic acid. Two spoil samples tested for NAG leach were moderately to weekly acidic and low in metals.

**5.8 Cation Exchange Capacity, Sodidity and Dispersion of Spoil**

Exchangeable cation concentrations are used to evaluate the potential ‘soil quality’ of materials. Exchangeable cation data [as cation exchange capacity (CEC)] is available for 370 potential spoil samples. The results are summarised in Figure 29.

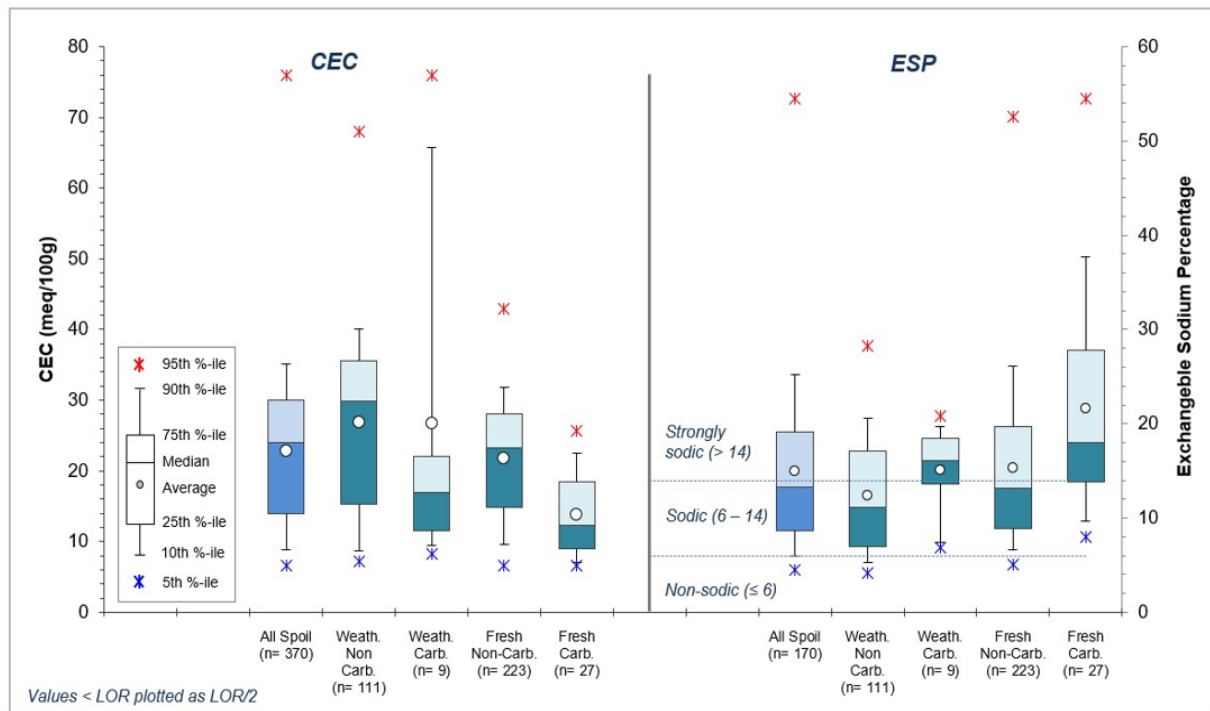


Figure 29: Cation exchange capacity (CEC) and exchangeable sodium percentage (ESP) of spoil.

The CEC spans a large range from 2.4 to 76 milliequivalents per 100 grams (meq/100g), with a relatively modest median CEC value of 24 meq/100g - which is typical for sedimentary materials in the Bowen Basin.

The exchangeable sodium percentage (ESP) results range from <1% to 55%, with a median ESP of 13%. Approximately 45% of samples had ESP values greater than 14%; and 45% of samples had ESP values between 6 and 14%. Therefore, based on the ESP values alone, essentially all spoil is regarded as being 'sodic' or 'strongly sodic' and, as such, a significant proportion of mine spoil at DNM can be expected to have potential for dispersion.

A subset of 154 spoil samples also underwent Emerson aggregate class tests to determine whether these samples were dispersive. Emerson aggregate class tests are a direct measure of soil dispersion, whereas ESP values are used as an indirect measure of the potential for a sample to have structural stability problems and hence may be dispersive. The results show that about 51% of the samples (79 out of 154 samples) - most (74 out of 79) of which were non-carbonaceous samples - had some dispersion [slaking] (Class 2). Another 23 samples had Emerson (Class 3) - dispersive [remoulded dispersion] and 3 samples had no dispersion - Emerson (Class 4). The remainder of the samples had Emerson Class 7 and 8 values (non-slaking). No samples were 'completely dispersive' (Class 1). Refer to Section 4.4.9 for class descriptions. These results are broadly consistent with the dispersion predictions from the CEC and ESP results.

Based on the CEC, ESP and Emerson aggregate class test results, a significant proportion of spoil at DNM is expected to be sodic to strongly sodic, and dispersive to varying degrees - with little distinction between lithology or degree of weathering.

These exchangeable cation (and Emerson aggregate class) results are common (if not typical) for Bowen Basin Permian and Tertiary material in the region – and highlight that spoil is likely to have mixed sodicity and dispersion potential.

## 5.9 OxCon Test-work

Data is available for OxCon test-work undertaken on one carbonaceous spoil sample classified as PAF-LC and one coal sample classified as PAF-LC. The test-work summarised in Table 19 – found that the carbonaceous spoil sample had moderate potential for acid generation and is unlikely to generate NMD or SD. In contrast, the coal sample had low potential for acid generation and is unlikely to generate NMD or SD. As such, the classification for spoil sample was confirmed to be PAF-LC/PAF and coal sample as PAF-LC.

Table 19: Summary of OxCon results for a single rejects sample.

SAMPLE ID	(DNM_177204_24.7-24.9M_CS)	(DNM_COAL_ORE_COMP1)
Type/source	Spoil	Coal
Preliminary (pre-Oxcon) AMD classification	PAF-LC	PAF-LC
Avg O <sub>2</sub> Consumption rate (mmol O <sub>2</sub> /kg/day)	0.75	0.68
Max. acidity generation rate (kg H <sub>2</sub> SO <sub>4</sub> /t/year)	14.4	13
Pyrite oxidation rate (wt. % pyrite/year)	47.53	0.42
Longevity of sulfide oxidation (years)	9	3
Lag time until ANC consumed (years)	0.75	1.5 – 2
Peak net acidity generation rate (kg H <sub>2</sub> SO <sub>4</sub> /t/year)	10	1.2
AMD Classification based on OxCon test	PAF	PAF-LC

## 6 SUMMARY OF GEOCHEMICAL CHARACTERISTICS

The geochemical characteristics of mineral waste (overburden/interburden [potential spoil] and coal processing waste [tailings, rejects and MPR]) from DNM have been assessed – as have the characteristics of coal samples that may report as ROM coal or as waste to the spoil dumps. The assessment was undertaken to understand the environmental characteristics of these samples, as being representative of their respective mineral waste types.

Within the context of this PRCP, spoil comprises approximately 98.5% of the mineral waste at DNM, with coal rejects (MPR<sup>8</sup>) comprising the remaining 1.5% (approximately). Spoil is comprised of approximately 94% non-carbonaceous material and approximately 6% of fresh carbonaceous material. Almost half of current spoil is weathered and the proportion of weathered to relative fresh material would remain the same as mining progresses due to seams at DNM being relatively flat (as opposed to sites where the pit gets a lot deeper).

### 6.1 AMD Potential of Mineral Waste and Coal Material Types.

#### 6.1.1 AMD Potential of Spoil – Non-carbonaceous

Non-carbonaceous spoil, which comprises about 94% of spoil (of which about 25% is weathered), is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), which is typical for sedimentary materials in the Bowen Basin.

The total S concentration of non-carbonaceous spoil is very low, with a 95th percentile total S concentration of 0.03% for weathered spoil and 0.11% for fresh spoil. As such, and combined with high ANC values (median 24 kg H<sub>2</sub>SO<sub>4</sub>/t, which is significantly higher than the MPA (median 0.61 kg H<sub>2</sub>SO<sub>4</sub>/t), approximately 99% of non-carbonaceous spoil samples tested (524 out of 529 samples) were classified as either NAF or UC(NAF).

The test-work demonstrated that the ANC for the non-carbonaceous spoil is generally expected to be approximately 67% (median) available under field conditions, with iron-dolomite being the main carbonate mineral contributing to the acid buffering potential of the spoil. Siderite, present in minor quantity, does not provide any net ANC. Overall, non-carbonaceous spoil has excess acid neutralising capacity.

Non-carbonaceous spoil has low enrichment in total metals and metalloids compared to unmineralised rocks. In particular, total metal and metalloid concentrations from 91 non-carbonaceous spoil samples tested are very low compared to average element abundance in soil in the earth's crust. A small number of samples (i.e. 1 out of 91 samples) had significant (GAI $\geq$ 3) enrichment with respect to As. There was no correlation found between AMD classifications of the non-carbonaceous spoil samples compared to elemental enrichment.

Soluble multi-element results (from 92 samples) indicate that leachate from NAF non-carbonaceous spoil is expected to contain low concentrations of soluble metals and metalloids. Four samples produced moderate soluble metal concentrations, having slightly elevated soluble concentrations in the leachate for one or more of the following elements: Al, As, Mn, Mo, Sb, Se. Peroxide leaching

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<sup>8</sup> MPR, hereafter referred to as coal rejects, primarily represents material generated (and disposed of) as MPR, comprising approximately 80% coarse rejects and 20% fine rejects, which are blended together at the CHPP, and will comprise the remaining 1.5% (approximately) of all mineral waste over the life of the operation.

undertaken on one non-carbonaceous spoil shows sample to be moderate to weekly acidic and low in metals.

Based on the results, non-carbonaceous spoil, being essentially all NAF characterised by very low total S concentration - has a negligible potential to generate AMD as either AD and/or NMD and/or SD.

#### 6.1.2 AMD Potential of Spoil – Carbonaceous

Carbonaceous spoil represents approximately 6% of spoil material at DNM and - as a bulk material - is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), similar to non-carbonaceous spoil.

The total S concentration of carbonaceous spoil is low, with a 95th percentile total S concentration of 0.18% for weathered spoil and 0.24% for fresh spoil. A small number of samples had low-moderate to moderate total S (and sulfide [Scr]) concentrations. Combined with generally low ANC values (median 10 kg H<sub>2</sub>SO<sub>4</sub>/t for weathered spoil and 13 kg H<sub>2</sub>SO<sub>4</sub>/t for fresh spoil) and relatively low MPA values (median 2 kg H<sub>2</sub>SO<sub>4</sub>/t for weathered spoil and 3 kg H<sub>2</sub>SO<sub>4</sub>/t for fresh spoil), approximately 88% of carbonaceous spoil samples (92 out of 104 samples) were classified as NAF. Five samples (5% of samples) were classified as UC(NAF) and eight samples (8%) were classified as PAF, PAF-LC, UC(PAF).

ANC in carbonaceous spoil is expected to be about 26% available under field conditions, with iron-dolomite being the main carbonate mineral contributing to the acid buffering potential of the spoil. Overall, carbonaceous spoil has relatively limited acid neutralising capacity.

Carbonaceous spoil has low enrichment in total metals and metalloids compared to unmineralised rocks. In particular, total metal and metalloid concentrations from 11 carbonaceous spoil samples tested are very low compared to average element abundance in soil in the earth's crust, and very similar to the assay concentrations from non-carbonaceous spoil. No samples had significant ( $GAI \geq 3$ ) enrichment. There was no correlation found between AMD classifications of the carbonaceous spoil samples compared to elemental enrichment.

Soluble multi-element results (from 15 samples) indicate that leachate from carbonaceous spoil is expected to contain low concentrations of soluble metals and metalloids - similar to the non-carbonaceous spoil samples. One sample produced low-moderate soluble metal concentrations, primarily due to slightly elevated soluble As. Peroxide leaching undertaken on one carbonaceous spoil classified as UC(NAF) show sample to be weekly acidic and low in metals.

Based on the results, carbonaceous spoil as a bulk material has a low potential to generate AD and/or NMD and/or SD. A small proportion of this material type has some potential to generate low-level AD and/or NMD and/or SD, however, is distributed amongst the bulk NAF material. As stated earlier, carbonaceous spoil represents approximately 6% of all spoil, therefore it is expected that the proportion of carbonaceous spoil that may have potential for AMD reporting to the spoil will be immaterial.

#### 6.1.3 AMD Potential of Coal Rejects Samples – Representing processing waste

For this study, tailings, rejects, and MPR were distinguished where data were available to better understand the geochemical properties and relative influence of each material type. However, coal rejects (MPR) are considered representative of all coal processing waste generated at DNM in the past, present, and future and are estimated to comprise approximately 1.5% of the total mineral waste at DNM.

The pH distribution of MPR, tailings, and rejects indicates that, as bulk materials, they are expected to generate alkaline to highly alkaline contact water (runoff and seepage).

MPR samples exhibited higher total S concentrations than potential spoil samples, ranging from 0.08% to 1.24%, with a low median value of 0.38% and a low-to-moderate 95th percentile value of 0.76%. Rejects showed a similar trend, with total S ranging from 0.13% to 1.00%, a low-moderate median value of 0.49%, and a low-moderate 95th percentile value of 0.80%. Tailings reported the highest total S concentrations, ranging from 0.18% to 1.59%, with a low-moderate median value of 0.63% and a low-moderate 95th percentile value of 1.06%.

When combined with generally moderate-to-high ANC values (median 43 kg H<sub>2</sub>SO<sub>4</sub>/t), low-to-moderate MPA values (median 11 kg H<sub>2</sub>SO<sub>4</sub>/t), and the wide range of NAG pH results, the data indicate that approximately 94% of MPR samples are NAF, with the remaining ~6% classified as either PAF-LC, UC(PAF) or NAF-S. A similar distribution was observed for tailings and rejects, where NAF samples represented 92% and 100%, respectively. The proportion of ANC likely available under field conditions was generally high across all coal processing waste materials, with medians of ~82% for tailings (n=13), ~75% for rejects (n=11), and ~79% for MPR (n=10) with iron-dolomite being the main carbonate mineral contributing to the acid buffering potential.

Two out of 28 rejects samples and two out of 22 tailings samples were significantly enriched in S [GAI ≥ 3], consistent with ABA data for these samples. There was no correlation found between AMD classifications of the samples compared to elemental enrichment.

Tailings (n=57), rejects (n=52), and MPR (n=86) samples were generally non-saline, with median EC1:5 values of 292, 331, and 281 μS/cm, respectively. Solubility data indicates that leachate from tailings, rejects and MPR under freshwater (deionised water) and saline water leaching conditions is expected to generate low soluble metal concentrations associated with near-neutral to alkaline pH. Peroxide leach data indicate that tailings, rejects, and MPR samples can generate elevated metal and metalloid loads under acidic conditions; however, sulfate (and salinity) loads are not expected to be elevated. Water quality associated with tailings, rejects, and MPR samples may, however, be influenced by the presence of organic acids.

Based on the results above, MPR encompasses the full geochemical range of tailings and rejects and is considered representative of the coal processing waste generated on site as their geochemical properties align with the weighted contribution of their fractions (approximately 80% coarse rejects and 20% fine rejects). Accordingly, approximately 95% of MPR (coal rejects) has a low potential to generate AMD as either AD and/or NMD and/or SD. However, 5% of coal rejects has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD. As such, as a bulk material, coal rejects has a low potential to generate AMD as either AD and/or NMD and/or SD.

## **6.2 Salinity, Sodicity and dispersion Potential of Mineral Waste and Coal Material Types**

### *6.2.1 Salinity, Sodicity, and Dispersion Potential of Spoil – Non-carbonaceous*

Non-carbonaceous spoil has EC values (from 159 samples) ranging from 86 to 1,460 μS/cm, with median and 90th percentile values of 297 and 493 μS/cm, and has very low total S concentrations. On this basis, contact water (run-off and seepage) is expected to be generally non-saline to slightly saline (<900 μS/cm), either as a result of dissolution of geogenic salts and/or from sulfide oxidation (sulphate salinity). A small number of weathered non-carbonaceous samples produced moderately saline leachate.

Non-carbonaceous spoil is expected to be sodic to strongly sodic with potential for dispersion (based on high sodicity values). In particular, non-carbonaceous spoil samples (n=334) had modest CEC values and generally high ESP values, resulting in approximately 42% of samples being classified as 'strongly sodic' and almost all remaining samples being classified as 'sodic'. Emerson aggregate class testing, conducted on a non-carbonaceous sample sub-set (n=132), reported 56% of samples (74 out of 132 samples) are likely to undergo 'some dispersion', 15% of samples (20 out of 132 samples) are found to be dispersive, and the remaining 38 samples had Emerson aggregate class values suggesting the samples were non-dispersive.

#### 6.2.2 *Salinity, Sodicity, and Dispersion Potential – Carbonaceous*

Carbonaceous spoil has EC values (from 104 samples, which were predominantly fresh carb. samples) ranging from 58 to 1000  $\mu\text{S}/\text{cm}$ , with median and 90th percentile values of 242 and 405  $\mu\text{S}/\text{cm}$ , and has generally low total S concentrations. On this basis, contact water (run-off and seepage) is expected to be non-saline to slightly saline, either as a result of dissolution of geogenic salts and/or from sulfide oxidation (sulfate salinity).

Carbonaceous spoil samples (n=36) had low CEC and high ESP values comparable to non-carbonaceous samples, resulting in 70% (25 out of 36 samples) being classified as 'strongly sodic' and almost all remaining being classified as 'sodic'. As such, and based solely on the high sodicity values, carbonaceous spoil is expected to be strongly sodic with potential for dispersion. Twenty-two samples also underwent Emerson aggregate class testing to directly measure dispersion, which found that 3 out of 22 samples to be dispersive, 5 samples displaying some dispersion and the remaining 14 samples had Emerson aggregate class values suggesting the samples were non-dispersive.

#### 6.2.3 *Salinity Potential of Coal*

Coal samples (n=89) have EC values ranging from 12 to 582  $\mu\text{S}/\text{cm}$ , with median and 90th percentile values of 119 and 310  $\mu\text{S}/\text{cm}$ , respectively, and has generally low total S concentrations. On this basis, contact water (run-off and seepage) from coal, as a bulk material, is expected to be non-saline, either as a result of dissolution of geogenic salts and/or from sulfide oxidation (sulfate salinity). A small number of coal samples produced slightly saline leachate.

#### 6.2.4 *Salinity Potential of Coal Processing Waste*

Coal rejects (MPR) have EC values ranging from 56 to 1340  $\mu\text{S}/\text{cm}$ , with median and 90th percentile values of 281 and 398  $\mu\text{S}/\text{cm}$ , respectively. These values fall within the range of both tailings (median 292  $\mu\text{S}/\text{cm}$ ; 90th percentile 543  $\mu\text{S}/\text{cm}$ ) and rejects (median 331  $\mu\text{S}/\text{cm}$ ; 90th percentile 468  $\mu\text{S}/\text{cm}$ ), with no significant difference between them. On this basis, contact water (run-off and seepage) from most coal rejects material is expected to be non-saline to slightly saline (<900  $\mu\text{S}/\text{cm}$ ). Only a small number of coal rejects samples produced moderately saline leachate. Most coal rejects have low to low-moderate total S concentrations, therefore the potential for SD (from sulfide oxidation) is low to low-moderate.

## 7 RISK ASSESSMENT

### 7.1 **Geochemical Source Hazard Assessment**

#### 7.1.1 *Spoil Landform*

At closure, DNM will comprise one large spoil landform (the Main landform), two smaller landforms (Pandora and OOPD landforms), and four residual voids. Three of the residual voids are located to the north of the Main landform (Titan North, Titan Central and Titan East), while the fourth residual void is located to the south (Pandora void, noting that Pandora Pit is a proposed future pit). The small Pandora landform is located south of the Pandora void, and the OOPD landform is located to the west of Pandora void. The general layout of the spoil landforms and residual voids at closure is shown in Figure 30.

The Main landform comprises mining overburden and interburden disposed behind the active mining face to form a low-wall spoil dump, with coal rejects (MPR, fine/coarse rejects) disposed into and encapsulated by spoil. Coal rejects are trucked from the CHPP and disposed into the northern half of the landform (i.e. closest to CHPP near Titan North, Titan Central and Titan East residual voids). Coal rejects comprise approximately 1.5% of all mineral waste at DNM. The Pandora landform and the OOPD landform will comprise predominantly mined spoil (approximately 99%), with an assumed 1% waste coal. No coal rejects will be disposed within Pandora or OOPD landforms.

At closure, all dumps will be reshaped into the final landforms and seeded (refer to the PRC Plan for spoil dump rehabilitation details).

The geochemical assessment has found that, from an environmental geochemical perspective, the geochemical differences between weathered and fresh materials are relatively minor. Considering that source materials within the spoil dumps are mainly represented by fresh material, the geochemical source hazard assessment has combined weathered and fresh mineral waste.

The source hazard assessment methodology outlined in Section 4.4.13 (AMD hazard scoring) and Section 4.4.14 (AMD likelihood ranking) has been applied to the spoil and coal rejects materials. Based on the geological database, carbonaceous spoil (overburden/interburden) comprises approximately 6.4% of all spoil, with non-carbonaceous spoil (overburden/interburden) comprising the remaining approximately 93.6% of all spoil.

At closure, overburden/interburden materials will account for approximately 98.5% of all mineral waste and the remaining 1.5% (approximately) present as coal rejects.

#### Main spoil landform

- Overburden/Interburden – non-carbonaceous (92.2%)
- Overburden/interburden – coaly and carbonaceous [excluding potential ROM coal] (6.3%);
- Coal rejects (1.5%)

#### Pandora and OOPD spoil landforms

- Overburden/interburden – non-carbonaceous (93.6%)
- Overburden/interburden – coaly and carbonaceous [excluding potential ROM coal] (6.4%);
- Coal rejects (0%)

The source hazard assessment, summarised in Table 20 for DNM Main landform and Table 21 for Pandora and OOPD landforms, has found that non-carbonaceous spoil poses a Low AMD source hazard, carbonaceous/coaly spoil poses a Moderate-Low AMD source hazard and rejects poses a Moderate AMD source hazard. On this basis, and taking into account material quantities (proportions):

- Main spoil landform poses a **Low** AMD hazard, with AMD generation rated as **Highly Unlikely**.
- Pandora landform and OOPD landform both pose a **Low** AMD hazard, with AMD generation rated as **Highly Unlikely**.

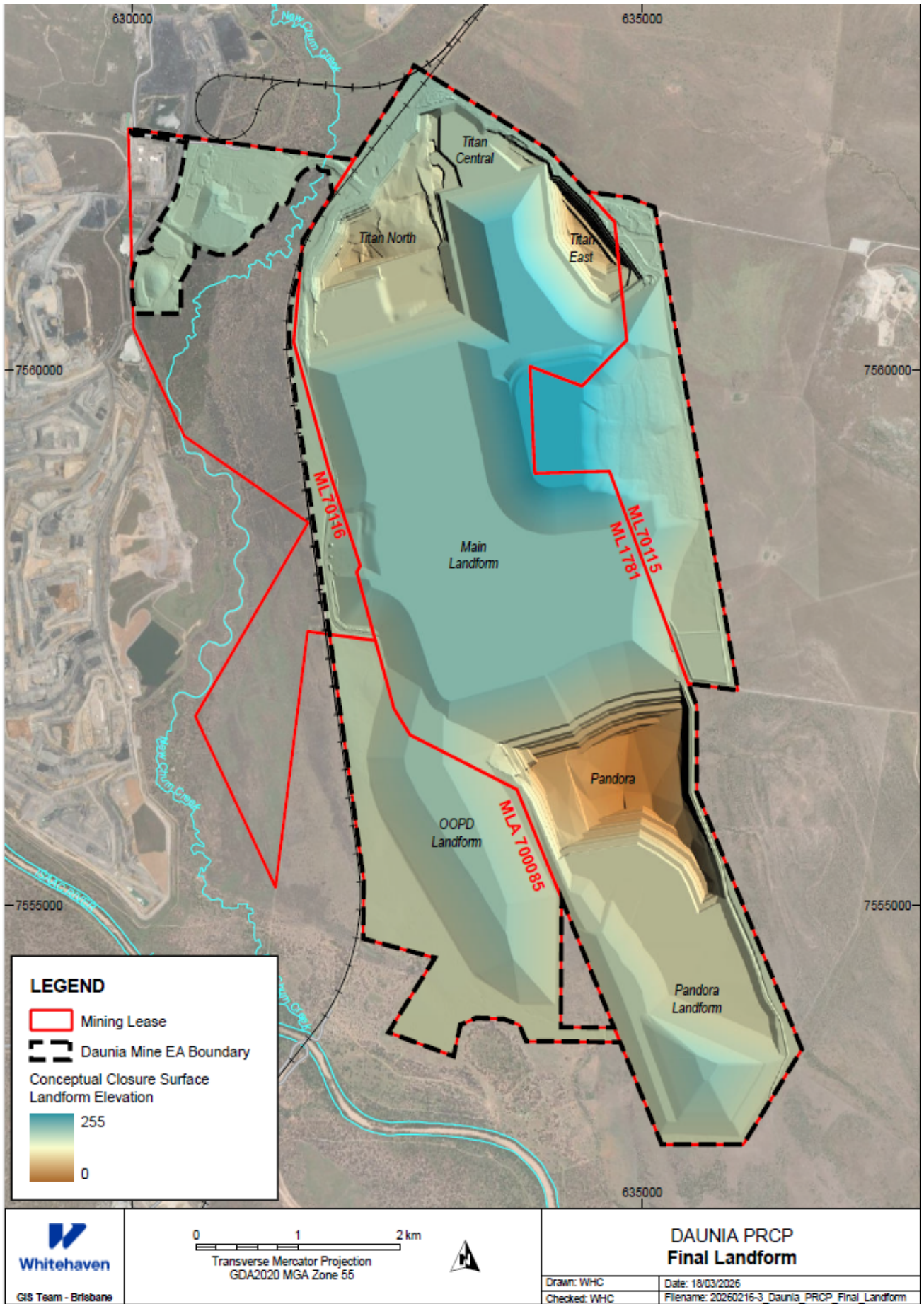


Figure 30: Conceptual final landform.

Table 20: AMD hazard scoring for source materials and likelihood for AMD generation from DNM Main landform

COMPONENTS	ESTIMATED MATERIAL PROPORTION %	% OF SAMPLES AS PAF	% OF MATERIAL IN LANDFORM ESTIMATED TO BE PAF	COMMENT	AMD PROPENSITY	AMD CAPACITY RATING	AMD QUANTITY RATING	AMD SOURCE HAZARD SCORE	DOMAIN AMD HAZARD SCORE	LIKELIHOOD FOR AMD GENERATION FROM MAIN LANDFORM AT DNM
Non-carbonaceous spoil Distributed throughout	92.2%	0.6%	0.5%	Very small proportion of PAF samples [incl. UC(PAF) and PAF-LC]. Total S is very low (75 <sup>th</sup> percentile = 0.03%). Non-carb spoil comprises at least 92% of mineral waste in DNM final landform. 75 <sup>th</sup> percentile EC of non-carbonaceous spoil = 381 µS/cm.	1 <i>Implausible</i>	1 <i>Low</i>	1 <i>Low</i>	2 <i>Low</i>	1.2 <i>Low</i>	Bulk spoil is overwhelmingly NAF with very low sulphur and excess neutralising capacity.  The hazard for AMD generation in the DNM main landform is based on 1.5% of the landform being coal rejects, of which about 5% is PAF and 6.3% of the landform being carbonaceous spoil, of which about 8% is conservatively estimated to be PAF. Overall, about 1.1% of the landform is expected to be either PAF, PAF-LC or UC(PAF) material.
Coaly and/or carbonaceous spoil Distributed throughout	6.3%	8%	0.5%	Based on sample numbers, up to 8% of coaly and carbonaceous spoil is classified as PAF, PAF-LC or UC(PAF). AMD capacity is based on a 75 <sup>th</sup> percentile S value of 0.11%. AMD quantity conservatively assumes proportion of PAF coaly/carb spoil samples approximates the proportion of coaly/carb spoil that is PAF. Assumes all coaly/carb spoil is distributed amongst non-carb spoil. 75 <sup>th</sup> percentile EC of non-carbonaceous spoil = 312 µS/cm.	5 <i>Plausible</i>	5 <i>Moderate</i>	5 <i>Moderate</i>	10 <i>Moderate</i>		All coal rejects and carbonaceous spoil is buried well within non-carbonaceous spoil. All coal rejects are co-disposed with spoil (segregation and selective handling). Carbonaceous spoil is comingled with non-carbonaceous spoil (operating mixing).  The 75 <sup>th</sup> percentile of EC of the landform (based on the EC of source materials proportionally represented) is estimated to be 370 µS/cm).
Coal Rejects	1.5%	5%	0.1%	5% of rejects are PAF, PAF-LC or UC(PAF). AMD capacity is based on a 75 <sup>th</sup> percentile S value of 0.56%. Some coal rejects samples will generate AMD. AMD quantity assumes proportion of PAF coal rejects samples approximates the proportion of coal rejects that are PAF. Coal rejects are disposed within predominantly non-carb and NAF spoil. 75 <sup>th</sup> percentile EC of rejects = 338 µS/cm.	5 <i>Plausible</i>	7 <i>Moderate High</i>	10 <i>High</i>	14 <i>Moderate</i>		The hazard for AMD generation from DNM main landform is considered to be <b>LOW</b> .  The likelihood for AMD generation from the final Main (spoil) landform at DNM is considered to be <b>Highly Unlikely</b> .

Table 21: AMD hazard scoring for source materials and likelihood for AMD generation from DNM Pandora and OOPD landforms.

COMPONENTS	ESTIMATED MATERIAL PROPORTION %	% OF SAMPLES AS PAF	% OF MATERIAL IN LANDFORM ESTIMATED TO BE PAF	COMMENT	AMD PROPENSITY	AMD CAPACITY RATING	AMD QUANTITY RATING	AMD SOURCE HAZARD SCORE	DOMAIN AMD HAZARD SCORE	LIKELIHOOD FOR AMD GENERATION FROM THE PANDORA AND OOPD LANDFORMS
Non-carbonaceous spoil Distributed throughout	93.6%	0.6%	0.6%	Very small proportion of PAF samples [incl. UC(PAF) and PAF-LC]. Total S is very low (75 <sup>th</sup> percentile = 0.03%). Non-carb spoil comprises at least 92% of mineral waste in landform. 75 <sup>th</sup> percentile EC of non-carbonaceous spoil = 381 µS/cm.	1 <i>Implausible</i>	1 <i>Low</i>	1 <i>Low</i>	2 <i>Low</i>		Bulk spoil is overwhelmingly NAF with very low sulfur and excess neutralising capacity.  The hazard for AMD generation in the Pandora and OOPD final landforms is based on 6.4% of the landform being carbonaceous spoil, of which about 8% is conservatively estimated to be PAF. Overall, about 1.1% of the landform is expected to be either PAF, PAF-LC or UC(PAF) material.
Coaly and/or carbonaceous spoil Distributed throughout	6.4%	8%	0.5%	Based on sample numbers, up to 13% of coaly and carbonaceous spoil is classified as PAF, PAF-LC or UC(PAF).  AMD capacity is based on a 75 <sup>th</sup> percentile S value of 0.11%. AMD quantity conservatively assumes proportion of PAF coaly/carb spoil samples approximates the proportion of coaly/carb spoil that is PAF.  Assumes all coaly/carb spoil is distributed amongst non-carb spoil. 75 <sup>th</sup> percentile EC of non-carbonaceous spoil = 312 µS/cm.	5 <i>Plausible</i>	5 <i>Moderate</i>	5 <i>Moderate</i>	10 <i>Moderate</i>	1.3 <i>Low</i>	All carbonaceous spoil is buried well within non-carbonaceous spoil.  The 75 <sup>th</sup> percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 375 µS/cm.  The hazard for AMD generation from the Pandora and OOPD landforms at DNM is considered to be <b>LOW</b> .  The likelihood for AMD generation from the final Pandora and OOPD landforms (spoil) at DNM is considered to be <b>Highly Unlikely</b> .

### 7.1.2 Exposed Walls and Floor

There are four pits at DNM that will remain at closure as residual voids – Titan North pit, Titan Central pit, Titan East pit (located to the north and northeast of the Main landform), and Pandora pit (south of the Main landform and north of the small Pandora landform).

Environmental geochemical data, coal quality data and drill-hole geological logs have been used to aid in the assessment of AMD risk associated with pit highwalls and pit floors, as explained in Section 4.2. Note that the source hazard assessment methodology outlined in Section 4.4 has been applied to the materials expected to be exposed on the pit highwalls and floor at closure.

The source materials within the highwall and floor of each pit comprise weathered and fresh materials. The depth of weathering is generally consistent across the site.

The statistical distribution of current pit highwall materials and the proportion of current exposed coal seam (groups) is shown in Figure 31 for the Titan North and Titan Central pits and Figure 32 for Titan East pit. The statistical distribution of expected pit highwall materials and the proportion of expected exposed coal seam (groups) for Pandora pit is shown in Figure 33.

Based on the information from the WHD Coal geological database, all pit highwalls are dominated by weathered and fresh non-carbonaceous materials. The current exposed seams on the highwall on Titan North, Titan Central and Titan East are the Leichhardt Seam and Lower Leichhardt Seam and are expected to comprise approximately about 5% (Titan North and Titan Central) and 7% (Titan East) of the pit highwalls. Remnant coal (Upper Vermont and Leichhardt seams) at Pandora pit is expected to comprise 4% of the pit highwalls.

The residual void highwall and floor assessment, summarised in Table 22 for Titan North and Titan Central residual voids, Table 23 for Titan East residual void and Table 24 for Pandora residual void show that approximately 3% to 4% of the pit highwall and approximately 44% of the pit floor – for all the pits – is conservatively estimated to be PAF, which includes material classified as PAF-LC and UC(PAF). As such, the assessment has found that AMD generation from the Titan North, Titan Central, Titan East and Pandora pit highwalls is Unlikely.

On a highly conservative assumption that the floor of each void is all coal, the void floor AMD hazard assessment has found that approximately 44% of the floor of each void is estimated to be “PAF”, which includes material classified as PAF and UC(PAF). As such, the conservative assessment has found that the likelihood of AMD generation from the floor of these voids is Probable/Likely until such time that the floor becomes submerged by groundwater (post-closure). In practice, mining takes all coal to the bottom seam, therefore insignificant coal quantity would be expected to remain on the floor of the voids.

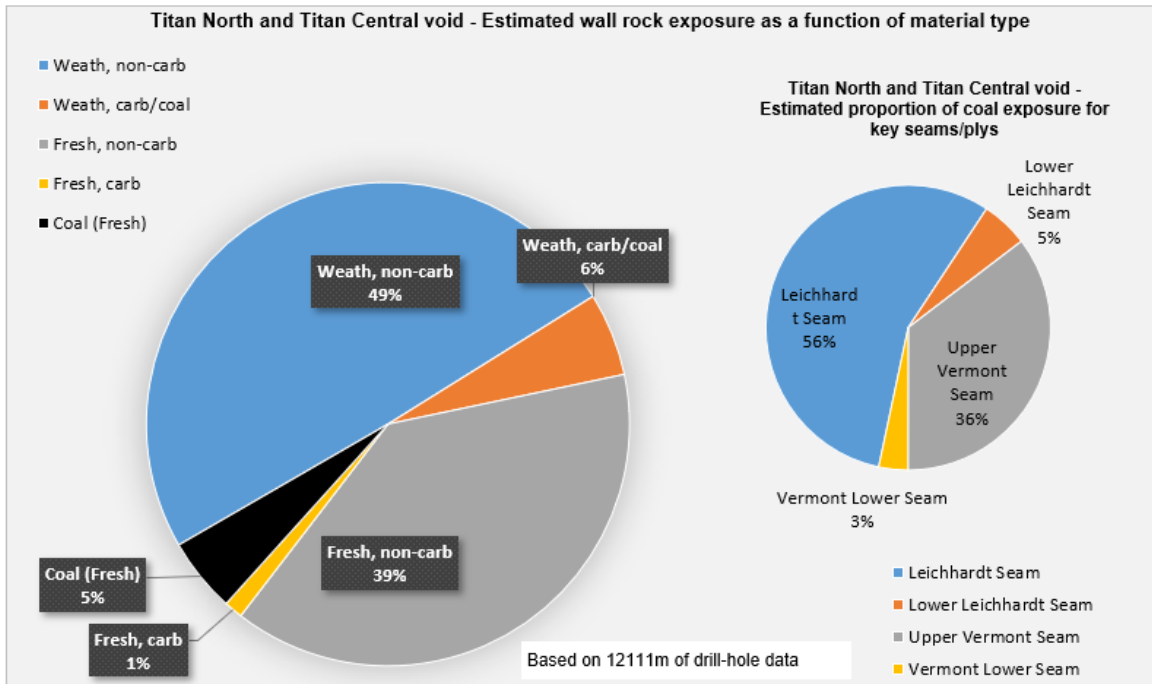


Figure 31: Estimated Titan North and Titan Central residual void highwall exposure by material type and proportion of coal exposure.

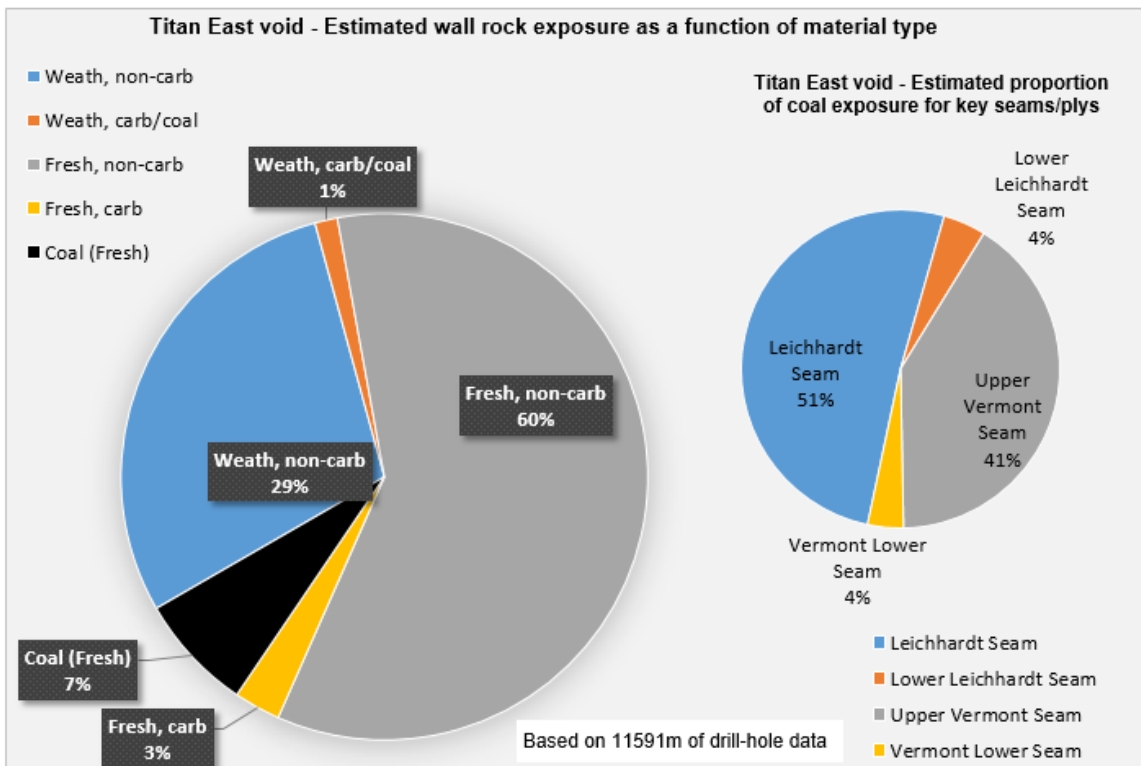


Figure 32: Estimated Titan East residual void highwall exposure by material type and proportion of coal exposure.

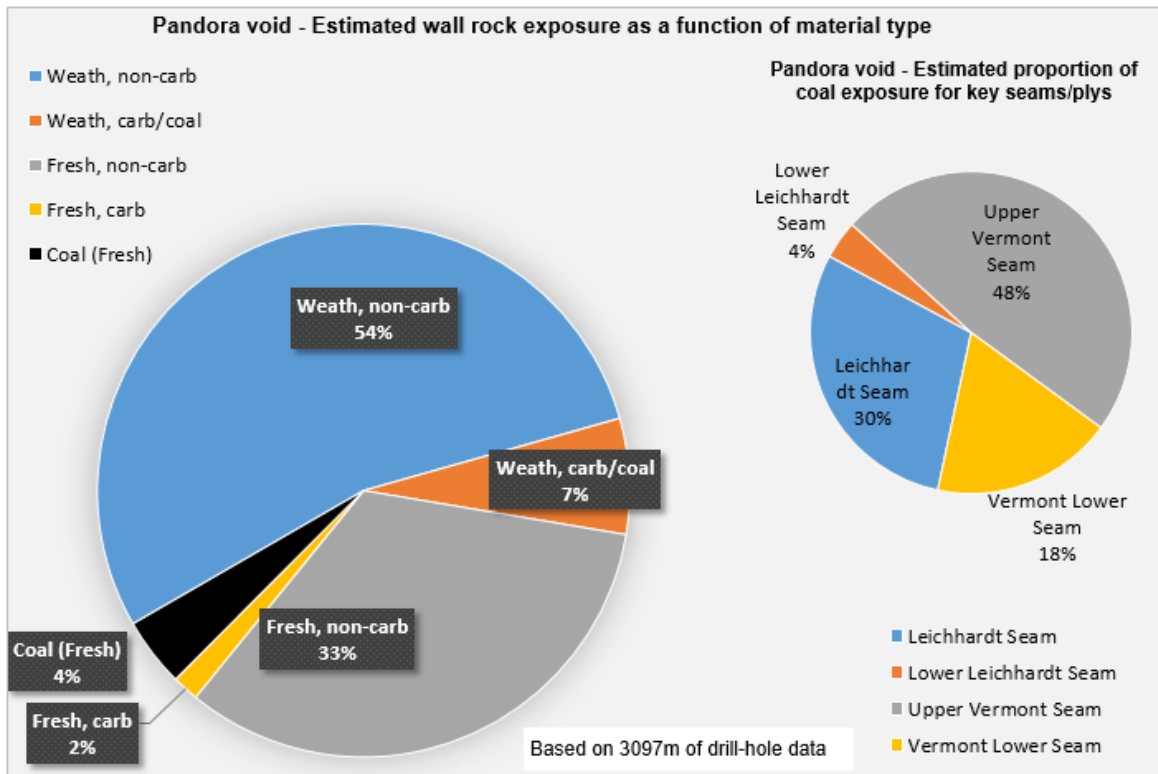


Figure 33: Estimated Pandora residual void highwall exposure by material type and proportion of coal exposure.

Table 22: AMD hazard scoring for source materials and likelihood for AMD generation from Titan North and Titan Central pit walls and floor.

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table	Below current water table	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Titan North & Titan Central Pit highwalls		
Titan North and Titan Central Pit Highwall	Weathered, non-carbonaceous	49.5%	47%	53%	0	0%	Total 0% of weathered non-carbonaceous samples (out of 136) were PAF-LC or PAF (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	0	This material is expected to comprise approximately 50% of the pit wall material by meterage. All weathered material (extremely to slightly). Assumed to be non-mineralised, with very low concentrations of reactive sulfide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.01%.	1	1	1	2	Fresh in-situ non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any.		
	Weathered, carbonaceous & coaly	5.6%	26%	74%	0	9%	Approximately 9% of weathered carbonaceous or coaly samples (1 samples out of 11) was PAF-LC (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is predominantly NAF. Approximately 26% of this material is currently above the water table and would be potentially subject to oxidation.	0.5	All weathered material with 9% of the samples collected from similar geological horizons were classed as PAF-LC. This material comprises 5.6% of the exposed highwall and does not contain significant sulphide minerals. PAF materials likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S is 0.09%.	5	7	1	9	The potential exposure of PAF materials on the highwall is estimated to represent less than 5% (vertical meterage). PAF domains may be largely confined to coal horizons. However, these will be embedded in a matrix of NAF and ANC-rich materials.		
	Fresh, non-carbonaceous	38.7%	45%	55%	100	1%	Approximately 0.8% of fresh, non-carbonaceous samples were PAF or PAF-LC or UC(PAF) (data from geochemical database) [3 out of 390 samples]. Approximately 45% of this material is currently above the water table and would be potentially subject to oxidation.	0.3	This material is estimated to comprise approximately 40% of the pit wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Based on the large number of samples tested (n=390) across DNM there is confidence that the proportion of PAF samples present within this material domain is negligibly small (~1% of samples classified as UC(PAF), PAF-LC or PAF). This material horizon is overwhelmingly NAF. The 75th percentile total S value is 0.04%.	1	1	1	2	Pit wall run-off reporting to the pit void is unlikely to produce acidity.		
	Fresh, carbonaceous	1.2%	28%	72%	100	6%	6 out of 93 samples (6.5% of samples) were PAF or UC(PAF) or PAF-LC (data from geochemical database). Approximately 28% of this material is currently above the water table and would be potentially subject to oxidation.	0.1	Generation of AMD from fresh carbonaceous units cannot be excluded as 6% of the samples tested were classed as PAF, UC(PAF) or PAF-LC. However, some carbonaceous overburden has excess ANC. The 75th percentile value for S is 0.11%.	5	7	1	9	The hazard for AMD generation from Titan North/Central highwall = LOW.		
	Coal (fresh)	5.0%	40%	60%	100	44%	34 out of 77 samples (44% of samples) were PAF or PAF-LC (data from geochemical database). Approximately 40% of this material is currently above the water table and would be potentially subject to oxidation.	2.2	Fresh coal is expected to comprise about 5% of the pit wall material by meterage. Geochemical data is available for 77 coal samples sourced from across DNM seams. Of these, 34 samples were classed as PAF, UC(PAF) or PAF-LC [i.e. 44% were PAF of some type]. The 75th percentile S value for all coal samples is low at 0.29%.	7	7	1	11	The likelihood for AMD generation from Titan North/Central highwall = UNLIKELY		
	Unknown	0.00	n/a	n/a	n/a	n/a	No 'unknown' material types from drill-hole database	n/a	No 'unknown' material types from drill-hole database	-	-	-	-			
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data								3.1	Source Scoring (average of all domains)			4	5	1	-
									Landform Scoring (50% weighting applied to AMD capacity and quantity)						7	
Material domain	Material type	Proportion of exposure on pit floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (geochemical database)	Comment	Estimated % PAF exposure on pit floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Titan North Pit floor			
Titan North and Titan Central Pit Floor	Coal: Upper Vermont Seam (V1, V2, V3, V23)	100%	0%	100%	100%	44%	PAF proportion estimated by applying a total S 'cut-off' of 0.40% to the coal quality data for Upper Vermont Seam samples (V1, V2, V3 and V23) (1499 samples). The S cut-off was based on the median total S value for PAF reject and coal samples (combined) from the geochemical database.  Based on coal database, 43% of 1499 coal samples were PAF. Based on the geochemical database, 44% of 77 coal samples were PAF or PAF-LC, therefore the estimate of 44% of the pit floor being PAF is likely to be conservative. All pit floor is below the water table and would become submerged shortly after mining ceases.	44%	The floor of Titan North/Central pit is likely to be Upper Vermont seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.45%.  Conservatively, 44% of Upper Vermont seam coal samples from DNM have been classed as PAF and, combined with the relatively low ANC in coal itself, the potential for AMD generation from a significant proportion of the pit floor cannot be excluded - assuming the entire pit floor comprises purely coal material.  No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding. This assessment adopts a highly conservative assumption that the pit floor will be coal or coaly, whereas it is most likely the pit floor will be predominantly non-coal material.	7	5	7	13	Conservatively, approximately 44% of the pit floor may comprise PAF coal. The geochemical hazard for Titan North/Central pit floor to develop AMD is moderate if the entire pit floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. Conservatively, the likelihood for AMD generation from exposed Titan North/Central Pit floor = PROBABLE/LIKELY		

Table 23: AMD hazard scoring for source materials and likelihood for AMD generation from Titan East pit walls and floor.

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table	Below current water table	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Titan East Pit highwall
Titan East Pit Highwall	Weathered, non-carbonaceous	29%	79%	21%	0	0%	Total 0% of weathered non-carbonaceous samples (out of 136) were PAF-LC or PAF (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	0	This material is expected to comprise approximately 30% of the pit wall material by meterage. All weathered material (extremely to slightly). Assumed to be non-mineralised, with very low concentrations of reactive sulphide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.01%.	1	1	1	2	Fresh in-situ non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any.
	Weathered, carbonaceous & coaly	1.4%	31%	69%	0	9%	Approximately 9% of weathered carbonaceous or coaly samples (1 samples out of 11) was PAF-LC (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is predominantly NAF. Approximately 26% of this material is currently above the water table and would be potentially subject to oxidation.	0.1	All weathered material, 9% of the samples collected from similar geological horizons were classed as PAF-LC. This material comprises less than 2% of the exposed highwall and does not contain significant sulphide minerals. PAF materials likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S value is 0.09%.	5	7	1	9	The potential exposure of PAF materials on the highwall is estimated to represent less than 5% (vertical meterage). PAF domains may be largely confined to coal horizons. However, these will be embedded in a matrix of NAF and ANC-rich materials.
	Fresh, non-carbonaceous	59%	20%	80%	100	1%	Approximately 0.8% of fresh, non-carbonaceous samples were PAF or PAF-LC or UC(PAF) (data from geochemical database) [3 out of 390 samples]. Approximately 45% of this material is currently above the water table and would be potentially subject to oxidation.	0.5	This material is estimated to comprise approximately 60% of the pit wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Based on the large number of samples tested (n=391) across DNM there is confidence that the proportion of PAF samples present within this material domain is negligibly small (~1% of samples classified as UC(PAF), PAF-LC or PAF). This material horizon is overwhelmingly NAF. The 75th percentile total S value is 0.04%.	1	1	1	2	Pit wall run-off reporting to the pit void is unlikely to produce acidity.
	Fresh, carbonaceous	2.9%	18%	82%	100	6%	8 out of 93 samples (8.5% of samples) were PAF or UC(PAF) or PAF-LC (data from geochemical database). Approximately 28% of this material is currently above the water table and would be potentially subject to oxidation.	0.2	Generation of AMD from fresh carbonaceous units cannot be excluded as 6% of the samples tested were classed as PAF, UC(PAF) or PAF-LC. However, some carbonaceous overburden has excess ANC. The 75th percentile value for S is 0.11%.	5	7	1	9	The hazard for AMD generation from Titan East highwall = LOW.
	Coal (fresh)	7.2%	15%	85%	100	44%	34 out of 77 samples (44% of samples) were PAF or PAF-LC (data from geochemical database). Approximately 40% of this material is currently above the water table and would be potentially subject to oxidation.	3.2	Fresh coal is expected to comprise about 7% of the pit wall material by meterage. Geochemical data is available for 77 coal samples sourced from across DNM seams. Of these, 34 samples were classed as PAF, UC(PAF) or PAF-LC (i.e. 44% were PAF of some type). The 75th percentile S value for all coal samples is low at 0.29%.	7	7	1	11	The likelihood for AMD generation from Titan East highwall = UNLIKELY
	Unknown	0	n/a	n/a	n/a	n/a	No 'unknown' material types from drill-hole database	n/a	No 'unknown' material types from drill-hole database	-	-	-	-	-
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data								3.9	Landform Scoring (50% weighting applied to AMD capacity and quantity)	4	5	1	-
Material domain	Material type	Proportion of exposure on pit floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (geochemical database)	Comment	Estimated % PAF exposure on pit floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Titan East pit floor	
Titan East Pit Floor	Coal: Upper Vermont Seam (V1, V2, V3, V23)	100%	0%	100%	100%	44%	PAF proportion estimated by applying a total S 'cut-off' of 0.40% to the coal quality data for Upper Vermont Seam samples (V1, V2, V3 and V23) (1499 samples). The S cut-off was based on the median total S value for PAF reject and coal samples (combined) from the geochemical database.  Based on coal database, 43% of 1499 coal samples were PAF. Based on the geochemical database, 44% of 77 coal samples were PAF or PAF-LC, therefore the estimate of 44% of the pit floor being PAF is likely to be conservative. <b>All pit floor is below the water table and would become submerged shortly after mining ceases.</b>	44%	The floor of Titan East pit is likely to be Upper Vermont seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.45%.  Conservatively, 44% of Upper Vermont seam coal samples from DNM have been classified as PAF and, combined with the relatively low ANC in coal itself, the potential for AMD generation from a significant proportion of the pit floor cannot be excluded - assuming the entire pit floor comprises purely coal material.  No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding. This assessment adopts a highly conservative assumption that the pit floor will be coal or coaly, whereas it is most likely the pit floor will be predominantly non-coal material.	7	5	7	13	Conservatively, approximately 44% of the pit floor may comprise PAF coal. The geochemical hazard for Titan East Pit floor to develop AMD is moderate if the entire pit floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. Conservatively, the likelihood for AMD generation from exposed Titan East Pit floor = PROBABLE/LIKELY

Table 24: AMD hazard scoring for source materials and likelihood for AMD generation from Pandora pit walls and floor.

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table	Below current water table	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental database)	Comment	Estimated % PAF exposure on highwall	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	AMD Source Material Hazard Score	Likelihood for AMD generation from Pandora Pit highwall			
Pandora Pit Highwall	Weathered, non-carbonaceous	54%	52%	46%	0	0%	Total 0% of weathered non-carbonaceous samples (out of 136) were PAF-LC or PAF (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF.	0.0	This material is expected to comprise approximately 54% of the pit wall material by meterage. All weathered material (extremely to slightly). Assumed to be non-mineralised, with very low concentrations of reactive sulfide minerals. Small proportion of samples may be PAF (if so, likely low capacity). The potential for AMD from acid sulphate minerals (e.g. jarosite) is very low or negligible. Likely source of ANC. The 75th percentile total S value is 0.01%.	1	1	1	2	Fresh in-situ non-carbonaceous rock is expected to have excess acid neutralising capacity, which should be sufficient to buffer AMD released from potential AMD sources exposed on the highwall, if any.  The potential exposure of PAF materials on the highwall is estimated to represent less than 5% (vertical meterage). PAF domains may be largely confined to coal horizons. However, these will be embedded in a matrix of NAF and ANC-rich materials.  Pit wall run-off reporting to the pit void is unlikely to produce acidity.  The hazard for AMD generation from Pandora highwall = LOW.  The likelihood for AMD generation from Pandora highwall = UNLIKELY			
	Weathered, carbonaceous & coaly	7%	36%	64%	0	9%	Approximately 9% of weathered carbonaceous or coaly samples (1 samples out of 11) was PAF-LC (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is predominantly NAF. Approximately 26% of this material is currently above the water table and would be potentially subject to oxidation.	0.6	All weathered material with 9% of the samples collected from similar geological horizons were classed as PAF-LC. This material comprises 5.6% of the exposed highwall and does not contain significant sulfide minerals. PAF materials likely to be low capacity (i.e. PAF-LC). The potential for AMD from acid sulphate salts is low. The 75th percentile total S is 0.09%.	5	7	1	9				
	Fresh, non-carbonaceous	33%	27%	73%	100	0.8%	Approximately 0.8% of fresh, non-carbonaceous samples were PAF or PAF-LC or UC(PAF) (data from geochemical database) [3 out of 390 samples]. Approximately 45% of this material is currently above the water table and would be potentially subject to oxidation.	0.3	This material is estimated to comprise approximately 33% of the pit wall material by meterage. Overall, fresh, non-carbonaceous spoil is overwhelmingly NAF with excess ANC. This material is likely to be an important source of ANC. Based on the large number of samples tested (n=390) across DNM there is confidence that the proportion of PAF samples present within this material domain is negligibly small (~1% of samples classified as UC(PAF), PAF-LC or PAF). This material horizon is overwhelmingly NAF. The 75th percentile total S value is 0.04%.	1	1	1	2				
	Fresh, carbonaceous	1.6%	24%	76%	100	6%	6 out of 93 samples (6.5% of samples) were PAF or UC(PAF) or PAF-LC (data from geochemical database). Approximately 28% of this material is currently above the water table and would be potentially subject to oxidation.	0.1	Generation of AMD from fresh carbonaceous units cannot be excluded as 6% of the samples tested were classed as PAF, UC(PAF) or PAF-LC. However, some carbonaceous overburden has excess ANC. The 75th percentile value for S is 0.11%.	5	7	1	9				
	Coal (fresh)	4.2%	20%	80%	100	44%	34 out of 77 samples (44% of samples) were PAF or PAF-LC (data from geochemical database). Approximately 40% of this material is currently above the water table and would be potentially subject to oxidation.	1.8	Fresh coal is expected to comprise about 4.2% of the pit wall material by meterage. Geochemical data is available for 77 coal samples sourced from across DNM seams. Of these, 34 samples were classed as PAF, UC(PAF) or PAF-LC [i.e. 44% were PAF of some type]. The 75th percentile S value for all coal samples is low at 0.29%.	7	7	1	11				
	Unknown	0.0	n/a	n/a	n/a	n/a	No 'unknown' material types from drill-hole database	n/a	No 'unknown' material types from drill-hole database	-	-	-	-		-		
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data								2.83	Source Scoring (average of all domains)					4	5	1
									Landform Scoring (50% weighting applied to AMD capacity and quantity)								7
Material domain	Material type	Proportion of exposure on pit floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (geochemical database)	Comment	Estimated % PAF exposure on pit floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Pandora Pit floor				
Pandora Pit Floor	Coal: Upper Vermont Seam (V1, V2, V3, V23)	100%	0%	100%	100%	44%	PAF proportion estimated by applying a total S 'cut-off' of 0.40% to the coal quality data for Upper Vermont Seam samples (V1, V2, V3 and V23) (1499 samples). The S cut-off was based on the median total S value for PAF reject and coal samples (combined) from the geochemical database.  Based on coal database, 43% of 1499 coal samples were PAF. Based on the geochemical database, 44% of 77 coal samples were PAF or PAF-LC, therefore the estimate of 44% of the pit floor being PAF is likely to be conservative. All pit floor is below the water table and would become submerged shortly after mining ceases.	44%	The floor of Pandora pit is likely to be Upper Vermont seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.45%.  Conservatively, 44% of Upper Vermont seam coal samples from DNM have been classified as PAF and, combined with the relatively low ANC in coal itself, the potential for AMD generation from a significant proportion of the pit floor cannot be excluded - assuming the entire pit floor comprises purely coal material.  No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding. This assessment adopts a highly conservative assumption that the pit floor will be coal or coaly, whereas it is most likely the pit floor will be predominantly non-coal material.	7	5	7	13	Conservatively, approximately 44% of the pit floor may comprise PAF coal. The geochemical hazard for Pandora Pit floor to develop AMD is moderate if the entire pit floor comprises purely coal material (unlikely) and if the coal floor remains exposed to air (unlikely). As such, the actual AMD hazard post-closure will likely be lower than indicated. Conservatively, the likelihood for AMD generation from exposed Pandora Pit floor = PROBABLE/LIKELY			

## 7.2 Geochemical Source Pathway Receptor

A post-closure hydrogeological conceptual model (HCM), which applies to the spoil landforms and residual voids at DNM, and the relationship that the spoil landforms and residual voids are expected to have with surface water and groundwater in the district, has been produced by SLR Consultants (2026) (Figure 34).

The HCM assists with the SPR assessment with regard to potential environmental geochemical impacts from mineral waste facilities. The HCM, which focusses on the relationship the post-mining landform, residual void lakes, infiltration through spoil and groundwater (these being the most relevant pathways and receptors for AMD and salinity), is used to illustrate the relationship between potential sources (e.g. spoil or void lakes), plausible receptors (e.g. creeks and groundwater) and the pathways between the two (e.g. seepage, groundwater flow).

The residual voids are classified as non-use management areas (NUMAs). Rainfall runoff and infiltration through the spoil landform will mostly drain into the residual voids where lakes will form. Groundwater modelling undertaken by SLR (2026) shows the residual voids will ultimately be groundwater 'sinks' for almost all seepage; that is, the residual voids will generally be receptors of run-off and seepage from the final landforms and run-off from void highwalls, as illustrated in the HCM (Figure 34). However, not all seepage from OOPD spoil landform is captured in Pandora residual void, as discussed below.

Recent groundwater modelling, including particle tracking, undertaken by SLR (2025) for the DNM West Infrastructure Project approval process, incorporating the OOPD indicates that enhanced recharge through the OOPD is expected to result in some localised groundwater mounding beneath the spoil dump generating a groundwater divide beneath the western part of the OOPD. Particle tracking shows that the majority of drainage through the OOPD migrates east and is captured by Pandora Pit, and seepage from the western margin of the OOPD migrates off lease to the west and is then expected to flow south. However, the particle tracking also indicates that the higher rate of recharge drives downward groundwater flow into deeper Permian coal measure (into the FCCM) rather than lateral migration through shallow aquifers.

The hydrogeological assessment undertaken for the PRCP (SLR, 2026) indicates that the nearest alluvial aquifer of significant spatial extent is located along the Isaac River floodplain, approximately 3 km west of DNM (approximately 3 km from the southern end of the site). The assessment indicates that shallow permeable strata may be present sporadically along, and/or near, several creeks at DNM. Where shallow groundwater is present, it is expected to occur well below the base of surface water features, suggesting that hydraulic connectivity between shallow groundwater and surface water is unlikely. Therefore, despite the apparent low likelihood of substantial connectivity between shallow groundwater and surface water features, the SPR assessment has adopted a conservative approach and assumed that a plausible shallow groundwater pathway may exist in isolated locations.

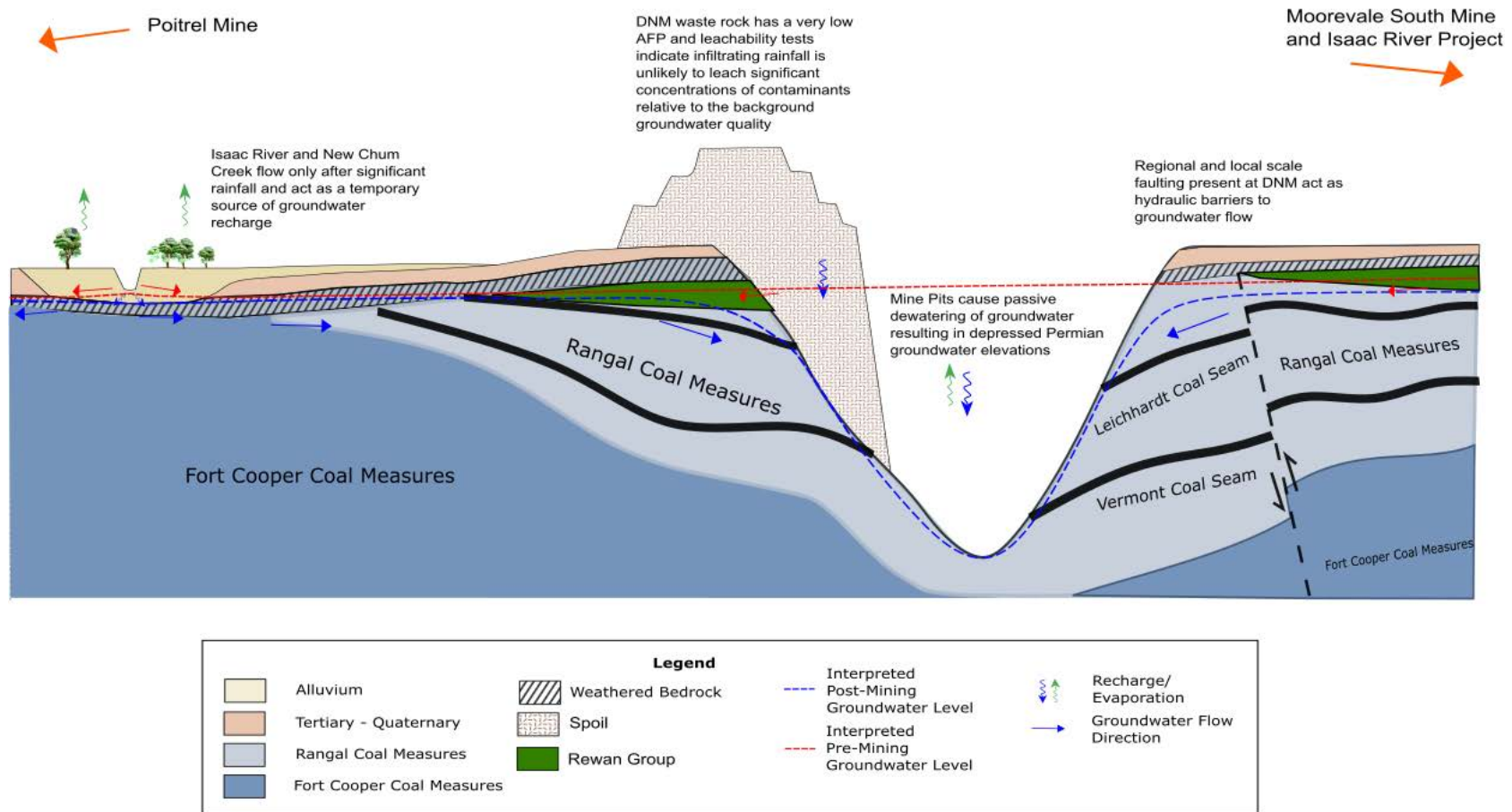


Figure 34: Source-Pathway-Receptor (SPR) hydrogeological conceptual model post-closure (SLR, 2026).

In the event of significant rainfall, New Chum Creek in the vicinity of the Titan North and Titan Central dump landforms (i.e. at the northern end of DNM), could represent a plausible receptor for surface water runoff from the Titan North and Titan Central dumps. During major rainfall events New Chum Creek provides recharge to the Isaac River alluvium. There are also three unnamed tributaries of North Creek to the north and northeast of the ML; however, the heads of these tributaries are located on the highwall side of the Titan North, Titan Central and Titan East residual voids and are therefore implausible receptors for significant site-derived runoff.

At the southern end of DNM, an unnamed tributary drains southwest into the Isaac River in close proximity to the Pandora residual void. During significant rainfall events, Isaac River wetlands located less than 1 km west of the OOPD and approximately 1 km southwest of the Pandora spoil landform may represent plausible receptors for surface runoff from the Pandora spoil landform. However, as discussed earlier, groundwater modelling indicates that seepage from the OOPD and other spoil landforms is not predicted to migrate through shallow groundwater systems to the Isaac River, and any limited off-site groundwater migration remains at depth with limited hydraulic connectivity to surface water environments.

For assessing the sources, plausible receptors and potential pathways between the sources and receptor, it is assumed that the overwhelming majority of spoil is in-pit and sediments have been mined out to the base of the Vermont Upper (V2/3) coal seams, as indicatively illustrated in the HCM (Figure 34).

With regard to the post-closure mineral waste facilities (spoil landforms and residual voids), the plausible mechanism for AMD affected water and/or non-oxidative salinity to report to receptors are identified in Table 25.

Table 25: Sources, plausible receptors and pathways between the source and receptor.

SOURCE	POTENTIAL PATHWAY	PLAUSIBLE RECEPTOR
<b>Spoil landform zones</b>		
Main dump @ Titan North and Titan Central (i.e. northern zone of the spoil landform)	Surface water run-off	-New Chum Creek -Titan North and Titan Central residual voids
	Seepage [shallow permeable strata]	-New Chum Creek
	Seepage [groundwater]	-Titan North and Titan Central residual voids
Main dump @ Titan East dump (i.e. north-eastern zone of the spoil landform)	Surface water run-off	-Titan East residual void
	Seepage [groundwater]	-Titan East residual void
Main dump @ Pandora (i.e. southern zone of the Main spoil landform)	Surface water run-off	-Isaac River -Pandora residual void
	Seepage [shallow permeable strata]	-Isaac River
	Seepage [groundwater]	-Pandora residual void
OOPD @ west of Pandora residual void	Surface water run-off	- Isaac River (+/- via unnamed tributary) - Pandora residual void
	Seepage [shallow permeable strata]	- Isaac River (+/- via unnamed tributary) - Pandora residual void
	Seepage [groundwater]	- Pandora residual void - Permian aquifer
	Surface water run-off	-Isaac River

SOURCE	POTENTIAL PATHWAY	PLAUSIBLE RECEPTOR
Pandora spoil landform (i.e. small landform south of Pandora void)		-Pandora residual void
	Seepage [shallow permeable strata]	-Isaac River
	Seepage [groundwater]	-Pandora residual void
<b>Void highwalls</b>		
Titan North and Titan Central voids	Surface water run-off	-Titan North and Titan Central residual voids
Titan East void	Surface water run-off	-Titan East residual void
Pandora void	Surface water run-off	-Pandora residual void

The geochemical source hazard assessment (Section 7.1) found that the Main spoil landform, which comprises approximately 92% non-carbonaceous spoil, had an AMD hazard score of ‘Low’, with AMD generation from the Main DNM landform rated as ‘Highly Unlikely’. The small Pandora and OOPD spoil landforms, which both comprise only spoil, also had an AMD hazard score of ‘Low’, with AMD generation also rated as ‘Highly Unlikely’.

The residual risk heating map (Table 26) has been adopted to assess the risks associated with the SPR assessment from both landforms.

In reference to the Risk Matrix, the SPR assessment includes the likelihood of the event occurring, the severity of the event (should it occur) and the calculated risk rating (likelihood x severity).

Table 26: Risk matrix for SPR assessment.

RISK RATING = LIKELIHOOD X SEVERITY		SEVERITY				
		S1	S2	S3	S4	S5
Likelihood	Highly Likely	Medium	Medium to High	High	High	High
	Likely	Low to Medium	Medium	Medium to High	High	High
	Probable	Low	Low to Medium	Medium	Medium to High	High
	Unlikely	Low	Low	Low to Medium	Medium	Medium to High
	Highly Unlikely	Low	Low	Low	Low to Medium	Medium

The risk rating for the spoil landforms with respect to plausible surface water and residual void receptors is shown in Table 27 (DNM Main landform), Table 28 (Pandora landform) and Table 29 (OOPD landform), and discussed in Section 7.2.1. The risk rating for the residual voids with respect to the void receptor is shown in Table 30 and discussed in Section 7.2.2. The potential impact of seepage, if any, from the residual voids into the Permian groundwater aquifer is discussed in the void closure plan (ERM, 2026).

The overall rating of the SPR assessment showed that the risk rating for AMD to impact receptors is Low; and the risk rating for non-oxidative salinity to impact receptors is conservatively rated as Low based on 75<sup>th</sup> percentile EC value applied to the source.

The assessment shows that all receptors are at low risk of direct or indirect environmental impact from mineral waste with respect to AMD (including acid/acidity, NMD and SD) and non-oxidative salinity.

The 'Low' risk rating was assigned with consideration for the key aspects for each key facility/domain.

### 7.2.1 Final Spoil Landform (Rehabilitated Spoil Dumps)

#### Source materials hazard

The Main spoil landform is comprised of approximately 92% non-carbonaceous overburden/interburden with coaly and carbonaceous material (including coal rejects) comprising the remaining 8% (approximately) of the final landforms. Non-carbonaceous overburden/interburden from Permian-age material in the Bowen Basin is widely recognised as posing a low-moderate AMD risk. Rejects at DNM poses a moderate AMD hazard, however is disposed (encapsulated) well within general spoil and does not report to final landform surfaces.

Source materials generally have low to low-moderate EC values and are expected to produce slightly to moderately saline run-off and seepage, with release of (non-oxidative) salinity rated as a low-hazard. The overall low total S and excess ANC of the combined mineral waste materials results in a 'Highly Unlikely' rating for AMD generation.

The Pandora and OOPD landforms being comprised of spoil only, and in the same proportions of non-carbonaceous and carbonaceous spoil as the Main landform, have also been assessed as posing a Low AMD hazard, with AMD generation rated as Highly Unlikely.

#### Pathways

##### Surface water

The closest surface water receptors to the Titan North and Titan Central dump zone (i.e. the northern end) of the final landform is New Chum Creek located within 300 m from the western extent of the final landform. Therefore, it is plausible for surface water run-off from the rehabilitated landform to reach New Chum Creek. Note that New Chum Creek flows north to south between DNM and neighbouring Poitrel Mine and receives run-off from both sites.

The closest surface water receptor to the southern end of the final Main landform (north of Pandora void) is an un-named tributary that drains into the Isaac River. The un-named tributary is within 200 m of the south-western zone of the Main landform. Therefore, it is plausible for surface water run-off from the southern zone of the final landform to reach the un-named tributary draining into the Isaac River.

In addition, the Isaac River traverses in the close proximity of the OOPD and Pandora landforms, with the closest distance being less than 1 km. As such, the Isaac River presents a plausible downstream surface water receptor for run-off from the rehabilitated OOPD and Pandora landforms.

##### Seepage / Groundwater

The water table is expected to intersect the deeper zones of the in-pit Main and Pandora landform within the Permian Coal Measures (SLR, 2026). It is plausible for seepage from the near-surface and unsaturated zone of these in-pit spoil landforms to migrate downwards into the water table. However, groundwater is captured by the residual void, which is a groundwater sink, in the long-term. Therefore, although a direct connection is expected to exist between deeper parts of the residual void and groundwater (the water table), the local groundwater will report to and be contained within the residual voids.

As discussed in Section 7.2, while the majority of seepage from OOPD is expected to report to the Pandora residual void, seepage from the western margin of OOPD may migrate off lease to the west and is then expected to flow south. However, the particle tracking indicates that the higher rate of recharge drives downward groundwater flow into deeper Permian coal measures (into the FCCM) units rather than lateral migration through shallow aquifers.

As outlined in Section 7.2.1, this SPR assessment has adopted a conservative approach by assuming that a potential shallow groundwater pathway may exist in isolated areas. However, it should be noted that, the particle tracking results indicate that elevated recharge rates promote predominantly downward groundwater flow into the deeper Permian coal measure units.

### Receptors

Plausible receptors identified in this qualitative assessment include the ephemeral New Chum Creek, the Isaac River, an un-named creek that flows from the southwestern corner of the site into Isaac River, and the residual voids. Due to the geochemical nature of the final landforms, the likelihood of undiluted salinity or AMD (if any) to impact on the water quality of surface water receptors or final void water quality has been rated 'Highly Unlikely'.

Consideration was also made to people living in the homesteads near DNM, of which the closest is 'Olive Downs' located approximately 1 km west of the ML boundary as the far southern end of the site (Figure 1). Groundwater modelling shows Pandora residual void to be a 'groundwater sink' - that is, the Pandora residual void will be a receptor of run-off and seepage from the southern zone of the Main landform, from the OOPD and Pandora landforms, and run-off from the Pandora pit highwall, as conceptually illustrated in the HCM (Figure 34). There is also a very minor un-named tributary (ephemeral drainage gully) located between the Olive Downs homestead and the southern zone of the landform. This gully would intersect (capture) surface water run-off from the landform, if any. Therefore, the potential for Olive Downs homestead to be impacted by AMD or saline drainage from the final landform is implausible.

### **SPR risk rating of final landforms**

There are plausible surface water and final void receptors and the run-off and seepage pathways linking the sources (final spoil landforms) to these receptors have been identified. However, the mineral waste materials within the final spoil landforms (source) pose a low AMD and non-oxidative salinity hazard. Therefore, the overall SPR risk rating from all spoil landforms (Main, Pandora and OOPD) at DNM is Low.

#### *7.2.2 Residual Voids*

### **Source materials hazard**

The surfaces of residual void highwalls comprise approximately 87 to 88% non-carbonaceous overburden/ interburden, about 4 to 6% coaly and carbonaceous overburden/interburden and about 4 to 7% coal (seams). Approximately 50% of the current Titan North highwall and an even greater proportion of the Titan Central Pit highwall are predicted to comprise weathered non-carbonaceous material at closure. In addition, approximately 30% of the current Titan East Pit highwall and 54% of the Pandora Pit highwall at closure are predicted to comprise weathered non-carbonaceous material, with the remainder being fresh, predominantly non-carbonaceous material. Fresh and weathered non-carbonaceous overburden/interburden from Permian-age material in the Bowen Basin is widely recognised as posing a low AMD risk. Coal seams at DNM pose a moderate AMD risk.

Generally, highwall materials have low EC values, with release of (non-oxidative) salinity rated as a low-hazard.

Overall, the hazard for AMD of residual void highwall material is low and the likelihood for AMD generation from final void highwalls is 'Unlikely'.

Pit floor (comprised of Upper Vermont seam in each void) are conservatively estimated to comprise approximately 44% PAF coal – and conservatively assuming 100% of the floor is coal and not some other material. The pit floor (of each residual void), as described, poses a moderate AMD hazard – which does not take into account likely mitigating factors, such as pit floor flooding. After flooding, the pit floor (of each void) would be expected to pose a low AMD hazard.

## **Pathways**

### Surface water

There are no plausible pathways between the residual voids and surface water. Surface water run-off from the void highwall will report to the void and, therefore, will remain within the final void.

### Seepage

Each residual void will act as a groundwater sink and the water table will intersect the deeper zones of each void, resulting in the formation of a relatively small pit lake within each void (SLR, 2026; and Figure 34) that will submerge the pit floor and lower section of the pit highwall and in-pit spoil. Seepage from the final landform (low-wall of the spoil dump) and run-off from the highwall will report to the residual void closest to that part of the spoil landform(s).

### Receptors

Modelling undertaken by SLR (2026) shows the final voids to be 'sinks' – receiving surface water run-off and seepage from final landforms and surface water run-off from pit (void) highwalls. Modelling also shows the final voids are expected to receive inflow from the Permian groundwater aquifer. The water quality of the pit voids and potential impact of water seeping, if any, from the final voids into the Permian groundwater aquifer is discussed in the void closure plan (ERM, 2026).

Due to the geochemical nature of the materials exposed in the highwall of each void, the likelihood of undiluted salinity or AMD (if any) to impact on final void water quality has been rated 'Highly Unlikely'.

Pit floor (floor of each residual void) will be covered post-closure by water as groundwater partially recovers and forms a pit lake. As such, PAF coal will no longer be exposed to atmospheric conditions and the risk of AMD being generated is greatly reduced. The likelihood of undiluted salinity or AMD from a flooded post-closure final void floor to impact on final void water quality to any significant degree has been rated 'Unlikely'.

Consideration was also made to people living in the homesteads near the project area, of which the closest is 'Olive Downs Homestead' located approximately 1 km west of the ML boundary at the far southern end of the site and, post-closure, will be located over 1 km from the Pandora Pit residual void. The potential for this homestead to be impacted by AMD from the Pandora residual void is implausible.

## **SPR risk rating of residual voids**

The final receptors for seepage from the low-wall of the final landforms and run-off from the highwall are the four residual voids. The AMD assessment has found that it's unlikely that undiluted salinity or AMD from a flooded post-closure final void floor (of any of the voids) would impact on final void water quality to any significant degree, as other processes such as evapo-concentration are the key drivers of residual void water quality (ERM, 2026; SLR, 2026). Therefore, the AMD SPR risk rating on the overall water quality of the residual voids is Low for each void.

Groundwater or surface water reporting to residual voids is expected to remain within the residual voids (excluding evaporative loss). Modelling undertaken by SLR (2026) shows that seepage from the pit lake of each void into groundwater, if any, would be limited.

Table 27: Source-Pathway-receptor (SPR) assessment of final Main spoil landform (to surface water receptors)

SOURCE	PATHWAY	RECEPTOR	EVENT (POTENTIAL HARM)	LIKELIHOOD OF EVENT	SEVERITY OF EVENT	RISK RATING
Main landform comprising three zones: - Titan North and Titan Central -Titan East; -Pandora (post-closure)  Comprised of approximately 92.2% non-carbonaceous overburden, approximately 6.3% coaly and carbonaceous material and 1.5% coal rejects material.  AMD source hazard: <b>Low</b>  Salinity (non-oxidative) source hazard: <b>Low</b>	Surface water run-off from Titan North and Titan Central landform into ephemeral New Chum Creek that flows into Isaac River.  Distance ~1 km to receptor (north-west)  Potential for AMD to enter pathway: <b>Unlikely</b>  Potential for salt (non-oxidative) >900 µS/cm to enter pathway: <b>Unlikely</b>	Ephemeral creek (New Chum Creek @ northern-western end of Titan landform and ML boundary)  Potential for AMD to reach receptor: <b>Unlikely</b>  Potential for salt (non-oxidative) >900 µS/cm to reach receptor: <b>Unlikely</b>	Acid/acidic drainage	Highly	S1	Low
			Low pH water impacting surface water	Unlikely		
			Neutral metalliferous drainage	Unlikely		
			Metals impacting surface water	Unlikely		
	Surface water run-off from southern end of main landform (north of Pandora void) into ephemeral un-named tributary, which flows into the Isaac River.  Distance ~200 m to receptor (west)  Potential for AMD to enter pathway: <b>Unlikely</b>  Potential for salt (non-oxidative) >900 µS/cm to enter pathway: <b>Unlikely</b>	Ephemeral creek (Un-named Tributary draining into the Isaac River @ south-western end of main landform).  Potential for AMD to reach receptor: <b>Unlikely</b>  Potential for salt (non-oxidative) >900 µS/cm to reach receptor: <b>Unlikely</b>	Acid/acidic drainage	Highly	S1	Low
			Low pH water impacting surface water	Unlikely		
			Neutral metalliferous drainage	Unlikely		
			Metals impacting surface water	Unlikely		
Saline drainage (from sulfide oxidation) Salt (sulphate) impacting surface water  Saline drainage (non-oxidative) Salt impacting surface water	Potential for AMD to reach receptor: <b>Unlikely</b>  Potential for salt (non-oxidative) >900 µS/cm to reach receptor: <b>Unlikely</b>	Saline drainage (from sulfide oxidation)	Highly	S1	Low	
		Salt (sulphate) impacting surface water	Unlikely			
		Saline drainage (non-oxidative)	Unlikely			
		Salt impacting surface water	Unlikely			

Table 28: Source-Pathway-receptor (SPR) assessment of Pandora spoil landform (to surface water receptors)

SOURCE	PATHWAY	RECEPTOR	EVENT (POTENTIAL HARM)	LIKELIHOOD OF EVENT	SEVERITY OF EVENT	RISK RATING
Pandora landform (Post-closure)  Comprised of approximately 93.6% non-carbonaceous overburden and approximately 6.4% coaly and carbonaceous material.  No coal rejects  AMD source hazard: <b>Low</b>  Salinity (non-oxidative) source hazard: <b>Low</b>	Surface water run-off from Pandora landform into ephemeral un-named tributary, which flows into Isaac River.  Distance ~200 m to receptor (west)  Potential for AMD to enter pathway: <b>Unlikely</b>  Potential for salt (non-oxidative) >900 µS/cm to enter pathway: <b>Unlikely</b>	Ephemeral creek (Un-named Tributary draining into the Isaac River @ western end of Pandora landform).  Potential for AMD to reach receptor: <b>Unlikely</b>  Potential for salt (non-oxidative) >900 µS/cm to reach receptor: <b>Unlikely</b>	Acid/acidic drainage Low pH water impacting surface water	Highly Unlikely	S1	Low
			Neutral metalliferous drainage Metals impacting surface water	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation) Salt (sulphate) impacting surface water	Highly Unlikely	S1	Low
			Saline drainage (non-oxidative) Salt impacting surface water	Unlikely	S2	Low

Table 29: Source-Pathway-receptor (SPR) assessment of OOPD spoil landform (to surface water receptors)

SOURCE	PATHWAY	RECEPTOR	EVENT (POTENTIAL HARM)	LIKELIHOOD OF EVENT	SEVERITY OF EVENT	RISK RATING
OOPD landform (Post-closure)  Comprised of approximately 93.6% non-carbonaceous overburden and approximately 6.4% coaly and carbonaceous material.  No coal rejects  AMD source hazard: <b>Low</b>  Salinity (non-oxidative) source hazard: <b>Low</b>	Surface water run-off from OOPD landform into Isaac River.	Isaac River @ western end of OOPD landform.	Acid/acidic drainage Low pH water impacting surface water	Highly Unlikely	S1	Low
	Distance <1km to receptor (west)	Potential for AMD to reach receptor: <b>Unlikely</b>	Neutral metalliferous drainage Metals impacting surface water	Unlikely	S1	
			Saline drainage (from sulfide oxidation) Salt (sulphate) impacting surface water	Highly Unlikely	S1	
	Potential for AMD to enter pathway: <b>Unlikely</b>	Potential for salt (non-oxidative) >900 µS/cm to reach receptor: <b>Unlikely</b>	Saline drainage (non-oxidative) Salt impacting surface water	Unlikely	S2	
			Potential for salt (non-oxidative) >900 µS/cm to enter pathway: <b>Unlikely</b>			

Table 30:Source-Pathway-Receptor (SPR) assessment of spoil landforms (to residual void receptor).

SOURCE	PATHWAY	RECEPTOR	EVENT (POTENTIAL HARM)	LIKELIHOOD OF EVENT	SEVERITY OF EVENT	RISK RATING
Main landform, Pandora landform and OOPD landform (post-closure)  Comprised of approximately 92% non-carbonaceous overburden, approximately 6.5% coaly and carbonaceous material (and the Main landform also includes approximately 1.5% coal rejects material).	Seepage / percolations into groundwater, which flows into residual voids. Residual voids are expected to intersect the water table. Residual voids are groundwater 'sinks', drawing all groundwater within landform catchment towards residual void.  Potential for AMD to enter pathway: <b>Unlikely</b>	Residual voids (NUMA's)	Acid/acidic drainage Low pH water impacting residual void water quality	Highly Unlikely	S1	Low
		Potential for AMD to reach residual void: <b>Unlikely</b>	Neutral metalliferous drainage Metals impacting residual void water quality	Unlikely	S1	Low
		Potential for salt (non-oxidative) >900 µS/cm to reach residual void: <b>Unlikely</b>	Saline drainage (from sulfide oxidation) Salt (sulphate) impacting residual void water quality	Highly Unlikely	S1	Low
		Potential for salt (non-oxidative) >900 µS/cm to reach residual void: <b>Unlikely</b>	Saline drainage (non-oxidative) Salt impacting residual void water quality	Unlikely	S2	Low
AMD source hazard: <b>Low</b>	Potential for salt (non-oxidative) >900 µS/cm to enter pathway: <b>Unlikely</b>					
Salinity (non-oxidative) source hazard: <b>Low</b>	Surface water run-off which flows into residual voids. Residual voids are terminal 'sinks' drawing majority of surface water run-off from the landform catchment.  Potential for AMD to enter pathway: <b>Highly Unlikely</b>  Potential for salt (non-oxidative) >900 µS/cm to enter pathway: <b>Highly Unlikely</b>	Residual voids (NUMA's)	Acid/acidic drainage Low pH water impacting residual void water quality	Highly Unlikely	S1	Low
		Potential for AMD to reach residual void: <b>Highly Unlikely</b>	Neutral metalliferous drainage Metals impacting residual void water quality	Highly Unlikely	S1	Low
		Potential for salt (non-oxidative) >900 µS/cm to reach residual void: <b>Highly Unlikely</b>	Saline drainage (from sulfide oxidation) Salt (sulphate) impacting residual void water quality	Highly Unlikely	S1	Low
		Potential for salt (non-oxidative) >900 µS/cm to reach residual void: <b>Highly Unlikely</b>	Saline drainage (non-oxidative) Salt impacting residual void water quality	Highly Unlikely	S1	Low

Table 31: Source-Pathway-Receptor (SPR) assessment of highwall and floor (to residual voids receptor).

SOURCE	PATHWAY	RECEPTOR	EVENT (POTENTIAL HARM)	LIKELIHOOD OF EVENT	SEVERITY OF EVENT	RISK RATING
Titan North, Titan Central, Titan East and Pandora pit highwall and pit floor (post-closure)	Surface water run-off from highwall into residual void. All voids are groundwater sinks.	Residual voids (NUMA's)	Acid/acidic drainage Low pH water impacting residual void water quality	Unlikely	S1	Low
Highwalls comprised of approximately 86 to 88% non-carbonaceous overburden and approximately 12 to 14% coaly and carbonaceous material including coal seams.	Potential for AMD to enter pathway: <b>Unlikely</b>	Potential for AMD to reach receptor (residual void): <b>Unlikely</b>	Neutral metalliferous drainage Metals impacting residual void water quality	Unlikely	S1	Low
			Saline drainage (from sulfide oxidation) Salt (sulphate) impacting residual void water quality	Unlikely	S1	Low
PAF exposure on highwalls expected to be less than 6% (vertical meterage).	Potential for salt (non-oxidative) >900 µS/cm to enter pathway: <b>Unlikely</b>	Potential for salt (non-oxidative) >900 µS/cm to reach residual void: <b>Unlikely</b>	Saline drainage (non-oxidative) Salt impacting residual void water quality	Unlikely	S2	Low
PAF exposure on pit floors conservatively estimated at approximately 44%, however pit floors will be submerged			Saline drainage (non-oxidative) Salt impacting residual void water quality			
AMD source hazard from exposed highwalls and submerged pit floors: Low						
Salinity (non-oxidative) source hazard: Low						

## 8 MANAGEMENT AND REHABILITATION MEASURES

The assessment has found that the environmental risks posed by mineral wastes likely to be present at closure are low. As such, no specific AMD management measures (e.g. alkaline amendment or capping systems) are expected to be required to manage mineral wastes during rehabilitation and closure – outside of operational mixing/burial of coal rejects, spoil placement and landform reshaping activities already proposed (refer below and to the main volume of the PRCP).

Decommissioning and rehabilitation activities related to mineral waste will be addressed as part of the milestone criteria for infrastructure, remediation of contaminated land, landform design, surface preparation and revegetation, where necessary.

Proposed mineral waste management and rehabilitation activities of relevance to this waste characterisation report comprise the following actions. Refer to the main volume of the PRCP for detailed information:

- Pits: will remain as four residual voids:
  - Titan North void;
  - Titan Central void;
  - Titan East void; and
  - Pandora void.
- Spoil dumps: will be reshaped into their respective spoil landforms (Main, Pandora and OOPD) and seeded.
- Coal rejects: Managed during operations (disposed within spoil) and progressively covered by spoil. No additional remediation for the rejects (at closure) is required. The optimal thickness of spoil cover to manage the AMD hazard of coal rejects will be determined following further assessment prior to covering.
- ROM pad: Remove remnant coal from the ROM Pad and dispose within spoil. The former ROM Pad will be reshaped, covered with soil, ripped and seeded.
- Coal stockpile: Remove remnant coal from the coal stockpile pad and dispose within spoil. Cover with suitable soil material, rip and seed.

## 9 REFERENCES

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## **10 LIMITATIONS**

Attention is drawn to the document “Limitations”, which is included in Appendix A of this report. The statements presented in this document are intended to provide advice on what the realistic expectations of this report should be, and to present recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Mine Waste Management, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so.

**APPENDIX A    LIMITATIONS**

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