BHP

Goonyella Riverside and Broadmeadow Mine

Progressive Rehabilitation and Closure Plan

Environmental Geochemical Characterisation and Risk Assessment of Mineral Waste

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EXECUTIVE SUMMARY

This report serves to document and discuss the environmental geochemical characteristics of mineral waste materials located on Goonyella Riverside and Broadmeadow Mine (GRBM), as supporting information for the progressive rehabilitation and closure plan (PRCP) for GRBM. GRBM comprises two operations: an open-cut mining operation called Goonyella Riverside Mine (GRM) and an underground mining operation called Broadmeadow Mine (BRM). Collectively, they are referred to here as GRBM.

The objective of the assessment is to evaluate the geochemical nature of mineral waste currently at GRBM 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.

GRBM is located approximately 25 kilometres (km) north of Moranbah township, in central Queensland, and is operated by BHP Mitsubishi Alliance Pty Ltd (BMA).

GRM commenced operations in 1971 and comprises typical open-pit coal mining facilities, such as open pits, waste rock (spoil) dumps, tailings storage facilities (TSFs), rejects dumps, coal stockpiles, coal processing facilities, rail loadout facilities, process water and raw water dams, surface water drains and administration areas. BRM commenced operations in 2005 and comprises longwall underground mining infrastructure to extract coal and surface infrastructure to transfer run-of-mine (ROM) coal via overland conveyor to the coal handling and preparation plants (CHPPs) located at GRM. In this report BRM is considered only the underground operations, therefore no mineral waste is located at BRM and BRM does not contain any pits that, at closure, may remain as residual voids. As such, this environmental geochemical assessment is focused on GRM – where all mineral waste is generated and/or disposed.

The BMA Red Hill Mine (RHM) is an approved longwall underground mine neighbouring GRBM. Coal from RHM is approved to be processed at GRBM and the tailings and rejects will be disposed at GRBM. As such – and consistent with BRM – no mineral waste will be located at RHM and RHM will not contain any pits that, at closure, may remain as residual voids.

Current activities of relevance to this waste characterisation report comprise:

- Disposal of spoil to in-pit spoil dumps behind the active mining face (in-pit low-wall spoil disposal);
- Run-of-mine (ROM) coal processing at two coal handling and preparation plants (CHPPs): Goonyella (GY) CHPP and Riverside (RV) CHPP, which both produce two mineral waste types:
  - Tailings. Clay, silt and very fine to medium-grain sized sand material; disposed as a slurry into TSFs;
  - Rejects. Coarse sand to cobble-sized material; primarily disposed (buried) within spoil dumps. Historic rejects from Riverside CHPP were disposed at the Riverside rejects dump. Rejects have also been used in construction of TSF embankments and infrastructure pads; and capping of tailings at TSFs.
- Disposal of tailings from the CHPPs to the in-pit Ramp 32 TSF (Airstrip pit) [active since approximately 2019];
- Disposal of rejects from the CHPPs to in-spoil disposal areas;
- Short-term storage of ROM coal on the ROM Pads;
- Short-term storage of product coal on the product coal stockpiles, awaiting off-site transport by rail;

Historic activities of relevance to this waste characterisation report comprise:

- Disposal of tailings from GY CHPP to the above-ground GS1 TSF [inactive since late 2020];
- Disposal of tailings from RV CHPP to the above-ground RS1 TSF [inactive since early 2021];
- Disposal of tailings from the CHPPs to the in-pit DRE5 TSF [inactive since 2022].

Material types and quantities

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

- Spoil (overburden and interburden) comprises approximately 98% of all mineral waste at GRBM and includes weathered waste (Tertiary and Permian-age) and fresh (unweathered) waste (all Permian-age).
- Tailings are generated at the CHPPs from processing ROM coal and typically represent the clay, silt and fine sand fractions of ROM waste. Throughout operations at GRBM, tailings have been disposed as a slurry into several TSFs – the current (active) TSF being Ramp 32 in-pit TSF. Tailings comprise approximately 0.5% of all mineral waste at GRBM – with this approximated proportion expected for the remaining life of asset mine plan.
- Rejects are generated at the CHPPs from processing ROM coal and typically represent coarser and rockier seam roof, partings and floor material. Rejects are trucked to spoil dumps and disposed (buried) within spoil. Historic rejects from RV CHPP were disposed at Riverside rejects dump. Some rejects have been used in construction of TSF embankments and infrastructure pads (e.g. ROM and coal stockpile pads) and for capping RS1 TSF. Rejects comprise approximately 1.5% of all mineral waste at GRBM – with this approximated proportion expected for the remaining life of asset mine plan.

Coal is also included in the assessment; however, coal is generally not considered mineral waste, with the exception of small quantities of sub-economic seams that may report to the spoil dumps, and remnant coal exposed on pit highwalls (such as in residual voids).

AMD Potential of Mineral Waste and Coal Material Types

Mineral waste 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 sulphide 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.

AMD potential of spoil – non-carbonaceous

Non-carbonaceous spoil, which comprises about 93% of spoil, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), which is typical for mine spoil in the Bowen Basin.

Based on the results, non-carbonaceous spoil has a low potential to generate AMD as either AD and/or NMD and/or SD, but for a small proportion that is assessed to have a higher potential to generate AMD (as AD, NMD and/or SD). However, in consideration of the mixing and dispersion of a small volume of waste at higher potential for AMD within the broader spoil material, the overall potential for non-carbonaceous spoil (and bulk spoil, generally) to generate AMD is assessed to be low.

The total sulphur (S) concentration of non-carbonaceous spoil is very low, with a 90th percentile total S concentration of 0.08%. As such, and combined with moderate to high acid neutralising capacity (ANC) values (median 40 kg H_2SO_4/t), approximately 96% of 1169 non-carbonaceous spoil samples tested were classified as non-acid forming (NAF), with a further 3% (approximately) of samples classified as UC(NAF) [uncertain, but expected to be NAF]. Only 1.5% (approximately) of non-carbonaceous spoil samples were classified as potentially acid forming (PAF), PAF-LC [PAF, low capacity] or UC(PAF) [uncertain, but expected to be PAF]. No samples were classified as NAF-S [NAF, but with total S greater than 1%].

The test-work undertaken has demonstrated that the ANC for the non-carbonaceous spoil is generally expected to be about 30-75% available under field conditions, with iron-dolomite and dolomite expected to be the main carbonate minerals contributing to the acid buffering potential of the spoil. Overall, non-carbonaceous spoil has excess acid neutralising capacity and is expected to be bulk acid consuming.

Total metal and metalloid concentrations from 114 non-carbonaceous spoil samples tested are very low compared to average element abundance in soil in the earth's crust. About 30% of samples were significantly enriched with regard to selenium (Se); and a further 12 samples (11% of samples) were significantly enriched with regard to one or more of arsenic (As), cadmium (Cd), copper (Cu), mercury (Hg), S and/or antimony (Sb). There was no clear correlation found between these 'enriched' samples and their AMD classifications, however the enrichment in these elements in a small number of samples is not cause for concern. In summary, non-carbonaceous spoil (as a bulk material) has low enrichment in total metals and metalloids compared to unmineralised rocks.

Soluble multi-element results (from 139 non-carbonaceous samples) indicate that leachate from this material is expected to contain low concentrations of soluble metals and metalloids under pH-neutral to alkaline conditions.

About 20% of samples produced moderate soluble metal concentrations in one or more of aluminium (Al), As, cobalt (Co), iron (Fe), manganese (Mn), nickel (Ni) and/or zinc (Zn) – under pH-neutral to alkaline leaching conditions (excluding two samples that produced weakly acidic pH leachate). Peroxide leaching undertaken on three non-carbonaceous spoil samples with PAF classification showed that some PAF material, when oxidised, has the potential to generate low pH leachate (AD) with elevated sulphate and soluble metal and metalloid concentrations.

AMD potential of spoil – carbonaceous

Carbonaceous spoil represents approximately 7% of spoil material at GRBM 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. Most carbonaceous spoil is fresh (unweathered).

Based on the results from 143 samples, most carbonaceous spoil has a generally low to moderate potential to generate AD and/or NMD and/or SD. Some carbonaceous spoil – generally associated with coal seams – has a greater potential to generate low-level AD and/or NMD and/or SD.

The total S concentration of carbonaceous spoil is low, with a 90th percentile total S concentration of 0.38% (from 202 samples).

Approximately 90% (128 out of 143) of carbonaceous spoil samples were classified as NAF. The remaining 10% of carbonaceous spoil samples were classified as PAF, PAF-LC or UC(PAF) and had a low-moderate 75th percentile total S value of 0.62%. No samples were classified as NAF-S.

The test-work undertaken on a small sub-set of six samples has demonstrated that the ANC in these samples is expected to be about 20-50% available under field conditions, with iron-dolomite expected to be the main carbonate mineral contributing to the acid buffering potential of the carbonaceous spoil. Overall, carbonaceous spoil has modest acid neutralising capacity.

Total metal and metalloid concentrations from 22 carbonaceous spoil samples tested are generally 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. Similar to non-carbonaceous spoil, 10 carbonaceous spoil samples out of 22 were significantly enriched with regard to one or more of As and/or Se. The enrichment in these elements in a small number of samples is not cause for concern. There was no clear correlation found between AMD classifications of the carbonaceous spoil samples compared to elemental enrichment. In summary, carbonaceous spoil (as a bulk material) has low enrichment in total metals and metalloids compared to unmineralised rocks.

Soluble multi-element results (from 22 samples) indicate that leachate from carbonaceous spoil is expected to contain generally low concentrations of soluble metals and metalloids – similar to the non-carbonaceous spoil samples. Of the 22 samples, 16 had low soluble metal and metalloid concentrations under pH-neutral to alkaline conditions, and one sample had low soluble metal and metalloid concentrations under weakly acidic conditions. The remaining five samples had moderate soluble metal and metalloid concentrations – predominantly under pH-neutral to alkaline conditions. Peroxide leaching was undertaken on two fresh carbonaceous spoil samples classified as PAF and UC(PAF), which showed that PAF samples, when oxidised, have the potential to generate low pH leachate (AD) with elevated sulphate and soluble metal and metalloid concentrations.

AMD potential of tailings

The geochemical characteristics differed between fresh tailings from the CHPPs verses aged tailings from the TSFs – particularly total S, ANC, net acid generation (NAG) pH and $pH_{1:5}$. However, the overall geochemical (AMD) hazard posed by tailings from the two sources (fresh vs aged) was generally similar. There was also no significant difference in the geochemical characteristics between the fresh tailings from each CHPP (i.e. GY CHPP versus RV CHPP) or between aged tailings from each of the main TSFs (i.e. GS1 TSF versus RS1 TSF). As such, the discussion that follows only differentiates between the two tailings sources (fresh versus aged) where the differences between the two sources was significant for some parameters and worthy of discussion. Else, the AMD potential of tailings is discussed as a bulk material – regardless of source.

Based on the results, approximately 51% of tailings has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, and remaining 49% (approximately) has a relatively low to low-moderate potential to generate AMD as either AD and/or NMD and/or SD.

The total S concentration of tailings is low-moderate, with a 75th percentile total S concentration of 0.7%. Fresh CHPP tailings had higher total S concentrations (median = 0.61%) compared to aged tailings samples (median = 0.39%) from TSFs. Scr accounts for approximately 49% (median value) of total S in fresh CHPP tailings and 45% (median value) of total S in aged tailings – the slightly lower proportion of Scr in aged tailings (compared to fresh tailings) is likely due to some sulphide in aged tailings being oxidised to sulphate (SO_4).

As a bulk material, tailings have generally moderate ANC (median 17 kg H_2SO_4/t), however the CHPP tailings had about twice the ANC of aged tailings – suggesting that a significant proportion of the neutralising material in tailings in the TSFs had been consumed since deposition. Combined with tailings (all) having generally low-moderate maximum potential acidity (MPA; median 17 kg H_2SO_4/t) values, resulted in approximately 49% of the tailings samples being classified as NAF [including 53 samples classified as UC(NAF)] and 48% of samples classified as PAF, PAF-LC or UC(PAF). Twelve samples were classified as NAF-S. That is, approximately half of all tailings were classified as 'PAF' (of some type) or NAF-S.

Test-work indicated that about 30-60% of the ANC is likely available under field conditions, however the 'field availability' of ANC ranged from 9% to 100%. The acid buffering characterisation curve (ABCC) data suggested iron-dolomite, dolomite, and lesser siderite, were the likely dominant carbonate minerals, which is broadly consistent with the mineralogy data. Carbonate concentrations were generally higher in fresh CHPP tailings (and rejects) samples compared to aged samples – the reason for this may be due to carbonate being consumed in the aged samples due to buffering reactions associated with sulphide oxidation. Consumption of carbonate is also consistent with the lower ANC values in aged tailings compared to fresh tailings.

Total metal and metalloid concentrations from 95 tailings samples tested are very low compared to average element abundance in soil in the earth's crust. However, all tailings samples were significantly enriched with regard with Se. Furthermore, 18 tailings samples were significantly enriched with regard to one or more of As and/or S. There was no clear correlation found between AMD classifications of the tailings samples compared to elemental enrichment.

Solubility data indicate that most tailings samples under freshwater (deionised water) leaching conditions are expected to have low soluble metals concentrations and have near-neutral to alkaline pH. About 5% of the tailings samples – mostly 'PAF' – had moderate soluble metals concentrations under weakly acidic to pH-neutral conditions; and one sample (classified as PAF) was elevated in soluble metals concentrations and was moderately acidic, confirming its' PAF classification. This suggests that overtime, 'PAF' tailings can generate AD as field ANC is consumed. Under saline leaching conditions tailings produced low concentrations of soluble metals and metalloids.

Peroxide leaching undertaken on 33 tailings samples (about two-thirds classified as 'PAF' of some type) showed that when exposed to highly oxidising conditions a significant proportion of tailings can produce weakly to highly acidic leachate with moderate to elevated soluble metals and metalloid concentrations. It must be noted that samples with potentially high organic carbon concentrations, such as some tailings samples, may be influenced by organic acids producing acidity and correspondingly elevated soluble metals concentrations unrelated to AMD. As such, the results for such coaly/carbonaceous samples should be interpreted with this in mind. Nevertheless, PAF tailings [including tailings classified as UC(PAF)] have typically produced moderate to elevated soluble metals and metalloid concentrations from the freshwater and peroxide leaching tests. These results indicate that PAF tailings have the potential to generate low pH leachate (AD), however the salinity (sulphate) loads are not expected to be high – due to generally low total S concentrations (with minor exceptions).

AMD potential of rejects

The geochemical characteristics of fresh rejects from the CHPP, aged rejects from TSFs and aged rejects from Riverside rejects dump were generally similar – except for NAGpH results. Excluding NAGpH, there was also no significant difference in the geochemical characteristics between the fresh rejects from each CHPP (i.e. GY CHPP versus RV CHPP) or between aged rejects from each of the main TSFs (i.e. GS1 TSF versus RS1 TSF) and/or between the TSFs and Riverside rejects dump. As such, the discussion that follows only differentiates between the three rejects sources (fresh versus aged TSF versus aged rejects dump) where the differences between the three sources was significant for some parameters and worthy of discussion. Else, the AMD potential of rejects is discussed as a bulk material – regardless of source.

Based on the results, 22% of the rejects (aged and fresh) has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, whereas the remaining 78% (aged and fresh) has a relatively low to low-moderate potential to generate AMD as either AD and/or NMD and/or SD.

The total S concentration of rejects (fresh and aged) is generally low, with a median value of 0.31%. Scr accounts for approximately 72% (median value) of total S in aged rejects from Riverside rejects dump; 56% (median value) of total S in fresh CHPP rejects; and 49% (median value) of total S in aged rejects from TSFs. The slightly lower proportion of Scr in aged rejects from the TSFs compared to fresh rejects, and also compared to aged rejects from Riverside rejects dump is likely due to some sulphide in aged rejects in the TSFs being oxidised to sulphate.

Similar to tailings, rejects have generally moderate ANC (median 18 kg H_2SO_4/t) and generally low MPA (median 9 kg H_2SO_4/t) values, resulting in approximately 78% of the rejects samples being classified as NAF or UC(NAF). One sample was classified as NAF-S. The remaining 22% (approximately) of samples were classified as PAF, PAF-LC or UC(PAF). Test-work indicated that about 25-50% of the ANC in fresh rejects is expected to be available under field conditions; and about 35-65% available for the aged rejects. The ABCC data suggested iron-dolomite, dolomite and siderite were expected to be the dominant carbonate minerals, which is broadly consistent with the mineralogy data.

Total metal and metalloid concentrations from 52 rejects samples tested are very low compared to average element abundance in soil in the earth's crust. However, similar to tailings samples, all rejects samples were significantly enriched with regard to Se. Nine rejects samples were also significantly enriched with As. There was no clear correlation found between AMD classifications of the rejects samples compared to elemental enrichment.

Solubility data indicate that most rejects samples (54 out of 61 samples) under freshwater (deionised water) leaching conditions are expected to have low soluble metals concentrations and have near-neutral to alkaline pH. Four (of 61) rejects samples have moderate metals concentration associated with near-neutral to alkaline pH; and three rejects samples have moderate metals concentration associated with moderately to weakly acidic pH.

Peroxide leaching undertaken on 11 rejects samples (of mixed NAF/PAF classifications) showed that when exposed to highly oxidising conditions PAF rejects can produce moderately to highly acidic leachate with moderate to elevated soluble metals and metalloid concentrations – consistent with PAF tailings. The results suggest that under acid/acidic conditions, some rejects are capable of generating elevated metal and metalloid loads, however the sulphate (and salinity) loads are not expected to be high – due to the generally low total S concentration (with some exceptions).

AMD potential of coal

Coal is not regarded as waste and ROM coal remains on-site for a relatively short period of time. However, some minor coal seams/plys will report directly as waste, and remnant coal (seams) will be exposed on the highwalls of residual voids at closure.

Coal represents about 8% (on average) of all lithological material at GRBM (about 5% to 10% of the highwall meterage) and, assuming the large majority all of this will report as ROM coal, we can conservatively assume that coal will represent a very small proportion of mineral waste (i.e. nominally 1-2% at the most).

Based on the results, and as a bulk material, ROM coal is assessed as having a low-moderate to moderate potential to generate AMD as either AD, NMD and/or SD. A small proportion of coal (all seams) would have a moderate to moderate-high potential to generate AMD. ROM coal, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage).

Coal samples had low total S values resulting in low MPA values (median 11 kg H_2SO_4/t), however due to the generally very low to low ANC values (median 6 kg H_2SO_4/t) resulted in 77% of coal samples being classified as PAF, PAF-LC or UC(PAF). The proportion of PAF (of any kind) is comparable across all coal seam groups being mined at GRBM. The low total S concentrations suggests that 'PAF' coal is unlikely to generate significant acid(ity).

Approximately 23% of coal samples tested (6 out of 26 samples) were classified as NAF, and coal seam material represented by these NAF samples has very low sulphur values, excess ANC (relative to the MPA) and clearly has negligible capacity to generate acidity or release significant sulphate from sulphide oxidation.

These results suggest that coal stored on the ROM pad, coal located within pit walls and un-economic coal seam material reporting as spoil (mixed with non-coal spoil) would likely be bulk PAF – albeit, low capacity. From an acid

generating perspective, coal poses a potential source hazard with respect to AD and/or NMD/SD; and overall, is expected to generate low acidity loads.

Solubility data from three composite coal samples (classified as PAF and PAF-LC) tested under freshwater (deionised water) leaching conditions indicates low soluble metals concentrations at near-neutral to alkaline pH. An additional composite coal sample (classified as PAF) had moderate soluble metals concentration associated with near-neutral to alkaline pH.

Salinity, Sodicity and Dispersion Potential of Mineral Waste and Coal Material Types

Salinity, sodicity and dispersion potential of spoil – non-carbonaceous

Non-carbonaceous spoil has low median and moderate 90th percentile electrical conductivity (EC)$_{1:5}$ values of 414 and 910 microSiemens per centimetre (µS/cm), respectively, 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, as a result of dissolution of geogenic salts more so than from sulphide oxidation (sulphate salinity). Weathered non-carbonaceous spoil generally has higher EC$_{1:5}$ values compared to fresh non-carbonaceous spoil.

Non-carbonaceous spoil has modest cation exchange capacity (CEC) values and generally high exchangeable sodium percentage (ESP) values, resulting in most samples being classified as ‘sodic’ to ‘strongly sodic’ and, therefore, with potential for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about 31% of the samples displayed some degree of dispersion. Although not entirely consistent with the ESP results, the Emerson Class test results suggest a significant proportion of spoil is expected to be dispersive to some degree.

Salinity, sodicity and dispersion potential of spoil – carbonaceous

Carbonaceous spoil has median and 90th percentile EC$_{1:5}$ values of 272 and 655 µS/cm, respectively, and has low total S concentrations. On this basis, contact water (run-off and seepage) is expected to be similar to non-carbonaceous spoil. That is, generally non-saline to slightly saline, primarily as a result of dissolution of geogenic salts more so than from sulphide oxidation (sulphate salinity).

Carbonaceous spoil samples had similar CEC values compared to non-carbonaceous spoil, and comparable ESP values – with the exception of weathered carbonaceous samples, which had lower ESP values compared to fresh samples. This resulted in the fresh samples being classified as ‘strongly sodic’ and the weathered samples classified as ‘sodic’ to ‘strongly sodic’. As such, and based solely on the moderate to high sodicity values, carbonaceous spoil is expected to be sodic (to some degree) with potential for dispersion. Sixteen carbonaceous spoil samples underwent Emerson aggregate class testing to directly measure dispersion, which found three (out of 16) samples were dispersive.

Salinity potential of tailings

Tailings samples have EC$_{1:5}$ values ranging from 118 to 5320 µS/cm, with median and 90th percentile EC$_{1:5}$ values of 717 and 1556 µS/cm, respectively. The EC$_{1:5}$ values were generally similar between fresh and aged tailings, resulting in tailings generally being slightly to moderately saline. The generally low total S for aged tailings and low-moderate total S for fresh tailings conservatively suggests a low-moderate potential for SD (from sulphide oxidation).

Salinity potential of rejects

Rejects samples have EC$_{1:5}$ values ranging from 389 to 3260 µS/cm, with median and 90th percentile EC$_{1:5}$ values of 389 and 774 µS/cm, respectively. The fresh CHPP rejects were generally non-saline with a 90th percentile EC$_{1:5}$ value of 550 µS/cm. Aged rejects had higher EC$_{1:5}$ values compared to fresh rejects with 90th percentile values of 792 µS/cm (for the TSF samples) and 1090 µS/cm (for Riverside rejects dump samples). Most rejects had low total S concentrations (median = 0.31%), suggesting the potential for SD (from sulphide oxidation) from rejects is low.

Salinity potential of coal

Coal has low median and 90th percentile EC$_{1:5}$ values of 90 and 524 µS/cm, respectively; and has generally low to low-moderate total S concentrations. On this basis, contact water (run-off and seepage) from coal, as a bulk

material, is expected to be non-saline to slightly saline, either as a result of dissolution of geogenic salts and/or from sulphide oxidation (sulphate salinity).

Geochemical Source Hazard Assessment of Material Types

A geochemical source hazard assessment was applied to the source material types comprising carbonaceous and non-carbonaceous spoil, tailings, rejects and coal (where relevant). The source hazard score is a formula devised by the authors that takes into account the propensity to generate AMD, the AMD capacity (severity) and the quantity (volume/tonnage) of material that could produce AMD. The AMD source hazard scores are as follows:

- Spoil – non-carbonaceous: AMD source hazard score = **Low-Moderate**
- Spoil – carbonaceous: AMD source hazard score = **Moderate**
- Tailings: AMD source hazard score = **Moderate-High** (score ranged from Moderate to High depending upon the TSF facility, but was generally Moderate-High).
- Rejects: AMD source hazard score = **Moderate** (score ranged from Low-Moderate to Moderate depending upon the rejects facility, but was generally Moderate)
- Coal: AMD source hazard score = **Low-Moderate**

When combined, and taking into account the proportion of material that could generate AMD relative to the total proportion of all materials in a final landform (spoil or TSF or rejects landform and residual voids), the AMD hazard score for the landforms, void highwalls and void floors at closure has been determined. The AMD source hazard of likely future mineral wastes generated from GRM, BRM and RHM is expected to be consistent with the AMD source hazard based on current data and existing mineral wastes.

Spoil landforms

There are four spoil landforms at GRBM that will remain at closure:

- Goonyella
- Thiess
- Airstrip
- Broadmeadow-Isaac

The GRBM PRCP considers Thiess spoil dump as part of Goonyella spoil landform. However, due to its' proximity to Thiess pit, it has been assessed herein as a separate spoil landform. Each landform will have a similar construction, comprising mined overburden and interburden disposed behind the active mining face to form a low-wall spoil dump, which will be reshaped to form a final spoil landform.

Goonyella, Airstrip and Broadmeadow-Isaac spoil landforms contain a small proportion of existing or planned future rejects (between 0.1% and 3%, depending on the landform). Thiess spoil landform comprises approximately 16% existing rejects located predominantly at R22 rejects dump. Due to the location of R22 rejects dump at the periphery of Thiess spoil landforms where rejects are concentrated, R22 rejects dump has been conservatively assessed as a 'stand-alone' rejects dump.

DRE5 in-pit TSF will be located within the north-western area of Thiess spoil dump at closure and will comprise less than 1% of the landform, and Ramp 32 in-pit TSF will be located within the Airstrip spoil dump and will comprise approximately 7% of the landform. Due to the location of these two TSFs at the base of their respective spoil landforms where tailings are concentrated, these two TSFs have been conservatively assessed as 'stand-alone' TSFs. There are no current tailings/TSFs within Goonyella or Broadmeadow-Isaac spoil landforms.

Taking into account material quantities (proportions) and expected proportion of PAF and NAF-S materials reporting to each individual landform:

- Each of the four spoil landforms poses a **Low** AMD hazard, with AMD generation rated as **Highly Unlikely**.

The 'Low' AMD hazard is largely a result of less than 2% of non-carbonaceous spoil samples being classified as PAF of some type (or NAF-S) – and non-carbonaceous spoil comprises the overwhelming majority of mineral waste within each spoil landform.

GS1 TSF landform

GS1 TSF is a large 'turkey's nest' style TSF. The embankments are comprised of earthen-filled 'starter' embankments then raised (expanded) with rejects. The core of the TSF contains tailings. The TSF operated from approximately 1971 to 2021, receiving tailings from GY CHPP.

The source materials within GS1 TSF includes tailings, which are estimated to comprise approximately 95% of the landform; and rejects, which are estimated to comprise about 5% of the landform and form the basis of the embankments. The assessment assumes the TSF landform also includes a small proportion (approximately 0.5%) of spoil/fill material, predominantly within embankments.

Investigative drilling coupled with near-surface sampling has demonstrated that some tailings in the field at GS1 TSF are generating AMD (as AD and SD). Oxidation fronts are present in the TSF as demonstrated by decreasing sulphide concentrations from surface down, consumption of ANC, presence of secondary minerals generated through sulphide oxidation, and acid contact pH water. AMD has also been observed in seepage from the toe of the TSF and in nearby Holding Paddock Creek.

The source hazard assessment for the mineral wastes within the TSF landform has utilised the same general methodology as applied to the spoil landforms. The source hazard assessment has found the tailings within GS1 TSF landform poses a **Moderate-High** AMD source hazard; and rejects poses a **Moderate** AMD source hazard. Fill material poses a **Low-Moderate** AMD source hazard. On this basis, and taking into account material quantities (proportions):

- GS1 TSF landform (currently, without a rehabilitation cover) poses a **Moderate-High** AMD hazard, with AMD generation rated as **Highly Likely** – the highest landform AMD likelihood category – noting that AMD processes and/or AMD impacted contact water have already been observed at/from this TSF. The AMD hazard is considered to predominantly lie with the tailings, and lesser so the rejects.

The AMD hazard scores for the tailings and rejects materials are considered to be conservative and the landform domain AMD hazard score for GS1 TSF is also considered to be conservative.

RS1 TSF

RS1 TSF is a large 'turkey's nest' style TSF. The TSF has been constructed as two compartments: a western compartment comprised of rejects and an eastern compartment comprised of tailings. The tailings (from RV CHPP) are contained within earth- and rejects-filled eastern and southern embankments and a northern embankment constructed from rejects. The western compartment contains (holds back) the tailings on the western side. The TSF commenced operations in approximately 1983 and ceased receiving tailings in 2021. Rejects from RV CHPP are currently disposed into the TSF (primarily the western compartment). Future rejects from RV CHPP are planned to be disposed onto the eastern compartment and will cover the tailings.

Separate AMD source hazard assessments have been completed for each compartment of RS1 TSF. The western compartment comprises rejects only. The eastern compartment is estimated to comprise approximately 85% tailings and 15% rejects. The assessment assumes the eastern compartment also includes a small proportion (approximately 0.5%) of spoil/fill material, predominantly within embankments.

Investigative drilling coupled with near-surface sampling has demonstrated that some tailings in the field at RS1 TSF are generating AMD (as AD and SD). Oxidation fronts are present in the TSF as demonstrated by decreasing sulphide concentrations from surface down, consumption of ANC, presence of secondary minerals generated through sulphide oxidation, and acid contact pH water.

- RS1 TSF western compartment [rejects only] (currently, without a rehabilitation cover) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable / Likely**.
- RS1 TSF eastern compartment [tailings and rejects] (currently, without a rehabilitation cover) poses a **Moderate-High** AMD hazard, with AMD generation rated as **Highly Likely** – noting that AMD processes and/or AMD impacted contact water have already been observed from RS1 TSF. The AMD hazard is considered to predominantly lie with the tailings, and lesser so the rejects.

The AMD hazard scores for the tailings and rejects materials are considered to be conservative and the AMD hazard scores for each compartment of RS1 TSF are also considered to be conservative.

DRE5 in-pit TSF

DRE5 in-pit TSF is located within the pit shell of Thiess pit (Thiess void) and within the Thiess spoil landform footprint. As such, it is not a true 'stand-alone' TSF landform, however, is conservatively assessed as such given the concentrated nature of tailings at the base of the spoil landform.

The source materials within the TSF includes tailings only. No investigative drilling has been undertaken in the vicinity of this TSF. No evidence of AMD has been observed in the field. The AMD source hazard assessment is based on data from fresh (CHPP) tailings.

The source hazard assessment for the tailings within the TSF has utilised the same general methodology as applied to other TSF landforms. The source hazard assessment has found the tailings within the TSF landform pose a **Moderate** AMD source hazard.

On this basis, and taking into account material quantities (all tailings):

- DRE5 in-pit TSF (prior to rehabilitation and when fully unsaturated) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable / Likely**.

The AMD hazard score for the tailings is considered to be conservative and the landform domain AMD hazard score for the TSF is also considered to be conservative.

Ramp 32 in-pit TSF

Ramp 32 in-pit TSF is located within Airstrip pit and within the Airfield spoil landform footprint. As such, it is not a true 'stand-alone' TSF landform, however, is conservatively assessed as such given the concentrated nature of tailings at the base of the spoil landform.

The source materials within the TSF includes tailings only. No investigative drilling has been undertaken in the vicinity of this TSF. No evidence of AMD has been observed in the field. The AMD source hazard assessment is based on data from fresh (CHPP) tailings.

The source hazard assessment for the tailings within the TSF has utilised the same general methodology as applied to other TSF landforms. The source hazard assessment has found the tailings within the TSF landform pose a **Moderate** AMD source hazard.

On this basis, and taking into account material quantities (all tailings):

- Ramp 32 in-pit TSF (prior to rehabilitation and when fully unsaturated) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable / Likely**.

The AMD hazard score for the tailings is considered to be conservative and the landform domain AMD hazard score for the TSF is also considered to be conservative.

Riverside rejects landform

Riverside rejects dump received rejects from RV CHPP until approximately 1998. The dump underwent some rehabilitation activities in the early 2000s, but due to the substantial corrective action required to achieve the required post-mining land use (PMLU) it has not been included as existing rehabilitation in the PRCP schedule. The dump will remain as a 'stand-alone' rejects landform at closure. The dump is located to the southwest of RS1 TSF.

Excluding the spoil cover currently in place, the dump essentially comprises only rejects (over 99% by volume). It is assumed a small amount of 'fill' (assume spoil) may lie within the dump, and the 'fill' is conservatively estimated to comprise approximately 0.5% of the landform.

The source hazard assessment for the mineral wastes within the rejects dump has utilised the same general methodology as applied to the spoil and TSF landforms. The assessment excludes the existing spoil cover. The source hazard assessment has found the rejects within the dump poses a **Moderate** AMD source hazard. Fill

material has been assessed as posing a **Low** AMD source hazard based on the geochemical characteristics of all GRBM spoil. Taking into account material quantities (proportions):

- Riverside rejects dump (excluding the cover) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable / Likely**. The AMD hazard lies with the rejects, which comprise essentially all of the dump.

The AMD hazard score for the rejects materials is considered to be conservative and the landform domain AMD hazard score for the rejects dump is also considered to be conservative.

GS2, GS11 and R22 rejects landforms

GS2, GS11 and R22 rejects dumps receive rejects from GY CHPP. GS2 dump is located to the northeast of (and adjacent to) GS1 TSF. GS11 dump is located east of GS1 TSF between Ramp 32 TSF and Eureka Creek. GS2 and GS11 rejects dumps are located outside of a spoil landform and will remain as 'stand-alone' rejects landforms at closure.

R22 rejects dump is located within the southwestern periphery of the Thiess spoil landform. As such, it is not a true 'stand-alone' rejects landform, however, is conservatively assessed as such given the concentrated nature of rejects near the edge of the spoil landform and where they are unlikely to be deeply buried by spoil within the core of the spoil landform. The rejects dump is situated on top of the Thiess spoil dump (i.e. it is underlain by spoil).

All three dumps essentially comprise only rejects (over 99% by volume). It is assumed a small amount of 'fill' (assume spoil) may lie within each dump, and the 'fill' is conservatively estimated to comprise approximately 0.5% of each landform.

The source hazard assessment for the mineral wastes within the rejects dumps has utilised the same general methodology as applied to the spoil and TSF landforms. The source hazard assessment has found the rejects within the dumps poses a **Low-Moderate** AMD source hazard. Fill material has been assessed as posing a **Low** AMD source hazard based on the geochemical characteristics of all GRBM spoil. Taking into account material quantities (proportions):

- GS2, GS11 and R22 rejects dumps pose a **Low-Moderate** AMD hazard, with AMD generation rated as **Unlikely**. The AMD hazard lies with the rejects, which comprise essentially all of each dump.

The AMD hazard score for the rejects materials is considered to be conservative and the landform domain AMD hazard score for the rejects dumps is also considered to be conservative.

Residual voids

There are five pit groups at GRBM that will remain at closure as residual voids:

- Goonyella void; approximately 11 km long with an average depth of 304 m (at closure);
- Thiess void; approximately 3.9 km long with an average depth of 78 m (at closure);
- Broadmeadow-Isaac void; approximately 5.1 km long with an average depth of 83 m (at closure);
- Ramp 32 East void; approximately 1.6 km long with an average depth of 94 m (at closure); and
- Ramp 32 South void; approximately 1.0 km long with an average depth of 69 m (at closure).

Environmental geochemical data, coal quality data and drill-hole geological logs have been used to aid in the assessment of AMD hazard associated with residual void highwalls and floors.

The highwall AMD hazard assessment has found that approximately 7% to 10% of the void highwall in all voids is estimated to be PAF, which includes material classified as UC(PAF), PAF-LC and NAF-S – and most of this is expected to be associated with coal seams. As such, the assessment has found that the overall likelihood of AMD generation from the void highwalls is **Unlikely**. The expression of AMD from coal seams in the highwalls of residual voids, if any, will most likely be localised.

Excluding Broadmeadow-Isaac void, the floor of all residual voids at closure will be the GLS seam. The floor of Broadmeadow-Isaac void is the GMS seam. Assuming the floor of each void is all coal – which is a highly conservative assumption – the void floor AMD hazard assessment has found that essentially all of the floor of each

void is estimated to be 'PAF', which includes material classified as PAF, UC(PAF), PAF-LC and NAF-S. 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 of the seam, therefore very little coal would be expected to remain on the floor of the voids.

Geochemical Source-Pathway-Receptor (SPR) Assessment

The source-pathway-receptor (SPR) assessment includes the likelihood of the event occurring (e.g. the likelihood of AMD impacting a local creek), the severity of the event (should it occur) and the calculated risk rating (likelihood times severity). A risk rating was calculated for each spoil landform, each TSF landform, each rejects landform and each residual void with respect to plausible surface water and groundwater receptors.

Conceptual site model and conceptual facility models

A post-mining conceptual site model (CSM), which applies generically to the spoil landforms and their respective residual voids at GRBM, and the relationship that spoil landforms and residual voids have with surface water and groundwater in the district, has been produced by AECOM (2024).

The CSM assists with the SPR assessment with regard to potential environmental geochemical impacts from mineral waste facilities. A key element of the CSM based on the AECOM (2024) hydrogeological assessment (which included groundwater modelling) was that all residual voids at GRBM will be groundwater 'sinks' (i.e. groundwater at GRBM will flow into/towards the residual voids, and the voids will be the receptors of seepage from all facilities at GRBM).

A conceptual facility model (CFM) has been developed for each TSF and for Riverside rejects dump to illustrate potential run-off and seepage pathways and surface water and groundwater receptors associated with these key mineral waste facilities.

Plausible pathways and receptors

Note: the assessment of shallow groundwater at GRBM – particularly where shallow permeable strata may be not present in some areas, discontinuous and/or not interconnected – is limited by/to the distribution of the shallow bore network, which is sporadic. Therefore, despite the apparent low likelihood of substantial connection between shallow permeable strata and surface water features, the SPR assessment has adopted a highly conservative approach and assumed a plausible pathway *may* exist between shallow permeable strata and surface water features. All creeks at GRBM are ephemeral. The surface water features (creeks) at GRBM are:

- Isaac River flows into the site from the northeast, then flows east of the Goonyella void and east of Broadmeadow-Isaac void, exiting the site south of Ramp 32 South void. The river channel is a diversion channel (i.e. not the original/natural watercourse) from approximately the southern end of Goonyella void through until the river exits the site;
- Goonyella Creek is located in the north-eastern area of the site and flows southwards into Isaac River east of Goonyella void;
- Eureka Creek traverses the site in an approximately northwest to southeast direction between Thiess pit/void and Broadmeadow-Isaac pit/void; and joins the Isaac River east of Broadmeadow-Isaac void and south of Goonyella void;
- Holding Paddock Creek is a small creek that flows from (and around) the southwestern and southern side of GS1 TSF southwards around Airstrip pit spoil dump and joins into Fisher Creek west of Ramp 32 South void;
- Fisher Creek flows into the southwestern corner of the site from the west, joining into Platypus Creek near the southern boundary of the site (ML boundary);
- Platypus Creek flows into the southwestern corner of the site from the west, joining into Isaac River at approximately the southern boundary of the site.

Minor tributaries flow into the above watercourses outside of GRBM.

With regard to the spoil landforms, the plausible mechanisms for AMD affected water and/or non-oxidative salinity, if any, to report to receptors are:

- Surface water run-off from spoil landforms into nearby creeks;
- Seepage from spoil landforms via shallow permeable strata into nearby creeks;
- Seepage from spoil landforms into the residual voids; and
- Surface water run-off and seepage from void highwalls into residual voids.

With regard to the TSF and rejects landforms, the plausible mechanisms for AMD affected water and/or non-oxidative salinity, if any, to report to receptors are:

- Surface water run-off from TSF or rejects landforms into nearby creeks;
- Seepage from TSF or rejects landforms via shallow permeable strata into nearby creeks; and
- Seepage from TSF or rejects landforms via groundwater into residual voids.

The SPR has conservatively assumed that shallow permeable strata are a plausible pathway linking a potential AMD source to deeper groundwater via downwards migration and linking a potential AMD source to nearby creeks via lateral migration. However, shallow permeable strata are assumed to be an *implausible final receptor* of run-off and seepage from final landforms and final voids. That is, the assumption based on information available is that AMD (source) entering shallow permeable strata (however (un)likely) will ultimately find its' way into deeper groundwater [residual voids] and/or local surface water features.

SPR risk rating of rehabilitated spoil landforms

There are plausible surface water and residual void receptors associated with final spoil landforms; and the run-off and seepage pathways linking the sources (final spoil landforms) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from final spoil landforms is **Low**. With respect to non-oxidative salinity the overall SPR risk from final spoil landforms is also rated as **Low**.

DRE5 in-pit TSF and Ramp 32 in-pit TSF are located within Thiess and Airstrip spoil landforms, respectively, and contain a concentration of tailings. As such, these two TSFs are addressed as stand-alone facilities and are not included as part of their respective spoil landforms. Similarly, R22 in-pit rejects landform is located within Thiess spoil landform (at the southern edge of the landform) and contains a concentration of rejects. As such, this rejects dump is addressed as a stand-alone facility and is not included as part of the Thiess spoil landform.

SPR risk rating of rehabilitated GS1 TSF landform

There are plausible surface water receptors located very close to GS1 TSF; and the run-off and seepage pathways linking the source (GS1 TSF landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure TSF landform is **Low** to **Medium**. The 'Low-Medium' risk rating applies to AMD associated with seepage via shallow permeable strata into Holding Paddock Creek, located less than 100 m from the TSF. The likelihood of AMD reaching Holding Paddock Creek is unlikely, however the severity of the event, should it occur, has been rated as moderate (S3). With respect to non-oxidative salinity the overall SPR risk from the post-closure TSF landform is rated as **Low**.

Groundwater modelling (AECOM, 2024) indicates there are no plausible groundwater receptors from GS1 TSF post-closure landform due to the significant depth to the water table below the TSF (>50 m) and the significant thickness of low-permeability sediments forming an aquitard.

SPR risk rating of rehabilitated RS1 TSF landform

There are plausible surface water and residual void receptors; and the run-off and seepage pathways linking the source (RS1 TSF landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure TSF landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure TSF landform is also rated as **Low**. The likelihood of AMD reaching any of the receptors was rated as 'Highly Unlikely' (due to the significant distance from the TSF to the nearest receptor [Eureka Creek]) however

the severity of AMD potentially impacting the water quality of Eureka Creek via a shallow permeable pathway, should it occur, has been rated as moderate (S3).

Groundwater modelling (AECOM, 2024) suggests that seepage from RS1 TSF would likely report to Goonyella residual void. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) TSF landform to impact on the water quality of Goonyella residual void has been rated 'Unlikely'.

SPR risk rating of rehabilitated Ramp 32 in-pit TSF landform

There are plausible residual void receptors, and the seepage pathways linking the source (Ramp 32 in-pit TSF landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure TSF landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure TSF landform is also rated as **Low**.

Groundwater modelling (AECOM, 2024) suggests that seepage from Ramp 32 in-pit TSF would likely report to Ramp 32 East and Ramp 32 South residual voids. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) TSF landform to impact on the water quality of these two residual voids has been rated 'Unlikely'.

SPR risk rating of rehabilitated DRE5 in-pit TSF landform

There are plausible residual void receptors, and the seepage pathways linking the source (DRE5 in-pit TSF landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure TSF landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure TSF landform is also rated as **Low**.

Groundwater modelling (AECOM, 2024) suggests that seepage from DRE5 in-pit TSF landform into groundwater will ultimately report to Goonyella residual void, likely via Thiess residual void. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) TSF landform to impact on the water quality of these two residual voids has been rated 'Unlikely'.

SPR risk rating of rehabilitated Riverside rejects landform

There are plausible surface water and residual void receptors; and the run-off and seepage pathways linking the source (Riverside rejects landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure rejects landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects landform is also rated as **Low**.

Groundwater modelling (AECOM, 2024) suggests that seepage from Riverside rejects landform would likely report to Goonyella residual void. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) rejects landform to impact on the water quality of Goonyella residual void has been rated 'Unlikely'.

SPR risk rating of rehabilitated GS2 rejects landforms

Eureka Creek is located very close to the facility; and the run-off and seepage pathways linking the source (GS2 rejects landform) to Eureka Creek have been identified. With respect to AMD, the overall SPR risk rating from the post-closure rejects landform is **Low**. The likelihood of seepage reaching nearby Eureka Creek is considered probable, however the severity of the event, should it occur, is low. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects landform is also rated as **Low**.

Groundwater modelling (AECOM, 2024) indicates there are no plausible groundwater receptors from GS2 rejects post-closure landform due to the significant depth to the water table below the facility (>50 m) and the significant thickness of low-permeability sediments forming an aquitard.

SPR risk rating of rehabilitated GS11 rejects landforms

There are plausible surface water and residual void receptors; and the run-off and seepage pathways linking the source (GS11 rejects landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure rejects landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects landform is also rated as **Low**.

Groundwater modelling (AECOM, 2024) indicates that seepage from GS11 rejects landform into groundwater is expected to report to Ramp 32 East residual void. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) rejects landform to impact on the water quality of Ramp 32 East residual void has been rated 'Unlikely'.

SPR risk rating of rehabilitated R22 rejects landform

There are plausible surface water and residual void receptors; and the run-off and seepage pathways linking the source (R22 rejects landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure rejects landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects landform is also rated as **Low**.

Groundwater modelling (AECOM, 2024) suggests that seepage from R22 rejects landform into groundwater is expected to report to Thiess residual void and then continue on towards Goonyella residual void. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) rejects landform to impact on the water quality of Thiess and Goonyella residual voids has been rated 'Unlikely'.

SPR risk rating of residual voids

Modelling undertaken by AECOM (2024) shows Goonyella void to be a strong groundwater sink – drawing in groundwater from most of the site. Thiess and Broadmeadow-Isaac voids will be local 'sinks' – receiving surface water run-off and seepage from their respective spoil landforms and surface water run-off from their void highwalls. Ultimately, seepage from Thiess and Broadmeadow-Isaac residual voids will migrate to Goonyella residual void. Ramp 32 East and South residual voids are expected to function as week groundwater sinks from their local area. Each residual void is expected to receive inflow from the Permian groundwater aquifer.

The AMD assessment has found that it's unlikely that undiluted salinity or AMD from a flooded post-closure residual void floor would impact on residual void water quality to any significant degree, as other processes such as evapoconcentration (WSP, 2024) 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 to Low-Medium**. A "Low to Medium" risk rating has been conservatively applied to the risk of AD or SD due to the AMD risk associated with exposed coal seams in the highwalls (coal seams comprise between 5% to 10% of the exposed highwalls). However, not all exposed coal is expected to be PAF (and/or have high total and sulphide concentrations).

Water reporting to residual voids is expected to remain within the residual voids (excluding evaporative loss). Modelling undertaken by AECOM (2024) shows that seepage from Thiess and Broadmeadow-Isaac void lakes into groundwater would report to (be captured by) Goonyella void, and that seepage from Goonyella void outwards into the regional groundwater aquifer is implausible due to Goonyella void being a strong groundwater sink. Modelling also shows that Ramp 32 East and South voids are expected to be weak groundwater sinks, therefore seepage from Ramp 32 East and South void lakes into groundwater is not expected and, if it were to occur, would be limited and would ultimately be captured by Goonyella void.

Management and Rehabilitation Measures

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

The environmental risk associated with the current (rehabilitated) Riverside rejects dump is generally low and there is no field evidence of AMD coming from the facility. The rejects buried within the landform have been assessed as posing a moderate AMD source hazard and the facility will continue to be monitored during operations. The facility will undergo further rehabilitation to meet the required PMLU.

Currently (i.e. prior to rehabilitation), the AMD source hazard associated with GS1 TSF is moderate-high and, as such, the TSF landform will require specific AMD management measures to manage this facility post-closure. Once rehabilitated, the post-closure environmental risk posed by this stand-alone TSF landform is expected to decrease.

Currently (i.e. prior to rehabilitation), the AMD source hazard associated with RS1 TSF is moderate to moderate-high. The western compartment comprising rejects only has a moderate source hazard (i.e. this compartment is essentially a rejects dump). The eastern compartment comprising predominantly tailings, with less rejects, has a moderate-high AMD source hazard (this compartment is the TSF). This stand-alone landform will require specific AMD management measures to manage this facility post-closure. Once rehabilitated, the post-closure environmental risk posed by this stand-alone landform is expected to decrease.

The AMD source hazard associated with Ramp 32 in-pit TSF (currently; prior to rehabilitation) is moderate. This in-pit TSF will be backfilled with spoil, which is an appropriate strategy to manage the AMD hazard posed by this facility post-closure. Once rehabilitated (backfilled), the post-closure environmental risk posed by this TSF is expected to decrease.

The AMD source hazard associated with DRE5 in-pit TSF (currently; prior to rehabilitation) is moderate. This small in-pit TSF will be partially backfilled with spoil to encourage free-drainage from the southern end of the facility onto the Thiess spoil landform. This is an appropriate strategy to manage the AMD hazard posed by this facility post-closure. Once rehabilitated, the post-closure environmental risk posed by this TSF is expected to decrease.

The AMD source hazard associated with GS2, GS11 and R22 rejects dumps (currently; prior to rehabilitation) is low-moderate. After re-shaping and installation of a spoil cover (i.e. once rehabilitated) the post-closure environmental risk posed by these spoil dumps is expected to decrease.

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 residual voids under five groups:
    - Goonyella void;
    - Thiess void;
    - Broadmeadow-Isaac void;
    - Ramp 32 East void; and
    - Ramp 32 South void.
- Spoil dumps: Lenton pit is currently being backfilled and becoming part of the Goonyella spoil landform. Airstrip spoil dump (associated with Ramp 32 East and Ramp 32 South voids) will be reshaped and rehabilitated. All other spoil dumps will be reshaped into three final spoil landforms (as related to their respective voids listed above) and seeded.
- GS1 TSF (out-of-pit; above ground; stand-alone) will be covered by an engineered spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of the out-of-pit TSF will be determined following further assessment prior to covering.
- RS1 TSF (out-of-pit; above ground; stand-alone) will be covered by an engineered spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of the out-of-pit TSF will be determined following further assessment prior to covering.
- DRE5 in-pit TSF will be covered by spoil (partially backfilled) within the Thiess spoil landform – noting that Thiess spoil landform is a sub-zone within Goonyella spoil landform. The optimal design and thickness of spoil cover to manage the AMD hazard of the in-pit TSF will be determined following further assessment prior to covering.
- Ramp 32 in-pit TSF (Airstrip pit) will be backfilled by spoil within the Airstrip spoil landform.
- Riverside rejects dump (above ground; stand-alone) is already covered with spoil, but further rehabilitation activities are scheduled to achieve the PMLU.
- GS2 and GS11 rejects dumps (out-of-pit; above ground; stand-alone) will be covered by a spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of these two rejects dumps will be determined following further assessment prior to covering.

- R22 in-pit rejects dump will be covered by a spoil cover within the Thiess spoil landform. The optimal design and thickness of spoil cover to manage the AMD hazard of this rejects dump will be determined following further assessment prior to covering.
- All other rejects (in-spoil co-disposal): 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 rejects will be determined following further assessment prior to covering.
- ROM pads: Remove remnant coal from ROM pads and dispose within spoil. All former ROM pads will be reshaped, covered with soil, ripped and seeded.
- Coal stockpiles: Remove remnant coal from coal stockpile pads and dispose within spoil. Cover with suitable soil material, rip and seed.

GLOSSARY OF TERMS

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

Acid	A measure of hydrogen ion (H^+) concentration in water; generally expressed as pH.
Acidity	A measure of hydrogen concentration and latent acidity generated by metal hydroxylation, expressed as mg/L.
Acid-Base Account (ABA)	Evaluation of the balance between acid generation and acid neutralisation processes. Generally determined by the maximum potential acidity (MPA) and the inherent acid neutralising capacity (ANC), as defined below. See also ANC and MPA.
AD	Acid drainage. A component of AMD, AD occurs where drainage is acidic as a result of sulphide oxidation reactions, and contains elevated trace metals and metalloids in solution.
AMD	Acid and metalliferous drainage. AMD has three components: acid drainage (AD), pH-neutral and metalliferous drainage (NMD) and/or sulphide-derived saline drainage (SD) – and/or any combination of these, all generated by sulphide oxidation processes +/- neutralisation reactions.
ANC	Acid neutralising capacity, expressed as kg H_2SO_4 per tonne of rock/material. A measure of a sample's maximum potential ability to neutralise acid.
ANC/MPA ratio	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.
BRM	Broadmeadow Mine. The name of the underground mining operation at GRBM.
CFM	Conceptual facility model.
CHPP	Coal handling and preparation plant. GRBM has two CHPPs: Goonyella (GY) CHPP and Riverside (RV) CHPP.
Co-Disposal	The practice of disposing different waste types together. For example, disposing coarse reject amongst spoil.
CFM	Conceptual facility model.
CSM	Conceptual site model.
EC	Electrical conductivity, expressed as µS/cm.
GLS	Goonyella Lower Seam group.
GMS	Goonyella Middle Seam group.
GUS	Goonyella Upper Seam group.
GRBM	Goonyella Riverside and Broadmeadow Mine. The name of the site subject to this PRCP.
GRM	Goonyella Riverside Mine. The name of the open-pit mining operation at GRBM.
Interburden	Potential spoil material located between mined coal seams. See also Overburden, Mineral waste and Spoil.
Kinetic test	Procedure used to measure the geochemical/weathering behaviour of a sample of mine material over time.
Mineral waste	Material comprising mine spoil, ± coarse/fine reject, ± waste coal. Sometimes called 'mine waste' or 'mining waste'.

MPA	Maximum potential acidity. Calculated by multiplying the total sulphur (S) content of a sample by 30.6 (stoichiometric factor) and expressed as kg H_2SO_4 per tonne of rock/material (kg H_2SO_4/t). Assumes all sulphur is present as sulphide and will oxidise to generate acid.
NAF	Non-acid forming. Geochemical classification criterion for a sample that would not generate acid conditions. A sample classified as NAF may, or may not, have a significant sulphur content but the availability of neutralising material within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals. As such, material classified as NAF is considered unlikely to be a source of acid(ic) drainage, however NAF material may still develop NMD and/or SD, depending on sulphur concentration.
NAG	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_2SO_4/t. At the conclusion of the NAG test the resulting liquor is called peroxide (NAG) leachate, and can be analysed for various parameters, such as soluble metals.
NAPP	Net acid producing potential, expressed as kg H_2SO_4 per tonne of rock/material (kg H_2SO_4/t). Calculated by subtracting the ANC from the MPA.
NMD	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.
Org S	Organic sulphur.
Overburden	Mineral (mining) waste located above (overburden proper) or between (interburden) coal seams and reports to spoil 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.
PAF	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.
PAF-LC	Potentially acid forming (low capacity). Geochemical classification criterion for a sample that has the potential to generate relatively low-level AD.
PRCP	Progressive rehabilitation and closure plan.
Product coal	Coal produced from the CHPP after being washed/processed. Coal that is ready for sale.
Rejects	Coarse sand to cobble-sized rock material produced during coal processing. Rejects are typically associated with the roof, floor and partings of coal seams and are separated from ROM coal in the CHPP. Rejects comprises about 1.5% of mineral waste at GRBM.
Rejects dump	In-pit or out-of-pit reject disposal location.
ROM	Run-of-Mine. The term given to mined coal before being processed at the CHPP.
ROM pad	Location where ROM coal is temporarily stored pending processing at the CHPP.
S	Sulphur.
Scr	Chromium reducible sulphur. Analytical procedure to determine the sulphide-sulphur concentration in a sample. This typically represents the proportion of sulphur associated with sulphide (reactive) minerals.

SD Saline drainage. A component of AMD, SD occurs where drainage is saline due to elevated sulphate as a result of sulphide oxidation and neutralisation reactions.

SO_4 Sulphate.

Spoil 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. Spoil comprises about 98% of mineral waste at GRBM.

Spoil dump In-pit or out-of-pit spoil disposal location.

SPR Source-pathway-receptor.

Static test 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.

Tailings Very fine to medium grained sand, silt and clay-sized material, which is commonly coaly and carbonaceous, produced during coal washing. Tailings are associated with coal seams and are separated from ROM coal in the CHPP. Tailings produced at GRBM are disposed within Tailings Storage Facilities (TSFs). Tailings comprises about 0.5% of mineral waste at GRBM.

TSF Tailings storage facility. A dam or pit used to dispose tailings, which are delivered to the TSF as a slurry. The tailings solid forms a 'beach' and the water drains to one end of the TSF in an area referred to as the decant pond. The decant water is recycled back into the mine water management system. At GRBM, tailings have been disposed into several above-ground and in-pit TSFs – the current (operational) TSF being Ramp 32 in-pit TSF.

Uncertain 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. At GRBM, all P seam coal reports as 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).

1 Introduction and Context

This report serves to document and discuss the environmental geochemical characteristics of mineral waste materials located at Goonyella Riverside and Broadmeadow Mine (GRBM), as supporting information for the progressive rehabilitation and closure plan (PRCP) for GRBM. GRBM comprises two operations: an open-cut mining operation called Goonyella Riverside Mine (GRM) and an underground mining operation called Broadmeadow Mine (BRM). Collectively, they are referred to here as GRBM.

The management of mineral wastes at GRBM are defined under the current Environmental Authority (EA) EPML00853413, held by BHP Mitsubishi Alliance (BMA). In this report the term 'mineral waste' refers to all geologic material (mine spoil, tailings and rejects) located at GRBM.

It is a requirement of a PRCP that mineral waste is adequately characterised such that appropriate rehabilitation strategies can be selected and implemented. The PRCP guidance document: "*Guideline – Progressive Rehabilitation and Closure Plans*" (DES, 2023) 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 GRBM 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 forward 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 GRBM 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

GRBM is located approximately 25 kilometres (km) north of Moranbah township, in central Queensland, and is operated by BHP Mitsubishi Alliance Pty Ltd (BMA). The site is located between North Goonyella underground mine to the north (operated by Peabody), Moranbah North mine to the south (operated by Anglo American) and is flanked on the east and west by pastoral leases. Open-cut mining commenced at GRM in 1971 and underground mining commenced at BRM in 2005.

GRM commenced operations in 1971 and comprises typical open-pit coal mining facilities, such as open pits, waste rock (spoil) dumps, tailings storage facilities (TSFs), rejects dumps, coal stockpiles, coal processing facilities, rail loadout facilities, process water and raw water dams, surface water drains and administration areas.

BRM commenced operations in 2005 and comprises longwall underground mining infrastructure to extract coal and surface infrastructure to transfer run-of-mine (ROM) coal via overland conveyor to the coal handling and preparation plants (CHPPs) located at GRM. That is, all coal produced from BRM is processed at GRM, no mineral waste is located at BRM and BRM does not contain any pits that, at closure, may remain as residual voids.

The BMA Red Hill Mine (RHM) is an approved longwall underground mine neighbouring GRBM. ROM coal from RHM is approved to be processed at the GRBM CHPPs and the tailings and rejects will be disposed at GRBM. As such – and consistent with BRM – no mineral waste will be located at RHM, nor will RHM contain any pits that, at closure, may remain as residual voids.

As such, this environmental geochemical assessment is focused on GRM – where all mineral waste is generated and/or disposed.

The key facilities and natural features at GRBM of relevance to this waste characterisation report are shown on **Figure 1**. [Also shown on **Figure 1** are geochemical sampling locations and the locations of geological sections along and across each pit group].

Current activities of relevance to this waste characterisation report comprise:

- Disposal of spoil to in-pit spoil dumps behind the active mining face (in-pit low-wall spoil disposal);
- ROM coal processing at two CHPPs: Goonyella (GY) CHPP and Riverside (RV) CHPP, which both produce two mineral waste types:
  - Tailings. Clay, silt and very fine to medium-grain sized sand material; disposed as a slurry into TSFs;
  - Rejects. Coarse sand to cobble-sized material; disposed at a number of locations (refer below). Rejects have also been used in construction of TSF embankments and infrastructure pads; and capping of tailings at TSFs.
- Disposal of tailings from the CHPPs to the in-pit Ramp 32 TSF (Airstrip pit) [active since approximately 2019];
- Disposal of rejects from RV CHPP to RS1 TSF western compartment, with some rejects also disposed into spoil areas;
- Disposal of rejects from GY CHPP to GS2, GS11 and R22 rejects areas;
- Short-term storage of ROM coal on the ROM Pads;
- Short-term storage of product coal on the product coal stockpile, awaiting off-site transport by rail;

Historic activities of relevance to this waste characterisation report comprise:

- Disposal of tailings from GY CHPP to the above-ground GS1 TSF [inactive since late 2020];
- Disposal of tailings from RV CHPP to the above-ground RS1 TSF [inactive since early 2021];
- Disposal of tailings from the CHPPs to the in-pit DRE5 TSF [inactive since 2022];
- Disposal of rejects from RV CHPP to Riverside rejects dump [inactive since approximately 2000].

RHM has approval to construct a new (additional) CHPP at GRBM. As such, future ROM coal from GRM, BRM and/or RHM could be processed at all three CHPPs, with tailings and rejects disposed and managed at GRBM as approved.

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

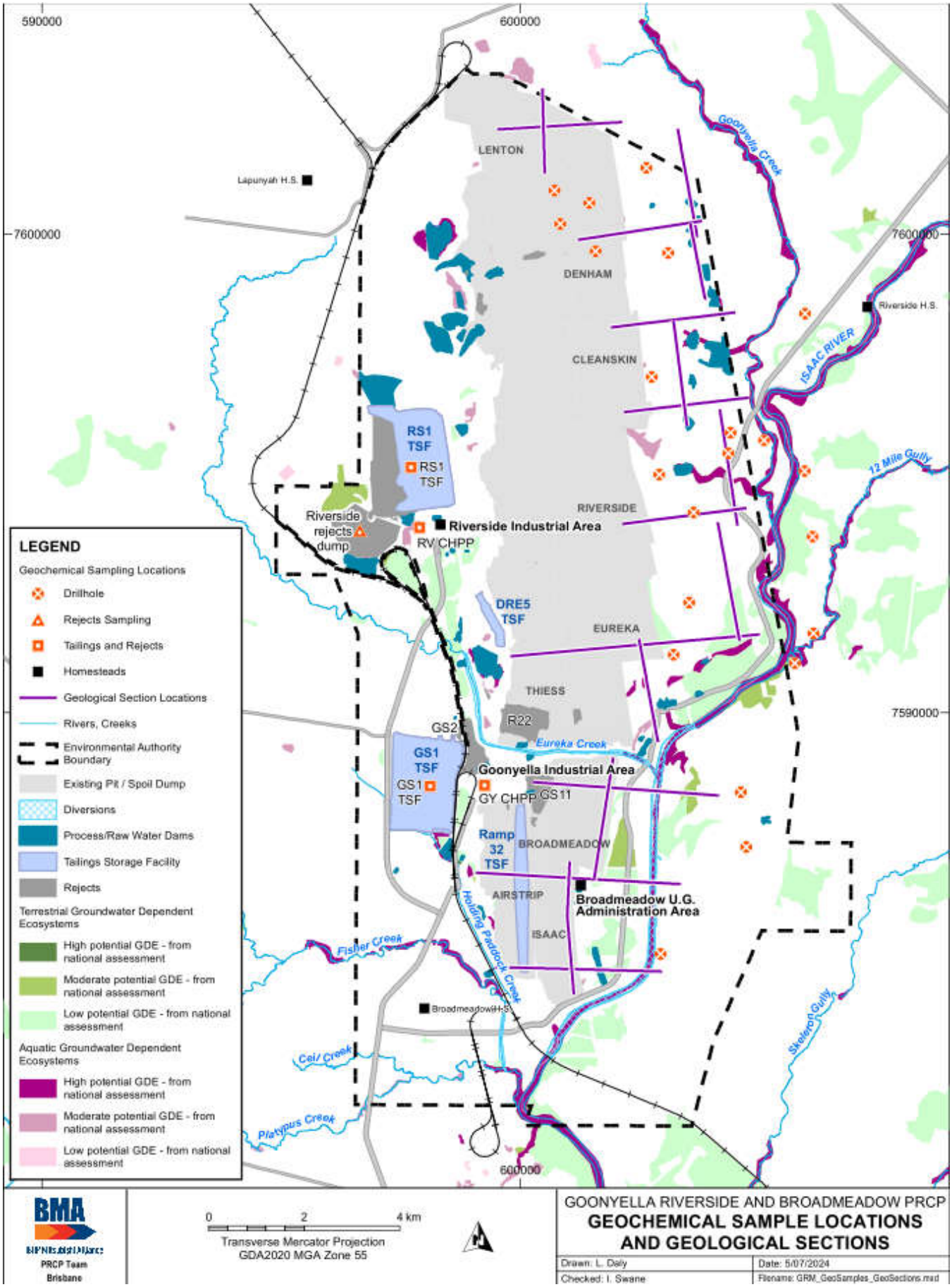


Figure 1. Current mine layout, geochemical sample locations and locations of geological sections

2.2 Mine Domains

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

- Residual voids (pits remaining at end of mine life):
    - Goonyella residual void
    - Thiess residual void
    - Broadmeadow-Isaac residual void
    - Ramp 32 East residual void
    - Ramp 32 South residual void

  A number of pits will be backfilled during operations, including historic Lenton, Mitsui and Dampier pits, which have already been backfilled and currently form part of (what will ultimately be) Goonyella spoil landform.

  DRE5 in-pit TSF will be partially backfilled during operations and will form part of Thiess spoil landform. Airstrip pit (Ramp 32 in-pit TSF) will be backfilled during operations and will form part of Airstrip spoil landform.

- Spoil landforms:
    - Goonyella spoil landform [including several backfilled pits as outlined above].
    - Thiess spoil landform [including partially backfilled DRE5 in-pit TSF and R22 in-pit rejects dump].

      From a rehabilitation and post-closure perspective the low-wall west of the Thiess pit/void will form part of the Goonyella spoil landform. However, for the purposes of this AMD assessment, the low-wall spoil dump associated with Thiess pit is assessed as a separate spoil landform, herein called Thiess spoil landform.
    - Broadmeadow-Isaac spoil landform.
    - Airstrip spoil landform [including backfilled Ramp 32 in-pit TSF].

  Note: these spoil landforms are not 'discrete' (completely stand-alone) features. Instead, they should be thought of as zones within a single landform with a hummocky, rolling topography – higher spoil areas behind (west of) each residual void, where mining occurred – and lower between voids, where pit ramps were located.

  DRE5 TSF (inactive) is an in-pit TSF located at the periphery of the Thiess spoil landform. Due to the concentration of tailings at this TSF situated near the edge of the spoil landform where the tailings will not be deeply buried within the core of the spoil landform, and also at the base of the spoil landform, this TSF has been conservatively assessed as a TSF landform (adjoining spoil landforms), rather than the tailings being assessed as a relatively minor component of its' much larger spoil landform. See TSF landforms below.

  R22 in-pit rejects dump (active) is located at the southwestern periphery of the Thiess spoil landform. Due to the concentration of rejects and situated near the edge of the spoil landform where the rejects will not be deeply buried within the core of the spoil landform, this rejects dump has been conservatively assessed as a 'stand-alone' rejects landform, rather than the rejects being assessed as a relatively minor component of its' much larger spoil landform. See rejects landforms below.

  Ramp 32 TSF (the current/active TSF) is an in-pit TSF within Airstrip pit, which will be backfilled during or prior to closure. Due to the concentration of tailings at this TSF situated at the base of the Airstrip spoil landform, this TSF has been conservatively assessed as a TSF landform (within a spoil landform), rather than the tailings being assessed as a relatively minor component of its' much larger spoil landform. See TSF landforms below.

- TSF landforms:
    - RS1 TSF is an out-of-pit above-ground facility [i.e. not located within a pit shell or spoil landform 'footprint']. The TSF has a western compartment comprising rejects only (the current/active rejects disposal location for rejects from RV CHPP) and an inactive eastern compartment predominantly comprising tailings, with minor rejects.

  - GS1 TSF (inactive/decommissioned) is an out-of-pit above-ground facility [i.e. not located within a pit shell or spoil landform 'footprint'].
  - DRE5 TSF (active) is an in-pit facility located at the western periphery of the Thiess pit shell, within the Thiess spoil landform 'footprint'. The TSF is maintained as a 'commissioned' TSF to allow for temporary use (in the event that tailings cannot be discharged into the active TSF).
  - Ramp 32 TSF (active) is an in-pit facility within Airstrip pit, which will be backfilled with spoil. The pit will be within the Airstrip spoil landform 'footprint', which ultimately is part of the Ramp 32 East, Ramp 32 South and Broadmeadow-Isaac void shell.

- Rejects landforms: excluding rejects broadly co-disposed within a spoil landform.
  - Riverside rejects dump (inactive/decommissioned) is an out-of-pit above-ground facility [i.e. not located within a pit shell or spoil landform 'footprint']. The dump was rehabilitated in the early 2000s, but due to the substantial corrective action required to achieve the PMLU it has been scheduled for further rehabilitation in the PRCP schedule.
  - GS2 rejects dump (active) is an out-of-pit above-ground facility [i.e. not located within a pit shell or spoil landform 'footprint']. The dump is located northeast of and adjacent to GS1 TSF.
  - GS11 rejects dump (active) is an out-of-pit above-ground facility [i.e. not located within a pit shell or spoil landform 'footprint']. The dump is located north of Ramp 32 TSF, between the TSF and Eureka Creek.
  - R22 rejects dump (active) is an in-pit facility within the southwestern periphery of the Thiess pit shell, within the Thiess spoil landform 'footprint'.
- Coal stockpiles: ROM coal pads and stockpiles; and Product coal pads and stockpiles.

2.2.1 Material Types and Quantities

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

- Spoil (overburden and interburden) currently comprises approximately 98% of all mineral waste at GRBM and includes weathered waste (Tertiary and Permian-age) and fresh (unweathered) waste (all Permian-age).
- Tailings are generated at the CHPPs from processing ROM coal and typically represent the clay, silt and fine sand fractions of ROM waste. Throughout operations at GRBM, tailings have been disposed as a slurry into several TSFs – the current (active) TSF being Ramp 32 in-pit TSF (Airstrip pit). Tailings comprise approximately 0.5% of all mineral waste at GRBM – with this approximated proportion expected for the remaining life of asset mine plan.
- Rejects are generated at the CHPPs from processing ROM coal and typically represents coarser and rockier seam roof, partings and floor material. Rejects are disposed into several current and historic rejects dumps and into spoil dumps. Rejects have also been used in construction of TSF embankments and infrastructure pads (e.g. ROM and coal stockpile pads). Rejects comprise approximately 1.5% of all mineral waste at GRBM – with this approximated proportion expected for the remaining life of asset mine plan.

Coal is also included in the assessment; however, coal is generally not considered mineral waste, with the exception of small quantities of sub-economic seams that may report to the spoil dumps, and remnant coal exposed on pit highwalls (such as in residual voids).

2.3 Baseline Information

2.3.1 Topography

The topography at GRBM is relatively flat. The mine is located within a broad valley through which the Isaac River flows. The valley is defined to the west by the Denham Range and to the east by the Carborough Range. The southern end of the valley broadens out on to a wide flood plain. A low broad ridge to the north defines the northern

part of the Isaac River catchment. The low hills located to the east of the Isaac River near the existing mine are strongly undulating with a well-developed system of drainage lines.

The topography of the Isaac River valley near the GRBM area varies from approximately 250m Australian Height Datum (AHD) along the Isaac River to the east to approximately 325m AHD elevation along portions of the Denham Range that define the western edge of the valley. The relatively steep slopes associated with the Denham Range contrast with the extensive flat areas across the base of the river corridor, where gradients are generally less than 1:100.

2.3.2 Climate

The following information about climate is general and provided for broad context. Refer to the main volume of the PRCP for detailed information about climate at GRBM.

GRBM is located within Queensland's semi-arid climatic zone, which is characterised by high summer temperatures, warm dry winters and generally distinct wet and dry seasons; with higher rainfall and higher evaporation occurring over the summer months (December to February). Climate data (rainfall, evaporation and temperature) is available from Moranbah Water Treatment Plant and Moranbah Airport, located approximately 25 km and 33 km, respectively, south of GRBM.

Median maximum temperatures range from approximately 24°C in June/July to 35°C in December/January, with minimum temperatures ranging from approximately 9°C in July to 21°C in January. The average annual rainfall and evaporation are approximately 600 and 2000 mm per year, respectively, with evaporation greatly exceeding rainfall. The evaporation rate is highest in the summer months - mean daily rate of approximately 8 mm in December, and lowest in the cooler months - mean daily rate of approximately 3 mm in June. 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

GRBM is located on the north-western margin of the Bowen Basin on the Collinsville Shelf. The Bowen Basin in the area is characterised by a relatively thin accumulation of sediments, gentle easterly dips and minor to moderate deformation. The lithology at GRBM is characterised by typical basin-fill sediments, comprising mudstone, claystone, siltstone, sandstone (typically fine- to medium-grained), carbonaceous sediments and coal seams. Basalt is encountered within Tertiary-age material. The depth to base of weathering averages about 30 m below natural surface but ranges from about 20 m to 50 m below natural surface, depending on the local topography.

In coal environments (i.e. at coal mines) fresh carbonaceous materials typically have higher sulphide 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 sulphide mineral concentration. The key exception is that non-carbonaceous materials located within coal seams or immediately above and below (within, say, 0.5m of) coal seams tend to have a higher sulphide concentration compared to bulk overburden/interburden located away from seams.

The coal bearing sequences at GRBM are primarily from the Permian-age Moranbah Coal Measures (MCM), with minor coal from the Permian-age Fort Cooper Coal Measures (FCCM). These coal measures comprising the following seam groups in stratigraphic order, from youngest to oldest:

- Goonyella F (GF) seam group; the base seam group of the FCCM comprising several plys. The GF is a minor seam group, which is not present in the western pit areas of GRBM (i.e. post-closure, will only be exposed in Goonyella residual void). The GF seam group has not been mined for ROM coal to date, however some plys of the GF seam may be mined for ROM coal from the Goonyella pit group in later years;
- Goonyella Upper Seam (GUS) group; the uppermost seam group of the MCM and a significant seam group at GRBM that comprises several plys – not all of which are mined as ROM coal;
- P seam; a 'waste' seam group at GRBM (i.e. P seam is not mined as ROM coal);

- Goonyella Middle Seam (GMS) group; a significant seam group at GRBM that comprises several plys, most of which are mined as ROM coal; and
- Goonyella Lower Seam (GLS) group; a significant seam group at GRBM that comprises several plys, most of which are mined as ROM coal.

Below the GLS group lies the GLL seam group, which is not mined at GRBM.

The GUS is associated with a marine transgression (a brackish environment), whilst the GMS and GLS groups are interpreted to have formed in fresh(er) water basins.

Seam splitting and coalescing occurs along the length (north-south) of the site.

Mining at GRBM to date has been from the MCM and overlying Tertiary-age material. The FCCM sub-crop east of the current mining activities at GRBM. Based on the current mine plan, the FCCM will begin to be encountered (during mining) from approximately now (at the northern Goonyella pits) through until the end of mine life from all Goonyella pits. The FCCM is not encountered in Thiess, Airstrip, Ramp 32 East, Ramp 32 South or Broadmeadow-Isaac pits.

Overlying the FCCM/MCM is a thin veneer of Quaternary- and Tertiary-age sediments. Throughout the region, the Quaternary and Tertiary sediments are highly weathered, semi-consolidated and typically comprise sand, clay and gravel.

To date, all ROM coal mined from GRM (i.e. open-pit mining) has been from the GMS and GLS seam groups. P seam is mined as spoil. GF seam has not been encountered to any significant extent and, where encountered in northern pit areas, the GF seam has been mined as spoil. As mining progresses eastwards (down-dip) the GUS seam group will become more prevalent. In the latter stages of mining in Goonyella pits, some coal from GF seam may be mined as ROM.

All current ROM coal mined from BRM (i.e. underground) has been from the GMS seam group. Future mining will extract coal from the GMS and GLS seams. RHM (i.e. underground) is located adjacent to GRBM (east and northeast of GRBM) and will mine the GMS seam group – therefore ROM coal from RHM is expected to have similar geochemical characteristics to ROM coal from BRM.

An indicative stratigraphic column showing the seam groups is provided in **Figure 2**, which also includes the number of geochemical samples collected from each overburden and interburden zone, and also from within each seam group (refer to **Section 4.2** for information regarding sample collection).

Geological long-sections (indicatively north-south) approximately along the future highwall of the voids are provided in **Attachment A – Figures A1 to A3**. Geological cross-sections (indicatively west-east) through the pits are provided at **Attachment A – Figures A4 to A9**. Refer to **Figure 1** for section locations. The seam groups are shown in the geological sections. Note: some of the pits within the Goonyella void/pit area have already been backfilled or will be backfilled during operations and, as such, will not remain at closure.

Due to the generally eastward dip of the seams and the nature of the seams splitting and coalescing, the location of the weathered zone shown in the stratigraphic column (**Figure 2**) varies from pit to pit (north to south) and also from west (start of mining) to east (current and future mining). Refer to the geological sections in **Attachment A**.

Underlying the MCM is the Permian-age Back Creek Group, which has geological similarities with the host rock of the MCM (i.e. quartzose to lithic sandstone, siltstone, carbonaceous shale and minor coal).

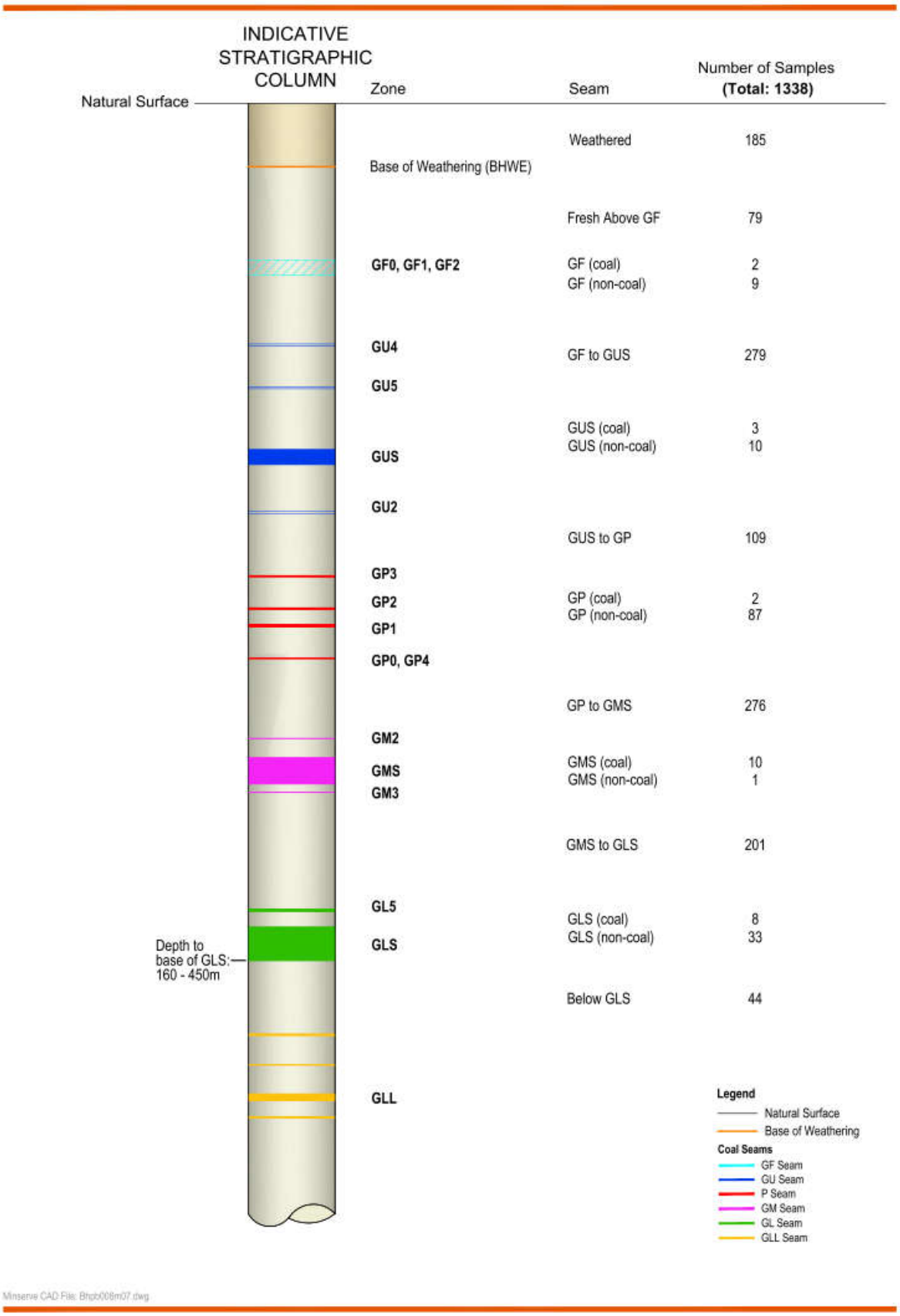


Figure 2. Indicative stratigraphic column

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 quality at GRBM.

GRBM is located within the Isaac Connors surface water catchment – a sub-catchment of the upper Fitzroy Basin. The surface water catchment for the GRBM begins west of the site and flows downstream to meet the Isaac River, which flows approximately north to south through the site (east of the highwalls/voids). The Isaac River is the dominant watercourse in the region.

All watercourses within and surrounding GRBM – including the Isaac River – are highly ephemeral and only flow briefly after significant rainfall, enough to generate sufficient overland flow. The creeks at GRBM are shown on **Figure 1** and include:

- Isaac River, which flows into the site from the northeast, then flows east of the Goonyella void and east of Broadmeadow-Isaac void, exiting the site south of Ramp 32 South void. The river channel is a diversion channel (i.e. not the original/natural watercourse) from approximately the southern end of Goonyella void through until the river exits the site;
- Goonyella Creek, located in the north-eastern area of the site and flows southwards into Isaac River east of Goonyella void;
- Eureka Creek, which traverses the site in an approximately northwest to southeast direction between the southern end of Thiess pit/void and the northern end of Broadmeadow-Isaac pit/void and joins the Isaac River east of Broadmeadow-Isaac void and south of Goonyella void;
- Holding Paddock Creek is a small creek that flows from (and around) the southwestern and southern side of GS1 TSF southwards around the western edge of Airstrip pit spoil dump and joins into Fisher Creek west of Ramp 32 South void;
- Fisher Creek, which flows into the southwestern corner of the site from the west, joining into Platypus Creek near the southern boundary of the site (ML boundary);
- Platypus Creek, which flows into the southwestern corner of the site from the west, joining into Isaac River at approximately the southern boundary of the site.

Minor tributaries flow into these creeks and Isaac River outside of GRBM.

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 groundwater quality at GRBM.

An aquifer is defined as a groundwater bearing formation sufficiently permeable to transmit and yield water in usable quantities. The Quaternary alluvial formations, Tertiary sediment and the Permian coal measures generally yield low sustainable volumes of poor-quality water. As such, these formations are not recognised as ‘true’ aquifers in the area. However, for the purpose of the discussion, groundwater-bearing zones at GRBM are referred to as aquifers.

The main factors influencing natural groundwater levels are groundwater recharge, evapo-transpiration and regional flow patterns. Due to the heterogeneity and discontinuity of the Quaternary alluvium aquifers and Tertiary sediment aquifers, the groundwater flow direction in these aquifers cannot be determined on a regional scale – and is likely to be topographically controlled, flowing from higher elevations to lower elevations. The ‘pre-mining’ groundwater flow direction within the Permian coal seams is generally west to east across the site, and consistent with recharge into sub-cropping seams west of GRBM.

The coal seams within the MCM are the primary aquifer at GRBM. The coal seams can be characterised as confined aquifers, with the GUS, GMS and GLS seam groups forming the main hydrostratigraphic units locally. The overburden and interburden within the MCM and FCCM act as aquitards and are typically dry or very low yielding.

The hydrogeological units at GRBM comprise:

- Quaternary alluvium – unconfined aquifer (sporadically discontinuous water-bearing strata of permeable unconsolidated sand or gravel) localised at or near to GRBM along the Isaac River, Eureka Creek and Goonyella Creek, and more regionally along the Isaac River where it is particularly well developed.
- Permian-age coal measures interburden and overburden units – low permeability sedimentary rock with aquitard properties; and
- Permian-age coal seams – exhibiting water bearing properties associated with secondary porosity through cracks and fissures.

2.3.6 Potential Environmental and Human Health Receptors

A conceptual environmental geochemical model (source-pathway-receptor (SPR) model) for GRBM 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:

Potential surface water receptors

The primary surface water feature in the district is the Isaac River, located within and adjacent to GRBM.

- The northern area of the site, comprising almost all of Goonyella spoil dumps/landform, Thiess spoil dumps/landform, RS1 TSF landform and Riverside rejects landform drains west / southwest /south to Eureka Creek and its tributaries.
    - The highwall area east of Goonyella void drains eastwards to Goonyella Creek (+/- via tributaries) and Isaac River.
- The central area – comprising the Thiess spoil dumps/landform, RS1 TSF landform and Riverside rejects landform drains west / southwest to Eureka Creek. The current Eureka spoil dump (future southern section of Goonyella spoil landform) drains south to Eureka Creek and Isaac River. The northern part of Broadmeadow spoil landform drains north to Eureka Creek.
- The southern area of the site comprising GS1 TSF landform and Airstrip spoil landform drains west and south to Holding Paddock creek.

All of these creeks eventually drain into the Isaac River. GRBM shares the Isaac River Catchment with several other coal mines upstream and downstream of GRBM.

Potential groundwater receptors

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

Potential domestic (human) receptors

The nearest homesteads to GRBM – both located within the PRCP area – are *Broadmeadow* homestead, located approximately 1.9 km southwest of Ramp 32 residual void, and *Riverside* homestead, located approximately 3.1 km east of Goonyella residual void highwall. These homesteads are located in surface water sub-catchments that do not receive drainage from GRBM and are located upgradient (via groundwater) from GRBM. *Riverside* homestead is situated above the future Red Hill underground mining area.

The next closest homesteads are *Lapunyah* homestead, located on the north-western side of GRBM about 1.2 km northwest of the ML boundary; and Red Hill homestead, located about 1 km east of the PRCP area and almost 6 km east of the Goonyella residual void. These homesteads are both located upstream (via surface water) and upgradient (via groundwater) from GRBM.

The two remaining homesteads in the district – both located well outside GRBM – are *Burton Downs* homestead, located over 4 km northeast of GRBM and *Denham* homestead, located approximately 5.8 km northwest of GRBM.

2.3.7 Acid and Metalliferous Drainage

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

2.3.8 Salinity, Sodicity and Dispersion

Environmental geochemical information with regard to salinity, sodicity and dispersion of mineral waste materials at GRBM 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 GRBM.

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 sulphide minerals (primarily pyrite and marcasite) and/or by the dissolution of acid generating sulphate 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 sulphide minerals (such as pyrite) are exposed to oxygen and water. Oxidation of sulphide minerals may result in the production of acid(ity), sulphate (SO_4) 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[1]; DIIS, 2016[2]). BHP (2021) 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 sulphate concentration due to oxidation of sulphide 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 sulphide concentration.

Whether contact water is impacted by AD, NMD and/or SD largely depends on the relative proportion of acid generating minerals (sulphides / sulphates) and acid neutralising minerals (carbonates) 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 sulphide oxidation.

1 INAP, 2009. Global Acid Rock Drainage Guide.

2 DIIS, 2016. Preventing Acid and Metalliferous Drainage. Handbook from Australian Federal Government's Leading Practice Sustainable Development Program for the Mining Industry. https://www.industry.gov.au/data-and-publications/leading-practice-handbook-preventing-acid-and-metalliferous-drainage.

4 Assessment Methodology

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

4.1 Information Review

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

4.2 Sample Collection

Drill-hole Samples – representing spoil, 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. Drill-hole samples for geochemical analysis have been collected from 22 drill-holes located throughout GRBM (shown in **Figure 1**), dating from 1996 through to 2024.

Most of the drill-holes are distributed along strike (approximately north-south) in the vicinity of the current pit highwalls of the pits that will comprise the Goonyella void. Some drillholes are located outside the open-pit mining area and were targeting sample collection for the current and planned underground mining areas. The drill-holes intersect all current mined geological units, with sampling undertaken from surface to full drill-hole depth (approximately to below the lowest mined seam). As such, the drill-hole samples that have undergone test-work are representative of the geology/stratigraphy at GRBM from existing mining (disturbance) areas. No drill-hole sampling has bene undertaken from the areas closely associated with Thiess pit, Airstrip pit, Broadmeadow pit or Isaac pit, however the geology and lithology of these old pit areas is consistent with the geology and lithology elsewhere on site.

With regard to future mining areas, the FCCM (overlying the MCM) are currently not mined at GRBM and won't be mined in significant quantities at GRBM for several years. The FCCM are only mined from the pits comprising the Goonyella void. As such, most of the drill-hole samples are from the MCM. The FCCM will essentially comprise overburden only – with the low possibility of some ROM coal being mined from the F seam group. The assessment has not differentiated between the MCM and FCCM (i.e. all samples are assessed the same regardless of whether from MCM or FCCM). Further geochemical characterisation and assessment of FCCM samples will be undertaken during operations to support and inform rehabilitation and closure planning. Drillhole samples from GMS and GLS seam groups from GRBM are representative of the geology/stratigraphy from future mining areas at GRM, BRM and RHM.

Geochemical data is available for 1338 drill-hole samples collected from 22 drill-holes. Geochemical samples collected and tested were sourced from the following key mineral waste domains:

- Weathered, non-carbonaceous spoil. 154 samples.
- Weathered, carbonaceous spoil, including weathered coal. 31 samples.
- Fresh, non-carbonaceous spoil. 1015 samples.
- Fresh, carbonaceous spoil. 112 samples. These samples typically include carbonaceous siltstone, carbonaceous sandstone, carbonaceous mudstone and coaly shale, but also includes similar coaly and carbonaceous materials other than coal.
- Fresh, coal. 26 samples.

All samples were collected from drill-core. The samples were collected as discrete samples – typically a 15-25 cm interval of core within targeted sampling zones. Most 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, such as carbonaceous spoil plus material located within and very close to coal seams, which includes roof/parting/floor (carbonaceous and non-carbonaceous), and coal.

A significant proportion of the spoil samples were sampled close to seams – typically interburden or parting between plys of the same seam group. As such, seam and near-seam zones were proportionally oversampled (relative to sampling of thick overburden/interburden areas well away from seams) to target seam zones that were interpreted as posing a higher AMD hazard compared to general spoil well away from seams. Therefore, this sampling technique is potentially biased towards higher AMD hazard materials.

It is understood that most fresh coal will report to ROM coal and be processed. A small fraction of coal will 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 floor 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.

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).

Tailings Samples – representing very fine to fine-grained coal process waste

Geochemical data is available (within the geochemical database) for 467 tailings samples, comprising:

- 244 'fresh' tailings samples collected from the two CHPPs;
- 139 'aged' tailings samples collected from geotechnical investigation drill-holes within GS1 TSF;
- 84 'aged' tailings samples collected from geotechnical investigation drill-holes within RS1 TSF.

Tailings data are presented and discussed as two groups being representative of:

- Fresh (CHPP) tailings samples [n=244]; and
- Aged (TSF) tailings samples [n=223].

Tailings samples collected from the CHPPs are deemed to be representative of 'fresh' tailings currently and recently produced at GRBM. Tailings samples collected from TSFs are deemed to be representative of 'aged' tailings within GS1 and RS1 TSFs at GRBM.

Rejects Samples – representing mid- to very coarse coal process waste

Geochemical data is available (within the geochemical database) for 338 rejects samples, comprising:

- 118 'fresh' rejects samples collected from the CHPPs;
- 20 'aged' rejects samples collected from geotechnical investigation drill-holes within GS1 TSF;
- 126 'aged' rejects samples collected from geotechnical investigation drill-holes within RS1 TSF;
- 74 'aged' rejects samples collected from drill-holes and test pits at Riverside rejects dump.

Rejects data are presented and discussed as three groups being representative of:

- Fresh CHPP rejects samples [n=118];
- Aged TSF rejects samples [n=146] – collected from GS1 TSF and RS1 TSF;
- Aged dump rejects samples [n=74] – collected from Riverside rejects dump.

Rejects samples collected from the CHPPs are deemed to be representative of 'fresh' rejects currently and recently produced at GRBM. Rejects samples collected from Riverside rejects dump and from TSFs are deemed to be representative of 'aged' rejects that may be found in at rejects disposal areas or within TSFs awaiting burial/rehabilitation.

Other Samples

Geochemical data is available (within the geochemical database) for three 'fill' samples and 18 'natural ground' samples collected from geotechnical investigation drillholes within RS1 TSF. These samples were collected and analysed as part of the geotechnical investigations. Fill (spoil) material is often used as part of TSF embankment construction. At the base of the investigation drillholes (base of the TSFs, below the base tailings or rejects) natural ground was encountered and was also sampled as part of the investigations.

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 GRBM, as discussed below.

Solid Samples – Static Tests

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.

Almost all samples have undergone 'screening' tests (stage 1 tests) for:

- pH and electrical conductivity (EC) on 1:5 w:v water extracts (on pulps [100% passing 212 microns]);
- Net acid producing potential (NAPP) test, which comprises total sulphur (total S) and acid neutralising capacity (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 sulphate (SO_4);
- Sulphide (chromium reducible sulphur – Scr) – a test to determine the proportion of total S present as sulphide;
- 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 sulphide 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_4, chloride (Cl) and fluoride (F)];

  - Alkalinity [total alkalinity, bicarbonate (HCO_3) and carbonate (CO_3)] 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, 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).

Tailings Liquor Samples

Tailings samples collected from the CHPPs are collected as a slurry – representative of the tailings slurry that reports to TSFs for disposal. At the TSF the water drains to one end of the TSF – called a decant pond/area – and is collected for re-use in the CHPPs. Geochemical data is available (in the geochemical database) for tailings liquor from 85 sampling events undertaken at the CHPPs (40 samples from GY CHPP and 45 samples from RV CHPP) between January 2022 and July 2023. The liquor samples were analysed for a typical suite of water quality parameters, such as pH and EC, major cations and anions and soluble metals and metalloids.

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.

AMD Classification

The Acid-Base Account (ABA) method was used to assess the acid-neutralising and acid-generating characteristics of the samples 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 sulphide, is able to oxidise and generate acid (H_2SO_4). 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 sulphur 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 pH, 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 1**.

Table 1. Preliminary AMD classification criteria

Preliminary classification	Sulphur %	NAPP kg H_2SO_4/t	ANC/MPA ratio	NAGpH (if data available)
NAF	≤ 0.01	-	-	-
	≤ 1	< 0	≥ 2	-
	≤ 1	< 0	-	≥ 4.5
NAF-Sulphur (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			

Sulphur Category

To ensure a consistent approach to describe the samples geochemical characteristics, specific total S cut-off values were used to discuss sulphur data, as shown in **Table 2**.

Table 2. Sulphur category and associated cut-off

Sulphur 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

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 3**.

Table 3. ANC category and associated cut-off

ANC category	ANC kg H_2SO_4/t
Very low	< 5
Low	5 - 15
Moderate	15 - 30
High	30 - 50
Very high	> 50

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, reject, 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 4** are expressed in units of microSiemens per centimetre (µS/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 4. Soil salinity classification

Soil salinity classification	EC1:5 µS/cm
Non-saline	< 450
Slightly saline	450 - 900
Moderately saline	900 - 2000
Saline	2000 - 4000
Strongly saline	> 4000

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) [and in a small number of cases 1:2 w:v] water extract procedure typically on pulp samples. The soil pH types shown in **Table 5** are based on a 1:5 w:v method. These soil pH types are used as an indicative guide.

Table 5. 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

Mineralogy

Mineralogical data (QXRD) provides supporting information for the geochemical data, particularly with regard to sulphide and carbonate mineralogy of a sample, showing results for mineralogical forms (e.g. what sulphide 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.

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 6**.

Table 6. 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).

Solubility

Metal/metalloid mobility from samples has been assessed using deionised water, 'saline' water and peroxide (NAG) leaching methods. The deionised and saline water leaches assess the initial solubility under fresh water and saline water conditions, whereas the peroxide leach assesses the solubility after the samples have been oxidised. The objective of the saline leaching procedure is to better mimic the brackish to moderately saline water commonly used in the CHPPs 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 oxidised. 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 7**. These same concentration cut-off values were also applied to tailings liquor data.

Table 7. 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 3**. 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.

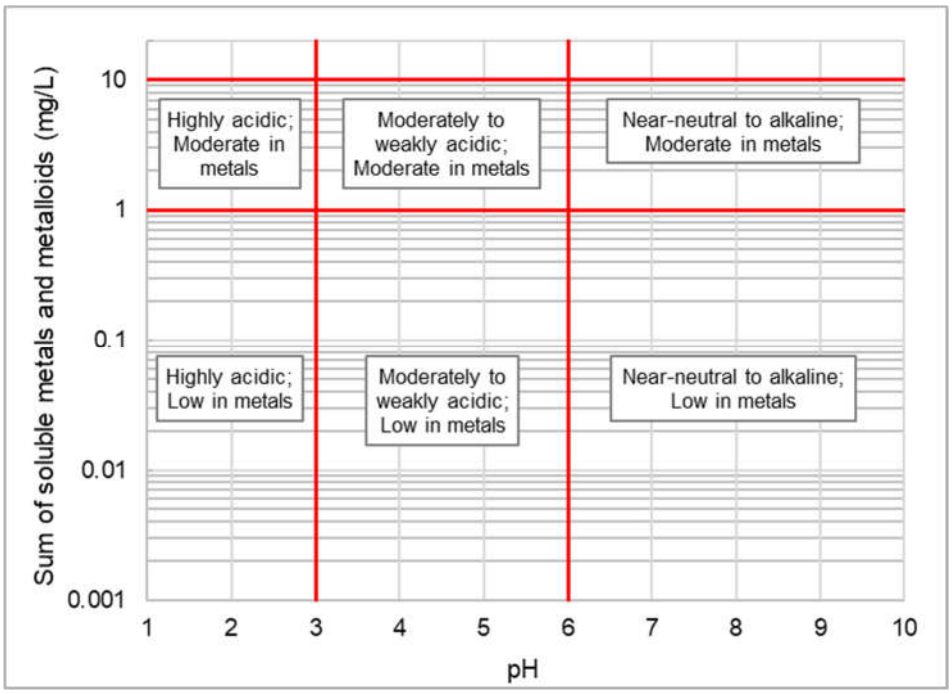


Figure 3. Classification of soluble metals and metalloids as a function of pH

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.

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 8** (after Northcote and Skene, 1972; Isbell, 2002):

Table 8. 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. Sodicity assessments only apply to materials likely to report to final landform surfaces, such as overburden/interburden (i.e. not coal reject or waste coal).

Sodicity 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 9**). 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 9. Emerson classifications

Class	Description	Class	Description
1	Slaking and complete dispersion	5	No calcite or gypsum present; dispersion
2	Slaking and some dispersion	6	No calcite or gypsum present; flocculation
3	Dispersion [remoulded]	7	Non-slaking and swelling
4	Calcite or gypsum present; dispersion	8	Non-slaking and non-swelling

4.4.1 Using Coal Quality Data for AMD Classification

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

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 sulphur grade range for each seam group to gain an understanding of the potential AMD hazard posed by each coal seam group. The results were then compared with detailed geochemical data available for coal to ‘calibrate’ the coal quality total sulphur data.

Coal samples from less than 20m depth were assumed to be completely or predominantly oxidised and were interpreted as ‘weathered carbonaceous spoil’ and, therefore, excluded from the assessment of potential ROM

coal. Acid producing sulphate minerals, such as jarosite, may be present within weathered coal and carbonaceous material, however, mineralogical data available from BMA mines in the district mining the MCM suggests that jarosite is an insignificant mineral within the MCM.

4.4.2 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 – being representative of the highwall of the residual void associated with a given pit group.

The frequency of occurrence of relevant material types within each pit was determined from the stratigraphic distribution within selected 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 GUS seam group had a frequency of occurrence (by meters) 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 void 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 most likely present in relatively minor proportions.

To estimate the proportion of key material domains on the highwalls in each void, exploration drill-holes in proximity to the future void highwall/s were selected by for each pit. Most holes extended to depths approximating future pit floor depths.

Stratigraphy, age, weathering, location with respect to the water table, and major stratigraphic horizons (as recorded in the BHP 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 plys were grouped into their respective seam groups, such as GUS, GMS, etc.

For each void highwall, a statistical assessment was conducted on each drill-hole sub-set (as applicable to each void) 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 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.

4.4.3 Residual Void Floor Assessment

An assessment of the AMD hazard associated with exposures of remnant coal on the floor of each pit group was undertaken – being representative of the floor of the residual void associated with a given pit group.

As explained in **Section 4.4.1** 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 pit-group basis), only the coal quality data from the seam group likely to form the pit floors at a given pit group was assessed. At GRBM, the GMS seam group forms the floor of the Broadmeadow-Isaac void and the GLS seam group forms the floor of all other voids.

It is acknowledged that there are generally minor geochemical differences between the various plys 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 / plys.

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.

4.4.4 TSF Assessment

At closure, GS1 TSF and RS1 TSF will both remain as discrete facilities (TSF landforms). These TSFs are non-operational and will undergo rehabilitation prior to or during mine closure. Geochemical data from samples collected from GS1 and RS1 TSFs were used to assess the geochemical AMD source hazard of these facilities.

RS1 TSF is constructed as two compartments: a western compartment, comprised of rejects only; and an eastern compartment predominantly comprised of tailings, with rejects embankments (i.e. a 'typical' TSF). The entire RS1 TSF landform will be rehabilitated as single landform, however the landform more closely resembles a rejects dump abutting (adjoining) a TSF. The AMD source hazard of each compartment has been determined.

The primary current/operational TSF is Ramp 32 TSF (Airstrip pit) – an in-pit TSF that will be backfilled during rehabilitation and will form part of the Airstrip spoil landform. However, due to the location of this TSF at the base of the Airstrip spoil landform, this TSF has been conservatively assessed as a discrete facility (TSF landform) within the spoil landform. The AMD source hazard of Ramp 32 TSF landform was assessed using tailings geochemical data from the CHPPs representing 'fresh' tailings samples. No rejects are located within this in-pit TSF.

DRE5 TSF is a small in-pit TSF that will be partially backfilled during rehabilitation and will form part of the Thiess spoil landform. However – and similar to Ramp 32 TSF – due to the location of this small TSF at the base of the Thiess spoil landform, this TSF has been conservatively assessed as a discrete facility (TSF landform) within the spoil landform. The AMD source hazard of DRE5 TSF landform was assessed using tailings geochemical data from the CHPPs representing 'fresh' tailings samples. No rejects are located within this in-pit TSF.

4.4.5 Reject Dump Assessment

At closure, Riverside rejects dump (located immediately southwest of RS1 TSF) will remain as a discrete facility (rejects landform). This inactive facility underwent rehabilitation in the early 2000s and has a spoil cover, however further rehabilitation is scheduled to ensure the PMLU is achieved. Geochemical data from samples collected from within this rejects dump were used to assess the geochemical AMD source hazard of this facility. The samples were collected from the facility in 2004, during rehabilitation (prior to the existing spoil cover placement).

GS2 rejects dump – located northeast of GS1 TSF – is located outside of a spoil landform area. As such, this facility has been assessed as a 'stand-alone' rejects landform. No geochemical data is specifically available from this rejects dump. The assessment has used data from all 'aged' rejects generated from GY CHPP – being the source of rejects disposed at this dump.

GS11 rejects dump – located north of Ramp 32 TSF (airstrip pit) between the TSF and Eureka Creek – is located outside of a spoil landform area. As such, this facility has been assessed as a 'stand-alone' rejects landform. No geochemical data is specifically available from this rejects dump. The assessment has used data from all 'aged' rejects generated from GY CHPP – being the source of rejects disposed at this dump.

R22 rejects dump – located within the southwestern periphery of Thiess spoil landform – is assessed as a 'stand-alone' facility due to the concentration of rejects close to the edge of the spoil landform. No geochemical data is specifically available from this rejects dump. The assessment has used data from all 'aged' rejects generated from GY CHPP – being the source of rejects disposed at this dump.

4.4.6 AMD Hazard Scoring

Estimating the AMD hazard is the first step in estimating the geochemical risk associated with potential sulphide oxidation of mineral wastes. The authors have developed an internal procedure to standardise the AMD hazard assessment to maintain consistency across all BHP coal sites and material domains, with the process described below.

AMD hazard scoring and the AMD geochemical likelihood 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 or tailings), whereas a landform is a domain comprising one or more source material types (e.g. rejects disposed within non-carbonaceous spoil). AMD hazard scorings are assigned for individual source materials reporting to a landform as well as to landforms as a whole (i.e. landform AMD hazard score).

The likelihood of a landform developing AMD was determined based on the landform AMD hazard score. AMD hazard scores (**Table 10**) are estimated by analysing three key components, which are used to describe the geochemical hazard of a source material/landform:

1. Geochemical propensity to generate AMD;
2. AMD capacity; and
3. 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, rejects landforms and aged/inactive TSF landforms are generally unsaturated. This assumption is also conservative, since the potential for oxidation (to some degree) is assumed.

Table 10. AMD hazard scoring matrix

Component	Rating		Definition
Propensity for AMD generation Per material types/domain: - Non-carb. - Coaly & carb. - Reject - Tailings Per 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	Evidence of AMD processes have been observed in the field
AMD **Capacity** Per material types/domain: - Non-carb. - Coaly & carb. - Reject - Tailings Per landform	1	Low	Source has a negligible potential for AMD generation. PAF samples have 75th percentile total S concentration less than 0.1%.
	3	Low-Moderate (NMD)	Assumed to be bulk NAF but sulphide bearing, with NAF samples having 75th percentile total S greater than 1% (i.e. the material is predominantly NAF-S). Dominant AMD sources contain material that will likely generate NMD and/or SD (related to sulphide oxidation).
	5	Moderate	PAF and NAF-S samples have 75th percentile total S concentration ranging 0.1-1.0% and with potential to generate AD.
	7	Moderate-High	PAF and NAF-S samples have 75th percentile total S concentration ranging 1.0-1.5% and with potential to generate AD.
	10	High	PAF and NAF-S samples have 75th percentile total S concentration greater than 1.5% and with potential to generate AD.
AMD **Quantity** Per material types/domain: - Non-carb. - Coaly & carb. - Reject - Tailings Per landform	1	Low	Material rated LOW for AMD capacity; or less than 5% of material reporting to a landform is rated LOW-MODERATE for AMD Capacity
	3	Low-Moderate	Less than 5% of material reporting to a landform rated as MODERATE for AMD capacity
	5	Moderate	Greater than 5% of material reporting to a landform rated as LOW-MODERATE or MODERATE for AMD capacity
	7	Moderate-High	Less than 5% of material reporting to a landform rated as MODERATE-HIGH or HIGH for AMD capacity
	10	High	Greater than 5% of material reporting to a landform rated as MODERATE-HIGH or HIGH for AMD capacity
AMD **Quantity** 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 or NAF-S
	3	Low-Moderate	Between 10% and 30% of drill-hole meters (or 10-30% of pit floor exposure) are classified as PAF or NAF-S
	7	Moderate-High	Greater than 30% of drill-hole meters (or greater than 30% of pit floor exposure) are classified as PAF or NAF-S
	10	High	Observed AMD on highwall or floor of pit 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 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. This approach is conservative, since sampling is slightly skewed towards material types considered to pose a potentially higher AMD hazard, such as carbonaceous materials.

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 sulphur 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 75th percentile value of the total S concentration for the samples classified as PAF and NAF-S. This is a conservative assumption, as not all total S is associated with reactive minerals and choosing the 75th 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.

Generally, amongst Bowen Basin Permian- and Tertiary-age materials, a very small number of samples are classified as NAF-S – almost all samples with high total S (>1%) are typically classified as 'PAF' of some type. Therefore, AMD Capacity does take into consideration potential NMD/SD by including NAF-S samples with PAF samples, however the very few NAF-S samples (compared to PAF samples) means that NAF-S samples typically have a negligent bearing on the AMD Capacity of a material. For example, of the 2164 samples at GRBM that underwent geochemical characterisation, only 13 samples – all of which were tailings – were classified as NAF-S.

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.

4.4.7 Landform AMD Likelihood Scoring

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

1. Source material AMD hazard score; and
2. Landform AMD hazard score.

Source material AMD hazard score: Describes the potential for AMD generation by the respective material types within each landform. 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 each final landform and each residual void. It is estimated from the source material AMD hazard scores for each material type assumed to be present within that specific landform.

At closure, GRBM has four spoil landforms, five residual voids, four TSF landforms [GS1 and RS1 above-ground TSFs; and Ramp 32 and DRE5 in-pit TSFs] and four rejects landforms [Riverside, GS2, GS11 and R22], as listed in **Section 2.2**.

- **Landforms**: The landform AMD hazard score is estimated from the weighted average of the source material AMD hazard and the proportion of PAF and NAF-S waste expected to report to the landform from each material type.
- **Residual voids**: the landform AMD hazard score is estimated from the average of the source material AMD hazard scores for each material type likely to be exposed on the highwall 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 11**) as consistent as possible with BHP risk management methodology, which is aligned with ISO 31000. ISO 31000 is a family of standards relating to risk management codified by the International Organization for Standardization. For landforms and residual voids with AMD hazard scores 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. This likelihood can be revised as more data, such as kinetic or field data, becomes available.

Table 11. Landform AMD hazard score and landform AMD likelihood

Landform AMD hazard score	Landform AMD likelihood
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

5 Results

Environmental geochemical data is available for 1312 overburden/interburden (spoil) samples and 26 coal samples [sampled from drill-core] and 244 fresh tailings samples, 223 aged tailings samples, 118 fresh rejects samples and 220 'aged' rejects samples – all of which have undergone a range of environmental geochemical tests. The samples are representative of the following mineral waste and coal groups:

Spoil

- Weathered Non-carbonaceous: Weathered non-carbonaceous overburden. 154 drill-hole samples
- Weathered Carbonaceous: Weathered carb. overburden [includes weathered coal]. 31 drill-hole samples
- Fresh, Non-carbonaceous: Fresh non-carbonaceous overburden/interburden. 1015 drill-hole samples;
- Fresh, Carbonaceous: Fresh carbonaceous overburden/interburden. 112 drill-hole samples

Coal

- Fresh Coal: Fresh coal, representative of ROM coal. 26 drill-hole samples

Tailings

- Fresh: Fresh tailings from the CHPPs. 244 samples
- Aged: Aged tailings from GS1 and RS1 TSFs. 223 drill-hole samples

Rejects

- Fresh: Fresh rejects from the CHPPs. 118 samples
- Aged: Aged rejects from GS1 and RS1 TSFs. 146 drill-hole samples
- Aged: Aged rejects from Riverside rejects dump (74 samples) from test pits and boreholes

Additional to the above waste material types, geochemical data is also available for three 'fill' samples and 18 natural ground samples collected from geotechnical investigation drill-holes within RS1 TSF. The fill samples are likely part of embankment construction. The natural ground samples usually represent the base of TSF (immediately below tailings) encountered during geotechnical investigations. This data is presented in the figures/graphs herein for context, however, is not discussed in detail.

5.1 Mineralogy

Data is available for 20 tailings samples and 6 rejects samples that underwent mineralogical analysis by Quantitative X-Ray Diffraction (QXRD). The samples were selected to cover a broad range of mineral waste types. The results are summarised in **Figure 4**. QXRD test-work for spoil samples is underway (results unavailable for this assessment).

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

- Most samples are dominated by clay and quartz minerals (silicate group minerals) and non-crystalline (amorphous) material, variable contributions of carbonate and other silicate minerals. Amorphous (non-crystalline) material was detected in all samples, but generally present in greater proportions in the aged tailings and rejects (combined) samples (median = 40%) compared to the fresh CHPP samples (median = 13%). The nature of the non-crystalline material is largely unknown, although for tailings and rejects it's likely associated with organic carbon.
- The tailings reported high concentrations of sulphide minerals, with 13 out of 20 samples having greater than 1.5% sulphide (as pyrite). Furthermore, fresh CHPP tailings reported higher sulphide mineral concentration (median = 2.55%) compared to aged tailings (median = 0.75%).

- The rejects generally reported low-moderate concentrations of sulphide minerals, with only 1 of the 6 samples having greater than 1.5% sulphide (as pyrite).
- Most fresh tailings and rejects samples have low sulphate concentrations (<1.5%), which is present as jarosite, gypsum and basanite.
    - Sulphate concentrations are slightly higher in the aged tailings samples compared to the fresh tailings samples. Comparatively, there is little difference in sulphate concentrations between fresh and aged rejects.
- Carbonate group minerals predominantly comprise calcite, ankerite and siderite in variable proportions and broadly aligned with the expected carbonate minerals based on the ABCC data.

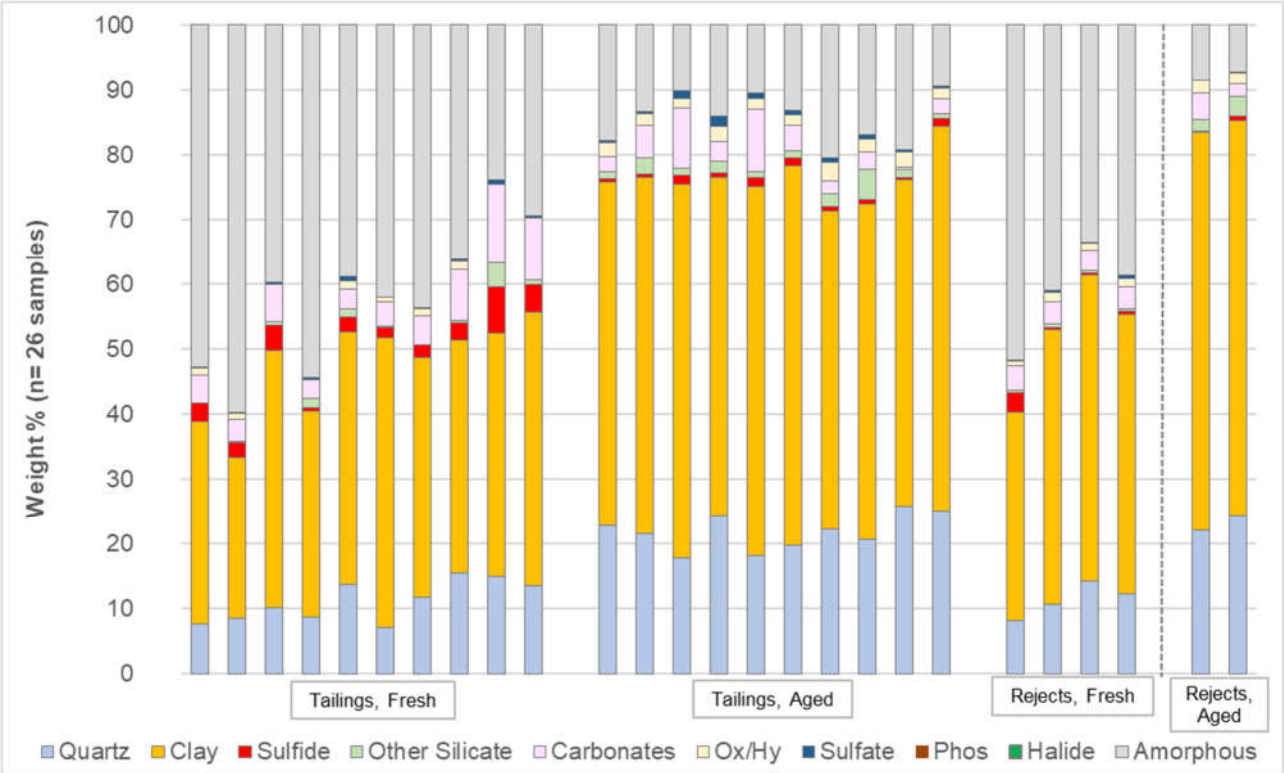


Figure 4. Mineral distribution within tailings and rejects samples

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 sulphuric acid per tonne of sample (kg H_2SO_4/t). The ABA results for the samples that underwent geochemical characterisation are statistically summarised in **Table 12** (spoil samples), **Table 13** (rejects and coal samples) and **Table 14** (tailings and TSF fill/natural ground samples) and discussed in the following sections.

Table 12. ABA results statistics for spoil samples

		Total S[1]	Scr[2] (S)	ANC	MPA[3]	NAPP	ANC/MPA	NAGpH[4]
		%		kg H_2SO_4/t			ratio	pH units
Spoil Weath[5]., non-carb[6].	Count (*n*)	*154*	*19 (19)*	*141*	*154*	*141*	*141*	*22*
	Maximum	0.64	0.44 (0.58)	298	20	17	715	8.3
	95th percentile	0.17	0.32 (0.32)	97	5.3	0.6	92	8.1
	75th percentile	0.05	0.14 (0.18)	15	1.5	-4.0	36	7.8
	Median	**0.02**	**0.06 (0.16)**	**7.3**	**0.6**	**-6.1**	**18**	**7.4**
	25th percentile	0.01	0.04 (0.13)	5.8	0.3	-11	6	4.9
	5th percentile	0.01	0.01 (0.1)	3.1	0.2	-85	1.4	3.1
	Minimum	<0.01	0.01 (0.08)	1.3	0.2	-297	<0.1	3.1
Spoil Weath., carb.	Count (*n*)	*31*	*18 (18)*	*31*	*31*	*31*	*31*	*9*
	Maximum	0.76	0.61 (0.76)	48	23	17	74	7.8
	95th percentile	0.67	0.53 (0.69)	36	21	11	23	7.5
	75th percentile	0.23	0.15 (0.42)	11	7.0	1.3	4.1	6.9
	Median	**0.14**	**0.08 (0.23)**	**6.0**	**4.3**	**-1.5**	**1.5**	**5.5**
	25th percentile	0.04	0.06 (0.16)	3.0	1.2	-6.4	0.9	4.2
	5th percentile	0.02	0.01 (0.11)	1.7	0.5	-24	0.3	3.6
	Minimum	<0.01	<0.01 (0.11)	0.8	0.2	-38	<0.1	3.2
Spoil Fresh, non-carb.	Count (*n*)	*1015*	*154 (154)*	*997*	*1015*	*997*	*997*	*90*
	Maximum	2.78	2.57 (2.78)	546	85	78	3311	11.4
	95th percentile	0.11	0.25 (0.33)	227	3.5	-5.5	443	10.8
	75th percentile	0.05	0.07 (0.1)	91	1.5	-21	108	9.3
	Median	**0.03**	**0.03 (0.05)**	**47**	**0.9**	**-45**	**46**	**8.9**
	25th percentile	0.02	0.02 (0.03)	23	0.6	-89	19	7.6
	5th percentile	0.01	0.01 (0.01)	8.8	0.3	-224	4.7	3.6
	Minimum	<0.01	<0.01 (0.01)	2.4	0.2	-544	<0.1	2.1
Spoil Fresh, Carb.	Count (*n*)	*112*	*27 (27)*	*112*	*112*	*112*	*112*	*19*
	Maximum	1.29	0.48 (0.72)	203	39	21	1326	9.4
	95th percentile	0.45	0.37 (0.51)	64	14	-1.2	54	9.0
	75th percentile	0.13	0.08 (0.24)	30	4.0	-8.7	19	8.7
	Median	**0.06**	**0.09 (0.19)**	**19**	**1.8**	**-16**	**8.7**	**7.3**
	25th percentile	0.03	0.02 (0.06)	13	0.9	-25	4.5	6.3
	5th percentile	0.02	0.01 (0.03)	5.9	0.6	-56	1.1	4.4
	Minimum	<0.01	<0.01 (0.02)	5.4	0.2	-203	0.4	3.0
Spoil ALL	Count (*n*)	*1312*	*218 (218)*	*1281*	*1312*	*1281*	*1281*	*140*
	Maximum	2.78	2.57 (2.78)	546	85	78	3311	11.4
	95th percentile	0.26	0.41 (0.47)	200	8.0	0.6	367	11
	75th percentile	0.06	0.11 (0.18)	80	1.8	-12	84	9.1
	Median	**0.03**	**0.04 (0.07)**	**35**	**0.9**	**-32**	**33**	**8.3**
	25th percentile	0.02	0.02 (0.03)	15	0.6	-77	13	6.5
	5th percentile	0.01	0.01 (0.01)	5.4	0.2	-196	1.4	3.5
	Minimum	0.01	0.01 (0.01)	0.8	0.2	-544	<0.1	2.1

[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 potential spoil samples with total S greater than 0.1%. Values in parentheses are the total S statistics for samples with Scr results.
[3] MPA calculated from total S. [4] NAGpH is final pH as NAG single addition and/or NAG extended and/or Stage 1 Seq. NAG.
[5] Weath.: weathered; [6] Carb.: carbonaceous.

Table 13. ABA results statistics for rejects and coal samples

		Total S[1]	Scr[2] (S)	ANC	MPA[3]	NAPP	ANC/MPA	NAGpH[4]
		%		kg H_2SO_4/t			ratio	pH units
Coal	Count (*n*)	*26*	*1*	*26*	*26*	*26*	*26*	*1*
	Maximum	0.50	0.05 (0.06)	75	15	13	27	9.0
	95th percentile	0.47	-	48	14	13	18	-
	75th percentile	0.40	-	12	12	9.0	1.1	-
	Median	**0.35**	**-**	**6.0**	**11**	**4.3**	**0.5**	**-**
	25th percentile	0.31	-	4.3	9.5	-1.1	0.3	-
	5th percentile	0.15	-	1.4	4.5	-44	0.1	-
	Minimum	0.06	0.05 (0.06)	1.4	1.8	-71	<0.1	9.0
Rejects Fresh CHPPs	Count (*n*)	*118*	*118 (118)*	*118*	*118*	*118*	*118*	*118*
	Maximum	1.64	1.22 (1.64)	44	50	26	8.3	8.8
	95th percentile	1.23	0.84 (1.23)	32	38	14	5.1	8.5
	75th percentile	0.38	0.25 (0.38)	24	12	-6.7	3.7	8.2
	Median	**0.27**	**0.15 (0.27)**	**21**	**8.3**	**-12**	**2.5**	**7.9**
	25th percentile	0.20	0.11 (0.2)	18	6.1	-16	1.5	6.7
	5th percentile	0.14	0.07 (0.14)	13	4.3	-22	0.7	3.4
	Minimum	0.09	0.05 (0.09)	11	2.8	-30	0.3	2.7
Rejects Aged GS1 & RS1 TSFs	Count (*n*)	*146*	*42 (42)*	*146*	*146*	*146*	*146*	*38*
	Maximum	2.12	0.52 (0.66)	30	65	45	8.9	8.5
	95th percentile	0.57	0.39 (0.55)	25	18	2.9	3.6	8.1
	75th percentile	0.35	0.20 (0.34)	18	11	-2.4	2.1	5.0
	Median	**0.30**	**0.15 (0.31)**	**14**	**9.2**	**-5.4**	**1.6**	**4.1**
	25th percentile	0.25	0.11 (0.26)	12	7.7	-8.4	1.3	3.6
	5th percentile	0.17	0.07 (0.15)	9.4	5.3	-17	0.8	3.2
	Minimum	0.09	0.04 (0.09)	6.3	2.8	-26	0.3	3.2
Rejects Aged Riverside Dump	Count (*n*)	*74*	*74 (74)*	*74*	*74*	*74*	*74*	*0*
	Maximum	1.24	0.79 (1.24)	49	38	34	5.0	-
	95th percentile	0.74	0.48 (0.73)	38	23	6.4	3.3	-
	75th percentile	0.49	0.39 (0.49)	28	15	0.9	2.1	-
	Median	**0.43**	**0.32 (0.43)**	**17**	**13**	**-4.4**	**1.3**	**-**
	25th percentile	0.39	0.21 (0.39)	12	12	-14	0.9	-
	5th percentile	0.31	0.07 (0.30)	9.2	9.4	-27	0.5	-
	Minimum	0.25	0.01 (0.25)	3.7	7.7	-34	0.1	-

[1] Total S values less than laboratory limit of reporting (LOR) were assigned a value of 0.5xLOR for statistical calculations.
[2] Scr values in parentheses are the total S statistics for samples with Scr results.
[3] MPA calculated from total S. [4] NAGpH is final pH as NAG single addition and/or NAG extended and/or Stage 1 Seq. NAG.

Table 14. ABA results statistics for tailings and TSF fill/natural ground samples

		Total S[1]	Scr[2] (S)	ANC	MPA[3]	NAPP	ANC/MPA	NAGpH[4]
		%		kg H_2SO_4/t			ratio	pH units
Tailings Fresh CHPPs	Count (*n*)	*244*	*244 (244)*	*244*	*244*	*244*	*244*	*182*
	Maximum	2.58	1.94 (2.58)	70	79	47	3.6	9.5
	95th percentile	1.25	0.94 (1.25)	35	38	17	2.2	9.0
	75th percentile	0.81	0.49 (0.81)	29	25	3.1	1.7	8.3
	Median	**0.61**	**0.30 (0.61)**	**24**	**19**	**-6.0**	**1.3**	**7.7**
	25th percentile	0.50	0.22 (0.5)	19	15	-11	0.9	4.0
	5th percentile	0.37	0.13 (0.37)	11	11	-16	0.5	3.2
	Minimum	0.22	0.05 (0.22)	1.1	6.7	-31	<0.1	2.8
Tailings Aged GS1 & RS1 TSFs	Count (*n*)	*223*	*90 (90)*	*223*	*223*	*223*	*223*	*74*
	Maximum	2.68	2.47 (2.68)	26	82	63	2.3	7.4
	95th percentile	1.44	1.02 (1.58)	20	44	36	1.6	6.6
	75th percentile	0.58	0.34 (0.63)	15	18	6.4	1.2	4.4
	Median	**0.39**	**0.20 (0.44)**	**12**	**12**	**0.2**	**1.0**	**3.3**
	25th percentile	0.33	0.10 (0.34)	9.1	10	-2.1	0.6	2.8
	5th percentile	0.26	0.04 (0.28)	3.7	8.0	-5.3	0.2	2.6
	Minimum	0.14	0.02 (0.21)	<0.5	4.2	-13	0.0	2.2
TSF Other (fill / Natural ground samples)	Count (*n*)	*21*	*4 (4)*	*21*	*21*	*21*	*21*	*4*
	Maximum	0.76	0.45 (0.76)	23	23	5.7	30	6.2
	95th percentile	0.40	0.41	18	12	1.7	15	6.2
	75th percentile	0.23	0.27	10	7.0	-1.7	5.8	6.2
	Median	**0.06**	**0.13**	**5.0**	**1.8**	**-3.1**	**2.8**	**4.9**
	25th percentile	0.03	0.04	4.0	0.9	-4.4	1.5	3.4
	5th percentile	0.01	0.02	2.6	0.3	-10	0.9	3.0
	Minimum	<0.01	0.02 (0.06)	2.6	0.2	-11	0.3	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 values in parentheses are the total S statistics for samples with Scr results.
[3] MPA calculated from total S. [4] NAGpH is final pH as NAG single addition and/or NAG extended and/or Stage 1 Seq. NAG.

Sulphur and Sulphide

The total sulphur (total S) distribution for all samples is presented in **Figure 5**. The total S concentration of spoil samples was generally very low to low with:

- A very low median value of 0.03%; and
- A low 95th percentile value of 0.26%.

Carbonaceous spoil samples had higher total S values compared to non-carbonaceous spoil. Of the 1312 spoil samples, only one sample had a high total S value (greater than 1.5%).

Total S concentration of most rejects, tailings and TSF fill samples were generally higher than most spoil samples, but generally comparable to coal samples. However, as evident in **Figure 5**, CHPP tailings had slightly higher total S concentrations compared to tailings samples from the TSFs.

Comparatively, the total S concentrations of fresh (CHPP) rejects and aged rejects from TSFs were similar. The total S concentrations from aged rejects from Riverside rejects dump was higher compared to fresh (CHPP) rejects and aged rejects from TSFs.

Natural ground samples from beneath the TSFs all have generally very low total S concentrations, as expected.

Coal samples from drill core had generally low total S values, with median and 75th percentile values of 0.35% and 0.40%, respectively. The 26 coal samples have a total S distribution lower than the larger BHP coal quality database. In particular, the 7011 'coal' samples from the GRBM coal quality database have median and 75th percentile total S values of 0.54% and 0.58%, respectively – noting that some of the samples in the coal quality database are not coal but are instead 'carbonaceous spoil' material within seams.

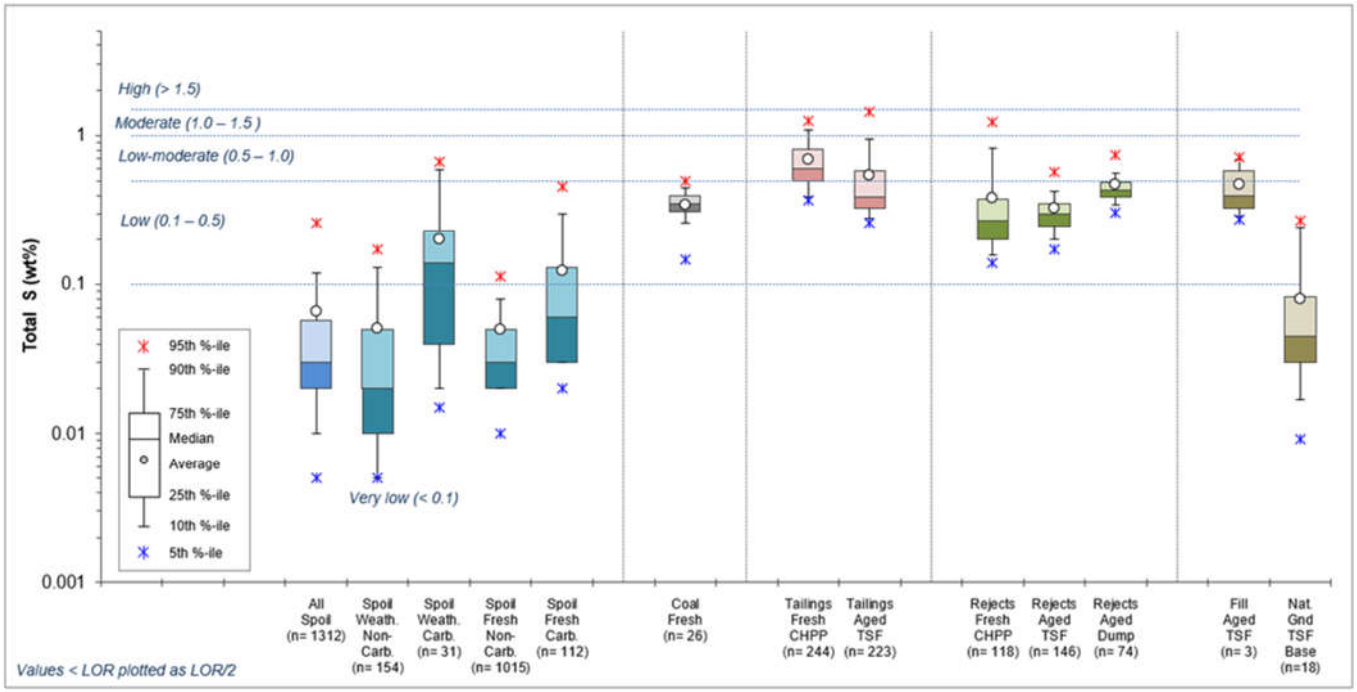


Figure 5. Sulphur (S) distribution

Chromium reducible sulphur (Scr) data is available for 218 spoil samples, 334 tailings samples, 234 rejects samples and one coal sample (**Tables 12, 13 and 14**). Scr was measured on most tailings and fresh rejects samples; and generally measured on all spoil samples with total S values greater than 0.1%. Where sulphide was measured in weathered spoil samples, this was generally only in those samples described as being 'slightly' weathered. The total S and Scr distribution for spoil samples is shown at **Figure 6**; and for tailings and rejects samples at **Figure 7**. Total S values are shown only for the samples that underwent Scr tests.

As evident in **Figure 6** all spoil samples had lower Scr distributions compared to the total S distributions from the same group of spoil samples. The differences were more pronounced in weathered spoil samples compared to fresh spoil samples.

As evident in **Figure 7**, all tailings and rejects samples have Scr values slightly lower than the total S values from the same samples, suggesting that a proportion of sulphur may be associated with organic S or sulphate; and also that oxidation of sulphide to sulphate is likely occurring in the aged samples, specifically.

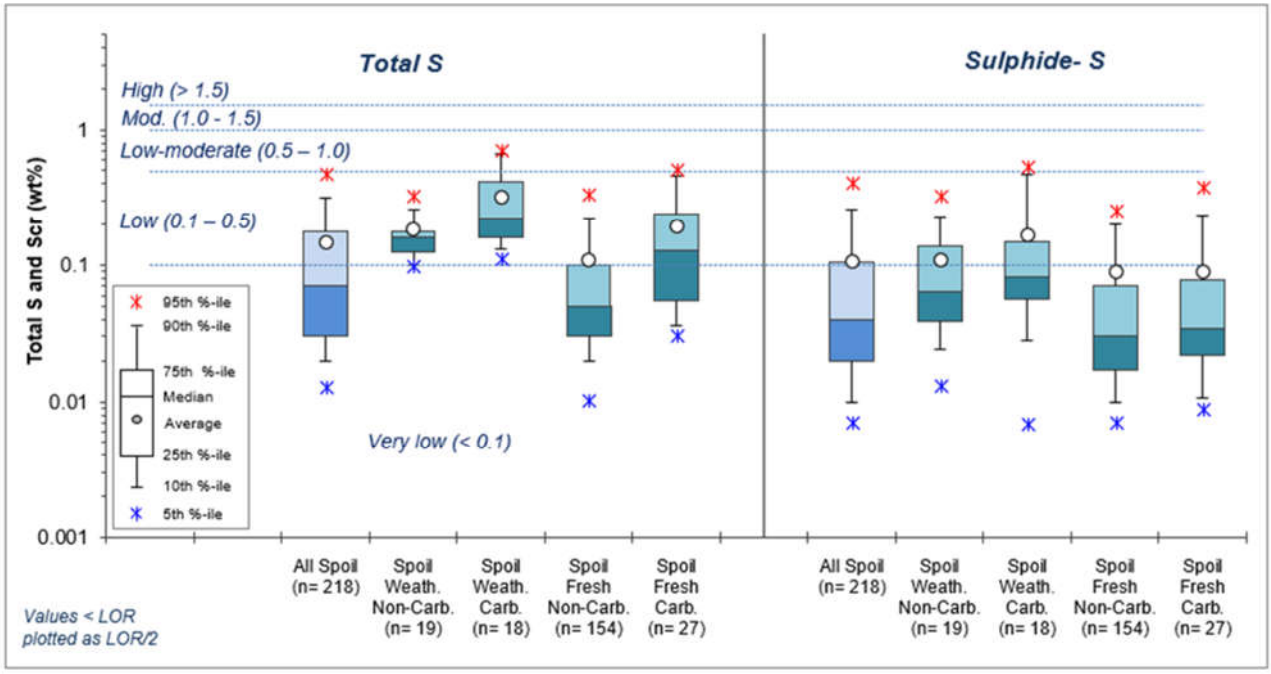


Figure 6. Sulphur (S) and sulphide (Scr) distribution of spoil samples

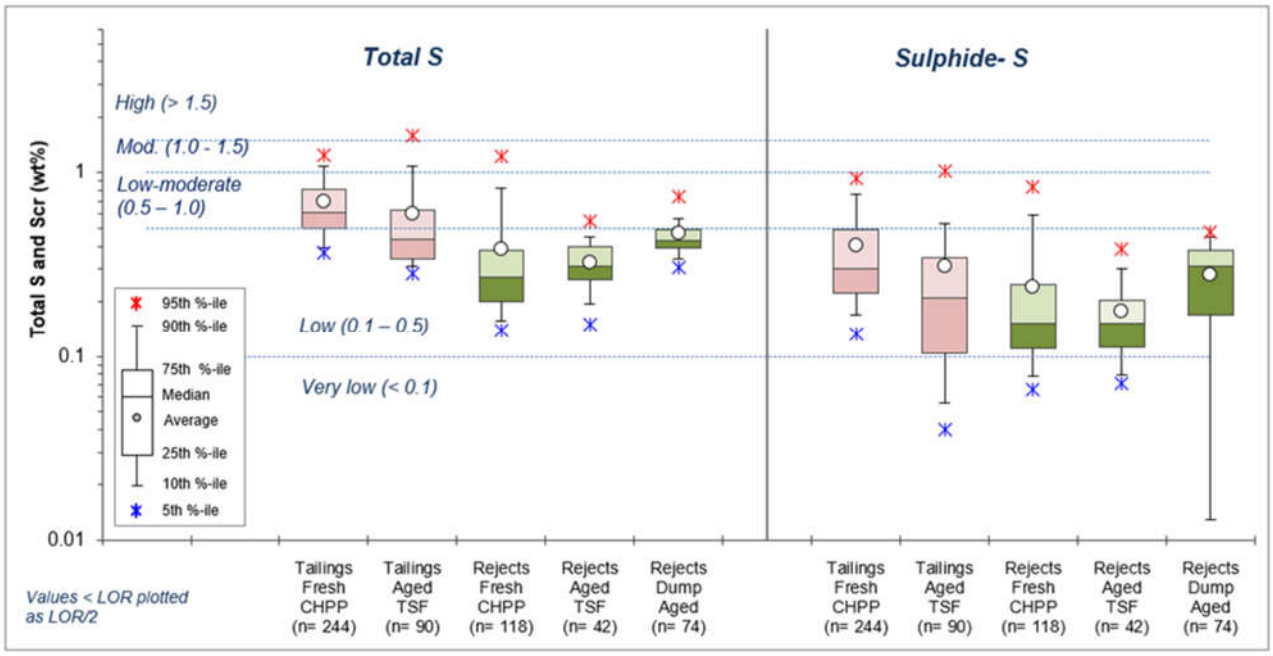


Figure 7. Sulphur (S) and sulphide (Scr) distribution of tailings and rejects samples

Where Scr data is available, the relationship between Scr versus total S is shown in **Figure 8** for spoil samples; and in **Figure 9** for tailings and rejects samples.

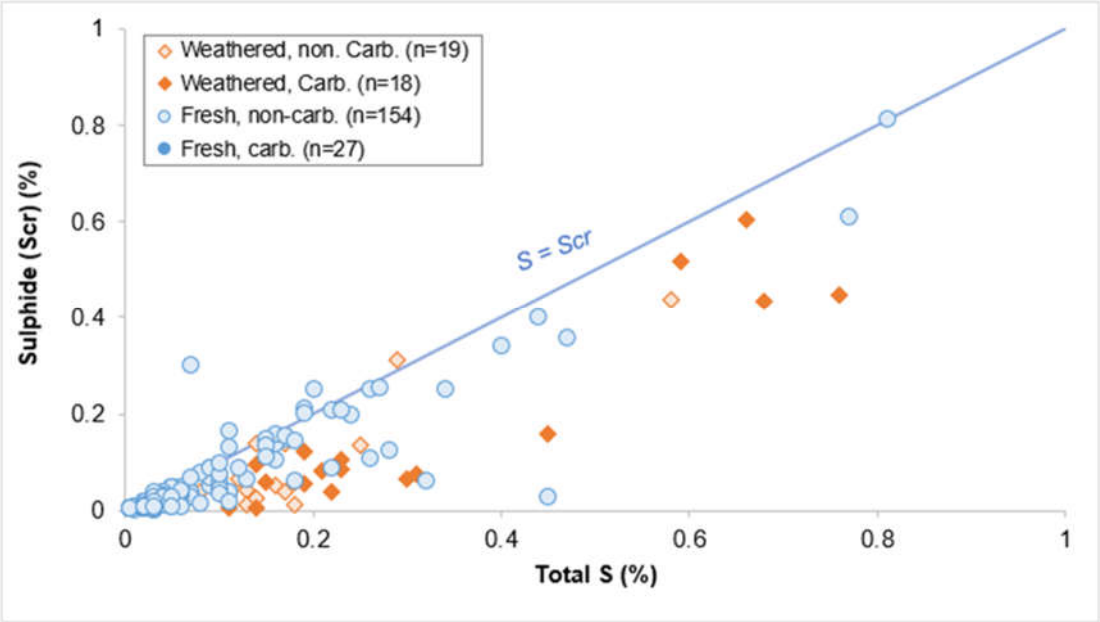


Figure 8. Sulphide (Scr) versus sulphur (S) for spoil samples
One non-carbonaceous fresh spoil sample had a total S value of 2.78% and Scr value of 2.57% and is not shown in the plot.

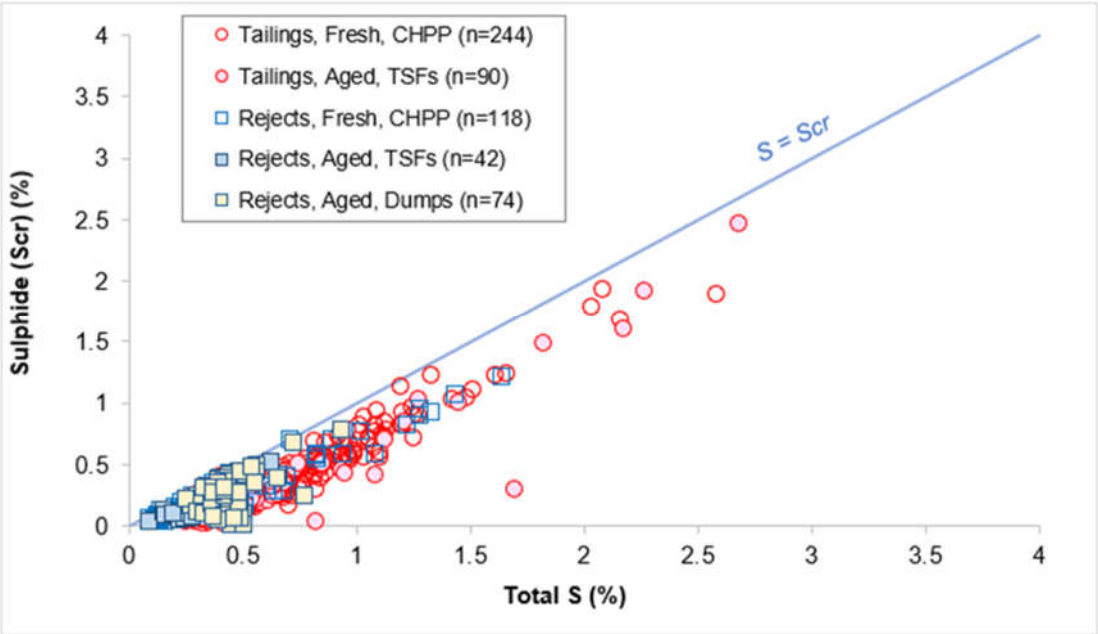


Figure 9. Sulphide (Scr) versus sulphur (S) for tailings and rejects samples

As a proportion of total S, Scr accounts for:

- Spoil samples: 57% (median value) of total S. Scr accounts for approximately 70% (median value) of total S in non-carbonaceous spoil and 32% (median value) of total S in carbonaceous spoil. The lower proportion of Scr in carbonaceous spoil (compared to non-carbonaceous spoil) is likely due to a larger proportion of total S being present as organic sulphur in the carbonaceous sample.

- Tailings samples: Scr accounts for approximately 50% (median value) of total S in fresh CHPP tailings and 48% (median value) of total S in aged tailings.

- Rejects samples: Scr accounts for approximately 56% (median value) of total S in fresh CHPP rejects; 49% (median value) of total S in aged rejects from TSFs; and 72% (median value) of total S in aged rejects from Riverside rejects dump. The slightly lower proportion of Scr in aged rejects from the TSFs compared to fresh rejects, and also compared to aged rejects from Riverside rejects dump is likely due to some sulphide in aged rejects in the TSFs being oxidised to sulphate. No sulphate data is available.

- Coal samples: Scr data is only available for one coal sample, of which almost all total S was present as Scr (Scr = 0.05%; total S = 0.06%). Sulphate data is available for seven coal samples and the sulphate concentrations were all less than 0.01% (as S). It is reasonable to assume that all fresh (unweathered) coal samples would have negligible sulfate concentrations and that a significant proportion of total S in all coal samples is likely present as organic sulphur.

These results indicate that the maximum potential acidity (MPA) that could be generated by most samples from these material domains is generally low and that using total S as an indication of AMD hazard will result in a conservative outcome.

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 5**). Due to the generally very low to low total S values for spoil samples the MPA was correspondingly low, with a 75th and 95th percentile MPA values of 1.8 and 8 kg H_2SO_4/t, respectively (n=1312 samples). As such, spoil represented by these samples is expected to have negligible potential to generate acid/acidity and negligible potential to release sulphate-derived salinity from sulphide oxidation. The small proportion of spoil with 'high' MPA (as a result of the high total S) would be well mixed throughout the bulk spoil and, as such, would not lead to spoil generating acid/acidity or sulphate-derived salinity.

Coal samples (n=26) produced MPA values generally higher than spoil – as expected by the higher overall total S values of coal samples. Coal samples had 75th and 95th percentile MPA values of 12 and 14 kg H_2SO_4/t, respectively.

Tailings and rejects produced total S values generally ranging from low to low-moderate, which resulted in a correspondingly similar low range of MPA values. Each tailings and rejects sub-type have a 75th percentile MPA value less than 25 kg H_2SO_4/t.

Acid Neutralising Capacity

The ANC distribution for all samples is presented in **Figure 10**. ANC values of spoil samples are typically in excess of the MPA values and span a very large range, from less than 0.5 to 546 kg H_2SO_4/t, with a moderate median ANC value of 35 kg H_2SO_4/t.

Over 84% of spoil samples have an ANC greater than 10 kg H_2SO_4/t which, if all ANC was readily available, would neutralise the acidity generated by material containing 0.33 wt% S. Approximately 2% of spoil samples had total S values greater than 0.33% – approximately equal proportions of carbonaceous and non-carbonaceous spoil samples.

The ANC for tailings and rejects samples was generally moderate, with median ANC values of approximately 20 kg H_2SO_4/t for each sub-type.

Coal samples had a wide range of ANC values from very low to high, but the overall ANC was low, with median and 10th percentile ANC values of 6 and 2 kg H_2SO_4/t, respectively. Fill samples from the TSFs had moderate ANC values and natural ground samples from the TSFs had very low to low ANC values.

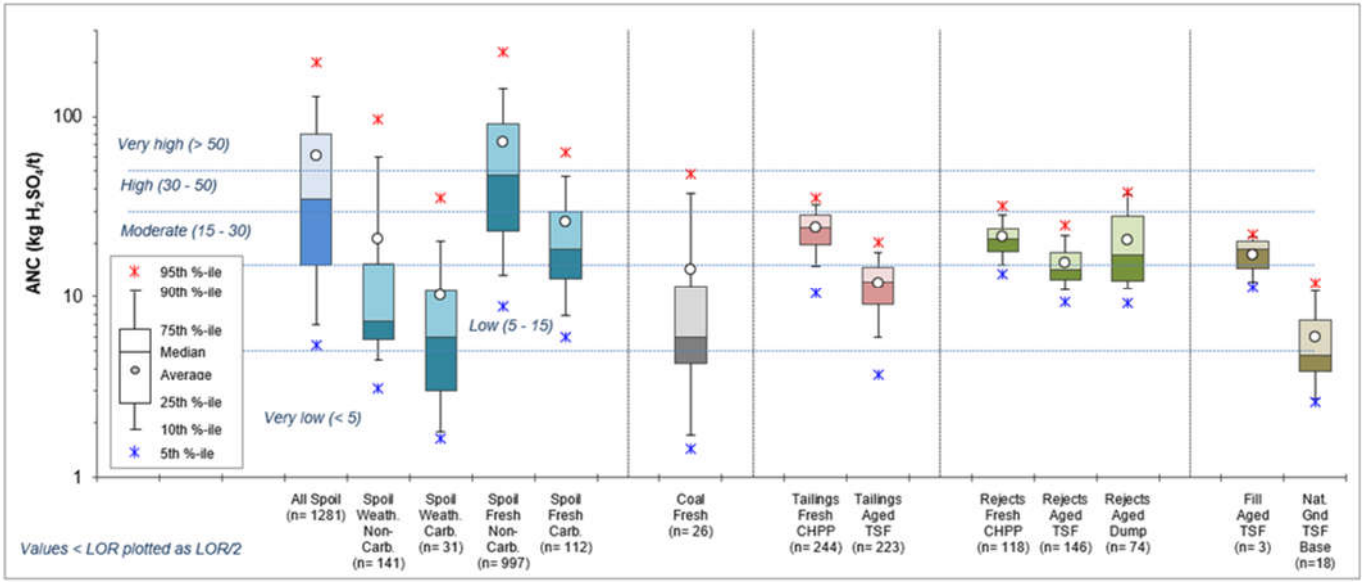


Figure 10. Acid neutralising capacity (ANC) distribution

Of the 997 fresh non-carbonaceous spoil samples, approximately 8% (84 samples) are located within 1.5 m above or below coal seams (i.e. 'near seam'). These near-seam samples have a median ANC of 18 kg H_2SO_4/t. Comparatively, the remaining 92% of fresh, non-carbonaceous samples have a median ANC of 53 kg H_2SO_4/t (i.e. approximately three times the 'near seam' ANC) – highlighting that fresh, non-carbonaceous spoil near seams has much lower ANC (generally), compared to fresh, non-carbonaceous spoil away from the seams. For the same two sample groups (i.e. near-seam versus distal to seams) the median total S was similar: 0.04% S for the 'near seam' samples and 0.03% S for samples away from seams.

Comparatively, of the 112 fresh carbonaceous spoil samples, approximately 23% (26 out of 112 samples) were located 'near seams'. These samples had a median ANC of 17 kg H_2SO_4/t and the samples away from seams had a similar median ANC of 20 kg H_2SO_4/t. Both groups had very similar median total S values: 0.060% S for the 'near seam' samples and 0.055% S for samples away from seams.

Available Acid Neutralising Capacity

Acid buffering characterisation curve (ABCC) tests were undertaken on 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. 'Ready availability' is regarded as the proportion of ANC that is available for buffering reaction at pH 4.5. The results are summarised in **Figure 11**.

- Spoil samples (n=62). The proportion of ANC likely available under field conditions ranged from 10% to nominally 100% of the ANC, with a median of approximately 51%[3];
- Tailings, fresh (n=31). The proportion of ANC likely available under field conditions ranged from 11% to nominally 100% of the ANC, with a median of approximately 49%[3];
- Tailings, aged (n=13). The proportion of ANC likely available under field conditions ranged from 9% to 66% of the ANC, with a median of approximately 35%;
- Rejects, fresh (n=16). The proportion of ANC likely available under field conditions ranged from 12% to 69% of the ANC, with a median of approximately 35%;
- Rejects, aged (n=5) [all from GS1 TSF]. The proportion of ANC likely available under field conditions ranged from 31% to nominally 100% of the ANC, with a median of approximately 43%[3].

3 Because the ABCC test is a separate test to the ANC test – performed on different sample splits – it is possible to achieve results with greater than 100% ANC being readily available for the same sample. Such a result effectively means that all of the ANC for that sample is in a readily available form (i.e. a practical maximum of 100% availability). Similarly, at the lower end, the lowest 'readily available' amount may actually be slightly greater.

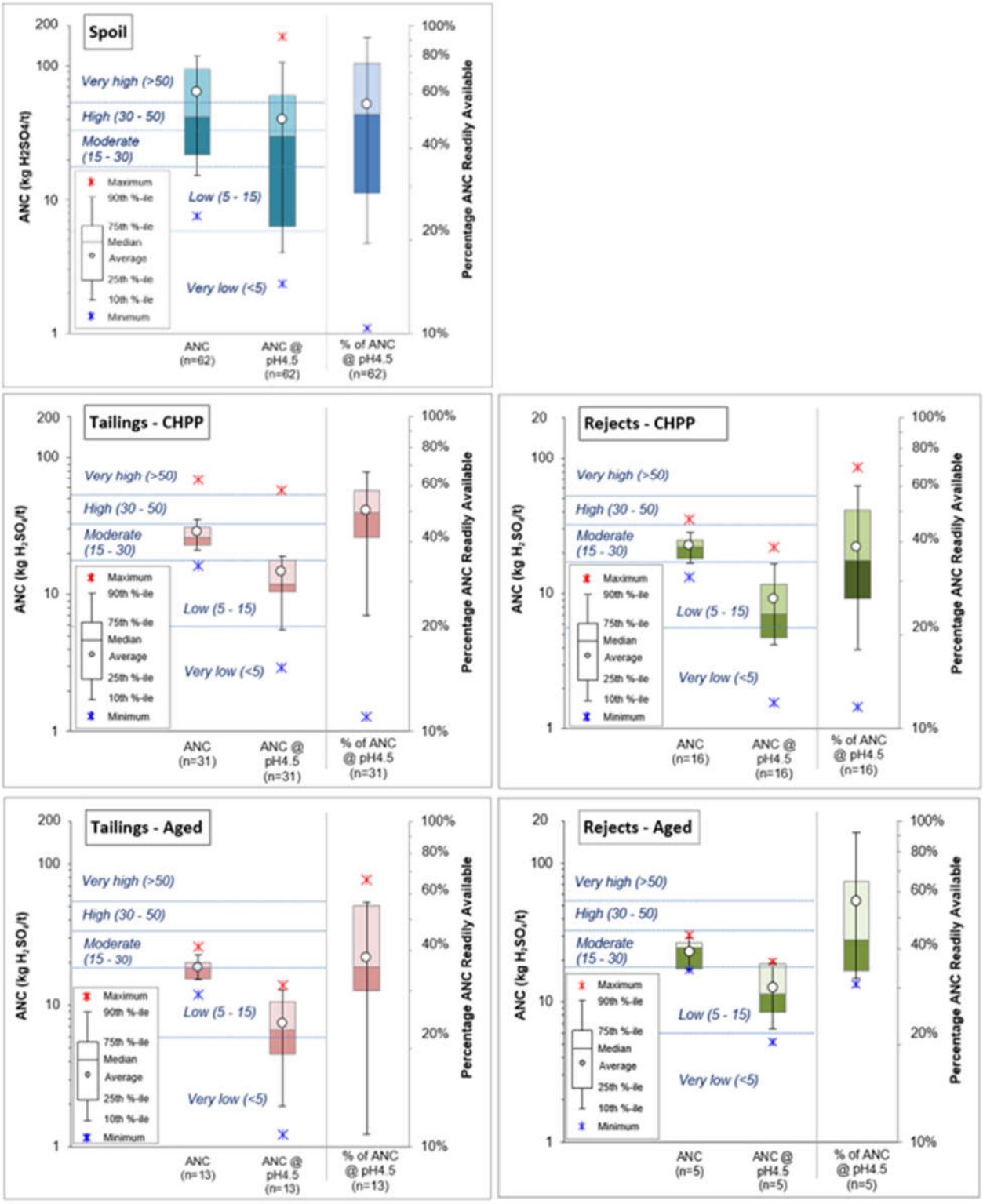


Figure 11. Distribution of acid neutralising capacity (ANC) [total], ANC at pH4.5 and proportion (%) of ANC expected to be readily available for spoil, tailings and rejects

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 12**.

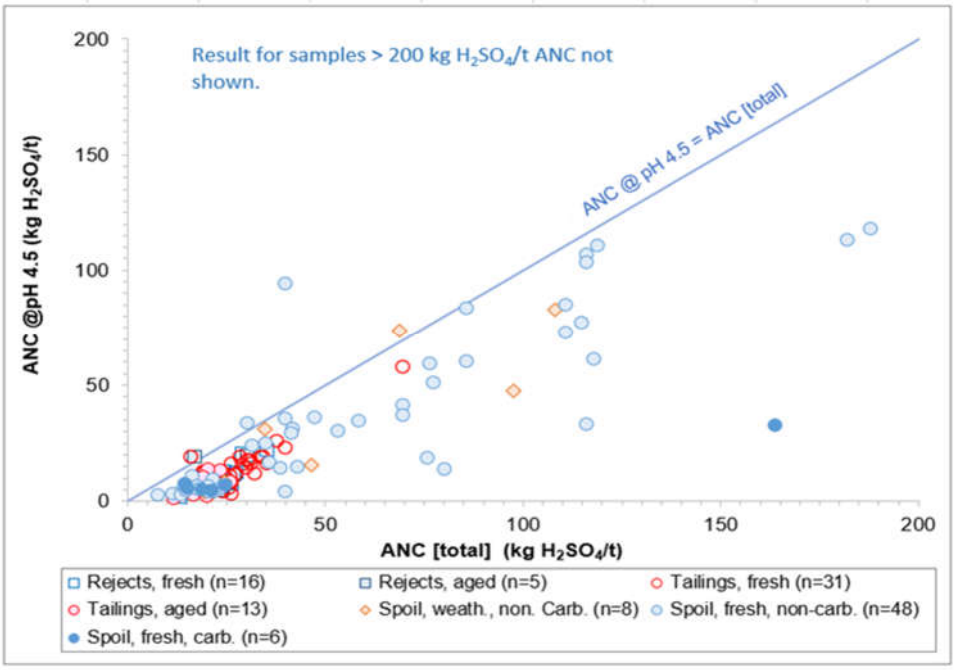


Figure 12. ABCC ANC [ANC @ pH 4.5] versus ANC

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 the spoil samples, iron dolomite (Fe-dolomite / ankerite) and dolomite appear to be the dominant carbonate minerals 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. For the tailings and rejects samples, Fe-dolomite is the dominant carbonate mineral based on the ABCC curves, with minor siderite. Several samples appear to have trace amounts of dolomite.

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

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[4]), especially where sulphide 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 13**, show that:

- Ninety-five per cent (95%) of 1281 spoil samples have an ANC/MPA ratio greater than two – noting that 79% of all spoil samples are fresh, non-carbonaceous. Approximately 91 of fresh carbonaceous spoil samples (102 out of 112 samples) have an ANC/MPA ratio greater than two.
- Most tailings samples (fresh and aged) had ANC/MPA ratios less than two.
- Most aged rejects have ANC/MPA ratios less than or equal to two, whereas fresh rejects have a range of ANC/MPA values – with 58% of the fresh rejects having ANC/MPA ratios greater than two.
- Coal samples mostly had ANC/MPA ratios less than or equal to two.
- Natural ground samples from the base of the TSFs (below the embankments and outer tailings) had ANC/MPA ratios greater than two.
- Fill samples (from the TSFs) had a similar range of ANC/MPA ratios to aged tailings and aged rejects samples – mostly with ANC/MPA ratios less than two.

4 INAP (2009) considers that mine materials with an ANC/MPA ratio greater than two are likely to be NAF unless significant preferential exposure of sulphide minerals occurs along fracture planes, in combination with insufficiently reactive ANC.

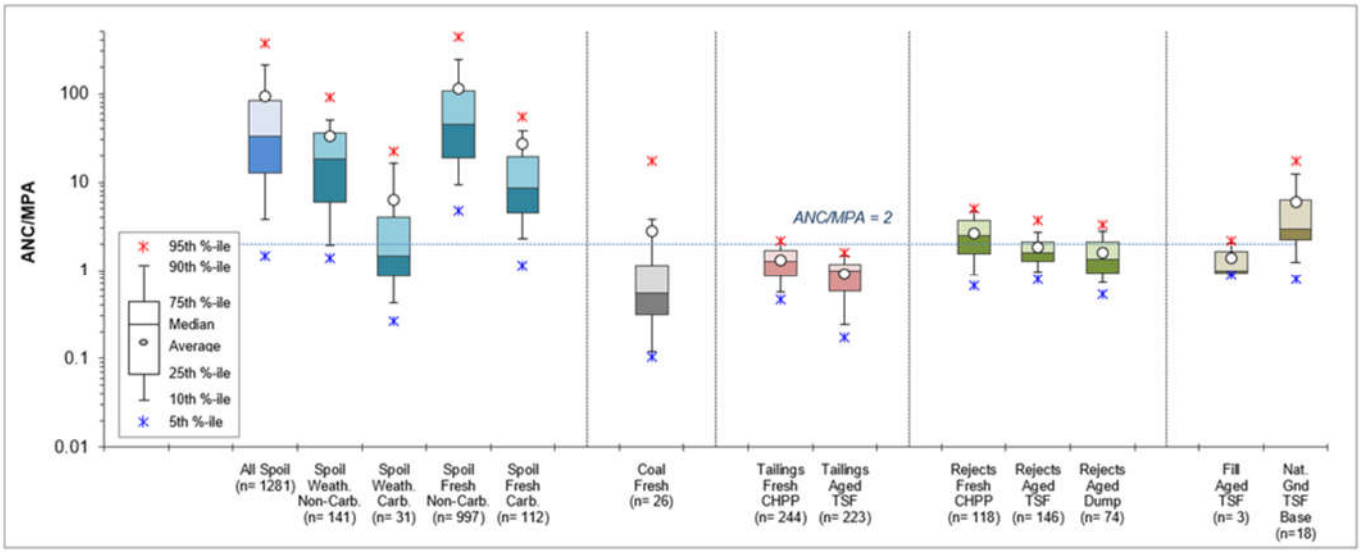


Figure 13. Distribution of the ratio of acid neutralising capacity (ANC) to maximum potential acidity (MPA) [ANC/MPA ratio]

Net Acid Producing Potential

The NAPP distribution for all samples is presented in **Figure 14**.

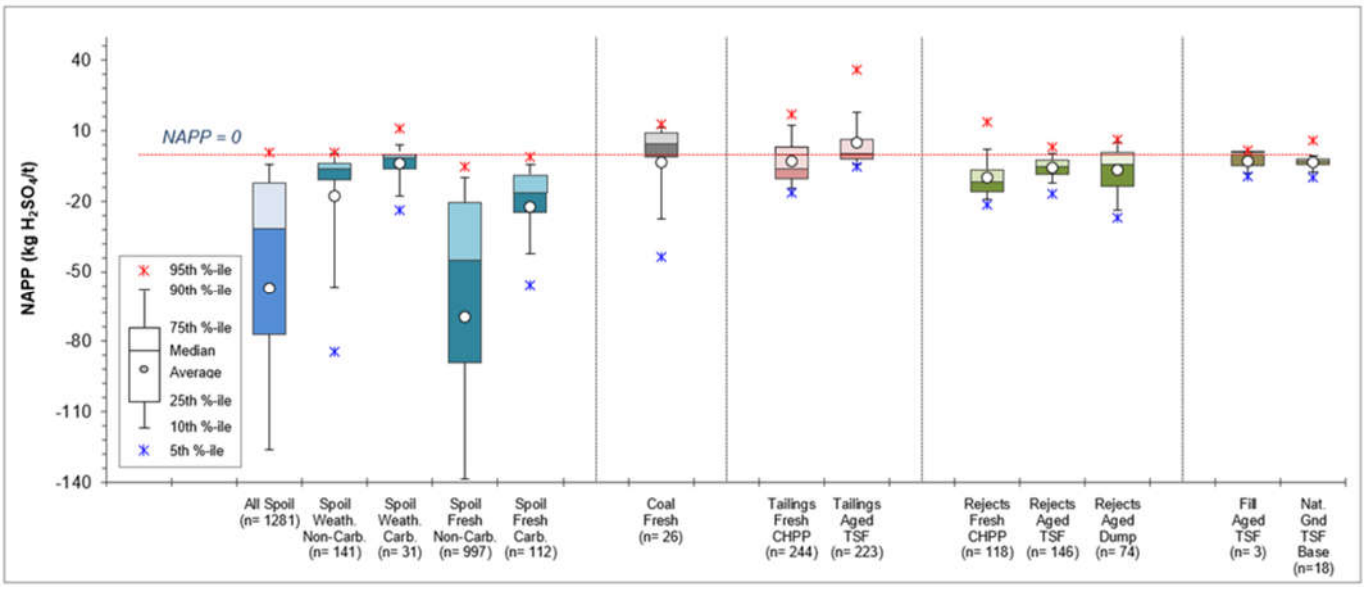


Figure 14. Distribution of net acid producing potential (NAPP)
Non-carbonaceous fresh spoil had a 5th percentile value of -224 kg H_2SO_4/t and is not shown in the plot. The 5th percentile for all spoil is -196 kg H_2SO_4/t.

Based on the generally low MPA and higher ANC values (relative to the MPA), the calculated NAPP values are negative for most of the spoil samples. Some carbonaceous spoil samples (those samples more closely associated with seams) have low positive NAPP values. The results indicate that, overall, there is significantly excess neutralising capacity (ANC) compared to potential acidity (MPA) for spoil samples. Most TSF fill and natural ground samples have negative NAPP values.

Coal, tailings and rejects have a mix of low negative and low positive NAPP values. About 15% of rejects samples, 40% of tailings samples and 73% of coal samples had positive NAPP values.

Net Acid Generation Capacity

NAG test results are used in conjunction with NAPP values in determining the acid classification of samples. The calculated NAPP value assumes that all sulphur (present as sulphide) 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 reaction 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_2SO_4/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_2SO_4/t). As a guide, NAG capacity values between 0.1 and 5 kg H_2SO_4/t are considered 'low capacity' (AMIRA, 2002).

NAG test data (a combination of single addition and extended boil NAG) is available for 140 spoil samples, 1 coal sample, 256 tailings samples, 156 rejects samples, 1 TSF fill sample and three TSF natural ground samples (**Tables 12, 13 and 14**) – with the NAGpH distribution for these samples shown in **Figure 15**. The majority of tailings samples (68% of samples) and fresh CHPP rejects (85% of samples) had NAGpH values greater than pH4.5. Fourteen out of 38 (37% of) aged rejects samples and 13 out of 74 (18% of) aged tailings samples tested had NAGpH values greater than pH4.5. One coal sample and two natural ground sample from TSF had NAGpH value greater than pH4.5. One TSF fill sample tested had NAGpH value less than pH4.5.

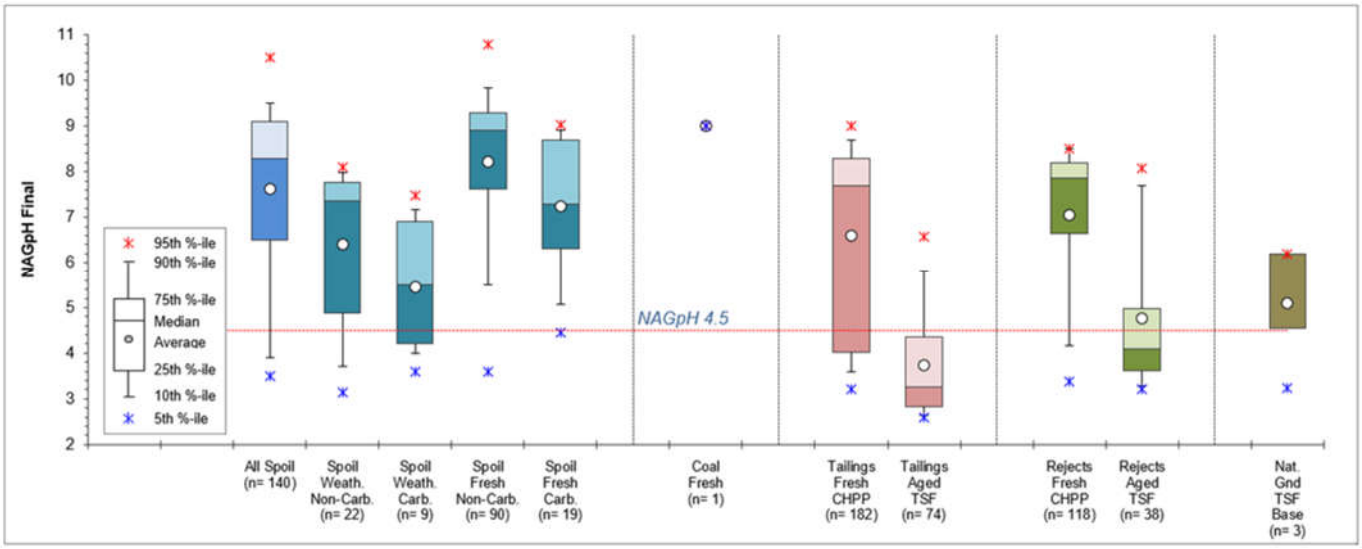


Figure 15. Distribution of net acid generation pH (NAG single or NAG Extended or Stage 1 NAG Sequential)

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 sulphuric acid). Organic acid is typically produced by samples with high organic carbon content – such as coal and highly carbonaceous samples. To attempt to resolve some of the uncertainty with the 'single addition' NAG test for coaly and highly carbonaceous samples, 40 samples comprising 6 rejects and 34 tailings samples underwent an Extended Boil NAG method (NAG Extended).

Sixteen (16) of these 40 samples (or 40% of samples) returned Extended NAGpH values greater than pH4.5, suggesting that for 40% of the samples tested, the acidity generated in the 'single addition' NAG test was likely associated with the oxidation of organic carbon and not with sulphide oxidation.

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 15**.

Table 15. Geochemical classification of samples

Material Type	NAF	UC(NAF)	NAF-S	UC(PAF)	PAF-LC	PAF
	Number and (%) of samples					
Spoil, weath, non-carb. (n=154)	135 (88%)	14 (9%)	-	-	2 (1%)	3 (2%)
Spoil, weathered carbonaceous (n=31)	24 (77%)	-	-	3 (10%)	2 (6.5%)	2 (6.5%)
Spoil, fresh non-carbonaceous (n=1015)	983 (97%)	19 (~2%)	-	9 (~1%)	1 (<0.5%)	3 (<0.5%)
Spoil, fresh carbonaceous (n=112)	104 (93%)	-	-	2 (~2%)	5 (~5%)	1 (<1%)
Spoil [all] (n=1312)	1246 (95%)	33 (~2%)	-	14 (~1%)	10 (~1%)	9 (~1%)
	1279 (97%)		***-***	***33 (~3%)***		
Coal (n=26)	6 (23%)	-	-	1 (4%)	15 (58%)	4 (15%)
	6 (23%)		***-***	***20 (77%)***		
Tailings, fresh, CHPPs (n=244)	150 (61%)	12 (5%)	12 (5%)	46 (19%)	14 (6%)	10 (4%)
Tailings, aged, GS1 & RS1 TSFs (n=223)	26 (12%)	41 (18%)	-	67 (30%)	61 (27%)	28 (13%)
Tailings [all] (n=467)	176 (38%)	53 (11%)	12 (3%)	113 (24%)	75 (16%)	38 (8%)
	229 (49%)		***12 (3%)***	***226 (48%)***		
Rejects, fresh, CHPPs (n=118)	99 (84%)	7 (6%)	1 (<1%)	3 (3%)	6 (5%)	2 (2%)
Rejects, aged, GS1 & RS1 TSFs (n=146)	51 (35%)	70 (48%)	-	9 (6%)	15 (10%)	1 (~1%)
Rejects, aged, Riverside dump (n=74)	23 (31%)	12 (16%)	-	12 (16%)	25 (34%)	2 (3%)
Rejects [all] (n=338)	173 (51%)	89 (26%)	1 (<1%)	24 (7%)	46 (14%)	5 (~1%)
	262 (78%)		***1 (<1%)***	***75 (22%)***		
Fill, aged, TSF (n=3)	1 (~33%)	-	-	1 (~33%)	1 (~33%)	-
Natural ground beneath TSFs (n=18)	16 (89%)	-	-	1 (~6%)	1 (~6%)	-

Spoil

The classifications in **Table 15** show that approximately 97% of spoil samples were classified as NAF or 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 sulphur concentration, significant excess ANC (relative to the MPA) and clearly have negligible capacity to generate AMD. The remaining 3% (approximately) of spoil samples (33 out of 1312 samples) were classified as PAF, PAF-LC or UC(PAF). No spoil samples were classified as NAF-S.

Data show that potential spoil, as a bulk material, would be overwhelmingly NAF – and essentially all spoil away from seams (which is the overwhelming bulk of spoil) is expected to be NAF. Furthermore, the very low sulphur concentrations in spoil indicates that the sulphate concentration that could be generated in spoil from sulphide oxidation (in addition to any salinity unrelated to sulphide oxidation) would also be very low.

Tailings

Forty-eight per cent (48%) of tailings samples were classified as PAF, PAF-LC or UC(PAF) – including moist to wet aged tailings samples from the TSFs and fresh (CHPP) tailings samples; and a further 3% (approximately) of

tailings samples were classified as NAF-S. Of the 'PAF' tailings samples, approximately 8% were classified as PAF (specifically), while 40% were classified as UC(PAF) or PAF-LC.

Approximately half of the tailings samples are classified as 'PAF' (of some type) or NAF-S. As such, from an acid generating perspective, tailings pose a source hazard with respect to AD and/or NMD and/or SD; and overall, are expected to generate low to moderate acidity loads.

Rejects

The results show that approximately 78% of the rejects samples (262 of 338 samples) were classified as NAF or UC(NAF) and the remaining 22% were classified as 'PAF' of some type, which included one NAF-S sample.

From an acid generating perspective rejects pose a potential source hazard with respect to AD and/or NMD/SD and are expected to generate low acidity loads.

Coal

Coal samples had higher total S values and marginally lower ANC values compared to spoil, which resulted in 77% of coal samples being classified as PAF, PAF-LC or UC(PAF). The proportion of PAF (of any kind) is comparable across all coal seam groups being mined at GRBM (and likely future mining at GRBM and RHM). It is worth noting that 16 out of 20 coal samples classified as some form of 'PAF' had generally low total S concentrations coupled with generally low ANC and, as such showed limited or uncertain capacity to generate acidity, suggesting that 'PAF' coal is unlikely to generate significant acid(ity).

Approximately 23% of coal samples tested (6 out of 26 samples) were classified as NAF, and coal seam material represented by these samples has very low sulphur values, excess ANC (relative to the MPA) and clearly has no capacity to generate acidity or release significant sulphate from sulphide 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 potentially be bulk PAF – albeit likely low-capacity. From an acid generating perspective, coal poses a potential source hazard with respect to AD and/or NMD/SD; and overall, is expected to generate low acidity loads.

Fill and Natural Ground

Most (2 out of 3) fill samples within the TSFs were classified as PAF-LC or UC(PAF).

Sixteen out of 18 natural ground samples beneath the TSFs were classified as NAF, as expected. The remaining two samples were classified as PAF-LC or UC(PAF).

5.3 Total Metals and Metalloids

Multi-element (metal and metalloid) data is available for 283 samples, comprising 136 spoil samples, 57 fresh tailings samples, 38 aged tailings samples from TSFs, 37 fresh rejects samples and 15 aged rejects samples from TSFs. The degree of enrichment with respect to elements potentially of environmental interest for the spoil, tailings and rejects materials is shown in **Figure 16**.

The GAI values show that 44 (out of 136) spoil samples were significantly enriched [GAI ≥3] with regard to one or more of arsenic (As), cadmium (Cd), copper (Cu), mercury (Hg), sulphur (S) and/or antimony (Sb) – and all 44 of these spoil samples were significantly enriched in Selenium (Se). Only three spoil samples were significantly enriched in S. The level of S enrichment in spoil samples is consistent with the ABA data for these same samples. Limited multi-element data (i.e. total concentration for a smaller suite of elements) is available for an additional 24 spoil samples, which showed that for the elements where data was available the degree of enrichment was comparable to the main spoil dataset.

All tailings and rejects samples were significantly enriched in Se; and 18 tailings and rejects samples were significantly enriched with one or more of As and/or S.

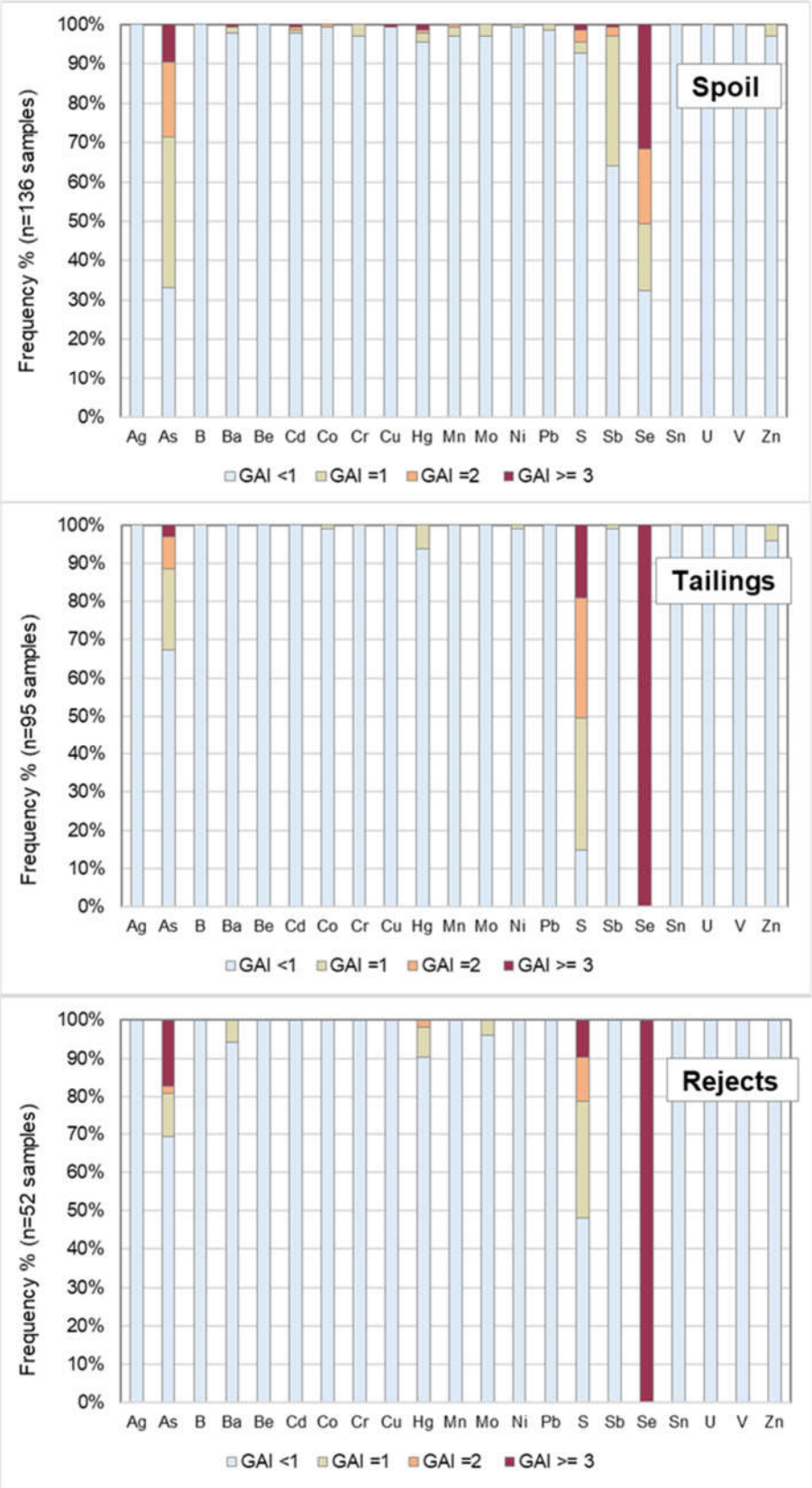


Figure 16. Frequency distribution of geochemical abundance indices (GAI) of selected elements in spoil, tailings and rejects

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 As, Hg, S, Sb and Se. A much smaller number of samples had minor

enrichment with regard to one or more of barium (Ba), Cd, chromium (Cr), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb) and/or zinc (Zn).

Overall, the results suggest that bulk mineral waste materials have generally low levels of metal and metalloid enrichment, which is consistent with Permian-age coal measures throughout eastern Australia. A small proportion of samples (of all material types) have a higher degree of enrichment in some metals – notably As, Cd, Cu, Se, Sb, Hg and S – however enrichment in these materials is not cause for concern.

5.4 Initial Solubility in Deionised Water

Water extract test results are available for a wide range of samples (**Table 16**). EC and pH results are available for 2406 samples, and test results for major ions and soluble metals/metalloids are available for 322 samples.

Therefore, a large dataset is available to assess the potential for leaching of salt and environmentally important elements from mineral wastes (spoil and rejects) and coal at GRBM. Water extract tests provide a preliminary indication of the elements that may be readily mobilised from any given material type.

Table 16. Samples subjected to deionised water solubility tests

Material type	pH and EC	Soluble metals and metalloids
	Number of samples	
Spoil	1541	161
Tailings	467	96
Rejects	347	61
Fill within TSF	3	-
Natural ground beneath TSF	18	-
Coal	30	4

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.

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

Electrical Conductivity (EC) and pH

EC and pH data is available for 2406 samples at 1:5 w:v on pulp (**Figure 17** and **Table 16**).

The $EC_{1:5}$ of 1541 spoil samples spanned a large range from 16 to 3680 µS/cm, with generally low median and 75th percentile $EC_{1:5}$ values of 401 and 545 µS/cm, respectively. The fresh (unweathered samples), which comprise the greatest proportion of spoil, have generally lower $EC_{1:5}$ values compared to the weathered samples, however spoil – as a bulk material – is generally non-saline to slightly saline. These $EC_{1:5}$ results are common (if not typical) for Bowen Basin Permian-age and Tertiary-age material in the region.

Coal samples are generally non-saline. Tailings samples are generally slightly to moderately saline with a 75th percentile $EC_{1:5}$ of 1100 µS/cm. All rejects samples are generally non-saline to slightly saline with a 75th percentile $EC_{1:5}$ of 538 µS/cm.

The pH distribution by material type shows most spoil, coal, fresh tailings and fresh rejects samples to be generally alkaline to highly alkaline. These pH results for spoil materials and fresh tailings/rejects are common (if not typical) for Bowen Basin Permian-age and Tertiary-age material in the region. Aged TSF rejects and TSF fill samples were also generally pH-alkaline.

The pH distribution of aged rejects from Riverside rejects dump ranged from moderately acidic to alkaline with a median value of pH 5.9. The natural ground samples from beneath the TSFs are generally weakly acidic to alkaline.

Of the 2406 samples, 112 samples (5% of samples) had $pH_{1:5}$ values less than pH 6.0. These comprised 32 spoil samples, 30 tailings samples, 44 rejects samples and 6 natural ground samples.

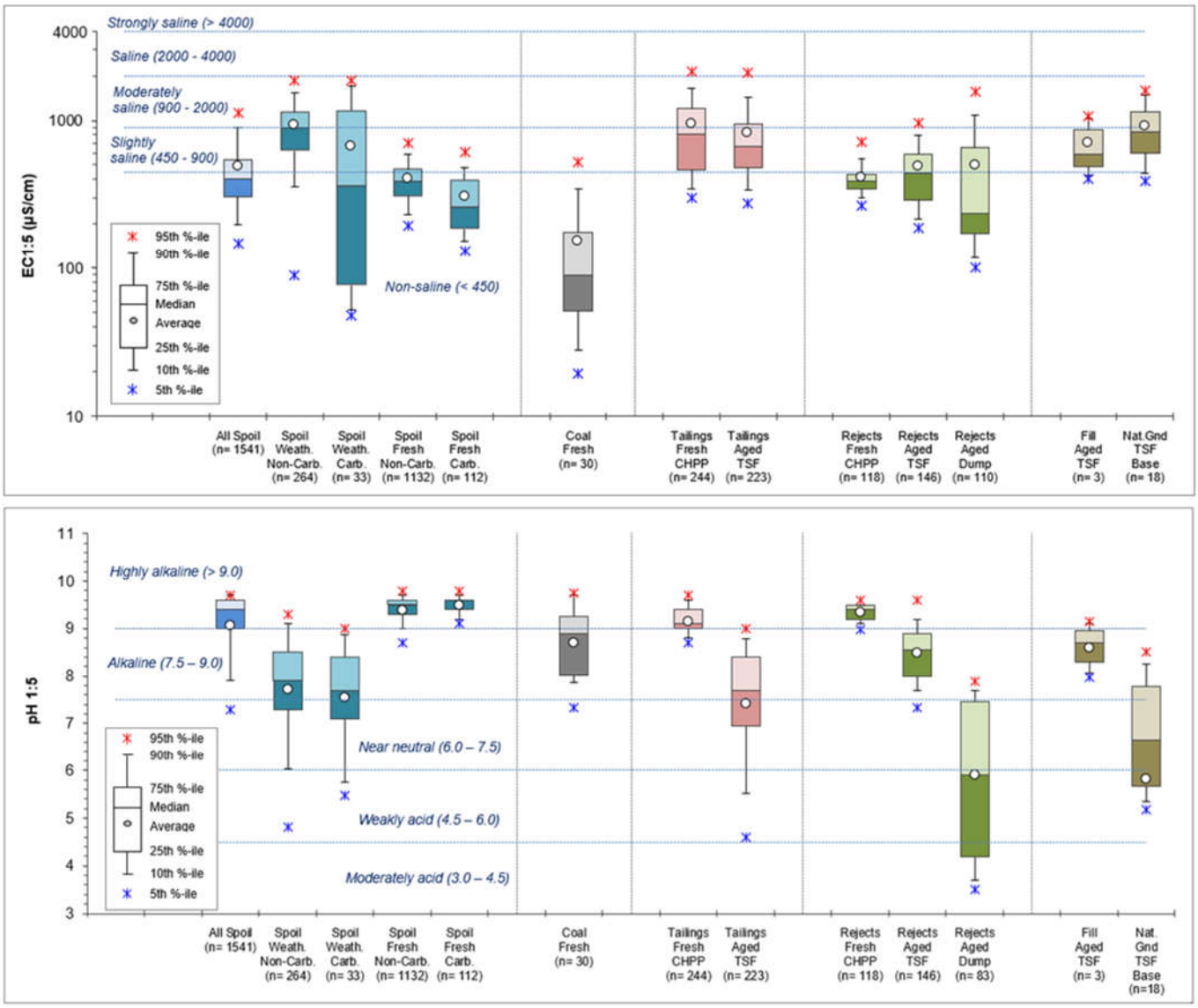


Figure 17. Electrical conductivity (EC) and pH distribution

Soluble Metals and Metalloids

Deionised water extract (leaching) data for major ions and a broad suite of metals/metalloids are available for 322 samples (**Table 16**). All samples underwent a 1:5 w:v (solid:water) water extract procedure on pulps, and were analysed under ICP-MS method. The sum of 16 environmentally important elements are plotted as a function of pH in **Figure 18**, 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, Cd, cobalt (Co), Cr, Cu, Pb, Hg, Mn, Mo, Ni, Se, uranium (U), vanadium (V) and Zn.

Of the 322 samples, 270 samples (84% of samples tested) have low soluble metals concentrations and have near-neutral to alkaline pH – indicating that under freshwater leaching conditions soluble metals concentrations are low for most mineral waste and coal materials.

Thirty-two (of 161) spoil samples, four (of 61) rejects samples, one (of 96) tailings samples, and one (of 4) coal samples have moderate metals concentrations associated with near-neutral to alkaline pH.

Three (of 161) spoil samples and four (of 96) tailings samples have moderate metals concentrations associated with moderately to weakly acidic pH (pH 3 to 6). All seven samples were classified as PAF. Four composite rejects samples were also found to have moderate metals concentrations associated with moderately to weakly acidic pH (pH 3 to 6).

One tailings sample (classified as PAF) had elevated metals concentration associated with moderately to weakly acidic pH. One composite rejects sample (classified as PAF-LC) had low soluble metals concentrations associated with moderately to weakly acidic pH (pH 3 to 6).

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.

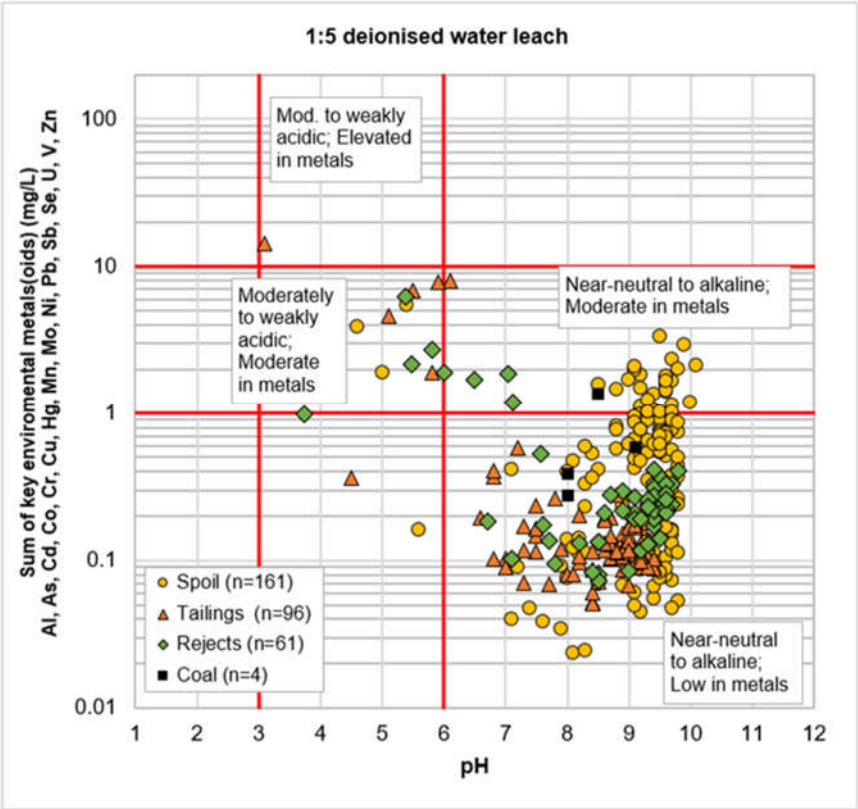


Figure 18. Sum of key environmental metals versus pH in deionised water extracts

The median concentrations of major ions and environmentally important metals/metalloids in deionised water extracts are shown in **Table 17** for spoil, coal, tailings and rejects.

Table 17. Median concentrations of major ions and selected elements in deionised water extracts for spoil, tailings and rejects

Median concentration mg/L	Spoil (n=161)	Tailings (n=96)	Reject (n=61)
≤ 0.0001	Cd, Hg	Cd, Hg	Cd, Hg,
≤ 0.001	Ag, Be, Bi, Co, Cr, Cu, Mn, Ni, Pb, Sn, U	Ag, Be, Bi, Co, Cr, Cu, Pb, Sb, Sn, U	Ag, Be, Bi, Co, Cr, Cu, Mn, Ni, Pb, Sb, Sn, U
≤ 0.01	Sb, Se, Ti, V, Zn	As, Mn, Ni, Se, Ti, V, Zn	As, Ti, V, Zn
≤ 0.1	Al, As, B, Ba, Fe, Mo	Al, B, Ba, Fe, Mo	Al, B, Ba, Fe, Mo, Se
≤ 1.0	F, Ca, Mg, P	F, P	F, Mg, P
≤ 10	K	Ca, Mg, K	Ca, K
≤ 100	Na, Cl, SO_4	SO_4, Cl, Na	SO_4, Cl, Na
≤ 1000	-	-	-

Limited deionised water extract (leaching) data is available for an additional four coal samples – all of which were collected from an older sampling program (mid-2000s). The water extract data for these additional four samples does not have solubility information for several of the key 16 elements identified in **Figure 18** and, as such, these samples have been excluded from the dataset shown in **Figure 18** (and **Table 17**). Where data is available for these coal samples it shows that all four samples were pH-neural to alkaline, three of the samples had low soluble metals concentrations, and the remaining sample had moderate soluble metals concentration.

5.5 'Saline' Water Solubility of Tailings and Rejects

Sixty-two (62) tailings and 38 rejects samples underwent a 1:5 w:v (solid:water) mildly saline (brackish) water extract procedure 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 sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the saline leach solution for tailings and rejects in **Figure 19** (along with the data for the tailings liquor solutions – see Section 5.6 below). The 16 selected metals/metalloids are the same elements as per the 1:5 deionised water leach.

The results have shown that the solubility of tailings and rejects is low under 'brackish' leaching conditions. Two tailings samples had moderately to weakly acidic pH – one of the samples had moderate soluble metals concentration and the other sample had low soluble metals concentration.

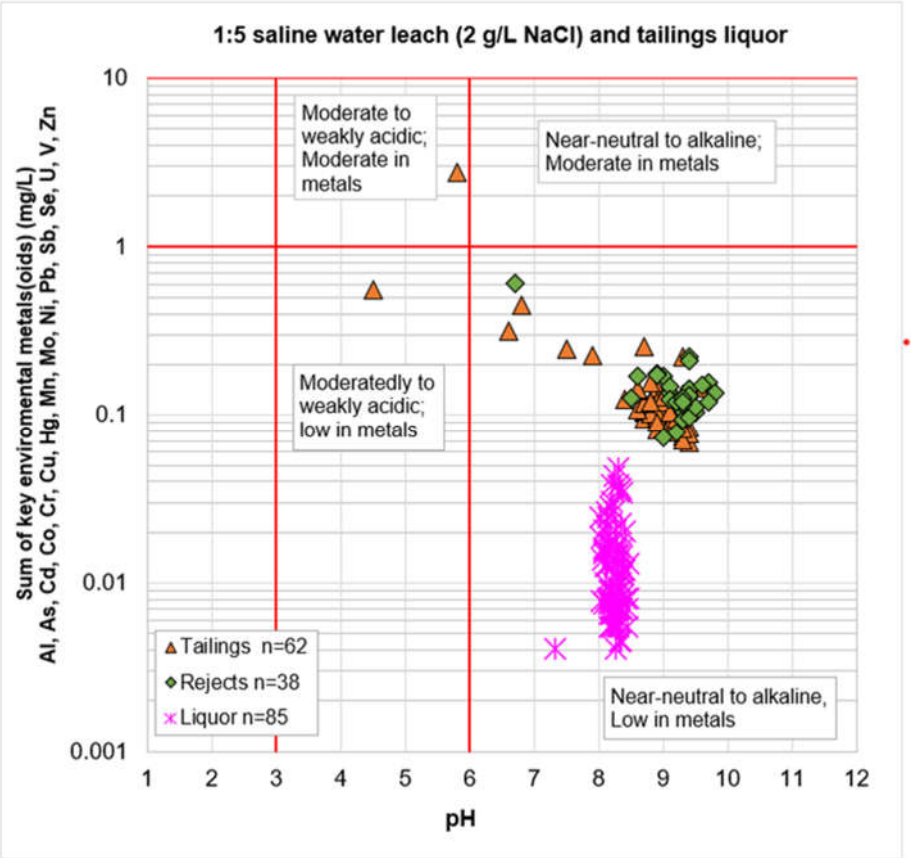


Figure 19. Sum of key environmental metals versus pH in saline water extracts and tailings liquor

5.6 Characteristics of Tailings Liquor (Water)

Water quality data for tailings liquor is available for 85 tailings slurry samples collected from the CHPP (at the thickener underflow). The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the tailings liquor solution in **Figure 19** (along with the data for the saline leach solutions). The 16 selected metals/metalloids are the same elements as per the 1:5 deionised water leach, saline water leach and peroxide leach.

All liquor samples have near neutral to alkaline pH and low soluble metals concentrations. The liquor is highly saline, with EC values ranging from 3160 to 6930 µS/cm (median = 5,830 µS/cm) and a median total dissolved solids (TDS) concentration of 3423 mg/L. The dominant cation is Na and the dominant anions are Cl and SO_4 (equally dominant). Tailings liquor has generally low to moderate alkalinity, median 198 mg/L as $CaCO_3$, and essentially all present as bicarbonate alkalinity.

Comparatively, the 2 g/L NaCl saline leach solution was much less saline, with a median TDS for tailings 'saline' leach samples of 685 mg/L, respectively; i.e. roughly one fifth the salinity of the tailings liquor. The dominant cations and anions in the saline leach were Na and Cl, respectively, as expected due to the NaCl used to create the saline solution.

5.7 Peroxide Leachate Solutions

Peroxide leachate (NAG leach) data is available for 61 samples, namely:

- 5 spoil samples (non-carbonaceous and carbonaceous) classified as PAF or UC(PAF);
- 33 tailings samples of mixed classifications (approximately two-thirds 'PAF', and remaining one-third NAF or UC(NAF));
- 11 rejects samples of mixed classifications (NAF and PAF, including UC(NAF), UC(PAF)).

Peroxide leachate is the solution resulting from a single addition (standard) NAG test after the sample has been oxidised with peroxide to encourage oxidation and associated neutralising reactions, if ANC is available. The test encourages complete and rapid oxidation and associated neutralisation, with the resulting leach representing an 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.

It must be noted that samples with potentially high organic carbon concentrations, such as coal, some tailings and some reject samples, may be influenced by organic acids producing acidity and correspondingly elevated soluble metals concentrations unrelated to AMD. As such, the results for coaly and highly carbonaceous samples should be interpreted with this in mind.

The sum of the concentration of 16 environmentally important elements are plotted as a function of pH from the peroxide leachate solution in **Figure 20**. The 16 selected metals/metalloids are the same elements as per the 1:5 deionised water leach and the saline leach.

After undergoing a peroxide (NAG) leach a significant number of samples have acidic pH (ranging from weakly to highly acidic) and moderate to elevated soluble metals concentrations – primarily due to the low pH enhancing solubility.

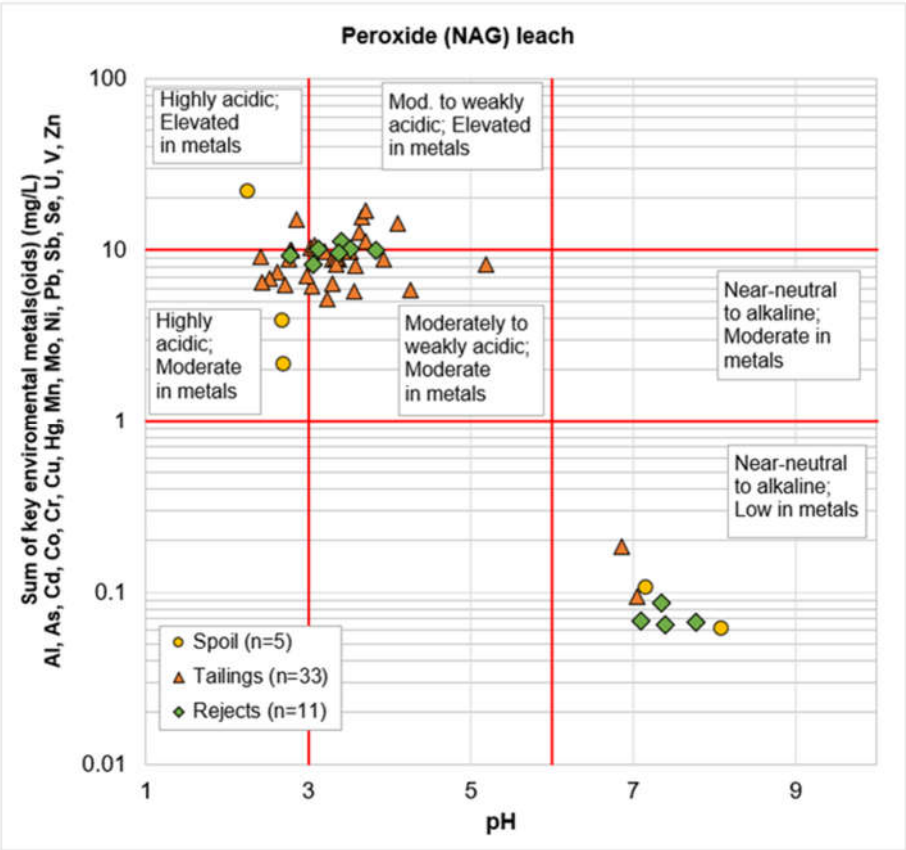


Figure 20. Sum of key environmental metals versus pH in peroxide (NAG) leachate solution

Three (out of 5) spoil samples, all classified as PAF, have moderate or elevated soluble metals concentrations and all were highly acidic (pH <3). The remaining two (out of 5) spoil samples have low soluble metals concentrations and near-neutral to alkaline pH.

Of the 11 rejects samples, six were moderately to weakly acidic with moderate to elevated metals concentrations – and most were classified as PAF of some type. One rejects sample that was classified as PAF has highly acidic pH and moderate metals concentration. The remaining four rejects samples – and were classified as NAF – have low soluble metals concentrations and near-neutral to alkaline pH.

Almost all (31 out of 33) tailings samples have moderate to elevated soluble metals concentrations associated with highly to weakly acidic pH. The remaining two tailings samples (and classified as NAF) have low soluble metals concentration associated with near-neutral to alkaline pH.

The median concentrations of major ions and environmentally important metals/metalloids in peroxide leachate solution from spoil, tailings and reject samples are shown in **Table 18**. Compared to the 1:5 deionised water extract solutions, the median concentration of several metals and metalloids in the peroxide leach solutions is higher, as expected, notably B, Ba, Cr, Co, Cu, Fe, Mg, Mn, Ni, SO_4 and Zn. However, overall, the concentrations of most elements and major ions in the peroxide leach solution are comparable to the deionised water solubility concentrations.

The results suggest that under acid/acidic conditions, materials represented by these samples are capable of generating elevated metal and metalloid loads for several metals/metalloids, however the SO_4 (and salinity) loads are not expected to be elevated – due to the generally low total S concentrations. These data suggest that if PAF/PAF-LC material is allowed to oxidise without ANC available in the bulk media to buffer acidity, material similar to that tested might mobilise metals and metalloids at elevated concentrations, over time.

Table 18. Median concentrations of major ions and selected elements in peroxide (NAG) leachate solution

Median concentration mg/L	Spoil (n=5)	Tailings (n=33)	Reject (n=11)
≤ 0.0001	Hg	Hg	Hg,
≤ 0.001	Sb, As, Be, Bi, Cd, Mo, Ag, Sn, U	Sb, As, Bi, Cd, Mo, Ag, Sn	Sb, As, Bi, Cd, Ag, Sn, U
≤ 0.01	Pb, Ni, Se, V	Be, Se, Ti, U, V	Be, Cr, Mo, Se, Ti, V
≤ 0.1	F, Cr, Co, Cu, Zn	Ba, B, Cr, Co, Pb, Ni	F, Ba, B, Co, Pb, Ni
≤ 1.0	Ba, B, Fe, Mn, P	F, Cu, P, Zn	Cu, P, Zn
≤ 10	Cl, Mg, K, Al	Mg, K, Al, Mn	Cl, Mg, K, Al, Mn
≤ 100	Ca, Na	Cl, Ca, Na, Fe	Ca, Na, Fe
≤ 1000	SO_4	SO_4	SO_4

5.8 Cation Exchange Capacity, Sodicity 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)] and exchangeable sodium percentage (ESP) data are available for 170 spoil samples. The results are summarised in **Figure 21**.

The CEC spans a moderate range from less than 1 milliequivalents per 100 grams (meq/100g) to 34 meq/100g, with a relatively low median CEC value of 11 meq/100g. The CEC for non-carbonaceous spoil was higher than carbonaceous spoil.

The ESP results generally ranged from less than 1% to 63%, with a median ESP of 32%. Approximately 94% of samples had ESP values greater than 14% and a further 4% of samples had ESP values between 6% and 14%. Therefore, based on the ESP values alone, approximately 98% of the spoil samples are regarded as being 'sodic' to 'strongly sodic' and, as such, essentially all mine spoil at GRBM can be expected to have potential for dispersion.

A subset of 91 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 25% of samples (23 out of 91 samples) had some dispersion [slaking] (Class 2), one sample had complete dispersion (Class 1), and two samples had an Emerson Class of 3 [calcite or gypsum present; dispersion] – meaning about 29% of samples were dispersive to some degree. The remaining 71% of samples (65 samples out of 91) had Emerson Class greater than 3, which indicates no dispersion.

In summary, the Emerson Class testing suggests about 30% of the samples may be prone to dispersion. Refer to **Section 4.4** for class descriptions. Although not entirely consistent with the ESP results, the Emerson Class test results suggest a significant proportion of spoil would be dispersive.

Based on the CEC, ESP and Emerson aggregate class test results, a significant proportion of spoil at GRBM is expected to be sodic to strongly sodic and dispersive.

These exchangeable cation (and Emerson aggregate class) results are common for Bowen Basin Permian and Tertiary material in the region.

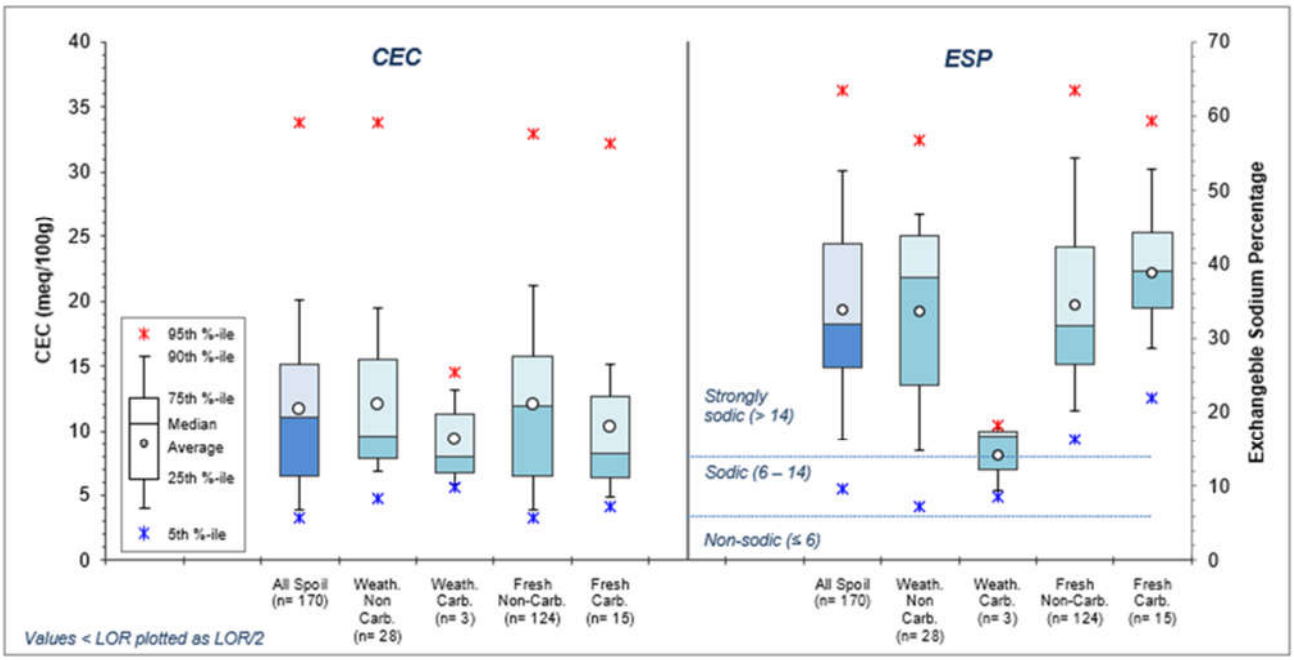


Figure 21. Cation exchange capacity (CEC) and exchangeable sodium percentage (ESP) of spoil

6 Summary of Geochemical Characteristics

The geochemical characteristics of mineral wastes (overburden/interburden [spoil], tailings and reject) from GRBM 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 geochemical characteristics of these samples, as being representative of their respective mineral waste types.

Within the context of this PRCP, spoil comprises essentially all of (approximately 98% of) the mineral waste at GRBM. Rejects and tailings comprise approximately 1.5% and 0.5%, respectively, of mineral waste at GRBM. Spoil is overwhelmingly comprised of non-carbonaceous material. Carbonaceous spoil (of which almost all is fresh/unweathered) comprises a small proportion of the spoil.

6.1 AMD Potential of Mineral Wastes and Coal

AMD Potential of Spoil – non-carbonaceous

Non-carbonaceous spoil, which comprises about 93% of spoil, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage), which is typical for mine spoil in the Bowen Basin.

Based on the results, non-carbonaceous spoil has a low potential to generate AMD as either AD and/or NMD and/or SD, but for a small proportion that is assessed to have a higher potential to generate AMD (as AD, NMD and/or SD). However, in consideration of the mixing and dispersion of a small volume of waste at higher potential for AMD within the broader spoil material, the overall potential for non-carbonaceous spoil (and bulk spoil, generally) to generate AMD is assessed to be low.

The total S concentration of non-carbonaceous spoil is very low, with a 90th percentile total S concentration of 0.08%. As such, and combined with moderate to high ANC values (median 40 kg H_2SO_4/t), approximately 96% of 1169 non-carbonaceous spoil samples tested were classified as NAF, with a further 3% (approximately) of samples classified as UC(NAF). Only 1.5% (approximately) of non-carbonaceous spoil samples were classified as PAF, PAF-LC or UC(PAF). No samples were classified as NAF-S.

The test-work undertaken has demonstrated that the ANC for the non-carbonaceous spoil is generally expected to be about 30-75% available under field conditions, with iron-dolomite and dolomite expected to be the main carbonate minerals contributing to the acid buffering potential of the spoil. Overall, non-carbonaceous spoil has excess acid neutralising capacity and is expected to be bulk acid consuming.

Total metal and metalloid concentrations from 114 non-carbonaceous spoil samples tested are very low compared to average element abundance in soil in the earth's crust. About 30% of samples were significantly enriched with regard to Se; and a further 12 samples (11% of samples) were significantly enriched with regard to one or more of As, Cd, Cu, Hg, S and/or Sb. There was no clear correlation found between these 'enriched' samples and their AMD classifications, however the enrichment in these elements in a small number of samples is not cause for concern. In summary, non-carbonaceous spoil (as a bulk material) has low enrichment in total metals and metalloids compared to unmineralised rocks.

Soluble multi-element results (from 139 non-carbonaceous samples) indicate that leachate from this material is expected to contain low concentrations of soluble metals and metalloids under pH-neutral to alkaline conditions. About 20% of samples produced moderate soluble metal concentrations in one or more of Al, As, Co, Fe, Mn, Ni and/or Zn – under pH-neutral to alkaline leaching conditions (excluding two samples that produced weakly acidic pH leachate). Peroxide [NAG] leaching undertaken on three non-carbonaceous spoil samples with PAF classification showed that some PAF material, when oxidised, has the potential to generate low pH leachate (AD) with elevated sulphate and soluble metal and metalloid concentrations.

AMD Potential of Spoil – carbonaceous

Carbonaceous spoil represents approximately 7% of spoil material at GRBM 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. Most carbonaceous spoil is fresh (unweathered).

Based on the results from 143 samples, most carbonaceous spoil has a generally low to moderate potential to generate AD and/or NMD and/or SD. Some carbonaceous spoil – generally associated with coal seams – has a greater potential to generate low-level AD and/or NMD and/or SD.

The total S concentration of carbonaceous spoil is low, with a 90th percentile total S concentration of 0.38% (from 202 samples).

Approximately 90% (128 out of 143) of carbonaceous spoil samples were classified as NAF. The remaining 10% of carbonaceous spoil samples were classified as PAF, PAF-LC or UC(PAF) and had a low-moderate 75th percentile total S value of 0.62%. No samples were classified as NAF-S.

The test-work undertaken on a small sub-set of six samples has demonstrated that the ANC in these samples is expected to be about 20-50% available under field conditions, with iron-dolomite expected to be the main carbonate mineral contributing to the acid buffering potential of the carbonaceous spoil. Overall, carbonaceous spoil has modest acid neutralising capacity.

Total metal and metalloid concentrations from 22 carbonaceous spoil samples tested are generally 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. Similar to non-carbonaceous spoil, 10 carbonaceous spoil samples out of 22 were significantly enriched with regard to one or more of As and/or Se. The enrichment in these elements in a small number of samples is not cause for concern. There was no clear correlation found between AMD classifications of the carbonaceous spoil samples compared to elemental enrichment. In summary, carbonaceous spoil (as a bulk material) has low enrichment in total metals and metalloids compared to unmineralised rocks.

Soluble multi-element results (from 22 samples) indicate that leachate from carbonaceous spoil is expected to contain generally low concentrations of soluble metals and metalloids – similar to the non-carbonaceous spoil samples. Of the 22 samples, 16 had low soluble metal and metalloid concentrations under pH-neutral to alkaline conditions, and one sample had low soluble metal and metalloid concentrations under weakly acidic conditions. The remaining five samples had moderate soluble metal and metalloid concentrations – predominantly under pH-neutral to alkaline conditions. Peroxide leaching was undertaken on two fresh carbonaceous spoil samples classified as PAF and UC(PAF), which showed that PAF samples, when oxidised, have the potential to generate low pH leachate (AD) with elevated sulphate and soluble metal and metalloid concentrations.

AMD Potential of Tailings

The geochemical characteristics differed between fresh tailings from the CHPPs verses aged tailings from the TSFs – particularly total S, ANC, NAGpH and $pH_{1:5}$. However, the overall geochemical (AMD) hazard posed by tailings from the two sources (fresh vs aged) was generally similar. There was also no significant difference in the geochemical characteristics between the fresh tailings from each CHPP (i.e. GY CHPP versus RV CHPP) or between aged tailings from each of the main TSFs (i.e. GS1 TSF versus RS1 TSF). As such, the discussion that follows only differentiates between the two tailings sources (fresh versus aged) where the differences between the two sources was significant for some parameters and worthy of discussion. Else, the AMD potential of tailings is discussed as a bulk material – regardless of source.

Based on the results, approximately 51% of tailings has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, and remaining 49% (approximately) has a relatively low to low-moderate potential to generate AMD as either AD and/or NMD and/or SD.

The total S concentration of tailings is low-moderate, with a 75th percentile total S concentration of 0.7%. Fresh CHPP tailings had higher total S concentrations (median = 0.61%) compared to aged tailings samples (median = 0.39%) from TSFs. Scr accounts for approximately 49% (median value) of total S in fresh CHPP tailings and 45% (median value) of total S in aged tailings – the slightly lower proportion of Scr in aged tailings (compared to fresh tailings) is likely due to some sulphide in aged tailings being oxidised to sulphate.

As a bulk material, tailings have generally moderate ANC (median 17 kg H_2SO_4/t), however the CHPP tailings had about twice the ANC of aged tailings – suggesting that a significant proportion of the neutralising material in tailings in the TSFs had been consumed since deposition. Combined with tailings (all) having generally low-moderate MPA (median 17 kg H_2SO_4/t) values, resulted in approximately 49% of the tailings samples being classified as NAF [including 53 samples classified as UC(NAF)] and 48% of samples classified as PAF, PAF-LC or UC(PAF). Twelve

samples were classified as NAF-S. That is, approximately half of all tailings were classified as 'PAF' (of some type) or NAF-S.

Test-work indicated that about 30-60% of the ANC is likely available under field conditions, however the 'field availability' of ANC ranged from 9% to 100%. The ABCC data suggested iron-dolomite, dolomite, and lesser siderite, were the likely dominant carbonate minerals, which is broadly consistent with the mineralogy data. Carbonate concentrations were generally higher in fresh CHPP tailings (and rejects) samples compared to aged samples – the reason for this may be due to carbonate being consumed in the aged samples due to buffering reactions associated with sulphide oxidation. Consumption of carbonate is also consistent with the lower ANC values in aged tailings compared to fresh tailings.

Total metal and metalloid concentrations from 95 tailings samples tested are very low compared to average element abundance in soil in the earth's crust. However, all tailings samples were significantly enriched with regard with Se. Furthermore, 18 tailings samples were significantly enriched with regard to one or more of As and/or S. There was no clear correlation found between AMD classifications of the tailings samples compared to elemental enrichment.

Solubility data indicate that most tailings samples under freshwater (deionised water) leaching conditions are expected to have low soluble metals concentrations and have near-neutral to alkaline pH. About 5% of the tailings samples – mostly 'PAF' – had moderate soluble metals concentrations under weakly acidic to pH-neutral conditions; and one sample (classified as PAF) was elevated in soluble metals concentrations and was moderately acidic, confirming its' PAF classification. This suggests that overtime, 'PAF' tailings can generate AD as field ANC is consumed. Under saline leaching conditions tailings produced low concentrations of soluble metals and metalloids.

Peroxide leaching undertaken on 33 tailings samples (about two-thirds classified as 'PAF' of some type) showed that when exposed to highly oxidising conditions a significant proportion of tailings can produce weakly to highly acidic leachate with moderate to elevated soluble metals and metalloid concentrations. It must be noted that samples with potentially high organic carbon concentrations, such as some tailings samples, may be influenced by organic acids producing acidity and correspondingly elevated soluble metals concentrations unrelated to AMD. As such, the results for such coaly/carbonaceous samples should be interpreted with this in mind. Nevertheless, PAF tailings [including tailings classified as UC(PAF)] have typically produced moderate to elevated soluble metals and metalloid concentrations from the freshwater and peroxide leaching tests. These results indicate that PAF tailings have the potential to generate low pH leachate (AD), however the salinity (sulphate) loads are not expected to be high – due to generally low total S concentrations (with minor exceptions).

AMD Potential of Rejects

The geochemical characteristics of fresh rejects from the CHPP, aged rejects from TSFs and aged rejects from Riverside rejects dump were generally similar – except for NAGpH results. Excluding NAGpH, there was also no significant difference in the geochemical characteristics between the fresh rejects from each CHPP (i.e. GY CHPP versus RV CHPP) or between aged rejects from each of the main TSFs (i.e. GS1 TSF versus RS1 TSF) and/or between the TSFs and Riverside rejects dump. As such, the discussion that follows only differentiates between the three rejects sources (fresh versus aged TSF versus aged rejects dump) where the differences between the three sources was significant for some parameters and worthy of discussion. Else, the AMD potential of rejects is discussed as a bulk material – regardless of source.

Based on the results, 22% of the rejects (aged and fresh) has a moderate to high potential to generate AMD as either AD and/or NMD and/or SD, whereas the remaining 78% (aged and fresh) has a relatively low to low-moderate potential to generate AMD as either AD and/or NMD and/or SD.

The total S concentration of rejects (fresh and aged) is generally low, with a median value of 0.31%. Scr accounts for approximately 72% (median value) of total S in aged rejects from Riverside rejects dump; 56% (median value) of total S in fresh CHPP rejects; and 49% (median value) of total S in aged rejects from TSFs. The slightly lower proportion of Scr in aged rejects from the TSFs compared to fresh rejects, and also compared to aged rejects from Riverside rejects dump is likely due to some sulphide in aged rejects in the TSFs being oxidised to sulphate.

Similar to tailings, rejects have generally moderate ANC (median 18 kg H_2SO_4/t) and generally low MPA (median 9 kg H_2SO_4/t) values, resulting in approximately 78% of the rejects samples being classified as NAF or UC(NAF). One sample was classified as NAF-S. The remaining 22% (approximately) of samples were classified as PAF,

PAF-LC or UC(PAF). Test-work indicated that about 25-50% of the ANC in fresh rejects is expected to be available under field conditions; and about 35-65% available for the aged rejects. The ABCC data suggested iron-dolomite, dolomite and siderite were expected to be the dominant carbonate minerals, which is broadly consistent with the mineralogy data.

Total metal and metalloid concentrations from 52 rejects samples tested are very low compared to average element abundance in soil in the earth's crust. However, similar to tailings samples, all rejects samples were significantly enriched with regard to Se. Nine rejects samples were also significantly enriched with As. There was no clear correlation found between AMD classifications of the rejects samples compared to elemental enrichment.

Solubility data indicate that most rejects samples (54 out of 61 samples) under freshwater (deionised water) leaching conditions are expected to have low soluble metals concentrations and have near-neutral to alkaline pH. Four (of 61) rejects samples have moderate metals concentration associated with near-neutral to alkaline pH; and three rejects samples have moderate metals concentration associated with moderately to weakly acidic pH.

Peroxide leaching undertaken on 11 rejects samples (of mixed NAF/PAF classifications) showed that when exposed to highly oxidising conditions PAF rejects can produce moderately to highly acidic leachate with moderate to elevated soluble metals and metalloid concentrations – consistent with PAF tailings. The results suggest that under acid/acidic conditions, some rejects are capable of generating elevated metal and metalloid loads, however the sulphate (and salinity) loads are not expected to be high – due to the generally low total S concentration (with some exceptions).

AMD Potential of Coal

Coal is not regarded as waste and ROM coal remains on-site for a relatively short period of time. However, some minor coal seams/plys will report directly as waste, and remnant coal (seams) will be exposed on the highwalls of residual voids at closure.

Coal represents about 8% (on average) of all lithological material at GRBM (about 5% to 10% of the highwall meterage; refer to **Table 20**) and, assuming the large majority all of this will report as ROM coal, we can conservatively assume that coal will represent a very small proportion of mineral waste (i.e. nominally 1-2% at the most).

Based on the results, and as a bulk material, ROM coal is assessed as having a low-moderate to moderate potential to generate AMD as either AD, NMD and/or SD. A small proportion of coal (all seams) would have a moderate to moderate-high potential to generate AMD. ROM coal, as a bulk material, is expected to generate pH-alkaline to highly alkaline contact water (run-off and seepage).

Coal samples had low total S values resulting in low MPA values (median 11 kg H_2SO_4/t), however due to the generally very low to low ANC values (median 6 kg H_2SO_4/t) resulted in 77% of coal samples being classified as PAF, PAF-LC or UC(PAF). The proportion of PAF (of any kind) is comparable across all coal seam groups being mined at GRBM. The low total S concentrations suggests that 'PAF' coal is unlikely to generate significant acid(ity).

Approximately 23% of coal samples tested (6 out of 26 samples) were classified as NAF, and coal seam material represented by these NAF samples has very low sulphur values, excess ANC (relative to the MPA) and clearly has negligible capacity to generate acidity or release significant sulphate from sulphide oxidation.

These results suggest that coal stored on the ROM pad, coal located within pit walls and un-economic coal seam material reporting as spoil (mixed with non-coal spoil) would likely be bulk PAF – albeit, low capacity. From an acid generating perspective, coal poses a potential source hazard with respect to AD and/or NMD/SD; and overall, is expected to generate low acidity loads.

Solubility data from three composite coal samples (classified as PAF and PAF-LC) tested under freshwater (deionised water) leaching conditions indicates low soluble metals concentrations at near-neutral to alkaline pH. An additional composite coal sample (classified as PAF) had moderate soluble metals concentration associated with near-neutral to alkaline pH.

6.2 Salinity, Sodicity and Dispersion Potential of Mineral Wastes and Coal

Salinity, Sodicity and Dispersion Potential of Spoil – non-carbonaceous

Non-carbonaceous spoil has low median and moderate 90th percentile $EC_{1:5}$ values of 414 and 910 µS/cm, respectively, 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, as a result of dissolution of geogenic salts more so than from sulphide oxidation (sulphate salinity). Weathered non-carbonaceous spoil generally has higher $EC_{1:5}$ values compared to fresh non-carbonaceous spoil.

Non-carbonaceous spoil has modest CEC values and generally high ESP values, resulting in most samples being classified as 'sodic' to 'strongly sodic' and, therefore, with potential for dispersion. Based on Emerson aggregate class testing to directly measure dispersion, about 31% of the samples displayed some degree of dispersion. Although not entirely consistent with the ESP results, the Emerson Class test results suggest a significant proportion of spoil is expected to be dispersive to some degree.

Salinity, Sodicity and Dispersion Potential of Spoil – carbonaceous

Carbonaceous spoil has median and 90th percentile $EC_{1:5}$ values of 272 and 655 µS/cm, respectively, and has low total S concentrations. On this basis, contact water (run-off and seepage) is expected to be similar to non-carbonaceous spoil. That is, generally non-saline to slightly saline, primarily as a result of dissolution of geogenic salts more so than from sulphide oxidation (sulphate salinity).

Carbonaceous spoil samples had similar CEC values compared to non-carbonaceous spoil, and comparable ESP values – with the exception of weathered carbonaceous samples, which had lower ESP values compared to fresh samples. This resulted in the fresh samples being classified as 'strongly sodic' and the weathered samples classified as 'sodic' to 'strongly sodic'. As such, and based solely on the moderate to high sodicity values, carbonaceous spoil is expected to be sodic (to some degree) with potential for dispersion. Sixteen carbonaceous spoil samples underwent Emerson aggregate class testing to directly measure dispersion, which found three (out of 16) samples were dispersive.

Salinity Potential of Tailings

Tailings samples have $EC_{1:5}$ values ranging from 118 to 5320 µS/cm, with median and 90th percentile $EC_{1:5}$ values of 717 and 1556 µS/cm, respectively. The $EC_{1:5}$ values were generally similar between fresh and aged tailings, resulting in tailings generally being slightly to moderately saline. The generally low total S for aged tailings and low-moderate total S for fresh tailings conservatively suggests a low-moderate potential for SD (from sulphide oxidation).

Salinity Potential of Rejects

Rejects samples have $EC_{1:5}$ values ranging from 389 to 3260 µS/cm, with median and 90th percentile $EC_{1:5}$ values of 389 and 774 µS/cm, respectively. The fresh CHPP rejects were generally non-saline with a 90th percentile $EC_{1:5}$ value of 550 µS/cm. Aged rejects had higher $EC_{1:5}$ values compared to fresh rejects with 90th percentile values of 792 µS/cm (for the TSF samples) and 1090 µS/cm (for Riverside rejects dump samples). Most rejects had low total S concentrations (median = 0.31%), suggesting the potential for SD (from sulphide oxidation) from rejects is low.

Salinity Potential of Coal

Coal has low median and 90th percentile $EC_{1:5}$ values of 90 and 524 µS/cm, respectively; and has generally low to low-moderate total S concentrations. On this basis, contact water (run-off and seepage) from coal, as a bulk material, is expected to be non-saline to slightly saline, either as a result of dissolution of geogenic salts and/or from sulphide oxidation (sulphate salinity).

7 Risk Assessment

7.1 Geochemical Source Hazard Assessment of Material Types

7.1.1 Spoil Landforms

There are four spoil landforms at GRBM – all associated with existing spoil dumps – that will remain at closure:

- Goonyella
- Thiess
- Airstrip
- Broadmeadow-Isaac

The GRBM PRCP considers Thiess spoil dump as part of Goonyella spoil landform. However, due to its' proximity to Thiess pit, it has been assessed herein as a separate spoil landform. Each landform will have a similar construction, comprising mined overburden and interburden disposed behind the active mining face to form a low-wall spoil dump, which will be reshaped to form a final spoil landform. The spoil dumps located close to the CHPPs contain rejects.

Rejects have been disposed into several locations at GRBM. Rejects from RV CHPP have primarily been disposed into Riverside rejects dump (now inactive) and into the western compartment of RS1 TSF. Minor rejects have also been disposed within the Goonyella spoil dump (Dampier spoil) and Thiess spoil dumps. Future rejects from RV CHPP are planned to be disposed into RS1 TSF area (western compartment and onto tailings in the eastern compartment), and potentially also co-disposed throughout general spoil within Goonyella spoil dump.

Rejects from GY CHPP have been disposed into the Thiess, Airstrip and Broadmeadow spoil dump areas, and into GS2, GS11 and R22 rejects dumps. Future rejects from GY CHPP are expected to be disposed at GS11 and R22 rejects dump and co-disposed throughout general spoil within Broadmeadow spoil dump.

R22 rejects dump is located at the southern periphery of Thiess spoil dump and will comprise about 16% of the Thiess spoil landform. Due to the location of the rejects dump close to the edge of the Thiess spoil landform, the AMD hazard has been assessed based on the rejects dump being a stand-alone facility (i.e. a rejects landform), rather than the component material (rejects) being assessed as part of the Thiess spoil landform. This provides a conservative assessment of this facilities risk and takes into account the rejects within this dump being concentrated in an area at the edge of the spoil landform.

DRE5 in-pit TSF will be located within the north-western area of Thiess spoil dump at closure and will comprise less than 1% of the landform. Ramp 32 in-pit TSF will be located within the Airstrip spoil dump and will comprise approximately 7% of the landform. These two in-pit TSFs are comprised only of tailings. Due to the location of both of these TSFs at the base of their respective spoil landforms, the AMD hazard has been assessed based on these TSFs being stand-alone facilities (i.e. TSF landforms), rather than their component materials (tailings) being assessed as part of the spoil landform. This provides a conservative assessment of these facilities risk and takes into account the tailings within these TSFs being concentrated in an area at the base of the spoil landform.

The locations of all TSFs and rejects landforms are shown in **Figure 22**. There are no current tailings/TSFs within Goonyella or Broadmeadow-Isaac spoil landforms. The general layout of the conceptual spoil landforms (and residual voids) at closure is shown in **Figure 22**, which shows that Goonyella spoil landform is considerably larger than all other spoil landforms – comprising approximately 91% of all spoil at GRBM. At closure, the current spoil dumps will be reshaped and rehabilitated (refer to the PRC Plan for spoil dump rehabilitation details).

The source materials within the spoil dumps comprise weathered and fresh spoil. The geochemical assessment has found that, from an environmental geochemical perspective, the geochemical differences between weathered and fresh spoil are relatively minor. As such, the geochemical source hazard assessment has combined weathered and fresh non-carbonaceous spoil, and weathered and fresh carbonaceous spoil, as appropriate. Furthermore, assuming all spoil is 'fresh' – particularly carbonaceous spoil – adds a degree of conservatism to the assessment, since fresh carbonaceous material poses a greater AMD hazard compared to weathered carbonaceous material.

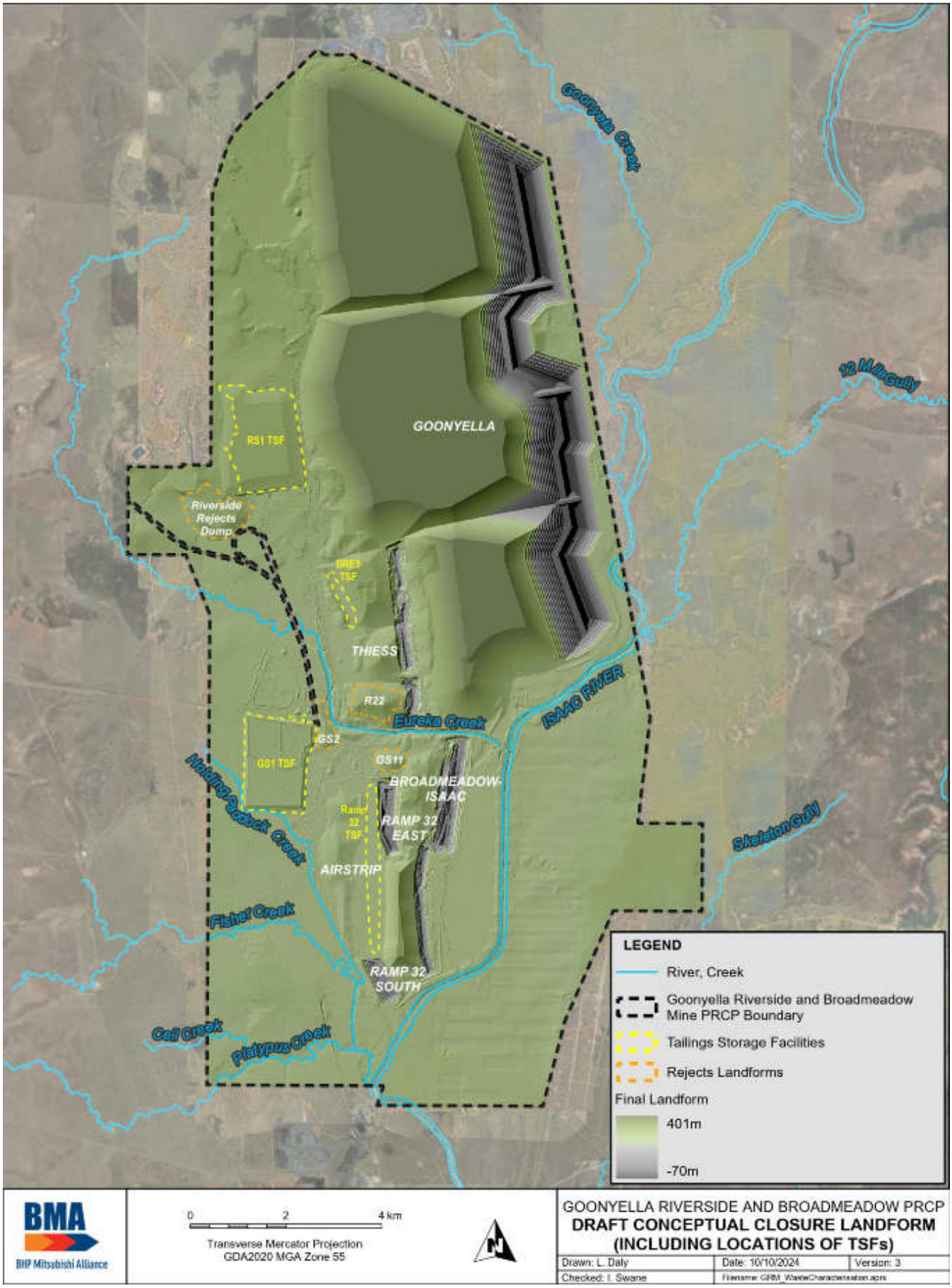


Figure 22. Conceptual closure landform

The source hazard assessment methodology outlined in **Section 4.4.6** (AMD hazard scoring) and **Section 4.4.7** (landform AMD likelihood scoring) has been applied to the spoil and rejects within each spoil landform (i.e. excluding DRE5 and Ramp 32 in-pit TSFs). Stratigraphic information from the coal geology database for GRBM was used to assess the proportion of carbonaceous lithologies relative to non-carbonaceous lithologies (and excluding coal) for each landform and void area – and from this, assign the same proportions to each spoil landform. The assessment found that carbonaceous spoil (overburden/interburden) is estimated to comprise approximately 5% to 9% (average 7%) of spoil within each landform, with non-carbonaceous spoil estimated to comprise the remaining 93% (approximately, on average) of all spoil. Assuming some fresh coal material currently assigned as 'coal' is not mined as ROM coal but remains as waste coal, the proportion of coaly and carbonaceous overburden in each landform is likely to be slightly higher. However, coal comprises approximately 8% of the stratigraphy at GRBM, therefore if a small amount of coal was to report as 'waste' the increase to the proportion of carbonaceous spoil would be minimal.

The source materials, and their approximate proportions within each spoil landform, based on geological, mining and coal processing information, are summarised in **Table 19**.

Table 19. Source material approximate proportions (%) within each spoil landform

Spoil landform	Spoil non-carbonaceous %	Spoil Carbonaceous and/or coaly[a] %	Rejects %	Tailings %
Goonyella	91	9	~0.1	none
Thiess[b,c]	91	9	~0.2[b]	none[c]
Airstrip[d]	92	5	3	none[d]
Broadmeadow-Isaac	91	8	1	none

a Coaly material refers to obvious waste coal lithologies (i.e. excludes potential ROM coal).

b R22 in-pit rejects dump is located within Thiess spoil dump and the assessment has not included this in-pit rejects dump as part of the Thiess spoil landform – instead assessed as a rejects landform.

c DRE5 in-pit TSF is located within Thiess spoil dump and the assessment has not included this in-pit TSF as part of the Thiess spoil landform – instead assessed as a TSF landform.

d Ramp 32 in-pit TSF is located within Airstrip spoil dump and the assessment has not included this TSF as part of the Airstrip spoil landform – instead assessed as a TSF landform.

The source hazard assessment, which describes the AMD hazard of individual material domains within each landform (i.e. also considers material quantity), has found that non-carbonaceous spoil – which comprises the significant majority of the mineral waste – poses a **Low-Moderate** AMD source hazard, and carbonaceous spoil has been assessed to pose a **Moderate** AMD source hazard. Rejects within each spoil landform have also been assessed to pose a **Low-Moderate** AMD source hazard. The AMD hazard scoring tables for spoil landforms are provided in **Attachment B – Tables B1 to B4**.

Approximately 3% of spoil samples have been classified as PAF of some type (no samples were classified as NAF-S) (**Table 15**) – and approximately half of this is from carbonaceous material, which comprises a minor proportion of spoil. Approximately one-third of the 'PAF' samples in overburden/interburden from drill-hole sampling were associated with seams as either roof, parting, floor or otherwise near-seam material (<1.5m above or below coal). As such, it is likely that some PAF spoil samples would be mined as part of ROM coal and would therefore end up as rejects instead of general spoil. Therefore, the AMD hazard score for spoil materials is considered to be conservative and consequently the final landform AMD hazard score also conservative.

On this basis and taking into account material quantities (proportions) and expected proportion of PAF and NAF-S materials reporting to each individual landform, each of the four spoil landforms poses a **Low** AMD hazard, with AMD generation rated as **Highly Unlikely**. The 'Low' AMD hazard is largely a result of non-carbonaceous NAF spoil comprising the overwhelming majority of mineral waste within each spoil landform, combined with the very small proportion of each landform expected to be 'PAF' – ranging from 2.4% to 5.5% (average 3%).

7.1.2 TSF Landforms

GS1 TSF and RS1 TSF will remain as stand-alone TSF landforms at closure and will not reside within a spoil landform. DRE5 in-pit TSF and Ramp 32 in-pit TSF will reside within their respective spoil landforms; however, as mentioned earlier, they have been assessed as stand-alone TSF landforms. Refer to **Figure 1** and **Figure 22** for the location of these TSFs.

GS1 TSF

GS1 TSF is a large 'turkey's nest' style TSF. The embankments are comprised of earthen-filled 'starter' embankments then raised (expanded) with rejects. The core of the TSF contains tailings. The TSF operated from approximately 1971 to 2021, receiving tailings from GY CHPP.

The source materials within GS1 TSF includes tailings, which are estimated to comprise approximately 95% of the landform; and rejects, which are estimated to comprise about 5% of the landform and form the basis of the embankments. The assessment assumes the TSF landform also includes a small proportion (approximately 0.5%) of spoil/fill material, predominantly within embankments.

Investigative drilling coupled with near-surface sampling has demonstrated that some tailings in the field at GS1 TSF are generating AMD (as AD and SD). Oxidation fronts are present in the TSF as demonstrated by decreasing sulphide concentrations from surface down, consumption of ANC, presence of secondary minerals generated through sulphide oxidation, and acid contact pH water. AMD has also been observed in seepage from the toe of the TSF and in nearby Holding Paddock Creek. Approximately 64% of the tailings samples collected from GS1 TSF are 'PAF' (of some type), whereas approximately 20% of the rejects samples from GS1 TSF are 'PAF'. As such, it is assumed that the AMD observed in/from GS1 TSF is primarily generated from tailings, more so than rejects.

The source hazard assessment for the mineral wastes within the TSF landform has utilised the same general methodology as applied to the spoil landforms. The source hazard assessment has found the tailings within GS1 TSF landform poses a **Moderate-High** AMD source hazard; and rejects poses a **Moderate** AMD source hazard. Fill material poses a **Low-Moderate** AMD source hazard. On this basis, and taking into account material quantities (proportions):

- GS1 TSF landform (currently, without a rehabilitation cover) poses a **Moderate-High** AMD hazard, with AMD generation rated as **Highly Likely** – noting that AMD processes and/or AMD impacted contact water have already been observed from GS1 TSF. The AMD hazard is considered to predominantly lie with the tailings, and lesser so the rejects.

The AMD hazard scores for the tailings and rejects materials are considered to be conservative and the landform domain AMD hazard score for GS1 TSF is also considered to be conservative. The AMD hazard scoring table for GS1 TSF landform is provided in **Attachment B – Table B5**.

RS1 TSF

RS1 TSF is a large 'turkey's nest' style TSF. The TSF has been constructed as two compartments: a western compartment comprised of rejects and an eastern compartment comprised of tailings. The tailings (from RV CHPP) are contained within earth- and rejects-filled eastern and southern embankments and a northern embankment constructed from rejects. The western compartment contains (holds back) the tailings on the western side. The TSF commenced operations in approximately 1983 and ceased receiving tailings in 2021. Rejects from RV CHPP are currently disposed into the TSF (primarily the western compartment). Future rejects from RV CHPP are planned to be disposed onto the eastern compartment and will cover the tailings.

Separate AMD source hazard assessments have been completed for each compartment of RS1 TSF. The western compartment comprises rejects only. The eastern compartment is estimated to comprise approximately 85% tailings and 15% rejects. The assessment assumes the eastern compartment also includes a small proportion (approximately 0.5%) of spoil/fill material, predominantly within embankments.

Investigative drilling coupled with near-surface sampling has demonstrated that some tailings in the field at RS1 TSF are generating AMD (as AD and SD). Oxidation fronts are present in the TSF as demonstrated by decreasing sulphide concentrations from surface down, consumption of ANC, presence of secondary minerals generated through sulphide oxidation, and acid contact pH water. Approximately 80% of the tailings samples collected from

RS1 TSF are 'PAF' (of some type), whereas approximately 17% of the rejects samples from RS1 TSF are 'PAF' (and approximately 30% of all aged rejects generated from RV CHPP are 'PAF'). As such, it is assumed that the AMD observed in/from RS1 TSF is primarily generated from tailings, more so than rejects.

- RS1 TSF western compartment [rejects only] (currently, without a rehabilitation cover) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable / Likely**.
- RS1 TSF eastern compartment [tailings and rejects] (currently, without a rehabilitation cover) poses a **Moderate-High** AMD hazard, with AMD generation rated as **Highly Likely** – noting that AMD processes and/or AMD impacted contact water have already been observed from RS1 TSF. The AMD hazard is considered to predominantly lie with the tailings, and lesser so the rejects.

The AMD hazard scores for the tailings and rejects materials are considered to be conservative and the AMD hazard scores for each compartment of RS1 TSF are also considered to be conservative. The AMD hazard scoring tables for RS1 TSF are provided in **Attachment B – Tables B6 and B7**.

DRE5 in-pit TSF

DRE5 in-pit TSF is located within the pit shell of Thiess pit (Thiess void) and within the Thiess spoil landform footprint. As such, it is not a true 'stand-alone' TSF landform, however, is conservatively assessed as such given the concentrated nature of tailings at the base of the spoil landform.

The source materials within the TSF includes tailings only. No investigative drilling has been undertaken in the vicinity of this TSF. No evidence of AMD has been observed in the field. The AMD source hazard assessment is based on data from fresh (CHPP) tailings.

The source hazard assessment for the tailings within the TSF has utilised the same general methodology as applied to other TSF landforms. The source hazard assessment has found the tailings within the TSF landform pose a **Moderate** AMD source hazard.

On this basis, and taking into account material quantities (all tailings):

- DRE5 in-pit TSF (prior to rehabilitation and when fully unsaturated) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable / Likely**.

The AMD hazard score for the tailings is considered to be conservative and the landform domain AMD hazard score for the TSF is also considered to be conservative. The AMD hazard scoring table for DRE5 in-pit TSF landform is provided in **Attachment B – Table B8**.

Ramp 32 in-pit TSF

Ramp 32 in-pit TSF is located within Airstrip pit and within the Airfield spoil landform footprint. As such, it is not a true 'stand-alone' TSF landform, however, is conservatively assessed as such given the concentrated nature of tailings at the base of the spoil landform.

The source materials within the TSF includes tailings only. No investigative drilling has been undertaken in the vicinity of this TSF. No evidence of AMD has been observed in the field. The AMD source hazard assessment is based on data from fresh (CHPP) tailings.

The source hazard assessment for the tailings within the TSF has utilised the same general methodology as applied to other TSF landforms. The source hazard assessment has found the tailings within the TSF landform pose a **Moderate** AMD source hazard.

On this basis, and taking into account material quantities (all tailings):

- Ramp 32 in-pit TSF (prior to rehabilitation and when fully unsaturated) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable / Likely**.

The AMD hazard score for the tailings is considered to be conservative and the landform domain AMD hazard score for the TSF is also considered to be conservative. The AMD hazard scoring table for Ramp 32 in-pit TSF landform is provided in **Attachment B – Table B9**.

7.1.3 Rejects Landforms

Riverside rejects dump

Riverside rejects dump received rejects from RV CHPP until approximately 1998. The dump underwent some rehabilitation activities in the early 2000s, but due to the substantial corrective action required to achieve the required post-mining land use (PMLU) it has not been included as existing rehabilitation in the PRCP schedule. The dump will remain as a 'stand-alone' rejects landform at closure. The dump is located to the southwest of RS1 TSF (**Figure 1** and **Figure 22**).

Excluding the spoil cover currently in place, the dump essentially comprises only rejects (over 99% by volume). It is assumed a small amount of 'fill' (assume spoil) may lie within the dump, and the 'fill' is conservatively estimated to comprise approximately 0.5% of the landform.

The source hazard assessment for the mineral wastes within the rejects dump has utilised the same general methodology as applied to the spoil and TSF landforms. The assessment excludes the existing spoil cover. The source hazard assessment has found the rejects within the dump (based on rejects sampled from the dump) poses a **Moderate** AMD source hazard. Fill material has been assessed as posing a **Low** AMD source hazard based on the geochemical characteristics of all GRBM spoil. Taking into account material quantities (proportions):

- Riverside rejects dump (excluding the cover) poses a **Moderate** AMD hazard, with AMD generation rated as **Probable / Likely**. The AMD hazard lies with the rejects, which comprise essentially all of the dump.

The AMD hazard score for the rejects materials is considered to be conservative and the landform domain AMD hazard score for the rejects dump is also considered to be conservative. The AMD hazard scoring table for Riverside rejects dump is provided in **Attachment B – Table B10**.

GS2 rejects dump

GS2 rejects dump receives rejects from GY CHPP and is located to the northeast of GS1 TSF (**Figure 1** and **Figure 22**). The dump will remain as a 'stand-alone' rejects landform at closure.

The dump essentially comprises only rejects (over 99% by volume). It is assumed a small amount of 'fill' (assume spoil) may lie within the dump, and the 'fill' is conservatively estimated to comprise approximately 0.5% of the landform.

The source hazard assessment for the mineral wastes within the rejects dump has utilised the same general methodology as applied to the spoil and TSF landforms. The source hazard assessment has found the rejects within the dump (based on rejects from GY CHPP) poses a **Low-Moderate** AMD source hazard. Fill material has been assessed as posing a **Low** AMD source hazard based on the geochemical characteristics of all GRBM spoil. Taking into account material quantities (proportions):

- GS2 rejects dump poses a **Low-Moderate** AMD hazard, with AMD generation rated as **Unlikely**. The AMD hazard lies with the rejects, which comprise essentially all of the dump.

The AMD hazard score for the rejects materials is considered to be conservative and the landform domain AMD hazard score for the rejects dump is also considered to be conservative. The AMD hazard scoring table for Riverside rejects dump is provided in **Attachment B – Table B11**.

GS11 rejects dump

GS11 rejects dump receives rejects from GY CHPP and is located east of GS1 TSF between Ramp 32 TSF and Eureka Creek (**Figure 1** and **Figure 22**). The dump is located at the periphery of Broadmeadow spoil dump and is not planned to be covered within the Broadmeadow-Isaac spoil landform. As such, it is expected to remain as a 'stand-alone' rejects landform at closure.

The dump essentially comprises only rejects (over 99% by volume). It is assumed a small amount of 'fill' (assume spoil) may lie within the dump, and the 'fill' is conservatively estimated to comprise approximately 0.5% of the landform.

The source hazard assessment for the mineral wastes within the rejects dump has utilised the same general methodology as applied to the spoil and TSF landforms. The source hazard assessment has found the rejects within the dump (based on rejects from GY CHPP) poses a **Low-Moderate** AMD source hazard. Fill material has been assessed as posing a **Low** AMD source hazard based on the geochemical characteristics of all GRBM spoil. Taking into account material quantities (proportions):

- GS11 rejects dump poses a **Low-Moderate** AMD hazard, with AMD generation rated as **Unlikely**. The AMD hazard lies with the rejects, which comprise essentially all of the dump.

The AMD hazard score for the rejects materials is considered to be conservative and the landform domain AMD hazard score for the rejects dump is also considered to be conservative. The AMD hazard scoring table for Riverside rejects dump is provided in **Attachment B – Table B12**.

R22 in-pit rejects dump

R22 in-pit rejects dump receives rejects from GY CHPP and is located at the southern periphery of, and within, the Thiess spoil landform footprint (**Figure 1** and **Figure 22**). As such, it is not a 'stand-alone' rejects landform, however, is conservatively assessed as such given the concentrated nature of rejects at the periphery of the spoil landform where they will not be buried deeply within the core of the spoil landform.

The dump comprises only rejects. It is assumed a small amount of 'fill' (assume spoil) may lie within the dump, and the 'fill' is conservatively estimated to comprise approximately 0.5% of the landform.

The source hazard assessment for the mineral wastes within the rejects dump has utilised the same general methodology as applied to the spoil and TSF landforms. The source hazard assessment has found the rejects within the dump (based on rejects from GY CHPP) poses a **Low-Moderate** AMD source hazard. Fill material has been assessed as posing a **Low** AMD source hazard based on the geochemical characteristics of all GRBM spoil. Taking into account material quantities (proportions):

- R22 rejects dump poses a **Low-Moderate** AMD hazard, with AMD generation rated as **Unlikely**. The AMD hazard lies with the rejects, which comprise essentially all of the dump.

The AMD hazard score for the rejects materials is considered to be conservative and the landform domain AMD hazard score for the rejects dump is also considered to be conservative. The AMD hazard scoring table for Riverside rejects dump is provided in **Attachment B – Table B13**.

7.1.4 Residual Voids – Exposed Walls and Floor

There are five pit groups at GRBM that will remain at closure as residual voids:

- Goonyella void; approximately 11 km long with an average depth of 304 m (at closure);
- Thiess void; approximately 3.9 km long with an average depth of 78 m (at closure);
- Broadmeadow-Isaac void; approximately 5.1 km long with an average depth of 83 m (at closure);
- Ramp 32 East void; approximately 1.6 km long with an average depth of 94 m (at closure); and
- Ramp 32 South void; approximately 1.0 km long with an average depth of 69 m (at closure).

Excluding Broadmeadow-Isaac void, the floor of all residual voids at closure will be the GLS seam. The floor of Broadmeadow-Isaac void will be the GMS seam.

Environmental geochemical data, coal quality data and drill-hole geological logs have been used to aid in the assessment of AMD hazard associated with residual void highwalls and floors, as explained in **Sections 4.4.1** to **4.4.3**.

The statistical distribution of residual void highwall materials and the proportion of exposed coal seam (groups) is summarised in **Table 20**. Also shown is the composition (proportion) of each seam group exposed on the highwall in each void (based on drill-hole data). As each void depth varies – especially Goonyella void compared to all other voids – not all seams are exposed in each void. For example, GF seam is only exposed in Goonyella void. Overall, remnant coal (seam) is expected to comprise between 5% to 10% (average 7.5%) of the highwalls in the residual voids.

Note that the source hazard assessment methodology outlined in **Section 4.4** has been applied to the materials expected to be exposed on the void highwalls and floor at closure.

The highwall AMD hazard assessment has found that approximately 7% to 10% of the void highwall in all voids is estimated to be PAF, which includes material classified as UC(PAF), PAF-LC and NAF-S – and most of this is expected to be associated with coal seams. As such, the assessment has found that the overall likelihood of AMD generation from the void highwalls is **Unlikely**. The expression of AMD from coal seams in the highwalls of residual voids, if any, will most likely be localised.

On the highly conservative (if not overly conservative) assumption that the floor of each void is all coal, the void floor AMD hazard assessment has found that essentially all of the floor of each void is estimated to be 'PAF', which includes material classified as PAF, UC(PAF), PAF-LC and NAF-S. 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 of the seam, therefore very little coal would be expected to remain on the floor of the voids. The AMD hazard scoring tables for the residual voids are provided in **Attachment B – Tables B14 to B18**.

Table 20. Estimated wall rock exposure as a function of material type for each residual void

Component		Goonyella	Thiess	Broadmeadow -Isaac	Ramp 32 East	Ramp 32 South
Weathered, non-carbonaceous	%	10	44	26	34	23
Weathered, carbonaceous	%	1.3	3.2	0.8	3	2
Fresh, non-carbonaceous	%	71	38	61	53	63
Fresh, carbonaceous	%	5.5	3.7	1.5	5	6
Unknown OB/IB	%	2.1	1.9	4.0	-	-
Coal (fresh)	%	10	9.4	6.7	5	6
Coal seam groups *Proportion of seam group (% of highwall exposure)*		*GF: 5.9%* *GUS: 0.9%* *P: 0.7%* *GMS: 1.5%* *GLS: 1.1%*	*GF: n/a* *GUS: n/a* *P: n/a* *GMS: 5.2%* *GLS: 4.2%*	*GF: n/a* *GUS: 0.5%* *P: 2.2%* *GMS: 4.0%* *GLS: n/a*	*GF: n/a* *GUS: n/a* *P: n/a* *GMS: 2.5%* *GLS: 2.5%*	*GF: n/a* *GUS: n/a* *P: n/a* *GMS: 3%* *GLS: 3%*

7.2 Geochemical Source-Pathway-Risk Assessment

7.2.1 Conceptual Site Model and Conceptual Facility Models

Conceptual site model

A post-closure conceptual site model (CSM), which applies to the spoil landforms and their respective residual voids and the relationship these facilities have with surface water and groundwater in the district, has been produced by AECOM (2024) (**Figure 23)**. The CSM assists with the source-pathway-receptor (SPR) assessment with regard to potential environmental geochemical impacts from mineral waste facilities. The CSM, which focuses on the relationship with surface water and groundwater (these being the most relevant pathways and receptors for AMD and salinity), is used to illustrate the relationship between potential sources of run-off and seepage (e.g. spoil, tailings), plausible receptors (e.g. creeks, groundwater) and the pathways between the two (e.g. seepage, drainage).

Permian groundwater flow at GRBM is towards the east and largely follows the coal seams down-dip. Shallower groundwater that is likely associated with shallow permeable strata is likely to flow in a direction that broadly mimics surface topography. Groundwater modelling undertaken by AECOM (2024) shows that residual voids will be receptors of run-off and seepage from the spoil landforms and run-off from void highwalls, as illustrated in the CSM (**Figure 23**). However, the modelling also shows that ultimately all groundwater will report to Goonyella residual void. Thiess and Broadmeadow-Isaac residual void lakes have potential to be 'sources' for groundwater on its' path towards Goonyella residual void. Ramp 32 East and Ramp 32 South residual voids are expected to be weak groundwater sinks – largely drawing in groundwater from their immediate vicinity. Groundwater associated with the underground mining areas (including future mining at RHM) will report to Goonyella residual void. The residual voids are classified as non-use management areas (NUMAs).

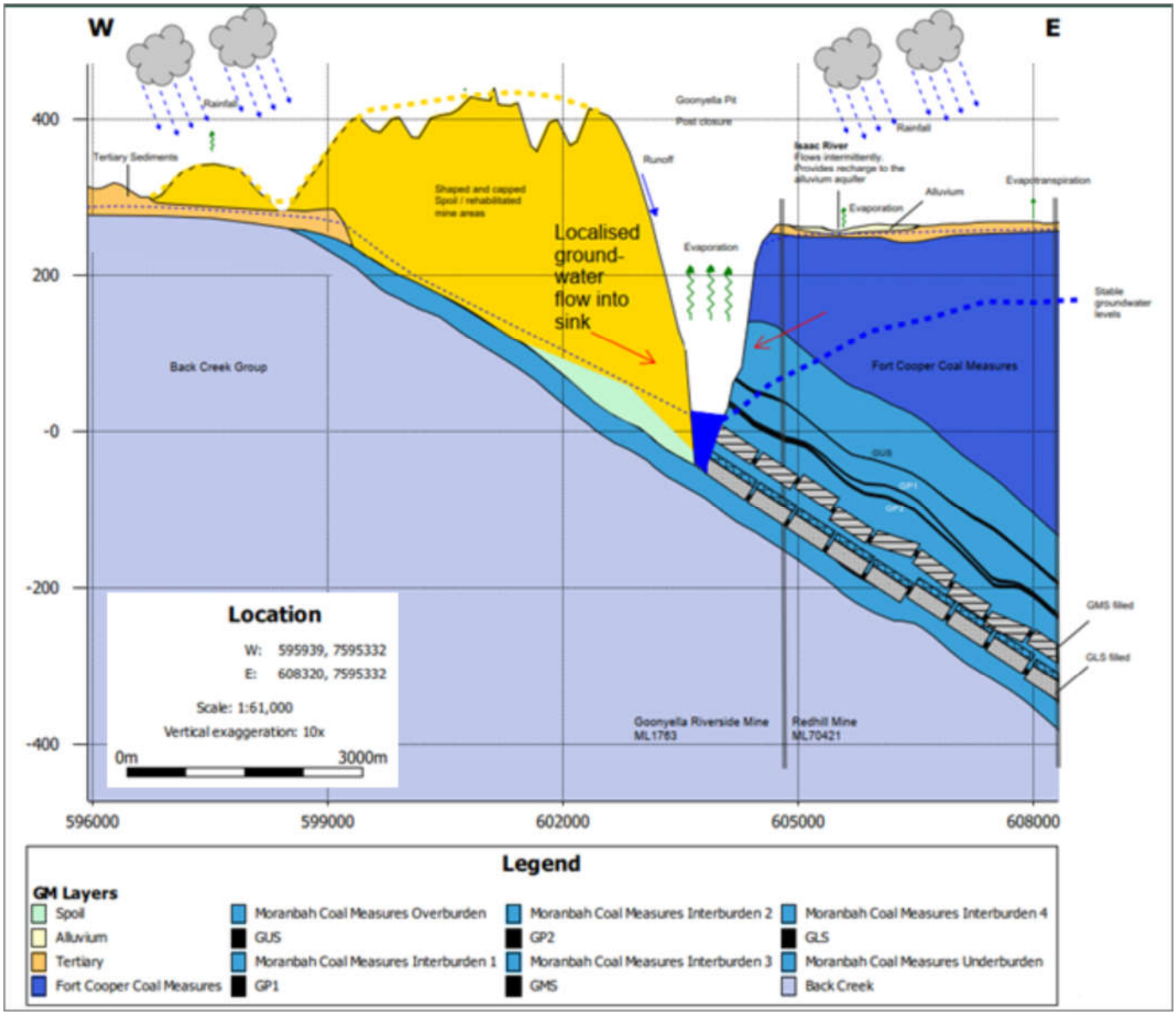


Figure 23. Source-Pathway-Receptor (SPR) conceptual site model post-closure
(AECOM, 2024)

The assessment indicates there may be shallow permeable strata present sporadically along (and/or near to) several creeks at GRBM and – where present – shallow groundwater is expected to be well below the base of all creeks in the area; suggesting that connectivity between shallow permeable strata and surface water features at GRBM is unlikely. Furthermore, modelling (including particle tracking) undertaken by AECOM (2024) found no evidence of connectivity between groundwater and surface water features. The model suggests that shallow

groundwater (and by extension shallow seepage) migrating through the site from the western side of the pit voids will be eventually report to the mine pits/voids [and, for most of the site, eventually reporting to Goonyella residual void]. The general downward migration of shallow groundwater (and seepage) into deeper groundwater and towards the residual voids is logical, given the very large drawdown (sink) of the voids – particularly Goonyella residual void.

The assessment of shallow groundwater at GRBM – particularly where shallow permeable strata may not be present in some areas, may be discontinuous and/or not interconnected – is limited by/to the distribution of the shallow bore network, which is sporadic. Therefore, despite the apparent low likelihood of substantial connection between shallow permeable strata and surface water features, the SPR assessment has adopted a *highly conservative approach* and assumed a plausible pathway *may* exist between shallow permeable strata and surface water features.

The Isaac River and adjacent wetlands are not plausible receptors of undiluted run-off and seepage from mineral waste landforms and seepage from residual voids due to lack of a connecting pathway.

Conceptual facility models

A conceptual facility model (CFM) has been developed for each TSF and rejects landform to illustrate potential run-off and seepage pathways and surface water and groundwater receptors associated with these key mineral waste facilities post-closure.

- GS1 TSF – prior to rehabilitation – has a Moderate-High AMD source hazard with the likelihood of AMD generation from the landform rated as Highly Likely – noting that AMD has already been observed from GS1 TSF. CFM shown at **Figure 24**;
- RS1 TSF – prior to rehabilitation. The western compartment has a Moderate AMD source hazard with the likelihood of AMD generation rated as Probable/Likely. The eastern compartment has a Moderate-High AMD source hazard with the likelihood of AMD generation rated as Highly Likely. CFM shown at **Figure 25** with Riverside rejects dump;
- DRE5 in-pit TSF within Thiess spoil landform – prior to rehabilitation – has a Moderate AMD source hazard with the likelihood of AMD generation from the landform rated as Probable/Likely. CFM shown at **Figure 26**;
- R22 in-pit rejects dump within Thiess spoil landform – prior to rehabilitation – has a Low-Moderate AMD source hazard with the likelihood of AMD generation from the landform rated as Unlikely. CFM shown at **Figure 27**.
- Ramp 32 in-pit TSF within Airstrip spoil landform – prior to rehabilitation – has a Moderate AMD source hazard with the likelihood of AMD generation from the landform rated as Probable/Likely. CFM shown at **Figure 28**;
- Riverside rejects dump – excluding the spoil cover – has a Moderate AMD source hazard with the likelihood of AMD generation from the landform rated as Probable/Likely. CFM shown at **Figure 25** with RS1 TSF;
- GS2 rejects dump – prior to rehabilitation – has a Low-Moderate AMD source hazard with the likelihood of AMD generation from the landform rated as Unlikely. CFM shown at **Figure 29**; and
- GS11 rejects dump – prior to rehabilitation – has a Low-Moderate AMD source hazard with the likelihood of AMD generation from the landform rated as Unlikely. CFM shown at **Figure 30**.

*Note: the intent of the simplified CFM illustrations shown as **Figures 24 to 30** is to conceptualise potential surface water run-off and seepage pathways between key landform domains and potential receptors. The CFM figures are not to scale and may not be a true representation of the system at each location.*

CFMs have not been developed for general rejects co-disposed (broadly distributed) throughout spoil dumps/ landforms, such as the small quantity of rejects currently disposed at Ramp 23 within Thiess spoil dump.

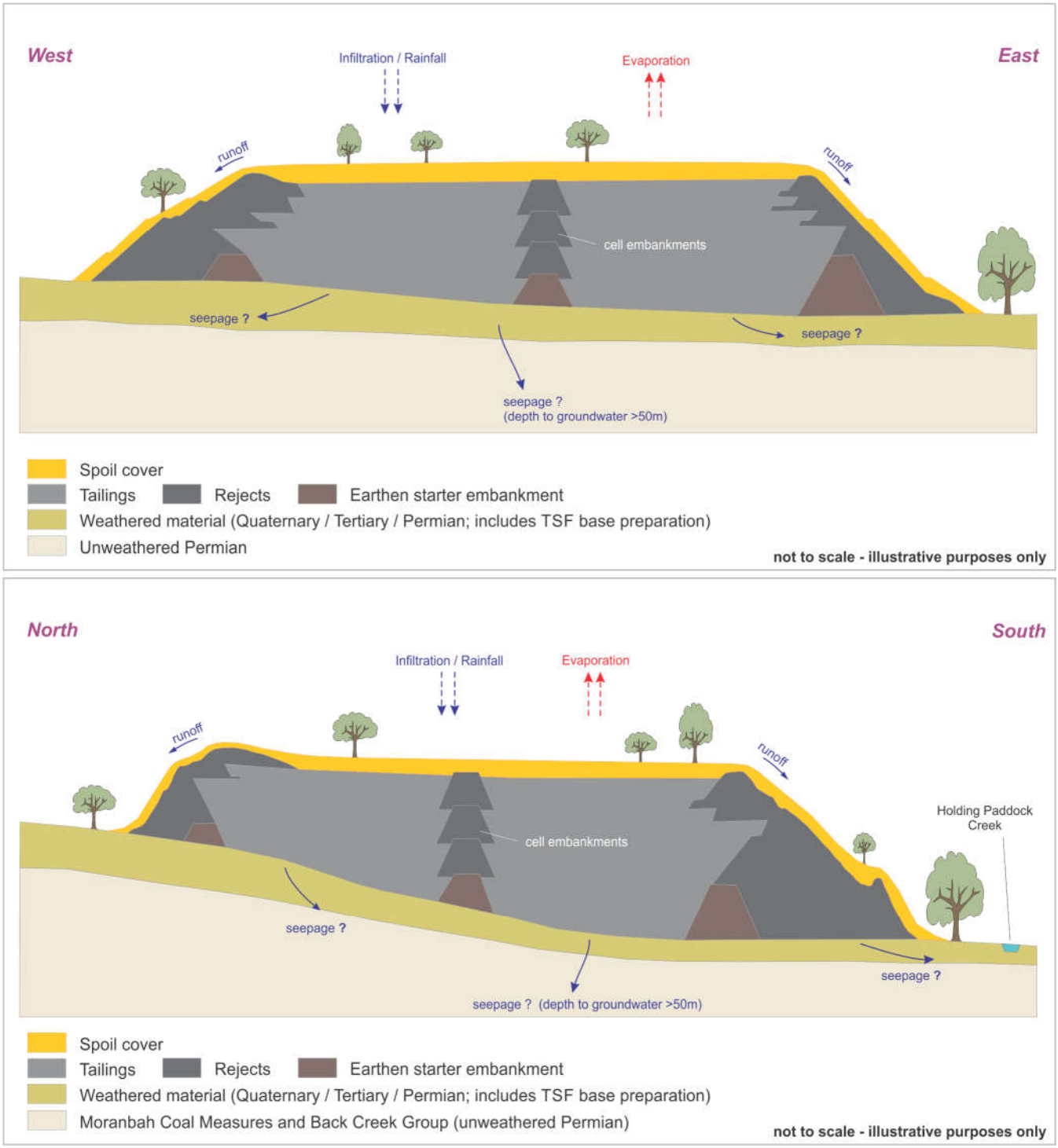
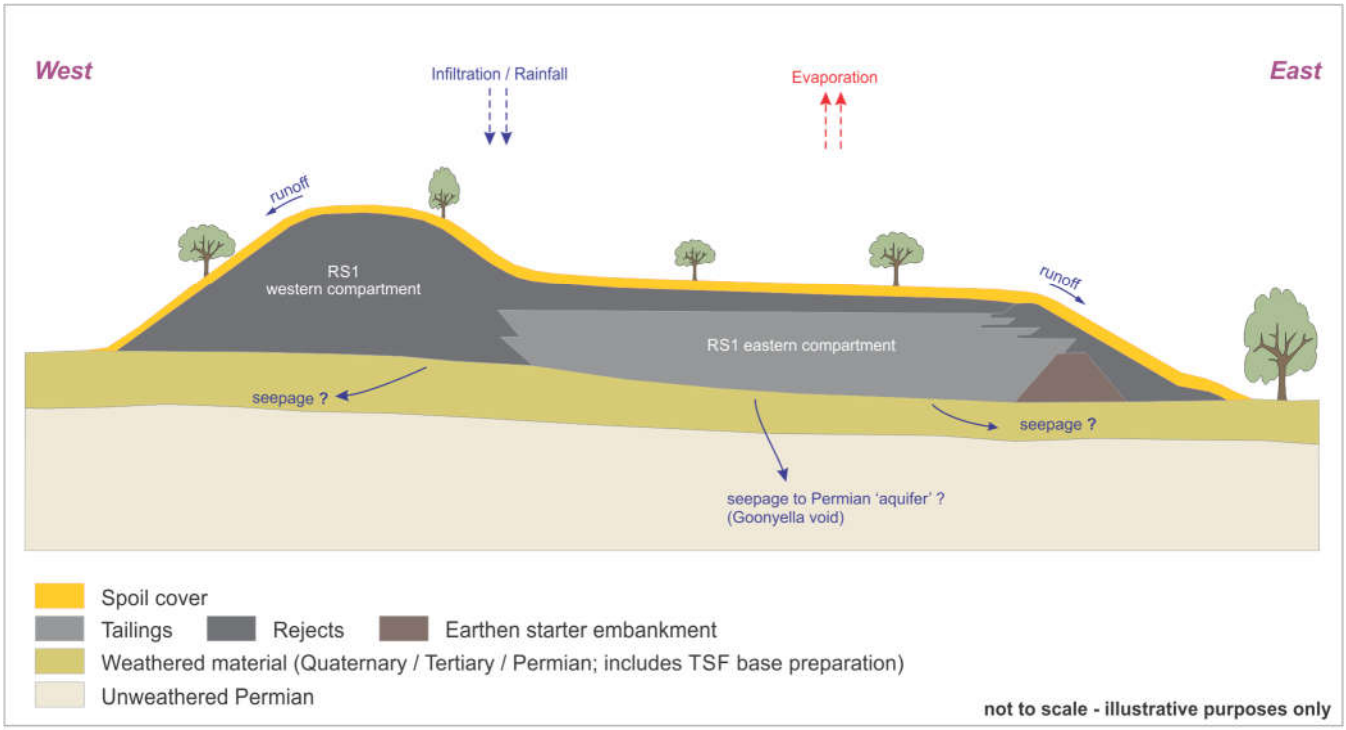


Figure 24. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for GS1 TSF landform



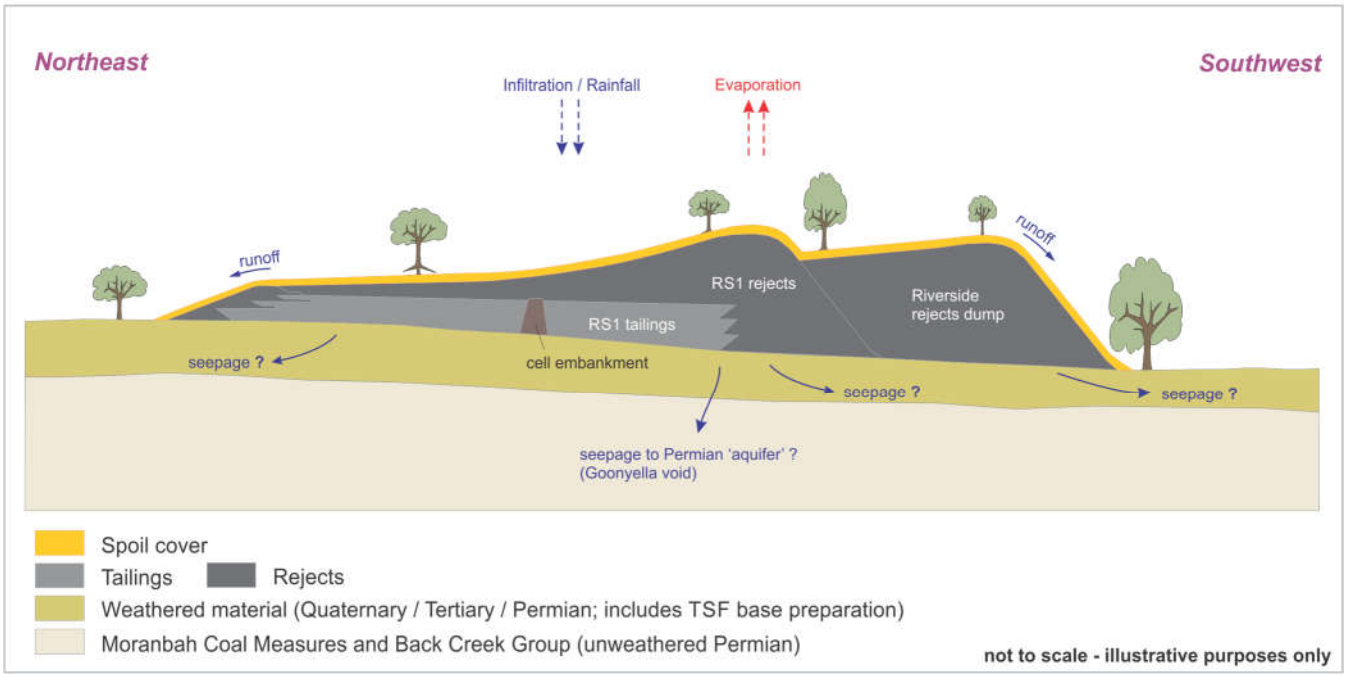


Figure 25. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for RS1 TSF landform and Riverside rejects landform

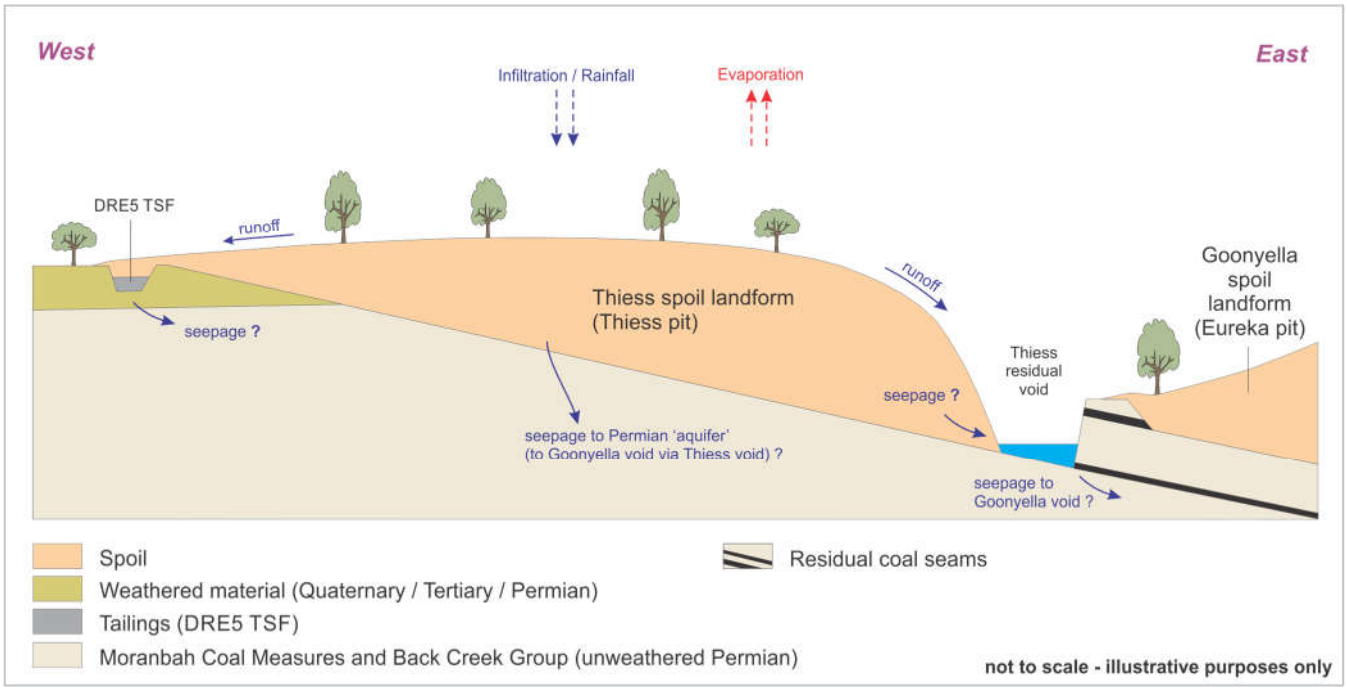


Figure 26. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for DRE5 in-pit TSF landform [within the Thiess spoil landform]

DRE5 in-pit TSF is a below-ground TSF within the footprint and pit shell of Thiess spoil landform and, as such, there are no plausible surface water receptors via run-off or via shallow permeable strata.

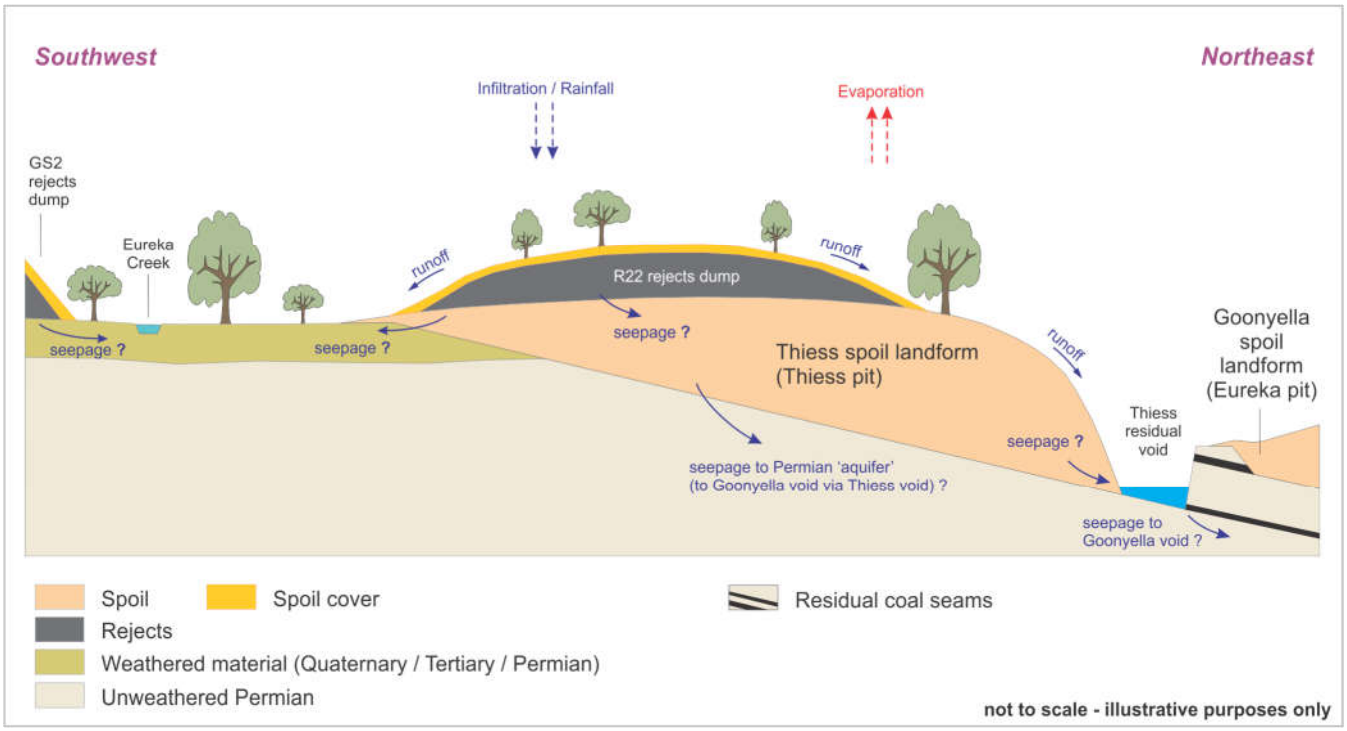


Figure 27. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for R22 in-pit rejects landform [within the southern end of Thiess spoil landform]

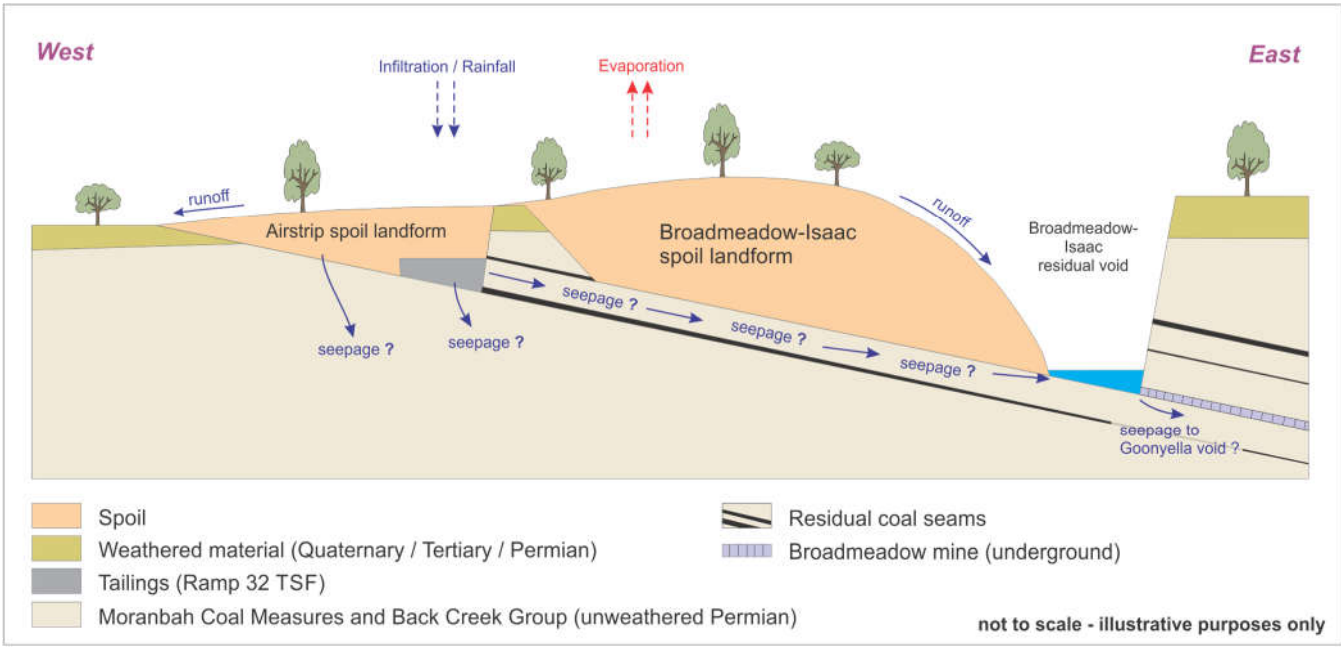


Figure 28. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for Ramp 32 in-pit TSF landform [within the Airstrip spoil landform]

Ramp 32 in-pit TSF is a below-ground TSF within the footprint and pit shell of Airstrip spoil landform and, as such, there are no plausible surface water receptors via run-off or via shallow permeable strata.

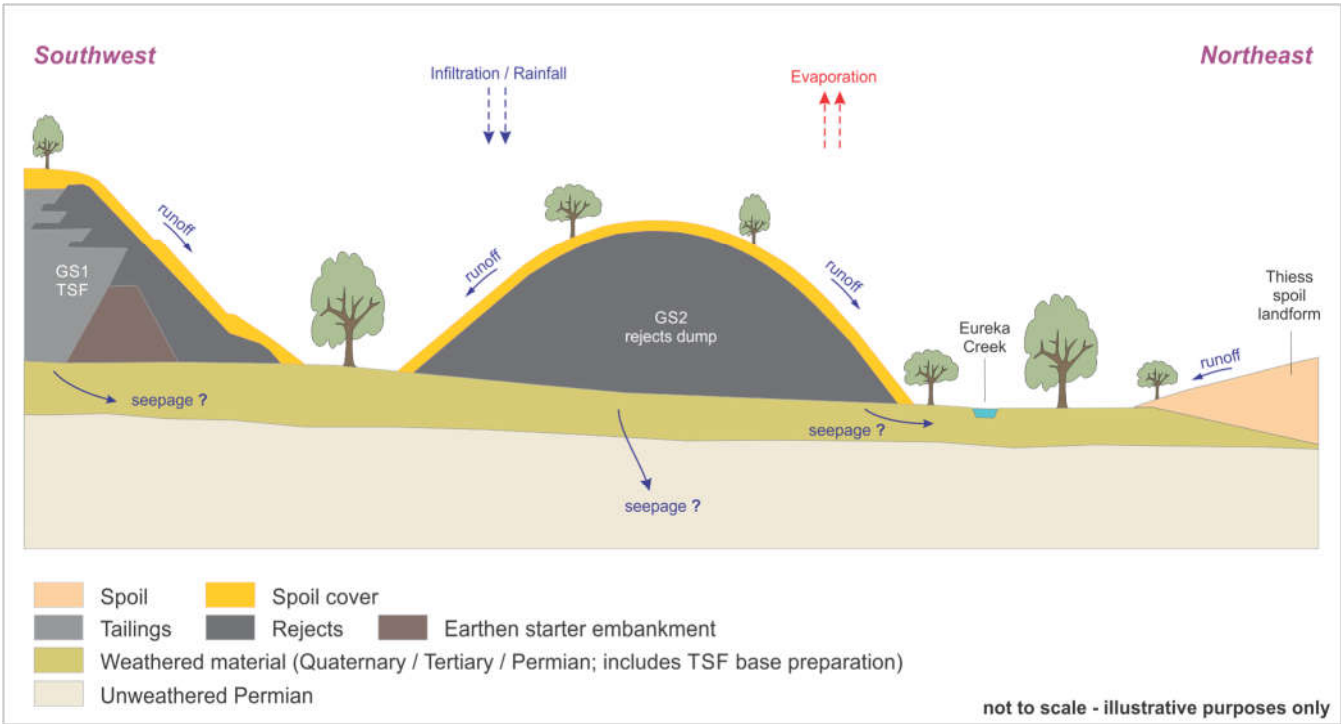


Figure 29. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for GS2 rejects landform

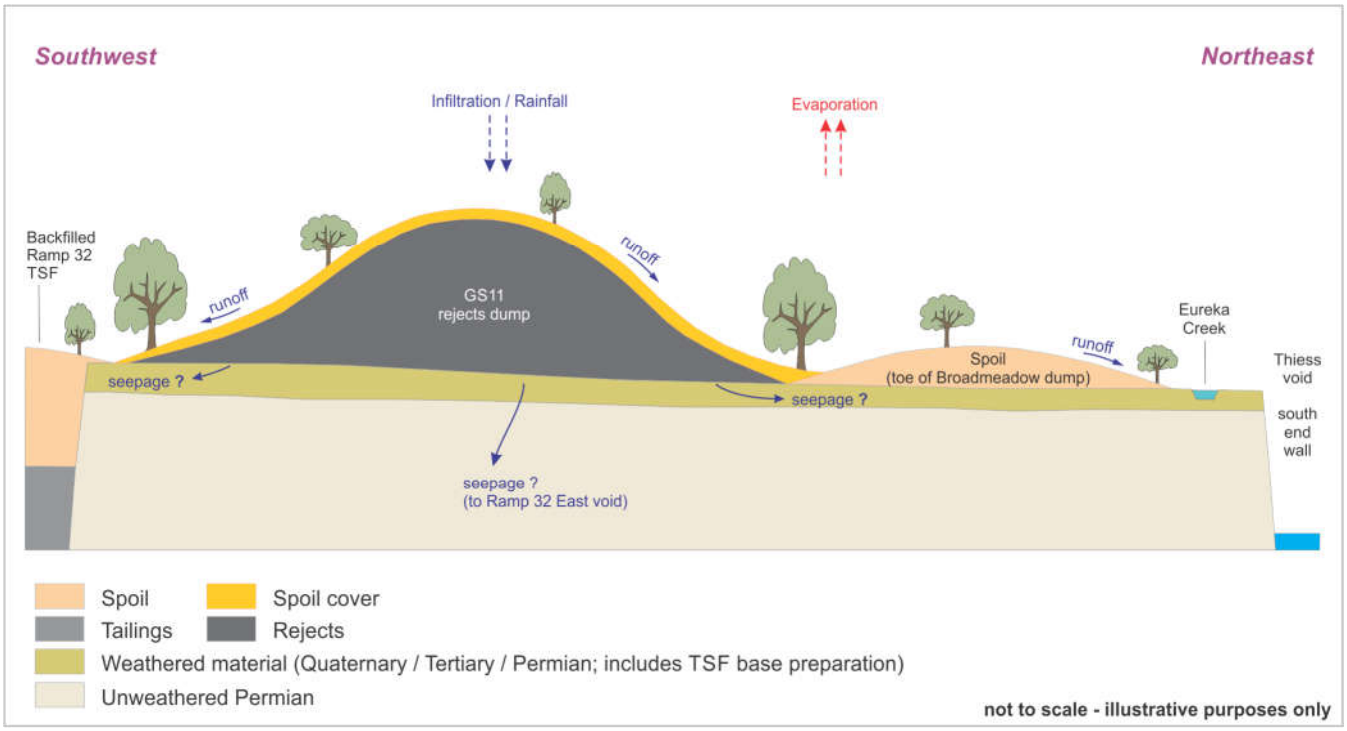


Figure 30. Post-closure Source-Pathway-Receptor (SPR) conceptual facility model (CFM) for GS11 rejects landform

With regard to the mineral waste facilities the plausible mechanisms for AMD affected water and/or non-oxidative salinity to report to receptors are identified in **Table 21** (spoil landforms), **Table 22** (TSF landforms) and **Table 23** (rejects landforms). With regard to void highwalls (as a potential source of AMD affected water and/or non-oxidative salinity), the only plausible receptor is the void, via surface water [run-off] from the highwall.

Table 21. Sources, potential receptors and potential pathways between the source and receptor (post-closure) for spoil landforms

Sources	Potential Pathways from Source	Potential Receptors from Source
Spoil landforms		
Goonyella	Surface water [run-off]	Goonyella Creek [+/- tributaries] (north) / Isaac River (south) / Eureka Creek (south) / Goonyella residual void
	Seepage [shallow permeable strata]	Goonyella Creek [+/- tributaries] (north) / Isaac River (south) / Eureka Creek (south)
	Seepage [groundwater 'aquifer']	Goonyella residual void
Thiess	Surface water [run-off]	Eureka Creek (west and south) / Thiess residual void
	Seepage [shallow permeable strata]	Eureka Creek (west and south)
	Seepage [groundwater 'aquifer']	Goonyella residual void via Thiess residual void
Airstrip	Surface water [run-off]	Holding Paddock Creek (west and southwest) / Ramp 32 East and South residual voids
	Seepage [shallow permeable strata]	Holding Paddock Creek (west and southwest)
	Seepage [groundwater 'aquifer']	Ramp 32 East and Ramp 32 South residual voids [+/-Broadmeadow-Isaac residual void]
Broadmeadow-Isaac	Surface water [run-off]	Eureka Creek (north) / Isaac River (south) / Ramp 32 East, Ramp 32 South and Broadmeadow-Isaac residual voids
	Seepage [shallow permeable strata]	Eureka Creek (north) / Isaac River (south)
	Seepage [groundwater 'aquifer']	Goonyella residual void via Broadmeadow-Isaac residual void

Table 22. Sources, potential receptors and potential pathways between the source and receptor (post-closure) for TSF landforms

Sources	Potential Pathways from Source	Potential Receptors from Source
TSF landforms		
GS1 TSF	Surface water [run-off]	Holding Paddock Creek (west and south) / Eureka Creek (north)
	Seepage [shallow permeable strata]	Holding Paddock Creek / Eureka Creek
	Seepage [groundwater 'aquifer']	*No plausible groundwater receptors (low-permeability aquitard; >50 m to groundwater)*
RS1 TSF	Surface water [run-off]	Eureka Creek [+/- tributaries] (west and south)
	Seepage [shallow permeable strata]	Eureka Creek [+/- tributaries] (west and south)
	Seepage [groundwater 'aquifer']	Goonyella residual void
DRE5 in-pit TSF	Surface water [run-off]	*No plausible receptors via surface water run-off (in-pit TSF below ground level within the pit shell)*
	Seepage [shallow permeable strata]	*No plausible receptors via shallow permeable strata (in-pit TSF below ground level within the pit shell)*
	Seepage [groundwater 'aquifer']	Goonyella residual void [+/- Thiess residual void]
Ramp 32 in-pit TSF	Surface water [run-off]	*No plausible receptors via surface water run-off (in-pit TSF below ground level within the pit shell)*
	Seepage [shallow permeable strata]	*No plausible receptors via shallow permeable strata (in-pit TSF below ground level within the pit shell)*
	Seepage [groundwater 'aquifer']	Ramp 32 East residual void

Table 23. Sources, potential receptors and potential pathways between the source and receptor (post-closure) for rejects landforms

Sources	Potential Pathways from Source	Potential Receptors from Source
Rejects landforms		
Riverside rejects dump	Surface water [run-off]	Eureka Creek [+/- tributaries]
	Seepage [shallow permeable strata]	Eureka Creek [+/- tributaries]
	Seepage [groundwater 'aquifer']	Goonyella residual void
GS2 rejects dump	Surface water [run-off]	Eureka Creek (east)
	Seepage [shallow permeable strata]	Eureka Creek (east)
	Seepage [groundwater 'aquifer']	*No plausible groundwater receptors (low-permeability aquitard; >50 m to groundwater)*
GS11 rejects dump	Surface water [run-off]	Eureka Creek (north) / Ramp 32 East residual void
	Seepage [shallow permeable strata]	Eureka Creek (north) / Ramp 32 East residual void / backfilled Airstrip pit (Ramp 32 TSF)
	Seepage [groundwater 'aquifer']	Ramp 32 East residual void
R22 in-pit rejects dump	Surface water [run-off]	Eureka Creek (west and south) / Thiess residual void
	Seepage [shallow permeable strata]	Eureka Creek (west and south)
	Seepage [groundwater 'aquifer']	Goonyella residual void via Thiess residual void

The BHP residual risk rating heat map (**Table 24**) has been adopted to assess the risks associated with SPR from the spoil, TSF and rejects 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 24. 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 ratings for the mineral waste landforms with respect to plausible surface water and void receptors is shown in **Attachment C** and report sections as follows:

Surface water receptors of landform sources

- Spoil landforms with respect to plausible surface water receptors: **Attachment C Tables C1 to C4** and discussed in **Section 7.2.2**;
- TSF and rejects landforms with respect to plausible surface water receptors: **Attachment C Tables C5 to C10** and discussed in **Sections 7.2.3** to **7.2.10**.

Residual void receptors of landform sources

Groundwater modelling (AECOM, 2024) has shown that Goonyella void – being very large and deep – will draw in seepage/groundwater from all pit/void areas at GRBM. That is, collectively, all residual voids at GRBM will be groundwater 'sinks'. As such, seepage into the Permian groundwater system from any/all facilities at GRBM will ultimately report into Goonyella residual void.

- Spoil landforms with respect to residual void receptors: **Attachment C Tables C11 and C12** and discussed in **Section 7.2.2**;
- TSF landforms with respect to residual void receptors: **Attachment C Table C13** and discussed in **Sections 7.2.3 to 7.2.6**;
- Rejects landforms with respect to residual void receptors: **Attachment C Table C14** and discussed in **Sections 0 to 7.2.10**.

Residual void receptors of highwalls and void floor sources

The risk ratings for the residual void highwall and floor (for each void) with respect to final void receptors is shown in **Attachment C Table C14** and discussed in **Section 7.2.11**. The potential impact of seepage from the residual voids into the Permian groundwater aquifer is discussed in the void closure plan (WSP, 2024).

7.2.2 Final spoil landforms

DRE5 in-pit TSF and Ramp 32 in-pit TSF are located within the 'footprint' of Thiess and Airstrip spoil landforms, respectively, and contain a concentration of tailings at the base of the spoil landforms. Similarly, R22 in-pit rejects dump is located within the 'footprint' of Thiess spoil landform, and contains a concentration of rejects at the

periphery of the spoil landform. As such, a conservative approach has been adopted and these two TSFs and R22 rejects dump are addressed as stand-alone facilities (as discussed in **Section 7.1.1**) and are not included as part of their respective spoil landforms for the purposes of the assessment.

Source materials hazard

Spoil landforms are predominantly comprised of non-carbonaceous overburden/interburden with coaly and carbonaceous material (predominantly in the form of carbonaceous spoil and reject) comprising a minor proportion – typically about 9% for most spoil landforms [and excluding rejects within R22 rejects dump at Thiess landform]. Non-carbonaceous overburden/interburden from Permian-age material in the Bowen Basin is widely recognised as posing a low to low-moderate AMD risk. Rejects generally pose a low-moderate to moderate AMD source hazard and comprise a very small proportion of each spoil landform (typically less than 1%).

Source materials generally have low to low-moderate EC values and are expected to produce slightly saline (potentially slightly to moderately saline) run-off and seepage, with release of (non-oxidative) salinity rated as a low to low-moderate hazard. Source materials generally have low to low-moderate total S values and generally excess ANC. The hazard for AMD generation for all spoil landforms is considered to be 'Low', with the likelihood for AMD generation from spoil landforms rated as 'Highly Unlikely'.

Pathways

Surface water

Surface water receptors (ephemeral creeks) are located adjacent to each spoil landform – typically less than 300m from some areas of each landform. It is plausible (highly likely) for surface water run-off from rehabilitated landforms to reach these creeks. Refer to **Figure 22** and **Table 21** for surface water receptors associated with each spoil landform.

Seepage / Groundwater

The water table is expected to intersect the deeper zones of each in-pit spoil landform within the Permian coal measures (AECOM, 2024). However – with the exception of Ramp 32 East and South residual voids – all groundwater on site is ultimately captured by the Goonyella residual void (as a large groundwater sink). Therefore, although a direct connection is expected to exist between deeper parts of the final landforms and groundwater (the water table), this groundwater will ultimately report to the Goonyella residual void – not to the broader aquifer beyond the site. Ramp 32 East and South residual voids are weak groundwater sinks for groundwater in their immediate vicinity only.

As discussed in **Section 7.2.1** it is plausible for seepage from the near-surface and unsaturated zone of the in-pit spoil landforms to migrate downwards into the water table. It is also plausible that seepage may occur into discontinuous shallow permeable strata locally associated with existing creeks or palaeodrainage channels. Due to the highly discontinuous and/or not interconnected nature of shallow permeable strata at GRBM, the understanding surrounding any potential link between shallow groundwater and surface water is limited. As such, whether seepage into shallow permeable strata would continue further downwards into deeper groundwater (primary aquifer) or, instead, report to nearby surface water features, is also somewhat unclear. Despite this potential limitation, the overall groundwater gradient at GRBM is downwards and towards (into) Goonyella residual void (potentially via the nearest residual void associated with each spoil landform). Therefore, it is reasonably assumed that the likelihood of seepage from spoil landforms reaching a surface water receptor via shallow groundwater is 'Unlikely'.

In summary, the SPR has assumed a plausible (although unlikely) local seepage pathway *may* exist between a spoil landform via shallow permeable strata into a nearby surface water receptor (ephemeral creek).

Refer to **Attachment C Tables C1 to C4** for conceptual shallow seepage pathways and nearby surface water receptors associated with the spoil landforms and **Attachment C Tables C11 and C12** for groundwater pathways from spoil landforms to the residual voids.

Receptors

Plausible receptors identified in this qualitative assessment include ephemeral creeks and residual voids. Refer to **Attachment C – Tables C1 to C4** for surface water receptors associated with each spoil landform and **Attachment C – Tables C11 and C12** for residual void receptors associated with the spoil landforms.

Due to the geochemical nature of the spoil landforms, the likelihood of AMD from spoil landforms to impact on the water quality of surface water receptors and on the water quality of residual voids has been rated unlikely. The likelihood of non-oxidative salinity from spoil landforms to impact on the water quality of surface water receptors (via surface water run-off) has been rated unlikely, and the severity should it occur is low, hence the risk rating is low.

Consideration was also made to people living in the homesteads near the project area. Homesteads within 2 km of GRBM are located in surface water sub-catchments that do not receive drainage from GRBM and/or are upstream (via surface water) from GRBM and/or upgradient (via groundwater) from GRBM. As such, all of these homesteads are implausible receptors of AMD or saline drainage from the final spoil landforms.

SPR risk rating of final spoil landforms

There are plausible surface water and residual void receptors; and the run-off and seepage pathways linking the sources (final spoil landforms) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from final spoil landforms is **Low**. With respect to non-oxidative salinity the overall SPR risk from final spoil landforms is also rated as **Low**. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) spoil landforms to impact on the water quality of the residual voids has been rated 'Unlikely'.

7.2.3 GS1 TSF landform

Source materials hazard

Excluding the final cover/cap to be installed over GS1 TSF, the TSF landform is currently comprised of approximately 95% tailings, with the remainder being rejects (about 5%, as embankment material). It is assumed the TSF may contain up to 0.5% fill material (predominantly within or close to embankments). Tailings within the unrehabilitated TSF pose a moderate-high AMD hazard and rejects (embankments) pose a moderate AMD hazard.

Source materials generally have low-moderate EC values and are expected to produce slightly saline run-off and seepage, with release of (non-oxidative) salinity rated as a low hazard. Overall, the hazard for AMD generation from the current GS1 TSF landform is 'Moderate-High' and the likelihood for AMD generation from the current landform is rated as 'Highly Likely' (the highest 'likelihood' rating available under the applied AMD hazard scoring methodology) – noting that field evidence of AMD (as AD) exists at the facility.

Pathways

Pathways from GS1 TSF landform to plausible receptors are shown in **Figure 22** (post-closure landform), **Figure 24** (CFM for GS1 TSF landform), **Table 22** and **Attachment C Table C5**. There are no plausible groundwater receptors (e.g. residual voids) from GS1 TSF.

<u>Surface water</u>

All surface water receptors are ephemeral. Holding Paddock Creek is located less than 100 m south of the TSF landform and Eureka Creek is located approximately 500 m northeast of the TSF landform. It is likely that surface water run-off from the TSF landform will reach these creek tributaries – particularly Holding Paddock Creek. The TSF will be covered by a spoil cover to manage the AMD source hazard, therefore all post-closure run-off from the TSF landform will be from general spoil (overburden/interburden) material and no tailings or rejects will be exposed to (or at risk of) surface water run-off.

<u>Seepage / Groundwater</u>

As discussed earlier, this assessment has conservatively assumed it is plausible that seepage may occur into discontinuous shallow permeable strata associated with existing creeks or palaeodrainage channels. Whether seepage into shallow permeable strata would continue further downwards into the deeper (primary) aquifer or,

instead, report through the shallow permeable strata into nearby surface water features (in this case, Holding Paddock Creek and Eureka Creek), is somewhat unclear. Despite this potential limitation, the overall seepage gradient at GRBM is downwards and towards the residual voids – including from areas outside of a pit shell, such as GS1 TSF.

Groundwater modelling (AECOM, 2024) shows the water table to be greater than 50 m below ground level at GS1 TSF (at closure), with low-permeability sediments forming an aquitard between the TSF and the nearest aquifer. However, due to the close proximity of Holding Paddock Creek to the above-ground TSF landform, it is reasonably assumed that the likelihood of seepage from GS1 TSF landform (post-closure) reaching a surface water receptor (particularly, Holding Paddock Creek) via shallow groundwater is 'Probable'.

In summary, the SPR has assumed a plausible (probable) local seepage pathway *may* exist between GS1 TSF landform via shallow permeable strata into nearby Holding Paddock Creek and a plausible (unlikely) local seepage pathway *may* exist between GS1 TSF landform via shallow permeable strata into Eureka Creek.

Receptors

Plausible receptors of surface water run-off and seepage from GS1 TSF landform are shown in **Figure 22** (Post-closure landform), **Figure 24** (CFM for GS1 TSF landform), **Table 22** and **Attachment C Table C5**. There are no plausible groundwater receptors from GS1 TSF.

Surface water

The only plausible surface water receptors identified in this qualitative assessment of GS1 TSF landform are two ephemeral creeks: Holding Paddock Creek located less than 100 m south of the TSF and Eureka Creek located approximately 500 m northeast of the TSF. This applies to potential surface water run-off and potential seepage through shallow permeable strata into the surface water receptor(s).

The rehabilitated TSF landform will have a spoil cover designed to manage the AMD hazard of the landform. The spoil cover has been assumed to pose a low AMD source hazard, based on the conservative AMD source hazard applied to general spoil. As such, the likelihood of AMD from the rehabilitated (post-closure) TSF landform to impact on the water quality of the surface water receptor(s) (via run-off or shallow seepage) has been rated unlikely. The likelihood of non-oxidative salinity from the TSF landform to impact on the water quality of the surface water receptor(s) has also been rated unlikely.

Seepage / Groundwater

Groundwater modelling (AECOM, 2024) indicates there are no plausible groundwater receptors from GS1 TSF post-closure landform due to the significant depth to the water table below the TSF (>50 m) and the significant thickness of low-permeability sediments forming an aquitard.

SPR risk rating of GS1 TSF landform

There are plausible surface water receptors located very close to GS1 TSF; and the run-off and seepage pathways linking the source (GS1 TSF landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure TSF landform is **Low** to **Medium**. The 'Low-Medium' risk rating applies to AMD associated with seepage via shallow permeable strata into Holding Paddock Creek, located less than 100 m from the TSF. The likelihood of AMD reaching Holding Paddock Creek is unlikely, however the severity of the event, should it occur, has been rated as moderate (S3). With respect to non-oxidative salinity the overall SPR risk from the post-closure TSF landform is rated as **Low**.

7.2.4 RS1 TSF landform

Source materials hazard

Excluding the final cover/cap to be installed over RS1 TSF, the TSF landform is currently comprised of approximately 85% tailings (located in the eastern compartment) and 15% rejects (predominantly located in the western compartment). It is assumed the eastern compartment may contain up to 0.5% fill material (predominantly within or close to embankments). Tailings within the unrehabilitated TSF pose a moderate-high AMD hazard and rejects pose a moderate AMD hazard.

Source materials generally have low-moderate EC values and are expected to produce slightly saline run-off and seepage, with release of (non-oxidative) salinity rated as a low hazard. Overall, the hazard for AMD generation from the current RS1 TSF landform is 'Moderate-High' and the likelihood for AMD generation from the current landform is rated as 'Highly Likely' (the highest 'likelihood' rating available under the applied AMD hazard scoring methodology) – noting that field evidence of AMD (as AD) exists at the facility.

Pathways

Pathways from RS1 TSF landform to plausible surface water and groundwater receptors are shown in **Figure 22** (Post-closure landform), **Figure 25** (CFM for RS1 TSF landform), **Table 22** and **Attachment C Tables C6 and C13**.

Surface water

Eureka Creek, an ephemeral creek, is located over 1 km south of the TSF landform with the closest tributary located approximately 800 m west-southwest of RS1 TSF. The TSF will be covered by a spoil cover to manage the AMD source hazard, therefore all post-closure run-off from the TSF landform will be from general spoil (overburden/interburden) material and no tailings will be exposed to (or at risk of) surface water run-off.

Seepage / Groundwater

As discussed earlier, this assessment has conservatively assumed it is plausible that seepage may occur into discontinuous shallow permeable strata associated with existing creeks or palaeodrainage channels. Whether seepage into shallow permeable strata would continue further downwards into the deeper (primary) aquifer or, instead, report through the shallow permeable strata into nearby surface water features (in this case, tributaries of Eureka Creek), is somewhat unclear. Despite this potential limitation, the overall seepage gradient at GRBM is downwards and towards Goonyella residual void – including from areas outside of a pit shell, such as RS1 TSF.

Groundwater modelling (AECOM, 2024) shows that seepage from RS1 TSF landform would report to Goonyella residual void. Therefore, it is reasonably assumed that the likelihood of seepage from RS1 TSF landform reaching a surface water receptor (approximately 800 m from the TSF) via shallow seepage is 'Highly Unlikely'.

In summary, the SPR has assumed a plausible (although unlikely) local seepage pathway *may* exist between RS1 TSF landform via shallow permeable strata into nearby surface water receptors (tributaries of Eureka Creek).

Receptors

Plausible receptors of surface water run-off and seepage from RS1 TSF landform are shown in **Figure 22** (Post-closure landform), **Figure 25** (CFM for RS1 TSF landform), **Table 22** and **Attachment C Tables C6 and C13**.

Surface water

The only plausible surface water receptor identified in this qualitative assessment of RS1 TSF landform is the ephemeral Eureka Creek, with the closest tributarily located approximately 800 m west-southwest of the TSF landform. This applies to potential surface water run-off and potential seepage through shallow permeable strata into the surface water receptor(s).

The rehabilitated TSF landform will have a spoil cover designed to manage the AMD hazard of the landform. The spoil cover has been assumed to pose a low AMD source hazard, based on the conservative AMD source hazard applied to general spoil. As such, the likelihood of AMD from the rehabilitated (post-closure) TSF landform to impact on the water quality of Eureka Creek (via run-off or shallow seepage) has been rated 'Highly Unlikely'. The likelihood of non-oxidative salinity from the TSF landform to impact on the water quality of Eureka Creek has been rated 'Highly Unlikely'.

Seepage / Groundwater

Groundwater modelling (AECOM, 2024) shows that seepage from RS1 TSF landform into groundwater will ultimately report to Goonyella residual void.

SPR risk rating of RS1 TSF landform

There are plausible surface water and residual void receptors; and the run-off and seepage pathways linking the source (RS1 TSF landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure TSF landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure TSF landform is also rated as **Low**. The likelihood of AMD reaching any of the receptors was rated as 'Highly Unlikely' (due to the significant distance from the TSF to the nearest receptor [Eureka Creek]) however the severity of AMD impacting the water quality of Eureka Creek via a shallow permeable pathway, should it occur, has been rated as moderate (S3). The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) TSF landform to impact on the water quality of Goonyella residual void has been rated 'Unlikely'.

7.2.5 Ramp 32 in-pit TSF landform

Source materials hazard

Excluding the spoil cover to be installed over Ramp 32 in-pit TSF, the TSF landform is currently comprised entirely of tailings, which pose a moderate AMD hazard.

The tailings generally have moderate EC values and are expected to produce moderately saline run-off and seepage, with release of (non-oxidative) salinity rated as a moderate hazard. Overall, the hazard for AMD generation from the current Ramp 32 in-pit TSF landform is 'Moderate' and the likelihood for AMD generation from the current landform is rated as 'Probable / Likely'.

Pathways

Ramp 32 in-pit TSF (i.e. below ground level) will be backfilled with spoil and will reside within the Airstrip spoil landform. As such, there are no plausible surface water receptors from the TSF via surface water run-off or via shallow permeable strata. All post-closure run-off from the backfilled pit (TSF) will be from general spoil (overburden/interburden) material and no tailings will be exposed to (or at risk of) surface water run-off.

Groundwater modelling (AECOM, 2024) suggests that seepage from Ramp 32 in-pit TSF would likely report to Ramp 32 East and Ramp 32 South residual voids. Pathways from Ramp 32 in-pit TSF landform to plausible groundwater (residual void) receptors are shown in **Figure 28** (CFM for Ramp 32 in-pit TSF landform), **Table 22** and **Attachment C Table C13**.

Receptors

Groundwater modelling (AECOM, 2024) suggests that seepage from Ramp 32 in-pit TSF landform into groundwater will ultimately report to Ramp 32 East and Ramp 32 South residual voids.

SPR risk rating of Ramp 32 in-pit TSF landform

There are plausible residual void receptors, and the seepage pathways linking the source (Ramp 32 in-pit TSF landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure TSF landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure TSF landform is also rated as **Low**. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) TSF landform to impact on the water quality of these two residual voids has been rated 'Unlikely'.

7.2.6 DRE5 in-pit TSF landform

Source materials hazard

Excluding the spoil cover to be installed over DRE5 in-pit TSF, the TSF landform is currently comprised entirely of tailings, which pose a moderate AMD hazard.

The tailings generally have moderate EC values and are expected to produce moderately saline run-off and seepage, with release of (non-oxidative) salinity rated as a moderate hazard. Overall, the hazard for AMD generation from the current DRE5 in-pit TSF landform is 'Moderate' and the likelihood for AMD generation from the current landform is rated as 'Probable / Likely'.

Pathways

DRE5 in-pit TSF (i.e. below ground level) will be backfilled/covered with spoil and will reside within the Thiess spoil landform. As such, there are no plausible surface water receptors from the TSF via surface water run-off or via shallow permeable strata. All post-closure run-off from the backfilled pit (TSF) will be from general spoil (overburden/interburden) material and no tailings will be exposed to (or at risk of) surface water run-off.

Groundwater modelling (AECOM, 2024) suggests that seepage from DRE5 in-pit TSF would likely report to Goonyella residual void, potentially via Thiess residual void. Pathways from DRE5 in-pit TSF landform to plausible groundwater (residual void) receptors are shown in **Figure 26** (CFM for DRE5 in-pit TSF landform), **Table 22** and **Attachment C Table C13**.

Receptors

Groundwater modelling (AECOM, 2024) suggests that seepage from DRE5 in-pit TSF landform into groundwater will ultimately report to Goonyella residual void, likely via Thiess residual void.

SPR risk rating of DRE5 in-pit TSF landform

There are plausible residual void receptors, and the seepage pathways linking the source (DRE5 in-pit TSF landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure TSF landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure TSF landform is also rated as **Low**. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) TSF landform to impact on the water quality of these two residual voids has been rated ‘Unlikely’.

7.2.7 Riverside rejects landform

Source materials hazard

Riverside rejects landform underwent some rehabilitation in the early 2000s and further rehabilitation activities are scheduled to achieve the PMLU. Excluding the spoil cover, the rejects landform is comprised almost entirely of rejects, which pose a moderate AMD hazard.

The rejects generally have low to low-moderate EC values and are expected to produce slightly saline run-off and seepage, with release of (non-oxidative) salinity rated as a low to low-moderate hazard. Overall, the hazard for AMD generation from the current Riverside rejects dump is ‘Moderate’ and the likelihood for AMD generation from the current landform is rated as ‘Probable / Likely’.

Pathways

Pathways from Riverside rejects landform to plausible surface water and groundwater receptors are shown in **Figure 22** (Post-closure landform), **Figure 25** (CFM for Riverside rejects and RS1 TSF landforms), **Table 23** and **Attachment C Tables C7 and C14**.

<u>Surface water</u>

Eureka Creek, an ephemeral creek, is located over 1 km south of the rejects landform with the closest tributary located approximately 350 m south of the landform. The rejects landform is already rehabilitated and covered by a spoil cover, which will be augmented if/as required to manage the AMD source hazard. Therefore, all post-closure run-off from the rejects landform will be from general spoil (overburden/interburden) material and no rejects will be exposed to (or at risk of) surface water run-off.

<u>Seepage / Groundwater</u>

As discussed earlier, this assessment has conservatively assumed it is plausible that seepage may occur into discontinuous shallow permeable strata associated with existing creeks or palaeodrainage channels. Whether seepage into shallow permeable strata would continue further downwards into the deeper (primary) aquifer or, instead, report through the shallow permeable strata into nearby surface water features (in this case, tributaries of Eureka Creek), is somewhat unclear. Despite this potential limitation, the overall seepage gradient at GRBM is

downwards and towards Goonyella residual void – including from areas outside of a pit shell, such as Riverside rejects dump.

Groundwater modelling (AECOM, 2024) shows that seepage from Riverside rejects landform would report to Goonyella residual void. Therefore, it is reasonably assumed that the likelihood of seepage from the rejects landform reaching a surface water receptor (approximately 350 m from the landform) via shallow seepage is 'Unlikely'.

In summary, the SPR has assumed a plausible (although unlikely) local seepage pathway *may* exist between Riverside rejects landform via shallow permeable strata into nearby surface water receptors (tributary of Eureka Creek).

Receptors

Plausible receptors of surface water run-off and seepage from Riverside rejects landform are shown in **Figure 22** (Post-closure landform), **Figure 25** (CFM for Riverside rejects and RS1 TSF landforms), **Table 23** and **Attachment C Tables C7 and C14**.

Surface water

The only plausible surface water receptor identified in this qualitative assessment of Riverside rejects landform is the ephemeral Eureka Creek, with the closest tributarily located approximately 350 m south of the rejects landform. This applies to potential surface water run-off and potential seepage through shallow permeable strata into the surface water receptor(s).

The rejects landform is already rehabilitated and covered by a spoil cover, which may be subject to additional rehabilitation to manage the AMD hazard of the landform. The spoil cover has been assumed to pose a low AMD source hazard, based on the conservative AMD source hazard applied to general spoil. As such, the likelihood of AMD from the rehabilitated (post-closure) rejects landform to impact on the water quality of Eureka Creek (via run-off or shallow seepage) has been rated 'Unlikely'. The likelihood of non-oxidative salinity from the rejects landform to impact on the water quality of Eureka Creek has been rated 'Unlikely'.

Seepage / Groundwater

Groundwater modelling (AECOM, 2024) shows that seepage from Riverside rejects landform into groundwater will ultimately report to Goonyella residual void.

SPR risk rating of Riverside rejects landform

There are plausible surface water and residual void receptors; and the run-off and seepage pathways linking the source (Riverside rejects landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure rejects landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects landform is also rated as **Low**. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) rejects landform to impact on the water quality of Goonyella residual void has been rated 'Unlikely'.

7.2.8 GS2 rejects landform

Source materials hazard

Excluding the spoil cover to be installed over GS2 rejects dump, the rejects landform is comprised almost entirely of rejects, which pose a low-moderate AMD hazard.

The rejects generally have low EC values and are expected to produce low- to slightly saline run-off and seepage, with release of (non-oxidative) salinity rated as a low hazard. Overall, the hazard for AMD generation from the current GS2 rejects landform is 'low-Moderate' and the likelihood for AMD generation from the current landform is rated as 'Unlikely'.

Pathways

Pathways from GS2 rejects landform to plausible receptors are shown in **Figure 22** (Post-closure landform), **Figure 29** (CFM for GS2 rejects landform), **Table 23** and **Attachment C Table C8**. There are no plausible groundwater receptors (e.g. residual voids) from GS2 rejects dump.

Surface water

Eureka Creek, an ephemeral creek, is located less than 150 m east of the rejects landform. It is likely that surface water run-off from the rejects landform will reach this creek. The rejects dump will be covered by a spoil cover to manage the AMD source hazard, therefore all post-closure run-off from the rejects landform will be from general spoil (overburden/interburden) material and no rejects will be exposed to (or at risk of) surface water run-off.

Seepage / Groundwater

As discussed earlier, this assessment has conservatively assumed it is plausible that seepage may occur into discontinuous shallow permeable strata associated with existing creeks or palaeodrainage channels. Whether seepage into shallow permeable strata would continue further downwards into the deeper (primary) aquifer or, instead, report through the shallow permeable strata into nearby surface water features (in this case, Eureka Creek), is somewhat unclear. Despite this potential limitation, the overall seepage gradient at GRBM is downwards and towards the residual voids – including from areas outside of a pit shell, such as GS2 rejects dump.

Groundwater modelling (AECOM, 2024) shows the water table to be greater than 50 m below ground level at GS2 rejects dump (at closure), with low-permeability sediments forming an aquitard between the rejects dump and the nearest aquifer. However, due to the close proximity of Eureka Creek to the above-ground rejects landform, it is reasonably assumed that the likelihood of seepage from GS2 rejects landform (post-closure) reaching Eureka Creek via shallow groundwater is 'Probable'.

In summary, the SPR has assumed a plausible (probable) local seepage pathway *may* exist between GS2 rejects landform via shallow permeable strata into nearby Eureka Creek.

Receptors

Plausible receptors of surface water run-off and seepage from GS2 rejects landform are shown in **Figure 22** (Post-closure landform), **Figure 29** (CFM for GS2 rejects landform), **Table 23** and **Attachment C Table C8**. There are no plausible groundwater receptors from GS2 rejects landform (post-closure).

Surface water

The only plausible surface water receptor identified in this qualitative assessment of GS2 rejects landform is Eureka Creek located less than 150 m east of the facility. This applies to potential surface water run-off and potential seepage through shallow permeable strata into Eureka Creek.

The rehabilitated rejects landform will have a spoil cover designed to manage the AMD hazard of the landform. The spoil cover has been assumed to pose a low AMD source hazard, based on the conservative AMD source hazard applied to general spoil. As such, the likelihood of AMD from the rehabilitated (post-closure) rejects landform to impact on the water quality of Eureka Creek (via run-off or shallow seepage) has been rated unlikely. The likelihood of non-oxidative salinity from the rejects landform to impact on the water quality of Eureka Creek has also been rated unlikely.

Seepage / Groundwater

Groundwater modelling (AECOM, 2024) indicates there are no plausible groundwater receptors from GS2 rejects post-closure landform due to the significant depth to the water table below the facility (>50 m) and the significant thickness of low-permeability sediments forming an aquitard.

SPR risk rating of GS2 rejects landform

Eureka Creek is located very close to the facility; and the run-off and seepage pathways linking the source (GS2 rejects landform) to Eureka Creek have been identified. With respect to AMD, the overall SPR risk rating from the post-closure rejects landform is **Low**. The likelihood of seepage reaching nearby Eureka Creek is considered

probable, however the severity of the event, should it occur, is low. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects landform is also rated as **Low**.

7.2.9 GS11 rejects landform

Source materials hazard

Excluding the spoil cover to be installed over GS11 rejects dump, the rejects landform is comprised almost entirely of rejects, which pose a low-moderate AMD hazard.

The rejects generally have low EC values and are expected to produce low- to slightly saline run-off and seepage, with release of (non-oxidative) salinity rated as a low hazard. Overall, the hazard for AMD generation from the current GS11 rejects landform is 'low-Moderate' and the likelihood for AMD generation from the current landform is rated as 'Unlikely'.

Pathways

Pathways from GS11 rejects landform to plausible receptors are shown in **Figure 22** (Post-closure landform), **Figure 30** (CFM for GS11 rejects landform), **Table 23** and **Attachment C Tables C9 and C14**.

Surface water

Eureka Creek, an ephemeral creek, is located approximately 400 m north of the rejects landform. It is plausible (although unlikely) that surface water run-off from the rejects landform could reach this creek. The rejects dump will be covered by a spoil cover to manage the AMD source hazard, therefore all post-closure run-off from the rejects landform will be from general spoil (overburden/interburden) material and no rejects will be exposed to (or at risk of) surface water run-off.

Seepage / Groundwater

As discussed earlier, this assessment has conservatively assumed it is plausible that seepage may occur into discontinuous shallow permeable strata associated with existing creeks or palaeodrainage channels. Whether seepage into shallow permeable strata would continue further downwards into the deeper (primary) aquifer or, instead, report through the shallow permeable strata into nearby surface water features (in this case, Eureka Creek), is somewhat unclear. Despite this potential limitation, the overall seepage gradient at GRBM is downwards and towards the residual voids.

Groundwater modelling (AECOM, 2024) shows that seepage from GS11 rejects landform is expected to report to Ramp 32 East residual void. Therefore, it is reasonably assumed that the likelihood of seepage from the rejects landform reaching a surface water receptor (approximately 400 m from the landform) via shallow seepage is 'Unlikely'.

In summary, the SPR has assumed a plausible (although unlikely) local seepage pathway *may* exist between GS11 rejects landform via shallow permeable strata into Eureka Creek.

Receptors

Plausible receptors of surface water run-off and seepage from GS11 rejects landform are shown in **Figure 22** (Post-closure landform), **Figure 30** (CFM for GS11 rejects landform), **Table 23** and **Attachment C Tables C9 and C14**.

Surface water

The only plausible surface water receptor identified in this qualitative assessment of GS11 rejects landform is Eureka Creek located approximately 400 m north of the facility. This applies to potential surface water run-off and potential seepage through shallow permeable strata into Eureka Creek.

The rehabilitated rejects landform will have a spoil cover designed to manage the AMD hazard of the landform. The spoil cover has been assumed to pose a low AMD source hazard, based on the conservative AMD source hazard applied to general spoil. As such, the likelihood of AMD from the rehabilitated (post-closure) rejects landform to

impact on the water quality of Eureka Creek (via run-off or shallow seepage) has been rated unlikely. The likelihood of non-oxidative salinity from the rejects landform to impact on the water quality of Eureka Creek has also been rated unlikely.

Seepage / Groundwater

Groundwater modelling (AECOM, 2024) indicates that seepage from GS11 rejects landform into groundwater is expected to report to Ramp 32 East residual void.

SPR risk rating of GS11 rejects landform

There are plausible surface water and residual void receptors; and the run-off and seepage pathways linking the source (GS11 rejects landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure rejects landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects landform is also rated as **Low**. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) rejects landform to impact on the water quality of Ramp 32 East residual void has been rated 'Unlikely'.

7.2.10 R22 rejects landform

Source materials hazard

Excluding the spoil cover to be installed over R22 rejects dump, the rejects landform is comprised almost entirely of rejects, which pose a low-moderate AMD hazard.

The rejects generally have low EC values and are expected to produce low- to slightly saline run-off and seepage, with release of (non-oxidative) salinity rated as a low hazard. Overall, the hazard for AMD generation from the current R22 rejects landform is 'low-Moderate' and the likelihood for AMD generation from the current landform is rated as 'Unlikely'.

Pathways

Pathways from R22 rejects landform to plausible receptors are shown in **Figure 22** (Post-closure landform), **Figure 27** (CFM for R22 rejects landform), **Table 23** and **Attachment C Tables C10 and C14**. R22 rejects dump is located on top of spoil within the southern end of Thiess pit shell.

Surface water

Eureka Creek, an ephemeral creek, is located approximately 250 m from the rejects landform. It is plausible that surface water run-off from the rejects landform could reach this creek. The rejects dump will be covered by a spoil cover to manage the AMD source hazard, therefore all post-closure run-off from the rejects landform will be from general spoil (overburden/interburden) material and no rejects will be exposed to (or at risk of) surface water run-off.

Seepage / Groundwater

As discussed earlier, this assessment has conservatively assumed it is plausible that seepage may occur into discontinuous shallow permeable strata associated with existing creeks or palaeodrainage channels. Whether seepage into shallow permeable strata would continue further downwards into the deeper (primary) aquifer or, instead, report through the shallow permeable strata into nearby surface water features (in this case, Eureka Creek), is somewhat unclear. Despite this potential limitation, the overall seepage gradient at GRBM is downwards and towards the residual voids.

Groundwater modelling (AECOM, 2024) shows that seepage from R22 rejects landform is expected to report to Thiess residual void and then continue on towards Goonyella residual void. Therefore, it is reasonably assumed that the likelihood of seepage from the rejects landform reaching Eureka Creek (approximately 250 m from the landform) via shallow seepage is 'Unlikely'.

In summary, the SPR has assumed a plausible (although unlikely) local seepage pathway *may* exist between R22 rejects landform via shallow permeable strata into Eureka Creek.

Receptors

Plausible receptors of surface water run-off and seepage from R22 rejects landform are shown in **Figure 22** (Post-closure landform), **Figure 27** (CFM for R22 rejects landform), **Table 23** and **Attachment C Tables C10 and C14**.

Surface water

The only plausible surface water receptor identified in this qualitative assessment of R22 rejects landform is Eureka Creek located approximately 250 m west and south of the facility. This applies to potential surface water run-off and potential seepage through shallow permeable strata into Eureka Creek.

The rehabilitated rejects landform will have a spoil cover designed to manage the AMD hazard of the landform. The spoil cover has been assumed to pose a low AMD source hazard, based on the conservative AMD source hazard applied to general spoil. As such, the likelihood of AMD from the rehabilitated (post-closure) rejects landform to impact on the water quality of Eureka Creek (via run-off or shallow seepage) has been rated unlikely. The likelihood of non-oxidative salinity from the rejects landform to impact on the water quality of Eureka Creek has also been rated unlikely.

Seepage / Groundwater

Groundwater modelling (AECOM, 2024) suggests that seepage from R22 rejects landform into groundwater is expected to report to Thiess residual void and then continue on towards Goonyella residual void.

SPR risk rating of R22 rejects landform

There are plausible surface water and residual void receptors; and the run-off and seepage pathways linking the source (R22 rejects landform) to these receptors have been identified. With respect to AMD, the overall SPR risk rating from the post-closure rejects landform is **Low**. With respect to non-oxidative salinity the overall SPR risk from the post-closure rejects landform is also rated as **Low**. The likelihood of AMD and non-oxidative salinity from the rehabilitated (post-closure) rejects landform to impact on the water quality of Thiess and Goonyella residual voids has been rated ‘Unlikely’.

7.2.11 Residual voids

Source materials hazard

The surfaces of residual void highwalls are comprised of approximately 83% to 90% non-carbonaceous overburden/ interburden, 2% to 8% carbonaceous overburden/interburden (incl. sub-economic seams reporting to waste) and about 5% to 10% coal (seams). The proportion of weathered material in the residual void highwalls ranges from approximately 11% in Goonyella void, 37% in Ramp 32 East void and 47% in Thiess void. Weathered material comprises about 25% of the highwall in Broadmeadow-Isaac and Ramp 32 South voids. Fresh and weathered non-carbonaceous overburden/interburden material in the Bowen Basin is widely recognised as posing a low AMD risk.

Therefore, due to the geochemical nature of the materials exposed in the highwall of each void and taking into account their proportions in the highwall, the overall hazard for AMD generation from residual void highwalls is low-moderate and the likelihood for AMD generation from residual void highwalls is ‘Unlikely’. Any expression of AMD from the highwalls of residual voids is likely to be localised and minimal.

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

Excluding the Broadmeadow-Isaac void, which has GMS seam as the floor, the floor of all other voids is comprised of GLS seam. Based on available geochemical data and applying a total S ‘cut-off value’ to data from the coal quality database based on the total S of ‘PAF’ coal samples, both the GMS and GLS seams are conservatively estimated to be predominantly comprised of PAF coal. Therefore, assuming at closure the pit floors comprise all coal (100% of the floor is coal) it is conservatively predicted that the pit-floors will expose materials at potential for AMD (i.e. PAF). However, this is a highly unlikely scenario as essentially all of the basal seam will have been mined out prior to closure (as is normal operational practice to remove all/most coal from pit floors), and the coal remining on the floor, if any, will not all be PAF. In the event that some coal will remain exposed on a pit floor, this will be eventually flooded, thus suppressing any AMD reaction.

Pathways

Surface water

There are no plausible pathways between the residual voids and surface water. Surface water run-off from the void highwall (of each void) will report to the void lake (of each void).

Seepage / Groundwater

The residual voids will act as local groundwater sinks and the water table will intersect the deeper zones of the residual voids, resulting in the formation of a relatively small void lake in each void (AECOM, 2024; and **Figure 23**) that will submerge the void floor and lower section of the void highwall. For each void, seepage from the spoil landform and run-off from the highwall will report to the residual void. Ultimately, seepage from Thiess and Broadmeadow-Isaac residual voids will migrate to Goonyella residual void.

Receptors

Modelling undertaken by AECOM (2024) shows Goonyella void to be a strong groundwater sink – drawing in groundwater from most of the site. Thiess and Broadmeadow-Isaac voids will be local 'sinks' – receiving surface water run-off and seepage from their respective spoil landforms and surface water run-off from their void highwalls. Ultimately, seepage from Thiess and Broadmeadow-Isaac residual voids will migrate to Goonyella residual void. Ramp 32 East and South residual voids are expected to function as week groundwater sinks from their local area.

Each residual void is expected to receive inflow from the Permian groundwater aquifer. The water quality of the void and potential impact of water seeping, if any, from the residual voids into the Permian groundwater aquifer is discussed in the void closure plan (WSP, 2024).

The floor of each residual void will be covered post-closure by water as rainfall and groundwater reporting to the void will form a void 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 residual void floor to impact on residual void water quality to any significant degree has been rated unlikely.

SPR risk rating of residual voids

The receptor for seepage from the spoil landform (for each spoil landform) and run-off from the highwall (of each void) is the void lake / residual void. The AMD assessment has found that it's unlikely that undiluted salinity or AMD from a flooded post-closure residual void floor would impact on residual void water quality to any significant degree, as other processes such as evapoconcentration (WSP, 2024) 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 to Low-Medium**. [**Attachment C Table C15**]. A "Low to Medium" risk rating has been conservatively applied to the risk of AD or SD due to the AMD risk associated with exposed coal seams in the highwalls (coal seams comprise between 5% to 10% of the exposed highwalls). However, not all exposed coal is expected to be PAF (and/or have high total and sulphide concentrations).

Water reporting to residual voids is expected to remain within the residual voids (excluding evaporative loss). Modelling undertaken by AECOM (2024) shows that seepage from Thiess and Broadmeadow-Isaac void lakes into groundwater would report to (be captured by) Goonyella void, and that seepage from Goonyella void outwards into the regional groundwater aquifer is implausible due to Goonyella void being a strong groundwater sink. Modelling also shows that Ramp 32 East and South voids are expected to be weak groundwater sinks, therefore seepage from Ramp 32 East and South void lakes into groundwater is not expected and, if it were to occur, would be limited and would ultimately be captured by Goonyella void.

8 Management and Rehabilitation Measures

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

The environmental risk associated with the current (rehabilitated) Riverside rejects dump is generally low and there is no field evidence of AMD coming from the facility. The rejects buried within the landform have been assessed as posing a moderate AMD source hazard and the facility will continue to be monitored during operations. The facility will undergo corrective rehabilitation to meet the required PMLU.

Currently (i.e. prior to rehabilitation), the AMD source hazard associated with GS1 TSF is moderate-high. This stand-alone TSF landform will require specific AMD management measures to manage this facility post-closure. Once rehabilitated, the post-closure environmental risk posed by this stand-alone TSF landform is expected to decrease.

Currently (i.e. prior to rehabilitation), the AMD source hazard associated with RS1 TSF is moderate to moderate-high. The western compartment comprising rejects only has a moderate source hazard (i.e. this compartment is essentially a rejects dump). The eastern compartment comprising predominantly tailings, with less rejects, has a moderate-high AMD source hazard (this compartment is the TSF). This stand-alone landform will require specific AMD management measures to manage this facility post-closure. Once rehabilitated, the post-closure environmental risk posed by this stand-alone landform is expected to decrease.

The AMD source hazard associated with Ramp 32 in-pit TSF (currently; prior to rehabilitation) is moderate. This in-pit TSF will be backfilled with spoil, which is an appropriate strategy to manage the AMD hazard posed by this facility post-closure. Once rehabilitated (backfilled), the post-closure environmental risk posed by this TSF is expected to decrease.

The AMD source hazard associated with DRE5 in-pit TSF (currently; prior to rehabilitation) is moderate. This small in-pit TSF will be partially backfilled with spoil to encourage free-drainage from the southern end of the facility onto the Thiess spoil landform. This is an appropriate strategy to manage the AMD hazard posed by this facility post-closure. Once rehabilitated, the post-closure environmental risk posed by this TSF is expected to decrease.

The AMD source hazard associated with GS2, GS11 and R22 rejects dumps (currently; prior to rehabilitation) is low-moderate. After re-shaping and installation of a spoil cover (i.e. once rehabilitated) the post-closure environmental risk posed by these spoil dumps is expected to decrease.

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 residual voids under five groups:
    - Goonyella void;
    - Thiess void;
    - Broadmeadow-Isaac void;
    - Ramp 32 East void; and
    - Ramp 32 South void.
- Spoil dumps: Lenton pit is currently being backfilled and becoming part of the Goonyella spoil landform. Airstrip spoil dump (associated with Ramp 32 East and Ramp 32 South voids) will be reshaped and rehabilitated. All other spoil dumps will be reshaped into three final spoil landforms (as related to their respective voids listed above) and seeded.

- GS1 TSF (out-of-pit; above ground; stand-alone) will be covered by an engineered spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of the out-of-pit TSF will be determined following further assessment.
- RS1 TSF (out-of-pit; above ground; stand-alone) will be covered by an engineered spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of the out-of-pit TSF will be determined following further assessment.
- DRE5 in-pit TSF will be covered by spoil (partially backfilled) within the Thiess spoil landform – noting that Thiess spoil landform is a sub-zone within Goonyella spoil landform. The optimal design and thickness of spoil cover to manage the AMD hazard of the in-pit TSF will be determined following further assessment.
- Ramp 32 in-pit TSF (Airstrip pit) will be backfilled by spoil within the Airstrip spoil landform.
- Riverside rejects dump (above ground; stand-alone) is already covered with spoil and partially rehabilitated, but further rehabilitation activities are scheduled to achieve the PMLU.
- GS2 and GS11 rejects dumps (out-of-pit; above ground; stand-alone) will be covered by a spoil cover. The optimal design and thickness of spoil cover to manage the AMD hazard of these two rejects dumps will be determined following further assessment.
- R22 in-pit rejects dump will be covered by a spoil cover within the Thiess spoil landform. The optimal design and thickness of spoil cover to manage the AMD hazard of this rejects dump will be determined following further assessment.
- All other rejects (in-spoil co-disposal): 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 rejects will be determined following further assessment.
- ROM pads: Remove remnant coal from ROM pads and dispose within spoil. All former ROM pads will be reshaped, covered with soil, ripped and seeded.
- Coal stockpiles: Remove remnant coal from coal stockpile pads and dispose within spoil. Cover with suitable soil material, rip and seed.

9 Forward Work Program

The environmental geochemical characterisation and assessment of mineral waste samples outlined in this report is representative of the mineral waste materials likely to require rehabilitation at closure. However, BHP will continue to undertake sampling of likely mineral waste materials (and subsequent characterisation and assessment of those samples) from GRBM (and RHM) during operations and into decommissioning – to validate the findings of the current assessment, ensure the risks continue to be understood and the management measures proposed are commensurate with the risks. Where required, management measures will be revised and implemented.

Further work may also be required prior to closure to better understand the relationship between shallow and deeper groundwater at GRBM and between shallow groundwater and surface water systems at GRBM – particularly in the vicinity of TSF and rejects landforms.

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Attachment A – Geological Sections

Pit and void highwall long-sections

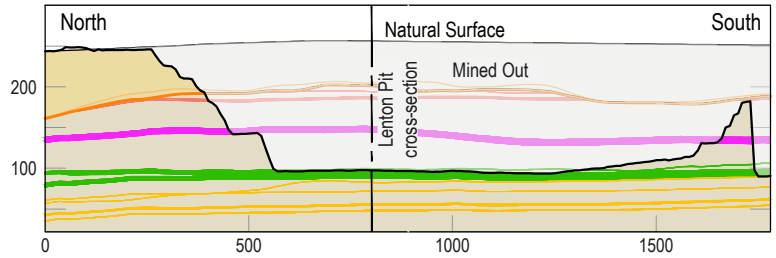
- Figure A1 Lenton pit; and Goonyella void at Red Hill and Denham pits
- Figure A2 Goonyella void at Cleanskin, Riverside and Eureka pits
- Figure A3 Eureka pit (south); and Broadmeadow-Isaac void at Broadmeadow and Isaac pits

Pit and void highwall cross-sections

- Figure A4 Ramp 14 North (Lenton pit); Ramp 14 (Denham pit and Goonyella void); Ramp 10 North (Cleanskin pit and Goonyella void)
- Figure A5 Ramp 10 South (Cleanskin pit and Goonyella void); Ramp 6 North (Riverside pit and Goonyella void)
- Figure A6 Ramp 6 South (Thiess and Eureka pits and Goonyella void); Ramp 4 South (Broadmeadow pit and Broadmeadow-Isaac void)
- Figure A7 Ramp 2 and Ramp 2 South (Airstrip and Isaac pits; and Broadmeadow-Isaac void)

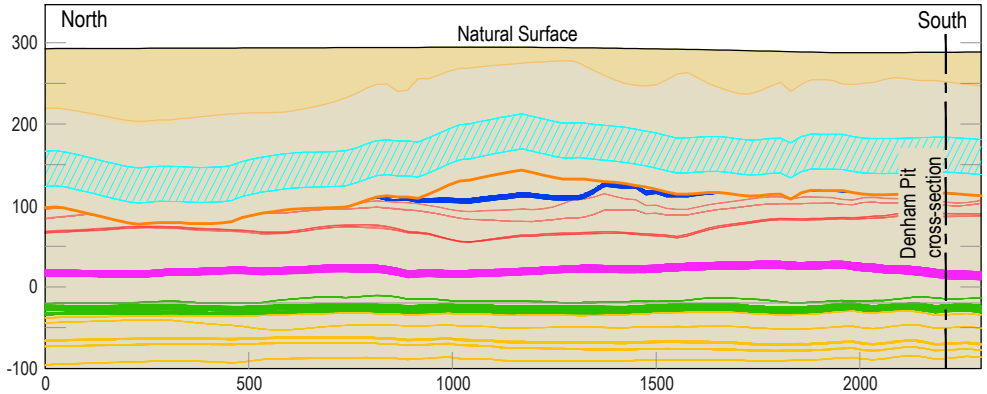
LONG SECTION | Lenton Pit

Viewed Looking North (Vertical Exaggeration x2.0)



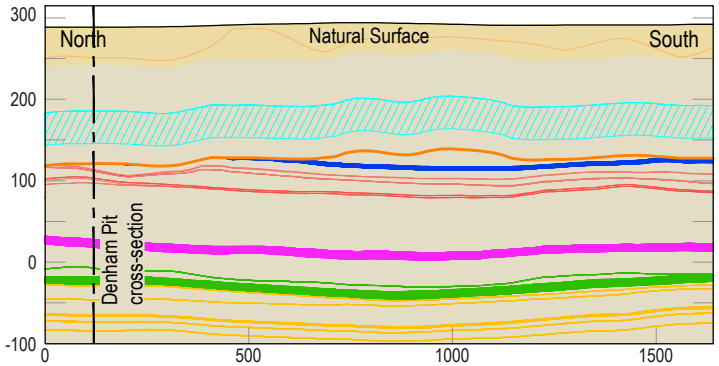
LONG SECTION | Red Hill Pit (Goonyella void)

Viewed Looking North (Vertical Exaggeration x2.0)



LONG SECTION | Denham Pit (Goonyella void)

Viewed Looking North (Vertical Exaggeration x2.0)



Legend

- Natural Surface
- Base of Weathering
- Current Pit Shell

Coal Seams

- GF Seam
- GU Seam
- P Seam
- GM Seam
- GL Seam
- GLL Seam

Vertical Scale

0 250m

Horizontal Scale

0 500m

(V/H = 2:1)

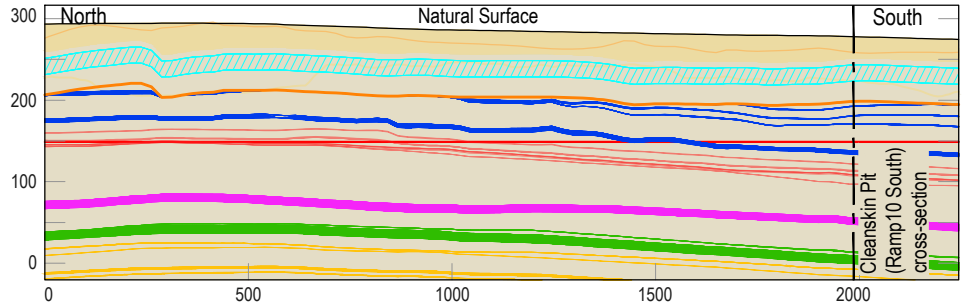
Pit highwall long-sections

Figure **A1**

Minserve CAD File: Bhpb008m08.dwg

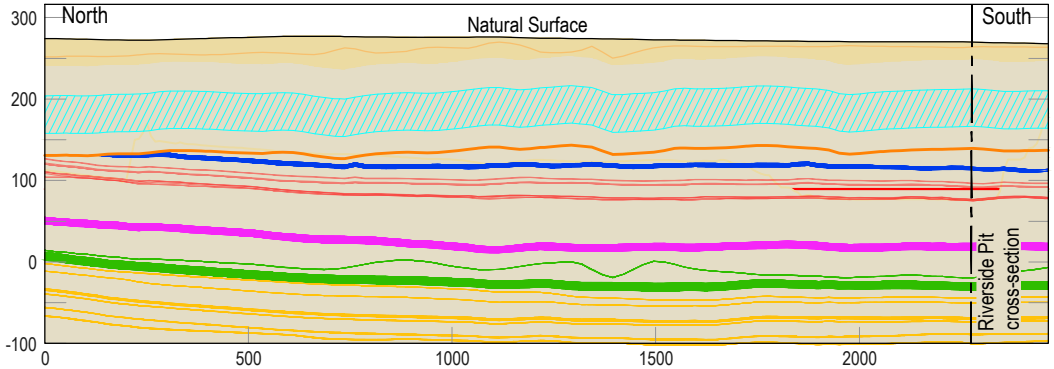
LONG SECTION | Cleanskin Pit (Goonyella void)

Viewed Looking North (Vertical Exaggeration x2.0)



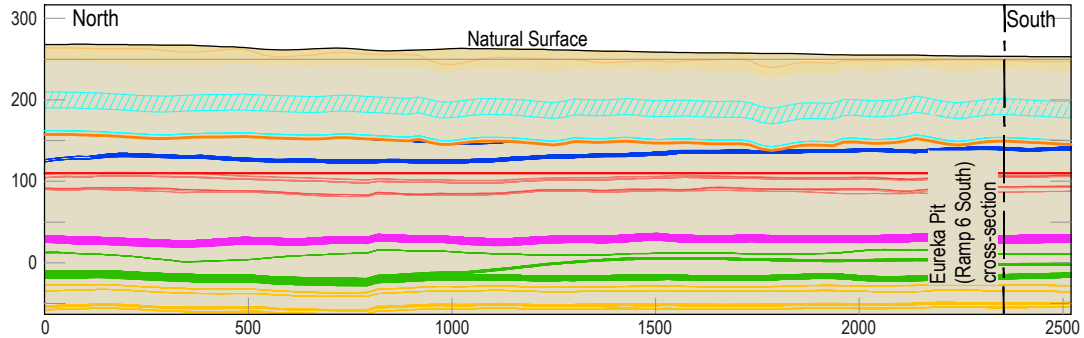
LONG SECTION | Riverside Pit (Goonyella void)

Viewed Looking North (Vertical Exaggeration x2.0)



LONG SECTION | Eureka Pit (Goonyella void)

Viewed Looking North (Vertical Exaggeration x2.0)



Legend

- Natural Surface
- Base of Weathering
- Current Pit Shell

Coal Seams

- GF Seam
- GU Seam
- P Seam
- GM Seam
- GL Seam
- GLL Seam

Vertical Scale

0 250m

Horizontal Scale

0 500m

(V/H = 2:1)

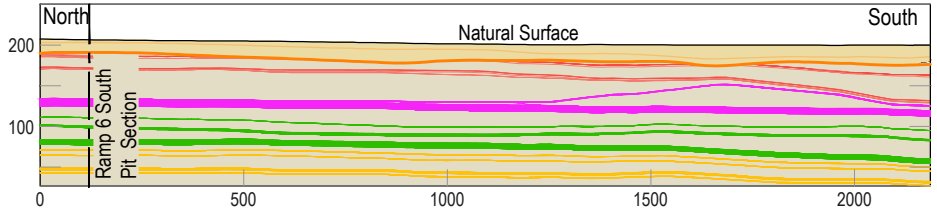
Pit highwall long-sections

Figure **A2**

Minserve CAD File: Bhpb008m08.dwg

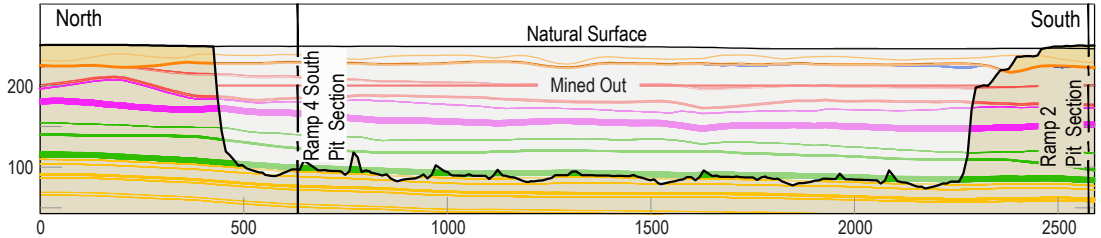
LONG SECTION | Eureka Pit South

Viewed Looking East (Vertical Exaggeration x2.0)



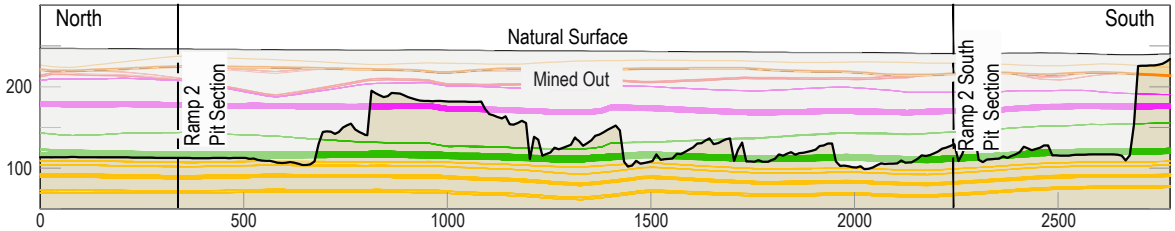
LONG SECTION | Broadmeadow Pit (Broadmeadow-Isaac void)

Viewed Looking East (Vertical Exaggeration x2.0)



LONG SECTION | Isaac Pit (Broadmeadow-Isaac void)

Viewed Looking East (Vertical Exaggeration x2.0)



Legend

- Natural Surface
- Base of Weathering
- Current Pit Shell

Coal Seams

- GF Seam
- GU Seam
- P Seam
- GM Seam
- GL Seam
- GLL Seam

Vertical Scale

0 — 250m

Horizontal Scale

0 — 500m

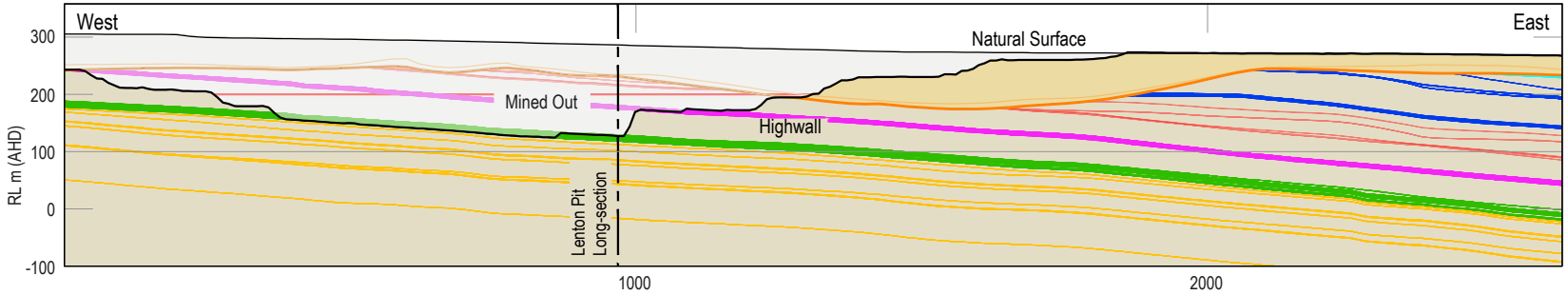
(V/H = 2:1)

Pit highwall long-sections

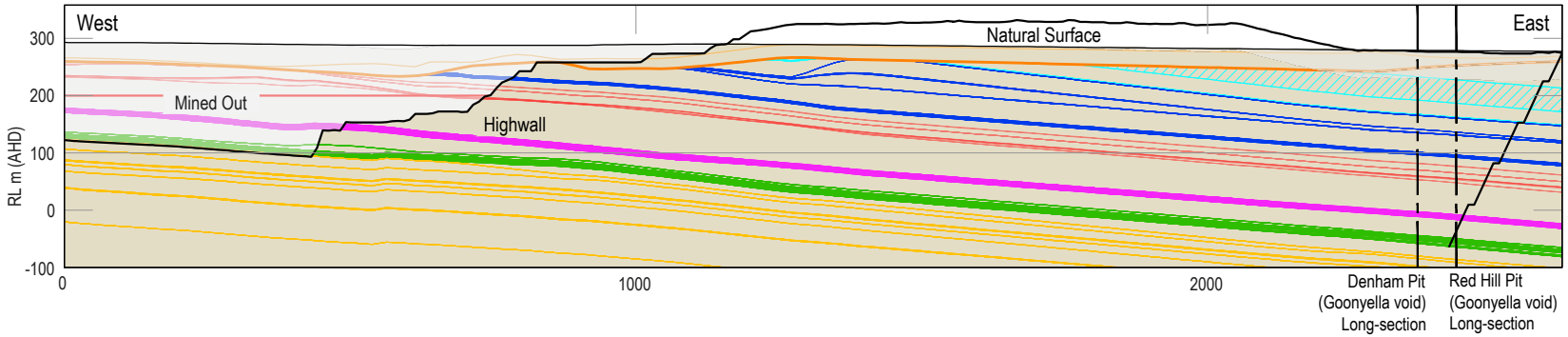
Figure **A3**

Minserve CAD File: Bhpb008m08.dwg

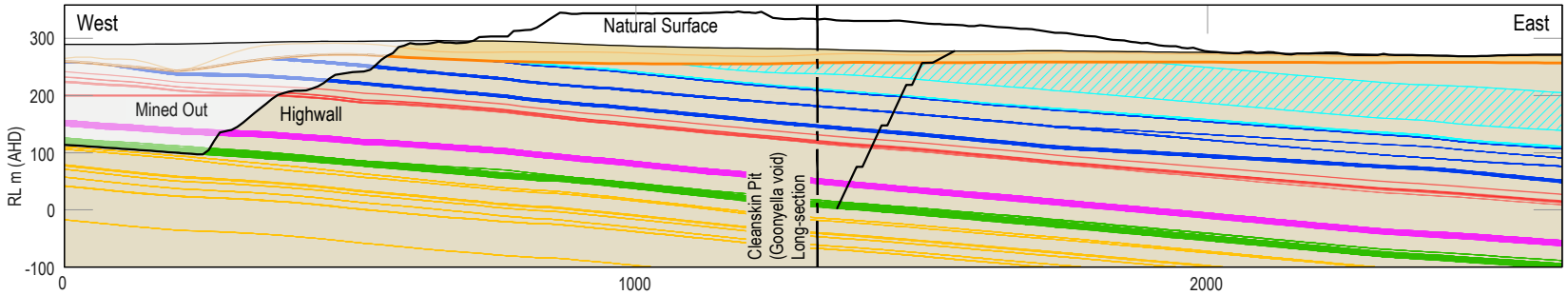
CROSS SECTION | Ramp14 North (Lenton Pit)
Viewed Looking North



CROSS SECTION | Ramp 14 (Denham Pit)
Viewed Looking North



CROSS SECTION | Ramp 10 North (Cleanskin Pit)
Viewed Looking North



Legend
- Natural Surface
- Base of Weathering
- Current Pit Shell

Coal Seams
- GF Seam
- GU Seam
- P Seam
- GM Seam
- GL Seam
- GLL Seam

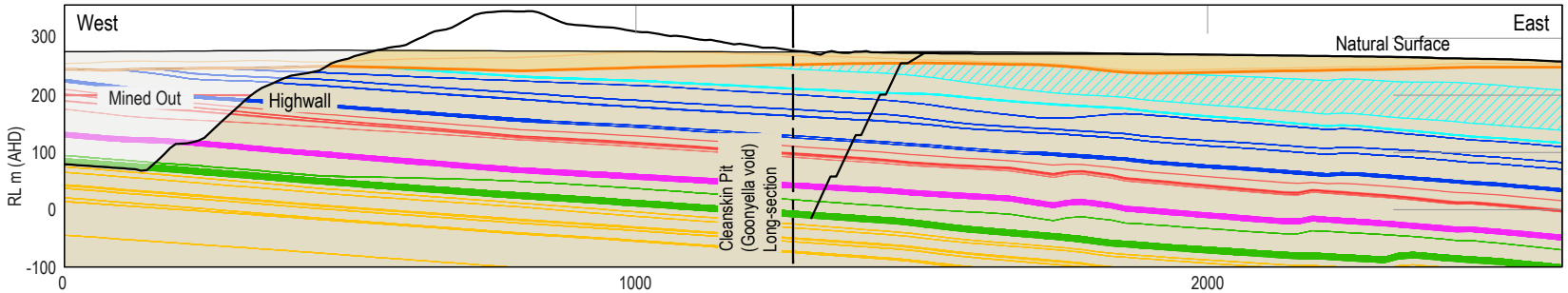
Scale
(V/H = 1)
0 200 400m

Pit cross-sections

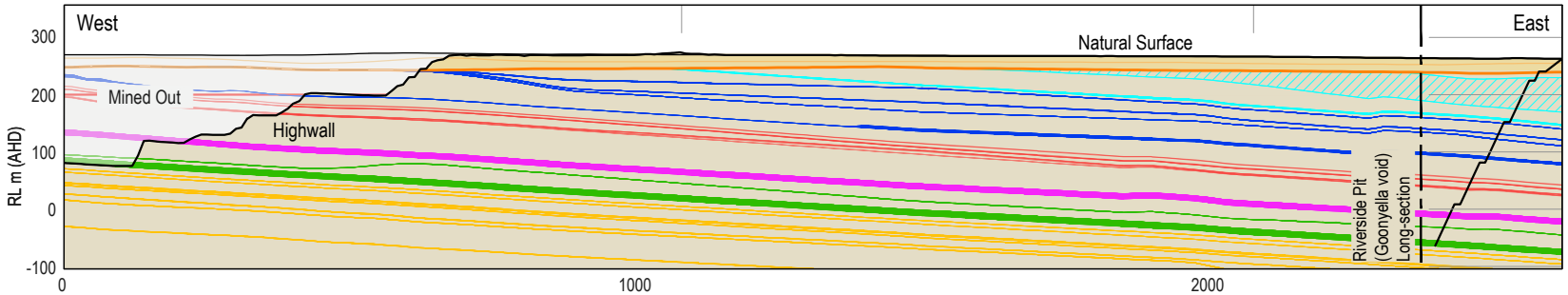
Figure **A4**

Minserve CAD File: Bhpb008m07.dwg

CROSS SECTION | Ramp 10 South (Cleanskin Pit)
Viewed Looking North



CROSS SECTION | Ramp 6 North (Riverside Pit)
Viewed Looking North



Legend
- Natural Surface
- Base of Weathering
- Current Pit Shell

Coal Seams
- GF Seam
- GU Seam
- P Seam
- GM Seam
- GL Seam
- GLL Seam

Scale
(V/H = 1)
0 200 400m

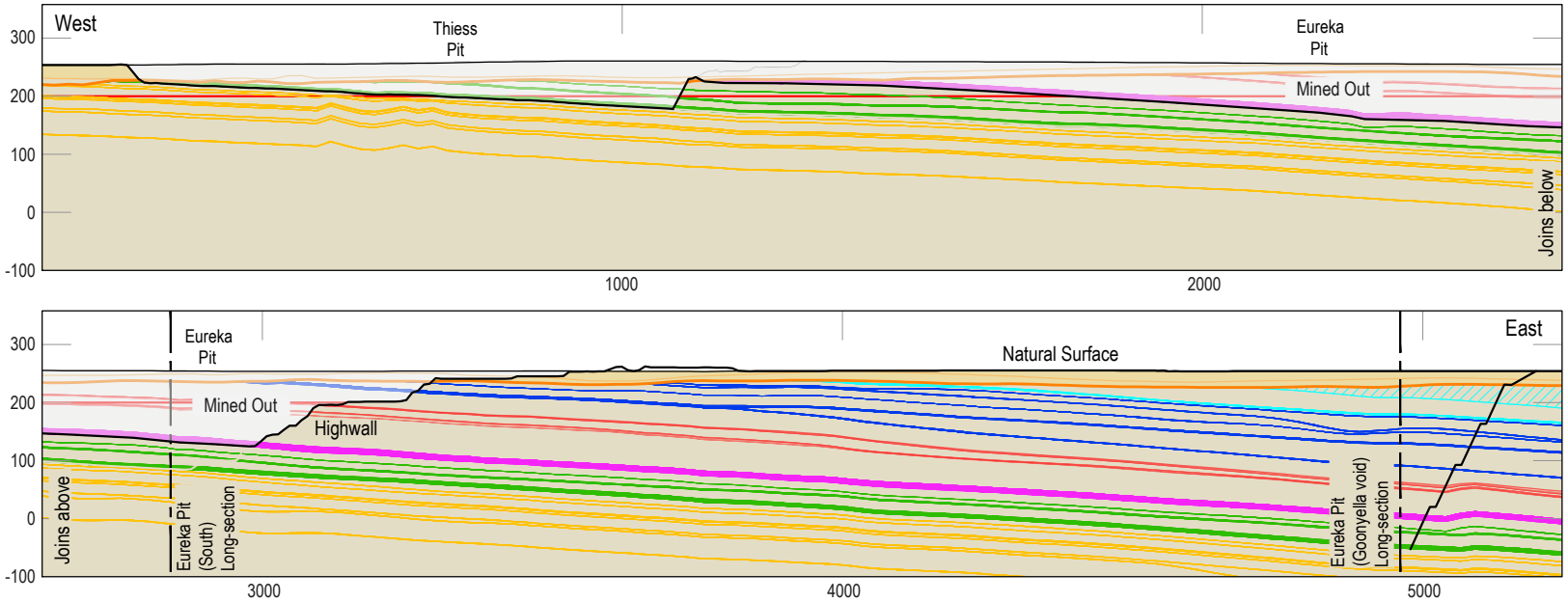
Pit cross-sections

Figure **A5**

Minserve CAD File: Bhpb008m07.dwg

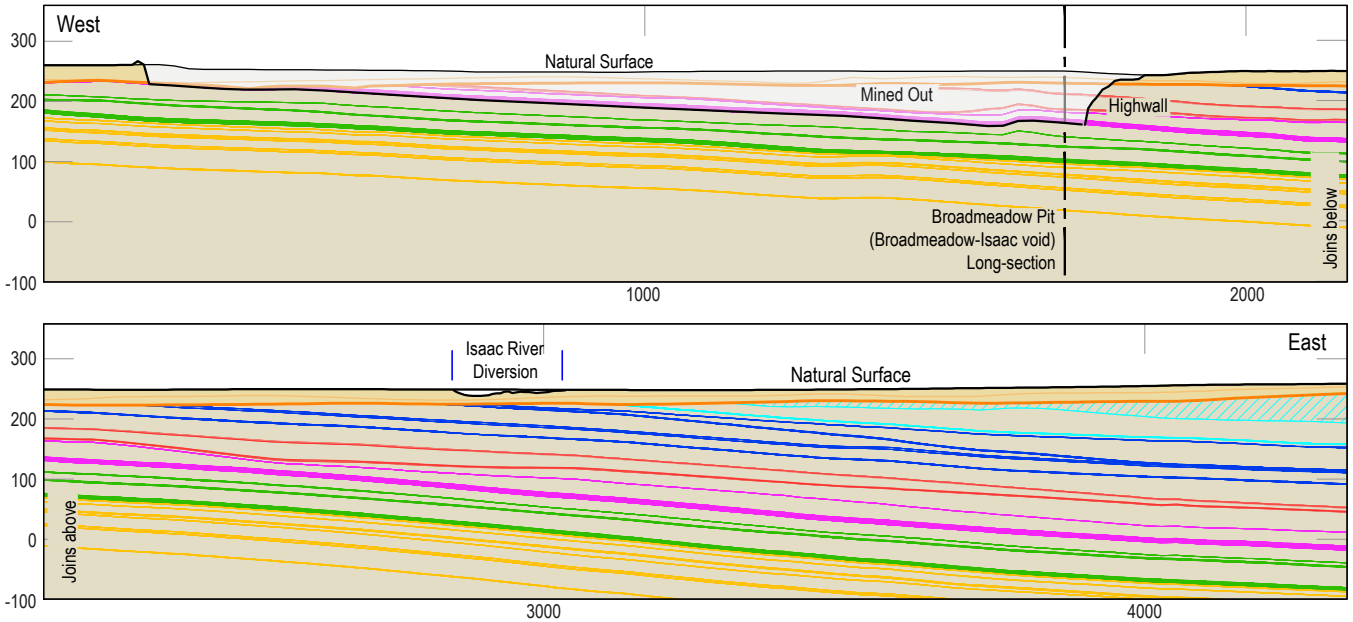
CROSS SECTION | Ramp 6 South (Thiess Pit, Eureka Pit and Goonyella void)

Viewed Looking North



CROSS SECTION | Ramp 4 South (Broadmeadow Pit)

Viewed Looking North



Legend

- Natural Surface
- Base of Weathering
- Current Pit Shell

Coal Seams

- GF Seam
- GU Seam
- P Seam
- GM Seam
- GL Seam
- GLL Seam

Scale

(V/H = 1)

0 200 400m

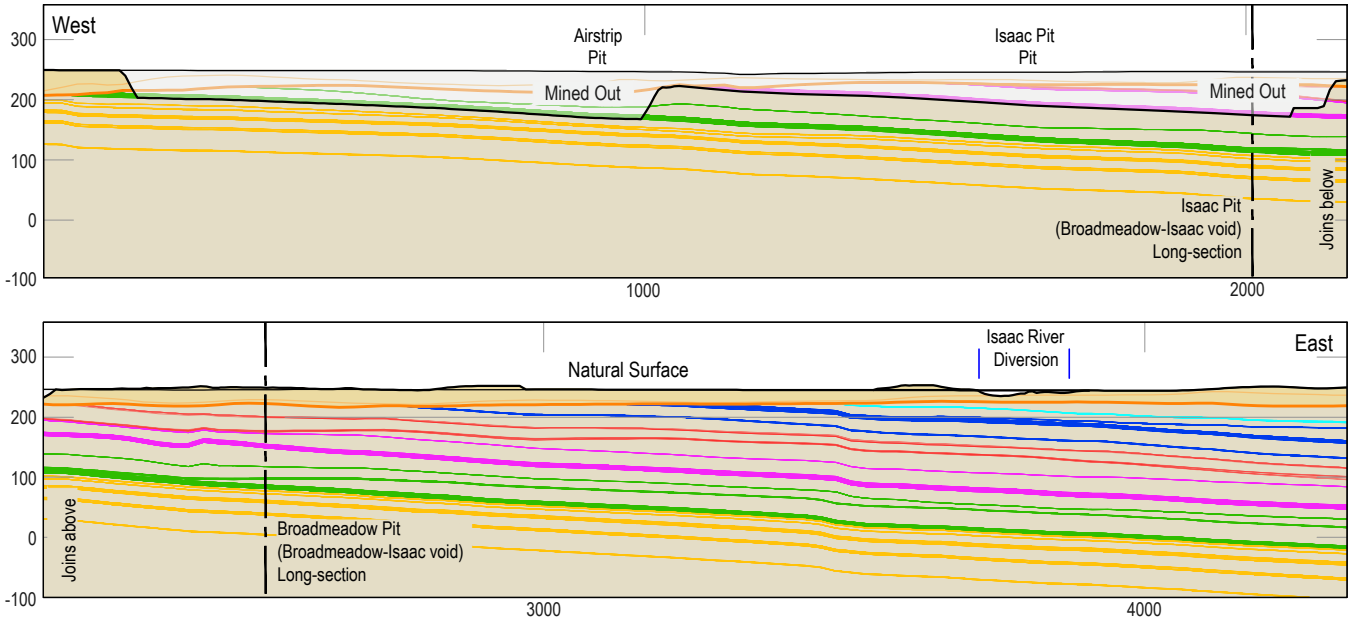
Minserve CAD File: Bhpb008m07.dwg

Pit cross-sections

Figure **A6**

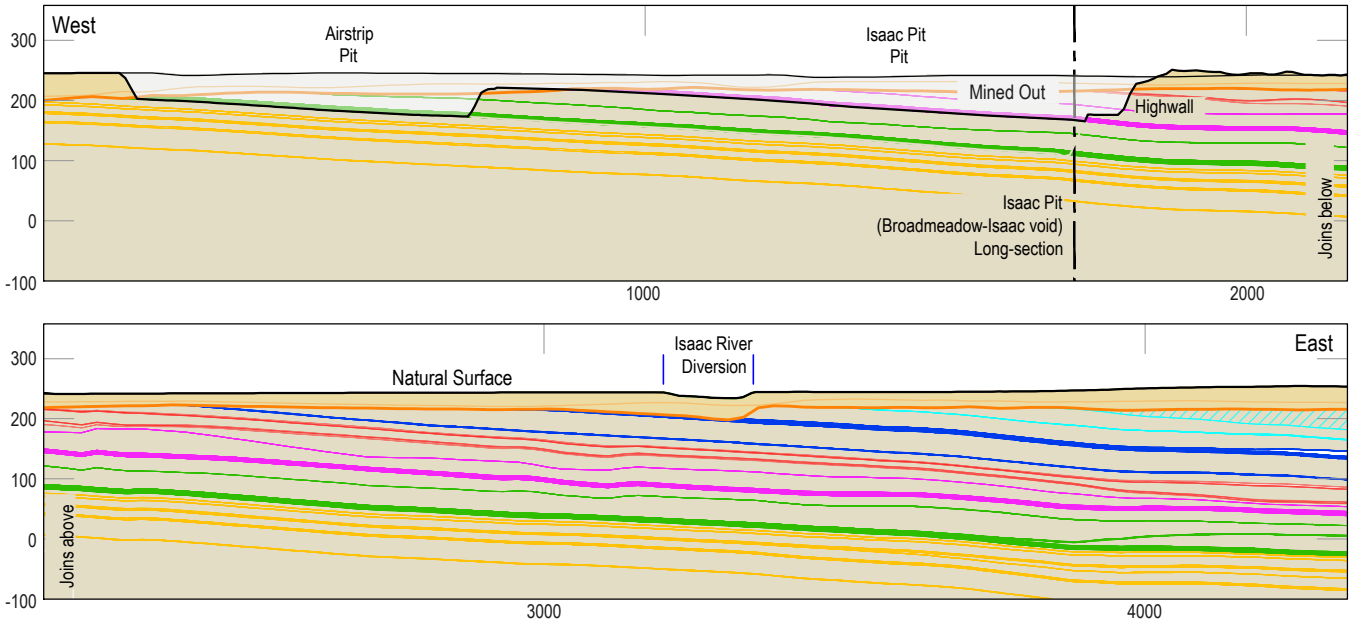
CROSS SECTION | Ramp 2 (Airstrip Pit and Isaac Pit - Broadmeadow-Isaac void)

Viewed Looking North



CROSS SECTION | Ramp 2 South

Viewed Looking North



Legend

- Natural Surface
- Base of Weathering
- Current Pit Shell

Coal Seams

- GF Seam
- GU Seam
- P Seam
- GM Seam
- GL Seam
- GLL Seam

Scale

(V/H = 1)

0 200 400m

Minserve CAD File: Bhpb008m08.dwg

Pit cross-sections

Figure **A7**

Attachment B – AMD Hazard Scoring Tables

AMD hazard and likelihood of AMD generation from spoil landforms

- Table B1 Goonyella final landform
- Table B2 Thiess final landform
- Table B3 Airstrip final landform
- Table B4 Broadmeadow-Isaac final landform

AMD hazard and likelihood of AMD generation from TSF landforms

- Table B5 GS1 TSF landform
- Table B6 RS1 TSF landform – western compartment
- Table B7 RS1 TSF landform – eastern compartment
- Table B8 DRE5 in-pit TSF landform
- Table B9 Ramp 32 in-pit TSF landform

AMD hazard and likelihood of AMD generation from rejects landform

- Table B10 Riverside rejects landform
- Table B11 GS2 rejects landform
- Table B12 GS11 rejects landform
- Table B13 R22 in-pit rejects landform

AMD hazard and likelihood of AMD generation from residual voids

- Table B14 Goonyella residual void walls and floor
- Table B15 Thiess residual void walls and floor
- Table B16 Ramp 32 East residual void walls and floor
- Table B17 Ramp 32 South residual void walls and floor
- Table B18 Broadmeadow-Isaac residual void walls and floor

Table B1. AMD hazard scoring for source materials and likelihood for AMD generation from Goonyella final landform

Goonyella: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Goonyella spoil landform
Non-carbonaceous spoil Distributed throughout	91%	1.5%	1.4%	Total S is very low (75th percentile = 0.05%). NAF samples have a very low 75th percentile total S value of 0.05%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a high 75th percentile total S value of 1.62% (and AMD capacity is based on this number). Based on sample numbers (n=1169), approximately 1.5% of non-carbonaceous spoil - mostly fresh/unweathered - is conservatively classified as 'PAF' of some type. 75th percentile EC of non-carbonaceous spoil = 470 µS/cm. About half of the 'PAF' samples are associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 91% of mineral waste in the landform. AMD quantity conservatively assumes proportion of PAF non-carbonaceous spoil samples approximates the proportion of non-carbonaceous spoil that is PAF.	**1** Low	**10** High	**1** Low	**7** Low-Moderate	**3.9** Low	Goonyella spoil landform - the largest of all spoil landforms at GRBM and accouting for approximately 90% of all mineral waste on site - is essentially comprised of spoil only. Rejects comprise approximately 0.1% of the landform. General spoil is overwhelmingly NAF with very low sulphur, excess neutralising capacity and low soluble metals concentration. About one-third of 'PAF' materials are associated with seams - as parting or within 1.5m (typically) above and below seams. As such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Approximately 22% of the rejects are 'PAF', however rejects comprise a negligible proportion of the landform (approximately 0.1%) and are disposed (buried) within spoil. Overall, about 2.4% of the landform is conservatively estimated to be either PAF, PAF-LC, UC(PAF) or NAF-S material, and about one-third of this is associated with near-seam spoil. Carbonaceous spoil is regarded as posing a moderate AMD source hazard and is expected to comprise about 9% of the landform. Rejects are regarded as posing a low-moderate AMD source hazard and are present in negligible quantities. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 464 µS/cm. The hazard for AMD generation from Goonyella spoil landform at GRBM is considered to be **LOW**. The likelihood for AMD generation from Goonyella spoil landform at GRBM is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	9.0%	10%	0.9%	Total S is low (75th percentile = 0.12%). NAF samples have a low 75th percentile total S value of 0.12%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a high 75th percentile total S value of 1.67% (and AMD capacity is based on this number). Based on sample numbers, approximately 10% of carbonaceous spoil is conservatively classified as 'PAF' of some type. 75th percentile EC of carbonaceous spoil = 400 µS/cm. 'PAF' samples were broadly distributed throughout the stratigraphy (ie. not just associated with seams). Non-carbonaceous spoil is estimated to comprise approximately 9% of mineral waste in the landform. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**10** High	**1** Low	**11** Moderate		
Rejects Small quantity of historic rejects disposed at northern area of landform (Lenton pit area)	0.1%	22%	0.0%	Approximately 22% of rejects at GRBM have been conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of these 'PAF' samples, most were classified as PAF-LC or UC(PAF). Total S is generally low (75th percentile = 0.12%). NAF samples have a 75th percentile S value of 0.37%, whereas 'PAF' samples have a 75th percentile S value of 0.65% (and AMD capacity is based on this number). 75th percentile EC of rejects = 538 µS/cm. Rejects will comprise a very small proportion of mineral waste in the landform - approximately 0.1%. That is, the final spoil landform will essentially be comprised of spoil. AMD quantity conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects that is PAF.	**5** Plausible	**5** Moderate	**1** Low	**8** Low-Moderate		
Tailings No current or future tailings disposed into landform	0%	51%	0%	No tailings located within Goonyella landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B2. AMD hazard scoring for source materials and likelihood for AMD generation from Thiess final landform

Thiess: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Thiess spoil landform
Non-carbonaceous spoil Distributed throughout	91%	1.5%	1.4%	Total S is very low (75th percentile = 0.05%). NAF samples have a very low 75th percentile total S value of 0.05%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a high 75th percentile total S value of 1.62% (and AMD capacity is based on this number). Based on sample numbers, approximately 1.5% of non-carbonaceous spoil - mostly fresh/unweathered - is conservatively classified as 'PAF' of some type. 75th percentile EC of non-carbonaceous spoil = 470 µS/cm. About half of the 'PAF' samples are associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 77% of mineral waste in the landform. AMD quantity conservatively assumes proportion of PAF non-carbonaceous spoil samples approximates the proportion of non-carbonaceous spoil that is PAF.	**1** Low	**10** High	**1** Low	**7** Low-Moderate	**3.8** Low	Excluding R22 rejects dump (which is assessed seperately), Thiess spoil landform is essentially comprised of spoil only. Rejects at Ramp 23 are estimated to comprise less than 0.5% of the landform. General spoil is overwhelmingly NAF with very low sulphur, excess neutralising capacity and low soluble metals concentration. About one-third of 'PAF' materials are associated with seams - as parting or within 1.5m (typically) above and below seams. As such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Excluding R22 rejects dump located at the periphery of the spoil landform, less than 0.5% of the landform is rejects located at Ramp 23. [DRE5 in-pit TSF - located within the western area of the spoil landform - is assessed as a 'stand-alone' TSF landform]. Overall, about 2.5% of the landform is conservatively estimated to be either PAF, PAF-LC, UC(PAF) or NAF-S material. Carbonaceous spoil is regarded as posing a moderate AMD source hazard and is expected to comprise about 9% of the landform. Rejects are regarded as posing a low-moderate AMD source hazard and are expected to comprise less than 0.5% of the landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 464 µS/cm. The hazard for AMD generation from Thiess spoil landform at GRBM is considered to be **LOW**. The likelihood for AMD generation from Thiess spoil landform at GRBM is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	9.0%	10%	0.9%	Total S is low (75th percentile = 0.12%). NAF samples have a low 75th percentile total S value of 0.12%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a high 75th percentile total S value of 1.67% (and AMD capacity is based on this number). Based on sample numbers, approximately 10% of carbonaceous spoil is conservatively classified as 'PAF' of some type. 75th percentile EC of carbonaceous spoil = 400 µS/cm. 'PAF' samples were broadly distributed throughout the stratigraphy (ie. not just associated with seams). Non-carbonaceous spoil is estimated to comprise approximately 8% of mineral waste in the landform. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**10** High	**1** Low	**11** Moderate		
Rejects Minor rejects located at Ramp 23. Almost all rejects are located at R22 rejects dump, which is assessed sperately (refer to Table B13).	0.2%	22%	0.1%	Approximately 22% of rejects at GRBM have been conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of these 'PAF' samples, most were classified as PAF-LC or UC(PAF). Total S is generally low (75th percentile = 0.12%). NAF samples have a 75th percentile S value of 0.37%, whereas 'PAF' samples have a 75th percentile S value of 0.65% (and AMD capacity is based on this number). 75th percentile EC of rejects = 538 µS/cm. Rejects at Ramp 23 are estimated to comprise less than 0.5% of mineral waste in the landform. AMD quantity conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects that is PAF.	**5** Plausible	**5** Moderate	**1** Low	**8** Low-Moderate		
Tailings DRE5 TSF at base of landform	0.0%	51%	0.0%	DRE5 TSF is located within the landform footprint. The TSF (pit) will be partially backfilled and become part of the spoil landform. Due to the concentrated nature of tailings at the base of the landform the TSF has been conservatively assessed as a 'stand alone' TSF landform. Refer to the AMD hazard assessment of DRE5 TSF landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B3. AMD hazard scoring for source materials and likelihood for AMD generation from Airstrip final landform

Airstrip: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Airstrip spoil landform
Non-carbonaceous spoil Distributed throughout	91%	1.5%	1.4%	Total S is very low (75th percentile = 0.05%). NAF samples have a very low 75th percentile total S value of 0.05%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a high 75th percentile total S value of 1.62% (and AMD capacity is based on this number). Based on sample numbers, approximately 1.5% of non-carbonaceous spoil - mostly fresh/unweathered - is conservatively classified as 'PAF' of some type. 75th percentile EC of non-carbonaceous spoil = 470 µS/cm. About half of the 'PAF' samples are associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 91% of mineral waste in the landform. AMD quantity conservatively assumes proportion of PAF non-carbonaceous spoil samples approximates the proportion of non-carbonaceous spoil that is PAF.	**1** Low	**10** High	**1** Low	**7** Low-Moderate	**3.7** Low	Airstrip spoil landform is essentially comprised of spoil only. Rejects are estimated to comprise approximately 1% of the landform. General spoil is overwhelmingly NAF with very low sulphur, excess neutralising capacity and low soluble metals concentration. About one-third of 'PAF' materials are associated with seams - as parting or within 1.5m (typically) above and below seams. As such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Approximately 1% of the landform is rejects (based on an assumed proportion of historic rejects potentially disposed in this landform), and approximately 22% of GRBM rejects are 'PAF'. Rejects (if any) within this landform are disposed (buried) broadly within spoil. [Ramp 32 in-pit TSF - located within the 'footprint' of the spoil landform - is assessed as a 'stand-alone' TSF landform]. Overall, about 2.5% of the landform (excluding Ramp 32 TSF) is conservatively estimated to be either PAF, PAF-LC, UC(PAF) or NAF-S material, and most of this is associated with spoil. Carbonaceous spoil is regarded as posing a moderate AMD source hazard and is expected to comprise about 8% of the landform. Rejects are regarded as posing a low-moderate AMD source hazard and are expected to comprise about 1% of the landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 465 µS/cm. The hazard for AMD generation from Airstrip spoil landform at GRBM is considered to be **LOW**. The likelihood for AMD generation from Airstrip spoil landform at GRBM is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	7.9%	10%	0.8%	Total S is low (75th percentile = 0.12%). NAF samples have a low 75th percentile total S value of 0.12%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a high 75th percentile total S value of 1.67% (and AMD capacity is based on this number). Based on sample numbers, approximately 10% of carbonaceous spoil is conservatively classified as 'PAF' of some type. 75th percentile EC of carbonaceous spoil = 400 µS/cm. 'PAF' samples were broadly distributed throughout the stratigraphy (ie. not just associated with seams). Non-carbonaceous spoil is estimated to comprise approximately 8% of mineral waste in the landform. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**10** High	**1** Low	**11** Moderate		
Rejects No known rejects. Assume some historic rejects disposed.	1.0%	22%	0.2%	Approximately 22% of rejects at GRBM have been conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of these 'PAF' samples, most were classified as PAF-LC or UC(PAF). Total S is generally low (75th percentile = 0.12%). NAF samples have a 75th percentile S value of 0.37%, whereas 'PAF' samples have a 75th percentile S value of 0.65% (and AMD capacity is based on this number). 75th percentile EC of rejects = 538 µS/cm. Rejects are estimated to comprise approximately 1% of mineral waste in the landform, based on assumed historic rejects disposal into this landform. AMD quantity conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects that is PAF.	**5** Plausible	**5** Moderate	**1** Low	**8** Low-Moderate		
Tailings Ramp 32 TSF at base of landform	0.0%	51%	0.0%	Ramp 32 TSF (Airstrip pit) is located within the landform footprint. The TSF (pit) will be backfilled and become part of the spoil landform. Due to the concentrated nature of tailings at the base of the landform the TSF has been conservatively assessed as a 'stand alone' TSF landform. Refer to the AMD hazard assessment of Ramp 32 TSF landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B4. AMD hazard scoring for source materials and likelihood for AMD generation from Broadmeadow-Isaac final landform

Broadmeadow-Isaac: Landform components	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score	Likelihood for AMD generation from Broadmeadow-Isaac spoil landform
Non-carbonaceous spoil Distributed throughout	92%	1.5%	1.4%	Total S is very low (75th percentile = 0.05%). NAF samples have a very low 75th percentile total S value of 0.05%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a high 75th percentile total S value of 1.62% (and AMD capacity is based on this number). Based on sample numbers, approximately 1.5% of non-carbonaceous spoil - mostly fresh/unweathered - is conservatively classified as 'PAF' of some type. 75th percentile EC of non-carbonaceous spoil = 470 µS/cm. About half of the 'PAF' samples are associated with seams - as parting or within 1.5m above and below seams. Non-carbonaceous spoil is estimated to comprise approximately 92% of mineral waste in the landform. AMD quantity conservatively assumes proportion of PAF non-carbonaceous spoil samples approximates the proportion of non-carbonaceous spoil that is PAF.	**1** Low	**10** High	**1** Low	**7** Low-Moderate	**3.4** Low	Broadmeadow-Isaac spoil landform is comprised of about 97% spoil. Rejects (based on estimated future rejects quantities potentially disposed in this landform) are estimated to comprise approximately 3% of the landform. General spoil is overwhelmingly NAF with very low sulphur, excess neutralising capacity and low soluble metals concentration. About one-third of 'PAF' materials are associated with seams - as parting or within 1.5m (typically) above and below seams. As such, (and also due to seams being over-sampled) the percentage of 'PAF' spoil samples is not respresentative of the overall percentage of PAF in general spoil. Approximately 22% of the rejects are 'PAF', however rejects comprise a small proportion of the landform (approximately 3%) and will be disposed (buried) within spoil. Overall, about 2.6% of the landform is conservatively estimated to be either PAF, PAF-LC, UC(PAF) or NAF-S material, and about one-third of this is associated with near-seam spoil. Carbonaceous spoil is regarded as posing a moderate AMD source hazard and are expected to comprise about 5% of the landform. Rejects are regarded as posing a low-moderate AMD source hazard and expected to comprise about 3% of the landform. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 469 µS/cm. The hazard for AMD generation from Broadmeadow-Isaac spoil landform at GRBM is considered to be **LOW**. The likelihood for AMD generation from Broadmeadow-Isaac spoil landform at GRBM is rated **HIGHLY UNLIKELY**.
Coaly and/or carbonaceous spoil Distributed throughout	4.9%	10%	0.5%	Total S is low (75th percentile = 0.12%). NAF samples have a low 75th percentile total S value of 0.12%. 'PAF' samples, which includes samples classified as PAF, PAF-LC, UC(PAF) or NAF-S, have a high 75th percentile total S value of 1.67% (and AMD capacity is based on this number). Based on sample numbers, approximately 10% of carbonaceous spoil is conservatively classified as 'PAF' of some type. 75th percentile EC of carbonaceous spoil = 400 µS/cm. 'PAF' samples were broadly distributed throughout the stratigraphy (ie. not just associated with seams). Non-carbonaceous spoil is estimated to comprise approximately 5% of mineral waste in the landform. AMD quantity conservatively assumes proportion of PAF carbonaceous spoil samples approximates the proportion of carbonaceous spoil that is PAF.	**5** Plausible	**10** High	**1** Low	**11** Moderate		
Rejects Negligible existing rejects. Future rejects likely located at the northern end of the landform.	3.0%	22%	0.7%	Approximately 22% of rejects at GRBM have been conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. Of these 'PAF' samples, most were classified as PAF-LC or UC(PAF). Total S is generally low (75th percentile = 0.12%). NAF samples have a 75th percentile S value of 0.37%, whereas 'PAF' samples have a 75th percentile S value of 0.65% (and AMD capacity is based on this number). 75th percentile EC of rejects = 538 µS/cm. Rejects are estimated to comprise approximately 3% of mineral waste in the landform, based on potential future rejects disposal into this landform. AMD quantity conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects that is PAF.	**5** Plausible	**5** Moderate	**1** Low	**8** Low-Moderate		
Tailings No tailings disposed into landform	0.0%	51%	0.0%	No tailings located within Broadmeadow-Isaac landform.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B5. AMD hazard scoring for source materials and likelihood for AMD generation from GS1 TSF landform (without cover)

GS1 TSF: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from GS1 TSF (before rehabilitation)
Tailings	95%	64%	61%	AMD (as AD and NMD/SD) has been observed in surface water and groundwater in the vicinity of GS1 TSF. Based on geochemical information it is assumed the AMD observed to date is primarily from tailings moreso than rejects. Based on data from 139 tailings samples from GS1 TSF, up to 64% of tailings are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a relatively low-moderate 75th percentile S value of 0.66% (PAF samples). NAF samples have a relatively low 75th percentile S value of 0.48%. Conservatively assumes proportion of PAF tailings samples approximates the proportion of tailings in the TSF that are PAF. Assumes equal distribution of PAF/NAF tailings throughout the TSF.	**15** Certain	**5** Moderate	**5** Moderate	**20** Moderate-High	**19** Moderate-High	The hazard for AMD generation is based on the bulk of the TSF being tailings (estimated at approximately 95%), of which 64% is conservatively estimated to be 'PAF' (which includes PAF, PAF-LC, UC(PAF) and NAF-S). Rejects - present in embankments - are conservatievly estimated to comprise about 5% of the TSF. Approximately 20% of rejects samples have been classified as 'PAF' of some type. Overall, about 62% of GS1 TSF is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material - most of which is tailings, which are assessed as posing a Moderate-High AMD source hazard. Rejects are estimated to comprise about 5% of the TSF (as embankment material) and are assessed as posing a Moderate AMD source hazard. Natural ground beneath the TSF is considered to pose a low-moderate AMD source hazard (lilkely due to AMD from the overlying tailings). The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 821 µS/cm. The hazard for AMD generation from GS1 TSF is conservatively considered to be **MODERATE-HIGH**. The likelihood for AMD generation from GS1 TSF is conservatively rated as **HIGHLY LIKELY** - noting that AMD has already been observed from GS1 TSF.
Rejects Located within embankments	5%	20%	1%	AMD (as AD and NMD/SD) has been observed in surface water and groundwater in the vicinity of GS1 TSF. Based on geochemical information it is assumed the AMD observed to date is primarily from tailings moreso than rejects. Based on data from 20 aged rejects samples from GS1 TSF, approximately 20% of the rejects are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a low 75th percentile S value of 0.30% (PAF samples). NAF samples also have a low 75th percentile S value of 0.30%. Conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects in the TSF that are PAF. Assumes equal distribution of PAF/NAF rejects throughout the areas of the TSF where rejects are located.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**11** Moderate		
Fill & Natural Ground Spoil fill within the embankments and natural ground material at the base of the TSF	0.5%	19.0%	0.1%	No geochemical data is available for fill or foundation material specifically from GS1 TSF. Have applied RS1 TSF fill and foundation data, on the assumption it would expected to be similar to GS1 TSF. AMD capacity is based on a 75th percentile S value of 0.49% (PAF samples). NAF samples have a 75th percentile S value of 0.06%.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		

Table B6. AMD hazard scoring for source materials and likelihood for AMD generation from RS1 TSF landform (without cover) – western compartment

RS1 TSF western compartment: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from RS1 TSF western compartment (before rehabilitation)
Tailings No tailings disposed into western compartment	0%	80%	0%	No tailings located within western compartment of RS1 TSF landform.	**n/a**	**n/a**	**n/a**	**n/a**	**12** Moderate	RS1 TSF is constructed and managed as two compartments: western and eastern. The western compartment (this table) comprises rejects only. Approximately 30% of rejects samples were is conservatively estimated to be 'PAF' (which includes PAF, PAF-LC, UC(PAF) and NAF-S) and, as such, about 30% of the western compartment of RS1 TSF is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material. Rejects are assessed as posing a Moderate AMD source hazard. The 75th percentile EC of the western compartment (based on the EC of the rejects) is estimated at 615 µS/cm. The hazard for AMD generation from the western compartment of RS1 TSF is conservatively considered to be **MODERATE**. The likelihood for AMD generation from the western compartment of RS1 TSF is conservatively rated as **PROBABLE / LIKELY**.
Rejects The western compartment is comprised almost entirely of rejects	100%	30%	30%	AMD (as AD and NMD/SD) has been observed in surface water and groundwater in the vicinity of RS1 TSF, however it is considered that the main source of this AMD is probably from the eastern compartment (the tailings), and lesser so the western compartment (rejects). Based on data from 200 aged rejects samples from RS1 TSF and Riverside rejects dump (ie. aged rejects originally derived from RV CHPP), approximately 30% of the rejects are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a relatively low-moderate 75th percentile S value of 0.56% (PAF samples). NAF samples have a low 75th percentile S value of 0.39%. Conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects in the western compartment that are PAF. Assumes equal distribution of PAF/NAF rejects throughout the western compartment of RS1 TSF.	**7** Expected	**5** Moderate	**5** Moderate	**12** Moderate		
Fill & Natural Ground Spoil fill within the western (rejects) compartment	0%	n/a	n/a	No fill samples have been identified or collected from the western compartment. If fill material was present, presumably would be spoil. Therefore, assume all (or predominantly) NAF with low total S.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B7. AMD hazard scoring for source materials and likelihood for AMD generation from RS1 TSF landform (without cover) – eastern compartment

RS1 TSF eastern compartment: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from RS1 TSF eastern compartment (before rehabilitation)
Tailings	85%	80%	68%	AMD (as AD and NMD/SD) has been observed in surface water and groundwater in the vicinity of RS1 TSF. Based on geochemical information it is assumed the AMD observed to date is primarily from tailings (eastern compartment) moreso than rejects. Based on data from 84 tailings samples from RS1 TSF, up to 80% of tailings are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a relatively low-moderate 75th percentile S value of 0.68% (PAF samples). NAF samples have a low 75th percentile S value of 0.34%. Conservatively assumes proportion of PAF tailings samples approximates the proportion of tailings in the TSF that are PAF. Assumes equal distribution of PAF/NAF tailings throughout the TSF.	**15** Certain	**5** Moderate	**5** Moderate	**20** Moderate-High	**16** Moderate-High	RS1 TSF is constructed and managed as two compartments: western and eastern. The eastern compartment (this table) comprises tailings as the major material, with rejects located in the eastern and southern embankments and as cover on the tailings. The hazard for AMD generation is based on the bulk of the TSF being tailings (estimated at approximately 85%), of which 80% is conservatively estimated to be 'PAF' (which includes PAF, PAF-LC, UC(PAF) and NAF-S). Rejects - present in embankments and capping tailings - are conservatievly estimated to comprise about 15% of the eastern compartment. Approximately 30% of rejects samples have been classified as 'PAF' of some type. Overall, about 72% of RS1 TSF eastern compartment is conservatively estimated to be either PAF, PAF-LC or UC(PAF) material - most of which is tailings, which are assessed as posing a Moderate-High AMD source hazard. Rejects are estimated to comprise about 15% of the eastern compartment and are assessed as posing a Moderate AMD source hazard. Natural ground beneath the TSF is considered to pose a low-moderate AMD source hazard (lilkely due to AMD from the overlying tailings). The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 799 µS/cm. The hazard for AMD generation from the eastern compartment of RS1 TSF is conservatively considered to be **MODERATE-HIGH**. The likelihood for AMD generation from the eastern compartment of RS1 TSF is conservatively rated as **HIGHLY LIKELY** - noting that AMD has already been observed from RS1 TSF (likely from the eastern compartment where tailings are located).
Rejects Located within the southern and eastern TSF embankments and covering some or all of the tailings	15%	30%	4.4%	AMD (as AD and NMD/SD) has been observed in surface water and groundwater in the vicinity of RS1 TSF. Based on geochemical information it is assumed the AMD observed to date is primarily from tailings moreso than rejects. Based on data from 200 aged rejects samples from RS1 TSF and Riverside rejects dump (ie. aged rejects originally derived from RV CHPP), approximately 30% of the rejects are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a relatively low-moderate 75th percentile S value of 0.56% (PAF samples). NAF samples have a low 75th percentile S value of 0.39%. Conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects in the eastern compartment that are PAF. Assumes equal distribution of PAF/NAF rejects throughout the eastern compartment of RS1 TSF.	**7** Expected	**5** Moderate	**3** Low-Moderate	**11** Moderate		
Fill & Natural Ground Spoil fill within the eastern compartment (part of embankments) and natural ground material at the base of the TSF	0.5%	19.0%	0.1%	Based on data from 18 natural ground samples from the base of RS1 TSF eastern compartment and three fill samples from within the TSF embankments of the eastern compartment, 17 (out of 21) samples were classified as NAF or UC(NAF). The remaining four samples were classified as PAF-LC or UC(PAF). The 75th percentile S value for all 21 samples = 0.23%. The 75th percentile S value for PAF samples is 0.49%. The 75th percentile S value for NAF samples is 0.06%.	**5** Plausible	**5** Moderate	**3** Low-Moderate	**9** Low-Moderate		

Table B8. AMD hazard scoring for source materials and likelihood for AMD generation from DRE5 in-pit TSF landform (without cover; prior to partial backfilling)

DRE5 TSF: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from DRE5 TSF (before rehabilitation)
Tailings	100%	34%	34%	No tailings samples have been collected from DRE5 in-pit TSF. This TSF is relatively new (commenced receiving tailings in approximately 2019). AMD source hazard is based on fresh CHPP tailings samples. Approximately 34% of tailings are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 1.07% (PAF samples). NAF samples have a low 75th percentile S value of 0.62%. Conservatively assumes proportion of PAF tailings samples approximates the proportion of tailings in the TSF that are PAF. Assumes equal distribution of PAF/NAF tailings throughout the TSF.	**5** Plausible	**7** Moderate-High	**10** High	**14** Moderate	**14** Moderate	The landform is comprised of tailings only, of which 34% of the tailings samples (based on data from fresh (CHPP) tailings samples) were conservatively estimated to be 'PAF' (which includes PAF, PAF-LC, UC(PAF) and NAF-S). The tailings are assessed as posing a Moderate AMD source hazard. The 75th percentile EC of the tailings is 1205 µS/cm. The hazard for AMD generation from DRE5 in-pit TSF is conservatively considered to be **MODERATE**. The likelihood for AMD generation from DRE5 in-pit TSF is conservatively rated as **PROBABLE / LIKELY**.
Rejects No rejects disposed into TSF	0%	n/a	n/a	No rejects located within DRE5 in-pit TSF.	**n/a**	**n/a**	**n/a**	**n/a**		
Fill No fill disposed into TSF	0%	n/a	n/a	No fill located within DRE5 in-pit TSF.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B9. AMD hazard scoring for source materials and likelihood for AMD generation from Ramp 32 in-pit TSF landform (without cover; prior to backfilling)

Ramp 32 TSF: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from Ramp 32 TSF (before rehabilitation)
Tailings	100%	34%	34%	No tailings samples have been collected from Ramp 32 in-pit TSF. This TSF is relatively new (commenced receiving tailings in approximately 2021). AMD source hazard is based on fresh CHPP tailings samples. Approximately 34% of tailings are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 1.07% (PAF samples). NAF samples have a low 75th percentile S value of 0.62%. Conservatively assumes proportion of PAF tailings samples approximates the proportion of tailings in the TSF that are PAF. Assumes equal distribution of PAF/NAF tailings throughout the TSF.	**5** Plausible	**7** Moderate-High	**10** High	**14** Moderate	**14** Moderate	The landform is comprised of tailings only, of which 34% of the tailings samples (based on data from fresh (CHPP) tailings samples) were conservatively estimated to be 'PAF' (which includes PAF, PAF-LC, UC(PAF) and NAF-S). The tailings are assessed as posing a Moderate AMD source hazard. The 75th percentile EC of the tailings is 1205 µS/cm. The hazard for AMD generation from Ramp 32 in-pit TSF is conservatively considered to be **MODERATE**. The likelihood for AMD generation from Ramp 32 in-pit TSF is conservatively rated as **PROBABLE / LIKELY**.
Rejects No rejects disposed into TSF	0%	n/a	n/a	No rejects located within Ramp 32 in-pit TSF.	**n/a**	**n/a**	**n/a**	**n/a**		
Fill No fill disposed into TSF	0%	n/a	n/a	No fill located within Ramp 32 in-pit TSF.	**n/a**	**n/a**	**n/a**	**n/a**		

Table B10. AMD hazard scoring for source materials and likelihood for AMD generation from Riverside rejects landform (currently with a spoil cover and rehabilitated)

Riverside rejects dump: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from Riverside rejects dump (before rehabilitation)
Tailings No tailings disposed into Riverside rejects landform.	0%	0%	0%	No tailings located within Riverside rejects dump	n/a	n/a	n/a	n/a	12 Moderate	Riverside rejects dump contains rejects generated from RV CHPP. The dump underwent rehabiliation (in the early 2000s) and has a spoil cover. This AMD source hazard assessment excludes the existing spoil cover and focusses on the rejects only. The hazard for AMD generation in Riverside rejects dump is based on the facility being comprised essentially of rejects only, of which 30% are conservatively estimated to be PAF, PAF-LC, UC(PAF) or NAF-S. Fill material within the rejects dump (ie. excluding any spoil cover) is assumed to comprise a negligible proportion. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 615 µS/cm. The hazard for AMD generation from Riverside rejects landform is conservatively considered to be **MODERATE**. The likelihood for AMD generation from Riverside rejects landform is conservatively rated as **PROBABLE / LIKELY**.
Rejects All of the landform is comprised of rejects	99.5%	30%	30%	The rejects dump is essentially comprised of rejects only with an assumed very minor (negligible) proportion of fill material. Based on data from 200 aged rejects samples from Riverside rejects dump and RS1 TSF (ie. aged rejects originally derived from RV CHPP), approximately 30% of the rejects are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a relatively low-moderate 75th percentile S value of 0.56% (PAF samples). NAF samples have a low 75th percentile S value of 0.39%. Conservatively assumes proportion of PAF rejects samples approximates the proportion of rejects in the eastern compartment that are PAF. Assumes equal distribution of PAF/NAF rejects throughout the eastern compartment of RS1 TSF.	7 Expected	5 Moderate	5 Moderate	12 Moderate		
Fill & natural ground Assume very minor proportion of fill disposed within Riverside rejects landform. Excludes spoil cover.	0.5%	2.5%	0.0%	No geochemical data is available for fill material specifically from Riverside rejects dump. Based on data from all spoil samples at GRBM, up to 2.5% of 'fill' is conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 0.58% (PAF samples). NAF samples have a 75th percentile S value of 0.05%. Conservatively assumes proportion of PAF fill samples approximates the proportion of fill in the rejects dump that are PAF. Assumes equal distribution of PAF/NAF fill throughout the areas of the rejects dump where fill may be encountered.	1 Low	5 Moderate	3 Low-Moderate	5 Low		

Table B11. AMD hazard scoring for source materials and likelihood for AMD generation from GS2 rejects landform (without cover)

GS2 rejects dump: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from GS2 rejects dump (before rehabilitation)
Tailings No tailings disposed into GS2 rejects dump	0%	0%	0%	No tailings located within GS2 rejects dump	**n/a**	**n/a**	**n/a**	**n/a**	**10** Low-Moderate	GS2 rejects dump receives rejects from GY CHPP and is located east of GS1 TSF - between GS1 TSF and Thiess spoil landform. The hazard for AMD generation in GS2 rejects dump is based on the facility being comprised esentially of rejects only, of which 7% are conservatively estimated to be PAF, PAF-LC, UC(PAF) or NAF-S. Fill material within the rejects dump (ie. excluding any spoil cover) is assumed to comprise a negligible proportion. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 412 µS/cm. The hazard for AMD generation from GS2 rejects landform is conservatively considered to be **LOW-MODERATE**. The likelihood for AMD generation from GS2 rejects landform is conservatively rated as **UNLIKELY**.
Rejects Essentially all of the landform is comprised of rejects	99.5%	7.1%	7.1%	The rejects dump is essentially comprised of rejects only with an assumed negligible proportion of fill material. GS2 rejects are generated from GY CHPP. Based on data from 70 rejects samples from GY CHPP and GS1 TSF (ie. GY rejects only) approximately 7% of rejects are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. PAF samples have a low 75th percentile S value of 0.31%. NAF samples have a 75th percentile S value of 0.27%. Conservatively assumes proportion of PAF and NAF-S rejects samples approximates the proportion of rejects in the rejects dump that are PAF and NAF-S. Assumes equal distribution of PAF/NAF rejects throughout the rejects dump.	**5** Plausible	**5** Moderate	**5** Moderate	**10** Low-Moderate		
Fill Negligible fill within the rejects dump	0.5%	2.5%	0.01%	No geochemical data is available for fill material specifically from GS2 rejects dump. Based on data from all spoil samples at GRBM, up to 2.5% of 'fill' is conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 0.58% (PAF samples). NAF samples have a 75th percentile S value of 0.05%. Conservatively assumes proportion of PAF fill samples approximates the proportion of fill in the rejects dump that are PAF. Assumes equal distribution of PAF/NAF fill throughout the areas of the rejects dump where fill may be encountered.	**1** Low	**5** Moderate	**3** Low-Moderate	**5** Low		

Table B12. AMD hazard scoring for source materials and likelihood for AMD generation from GS11 rejects landform (without cover)

GS11 rejects dump: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from GS11 rejects dump (before rehabilitation)
Tailings No tailings disposed into GS11 rejects dump	0%	0%	0%	No tailings located within GS11 rejects dump	**n/a**	**n/a**	**n/a**	**n/a**	**10** Low-Moderate	GS11 rejects dump receives rejects from GY CHPP and is located at the northwestern periphery of Broadmeadow-Isaac spoil landform, however is unlikely to be rehabilitated as part of the Broadmeadow-Isaac spoil landform. Hence, it has been assessed as a 'stand-alone' rejects landform. The hazard for AMD generation in GS11 rejects dump is based on the facility being comprised essentially of rejects only, of which 7% are conservatively estimated to be PAF, PAF-LC, UC(PAF) or NAF-S. Fill material within the rejects dump (ie. excluding any spoil cover) is assumed to comprise a negligible proportion. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 412 µS/cm. The hazard for AMD generation from GS11 rejects landform is conservatively considered to be **LOW-MODERATE**. The likelihood for AMD generation from GS11 rejects landform is conservatively rated as **UNLIKELY**.
Rejects Essentially all of the landform is comprised of rejects	99.5%	7.1%	7.1%	The rejects dump is essentially comprised of rejects only with an assumed negligible proportion of fill material. GS11 rejects are generated from GY CHPP. Based on data from 70 rejects samples from GY CHPP and GS1 TSF (ie. GY rejects only) approximately 7% of rejects are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. PAF samples have a low 75th percentile S value of 0.31%. NAF samples have a 75th percentile S value of 0.27%. Conservatively assumes proportion of PAF and NAF-S rejects samples approximates the proportion of rejects in the rejects dump that are PAF and NAF-S. Assumes equal distribution of PAF/NAF rejects throughout the rejects dump.	**5** Plausible	**5** Moderate	**5** Moderate	**10** Low-Moderate		
Fill Negligible fill within the rejects dump	0.5%	2.5%	0.01%	No geochemical data is available for fill material specifically from GS11 rejects dump. Based on data from all spoil samples at GRBM, up to 2.5% of 'fill' is conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 0.58% (PAF samples). NAF samples have a 75th percentile S value of 0.05%. Conservatively assumes proportion of PAF fill samples approximates the proportion of fill in the rejects dump that are PAF. Assumes equal distribution of PAF/NAF fill throughout the areas of the rejects dump where fill may be encountered.	**1** Low	**5** Moderate	**3** Low-Moderate	**5** Low		

Table B13. AMD hazard scoring for source materials and likelihood for AMD generation from R22 in-pit rejects landform (without cover)

R22 rejects dump: Components (without cover)	Estimated material proportion within landform	% of samples classified as PAF	% of material in landform estimated to be PAF	Comment	AMD propensity rating	AMD capacity rating	AMD quantity rating	AMD hazard score	Landform AMD hazard score (pre-rehabilitation)	Likelihood for AMD generation from R22 rejects dump (before rehabilitation)
Tailings No tailings disposed into R22 rejects dump	0%	0%	0%	No tailings located within R22 rejects dump	n/a	n/a	n/a	n/a	**10** Low-Moderate	
Rejects Essentially all of the landform is comprised of rejects	99.5%	7%	7%	The rejects dump is essentially comprised of rejects only with an assumed negligible proportion of fill material. R22 rejects are generated from GY CHPP. Based on data from 70 rejects samples from GY CHPP and GS1 TSF (ie. GY rejects only) approximately 7% of rejects are conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. PAF samples have a low 75th percentile S value of 0.31%. NAF samples have a 75th percentile S value of 0.27%. Conservatively assumes proportion of PAF and NAF-S rejects samples approximates the proportion of rejects in the rejects dump that are PAF and NAF-S. Assumes equal distribution of PAF/NAF rejects throughout the rejects dump.	**5** Plausible	**5** Moderate	**5** Moderate	**10** Low-Moderate		R22 rejects dump receives rejects from GY CHPP and is located at the south-western periphery of Thiess spoil landform. The hazard for AMD generation in R22 rejects dump is based on the facility being comprised essentially of rejects only, of which 7% are conservatively estimated to be PAF, PAF-LC, UC(PAF) or NAF-S. Fill material within the rejects dump (ie. excluding any spoil cover) is assumed to comprise a negligible proportion. The 75th percentile EC of the landform (based on the EC of the source materials proportionally represented) is estimated at 412 µS/cm. The hazard for AMD generation from R22 rejects landform is conservatively considered to be **LOW-MODERATE**. The likelihood for AMD generation from R22 rejects landform is conservatively rated as **UNLIKELY**.
Fill Negligible fill within the rejects dump	0.5%	2.5%	0.0%	No geochemical data is available for fill material specifically from R22 rejects dump. Based on data from all spoil samples at GRBM, up to 2.5% of 'fill' is conservatively classified as PAF, PAF-LC, UC(PAF) or NAF-S. AMD capacity is based on a 75th percentile S value of 0.58% (PAF samples). NAF samples have a 75th percentile S value of 0.05%. Conservatively assumes proportion of PAF fill samples approximates the proportion of fill in the rejects dump that are PAF. Assumes equal distribution of PAF/NAF fill throughout the areas of the rejects dump where fill may be encountered.	**1** Low	**5** Moderate	**3** Low-Moderate	**5** Low		

Table B14. AMD hazard scoring for source materials and likelihood for AMD generation from Goonyella residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal 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 Goonyella void highwall
Goonyella Void Highwall	Weathered, non-carbonaceous	10.3%	74%	26%	0%	3.2%	Five out of 154 weathered non-carbonaceous samples were 'PAF' (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF. Most of this material lies above the water table.	0.3%	Expected to comprise approximately 10% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Very low proportion of PAF material. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.05%. AMD capacity is based on PAF samples 75th %ile total S of 0.58%.	1	5	1	4	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. The potential exposure of PAF materials on the highwall is estimated to represent approximately 10% (vertical meterage). PAF domains are expected to be largely confined to coal horizons/seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Overall, void wall run-off reporting to the residual void is unlikely to produce significant acidity. The hazard for AMD generation from void highwall = **LOW-MODERATE**. The likelihood for AMD generation from void highwall (generally) = **UNLIKELY**
	Weathered, carbonaceous & coaly	1.3%	53%	47%	0%	23%	Seven out of 31 weathered carbonaceous samples were classified as 'PAF' (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard. About half of this material lies above the water table.	0.3%	Expected to comprise approximately 1.3% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Significant proportion of PAF material, however all predominantly oxidised and generally low S. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.23%. AMD capacity is based on PAF samples 75th %ile total S of 0.63%.	5	5	1	8	
	Fresh, non-carbonaceous	71%	43%	57%	71%	1.3%	Approximately 1.3% of the 1015 fresh, non-carbonaceous samples were classified as 'PAF' (data from geochemical database). Available drill-hole data indicates that approximately 43% of this material lies above the water table and would be potentially subject to oxidation.	0.9%	Estimated to comprise approximately 71% of the void wall material by meterage. Overall, fresh, non-carb. spoil is overwhelmingly NAF with excess ANC. Likely to be an important source of ANC. Approximately 1.3% of samples were PAF (of some type). This material is overwhelmingly NAF. The 75th %ile total S value is 0.05%. AMD capacity based on PAF samples 75th %ile total S of 0.47%.	1	5	1	4	
	Fresh, carbonaceous	5.5%	43%	57%	5.5%	7.1%	Approximately 7% of the 112 fresh, carbonaceous samples were classified as 'PAF' (data from geochemical database). Available drill-hole data indicates that approximately 43% of this material lies above the water table and would be potentially subject to oxidation.	0.4%	Generation of AMD from fresh carbonaceous units cannot be excluded as approximately 7% of the samples tested were classed as PAF (of some type), however most were closely associated with seams. Estimated to comprise approximately 5.5% of the void wall material. The 75th %ile total S value is 0.13%. AMD capacity based on PAF samples 75th %ile total S of 0.51%.	5	5	1	8	
	Coal (fresh)	10.2%	56%	44%	10.2%	77%	Approximately 77% of the 26 fresh, coal samples were classified as 'PAF' (data from geochemical database). Available drill-hole data indicates that approximately 56% of this material lies above the water table and would be potentially subject to oxidation.	7.9%	Expected to comprise about 10% of the void wall material by meterage and about 8% of the highwall is expected to be 'PAF' coal. The 75th %ile S value for all coal samples is 0.40%. AMD capacity based on PAF samples 75th %ile total S of 0.44%. With regard to the coal quality database (n=7011 samples), the 75th %ile total S value is 0.58% - higher, but generally consistent with the smaller geochemical database.	7	5	1	10	
	Unknown	2.1%	64%	36%	1.2%	7.1%	Lithology unknown. Majority of material is below base of weathering and above water table. Conservatively assume PAF samples based on fresh carb spoil.	0.1%	Very low proportion and majority is 'fresh'. Conservatively assume 'Moderate' AMD capacity rating - consistent with fresh carbonaceous material.	5	5	1	8	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							9.9%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Goonyella void floor	
Goonyella Void Floor	Coal: GLS (Goonyella Lower Seam)	100%	0%	100%	100%	98%	PAF proportion estimated by applying a total S 'cut-off' of 0.42% to the coal quality data for GLS seam samples (3372 samples). 3303 out of 3372 GLS samples (ie. 98% of samples) had total S ≥0.42%. The S cut-off was based on the median total S value for 'PAF' coal and rejects samples (combined) from the geochemical database. 'PAF' comprises samples classified as PAF, PAF-LC, UC(PAF) and NAF-S. Based on the geochemical database, 77% of 26 coal samples (from all seams) were conservatively classified as 'PAF' of some type. Whereas, based on the much larger coal quality database (3372 samples), almost all of the void floor is estimated to be PAF. The assessment assumes the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining.	98%	The floor of Goonyella void is expected to be GLS seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.57% (based on 3372 GLS samples in the coal quality database). AMD capacity is based on 75th percentile total S value of 0.44% for PAF coal samples from the geochemical database. Almost all of GLS seam coal samples from GRBM have been classified as PAF and, combined with the relatively low ANC in coal itself, the potential for AMD generation from essentially all of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	7	5	7	13	Almost alll of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is moderate if the entire void 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. The likelihood for AMD generation from exposed Goonyella void floor = **PROBABLE/LIKELY**

Table B15. AMD hazard scoring for source materials and likelihood for AMD generation from Thiess residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal 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 Thiess void highwall
Thiess Void Highwall	Weathered, non-carbonaceous	44%	100%	0%	0%	3.2%	Five out of 154 weathered non-carbonaceous samples were 'PAF' (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF. All of this material lies above the water table.	1.4%	Expected to comprise approximately 44% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Very low proportion of PAF material. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.05%. AMD capacity is based on PAF samples 75th %ile total S of 0.58%.	1	5	1	4	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. The potential exposure of PAF materials on the highwall is estimated to represent approximately 10% (vertical meterage). PAF domains are expected to be largely confined to coal horizons/seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Overall, void wall run-off reporting to the residual void is unlikely to produce significant acidity. The hazard for AMD generation from void highwall = **LOW-MODERATE**. The likelihood for AMD generation from void highwall (generally) = **UNLIKELY**
	Weathered, carbonaceous & coaly	3.2%	100%	0%	0%	23%	Seven out of 31 weathered carbonaceous samples were classified as 'PAF' (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard. All of this material lies above the water table.	0.7%	Expected to comprise approximately 3% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Significant proportion of PAF material, however all predominantly oxidised and generally low S. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.23%. AMD capacity is based on PAF samples 75th %ile total S of 0.63%.	5	5	1	8	
	Fresh, non-carbonaceous	38%	100%	0%	38%	1.3%	Approximately 1.3% of the 1015 fresh, non-carbonaceous samples were classified as 'PAF' (data from geochemical database). Available drill-hole data indicates that all of this material lies above the water table and would be potentially subject to oxidation.	0.5%	Estimated to comprise approximately 38% of the void wall material by meterage. Overall, fresh, non-carb. spoil is overwhelmingly NAF with excess ANC. Likely to be an important source of ANC. Approximately 1.3% of samples were PAF (of some type). This material is overwhelmingly NAF. The 75th %ile total S value is 0.05%. AMD capacity based on PAF samples 75th %ile total S of 0.47%.	1	5	1	4	
	Fresh, carbonaceous	3.7%	100%	0%	3.7%	7.1%	Approximately 7% of the 112 fresh, carbonaceous samples were classified as 'PAF' (data from geochemical database). Available drill-hole data indicates that all of this material lies above the water table and would be potentially subject to oxidation.	0.3%	Generation of AMD from fresh carbonaceous units cannot be excluded as approximately 7% of the samples tested were classed as PAF (of some type), however most were closely associated with seams. Estimated to comprise approximately 3.7% of the void wall material. The 75th %ile total S value is 0.13%. AMD capacity based on PAF samples 75th %ile total S of 0.51%.	5	5	1	8	
	Coal (fresh)	9.4%	100%	0%	9.4%	77%	Approximately 77% of the 26 fresh, coal samples were classified as 'PAF' (data from geochemical database). Available drill-hole data indicates that all of this material lies above the water table and would be potentially subject to oxidation.	7.2%	Expected to comprise about 9% of the void wall material by meterage and about 7% of the highwall is expected to be 'PAF' coal. The 75th %ile S value for all coal samples is 0.40%. AMD capacity based on PAF samples 75th %ile total S of 0.44%. With regard to the coal quality database (n=7011 samples), the 75th %ile total S value is 0.58% - higher, but generally consistent with the smaller geochemical database.	7	5	1	10	
	Unknown	1.9%	100%	0%	0.9%	7.1%	Lithology unknown. Half of material is below base of weathering and all above water table. Conservatively assume PAF samples based on fresh carb spoil.	0.1%	Very low proportion and about half is 'fresh'. Conservatively assume 'Moderate' AMD capacity rating - consistent with fresh carbonaceous material.	5	5	1	8	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							10%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Thiess void floor	
Thiess Void Floor	Coal: GLS (Goonyella Lower Seam)	100%	0%	100%	100%	98%	PAF proportion estimated by applying a total S 'cut-off' of 0.42% to the coal quality data for GLS seam samples (3372 samples). 3303 out of 3372 GLS samples (ie. 98% of samples) had total S ≥0.42%. The S cut-off was based on the median total S value for 'PAF' coal and rejects samples (combined) from the geochemical database. 'PAF' comprises samples classified as PAF, PAF-LC, UC(PAF) and NAF-S. Based on the geochemical database, 77% of 26 coal samples (from all seams) were conservatively classified as 'PAF' of some type. Whereas, based on the much larger coal quality database (3372 samples), almost all of the void floor is estimated to be PAF. The assessment assumes the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining.	98%	The floor of Thiess void is expected to be GLS seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.57% (based on 3372 GLS samples in the coal quality database). AMD capacity is based on 75th percentile total S value of 0.44% for PAF coal samples from the geochemical database. Almost all of GLS seam coal samples from GRBM have been classified as PAF and, combined with the relatively low ANC in coal itself, the potential for AMD generation from essentially all of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	7	5	7	13	Almost alll of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is moderate if the entire void 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. The likelihood for AMD generation from exposed Thiess void floor = **PROBABLE/LIKELY**

Table B16. AMD hazard scoring for source materials and likelihood for AMD generation from Ramp 32 East residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal 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 Ramp 32 East void highwall
Ramp 32 East Void Highwall	Weathered, non-carbonaceous	34%	unkn.	unkn.	0%	3.2%	Five out of 154 weathered non-carbonaceous samples were 'PAF' (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF. Water table information unknown - assume all above the water table.	1.1%	Expected to comprise approximately 34% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Very low proportion of PAF material. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.05%. AMD capacity is based on PAF samples 75th %ile total S of 0.58%.	1	5	1	4	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. The potential exposure of PAF materials on the highwall is estimated to represent approximately 7% (vertical meterage). PAF domains are expected to be largely confined to coal horizons/seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Overall, void wall run-off reporting to the residual void is unlikely to produce significant acidity. The hazard for AMD generation from void highwall = **LOW-MODERATE**. The likelihood for AMD generation from void highwall (generally) = **UNLIKELY**
	Weathered, carbonaceous & coaly	2.6%	unkn.	unkn.	0%	23%	Seven out of 31 weathered carbonaceous samples were 'PAF' (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF. Water table information unknown - assume all above the water table.	0.6%	Expected to comprise approximately 2.6% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Significant proportion of PAF material, however all predominantly oxidised and generally low S. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.23%. AMD capacity is based on PAF samples 75th %ile total S of 0.63%.	5	5	1	8	
	Fresh, non-carbonaceous	53%	unkn.	unkn.	53%	1.3%	Approximately 1.3% of the 1015 fresh, non-carbonaceous samples were classified as 'PAF' (data from geochemical database). Water table information unknown. Assume 50% of this material lies above the water table and would be potentially subject to oxidation.	0.7%	Estimated to comprise approximately 53% of the void wall material by meterage. Overall, fresh, non-carb. spoil is overwhelmingly NAF with excess ANC. Likely to be an important source of ANC. Approximately 1.3% of samples were PAF (of some type). This material is overwhelmingly NAF. The 75th %ile total S value is 0.05%. AMD capacity based on PAF samples 75th %ile total S of 0.47%.	1	5	1	4	
	Fresh, carbonaceous	5.0%	unkn.	unkn.	5.0%	7.1%	Approximately 7% of the 112 fresh, carbonaceous samples were classified as 'PAF' (data from geochemical database). Water table information unknown. Assume 50% of this material lies above the water table and would be potentially subject to oxidation.	0.4%	Generation of AMD from fresh carbonaceous units cannot be excluded as approximately 7% of the samples tested were classed as PAF (of some type), however most were closely associated with seams. Estimated to comprise approximately 5% of the void wall material. The 75th %ile total S value is 0.13%. AMD capacity based on PAF samples 75th %ile total S of 0.51%.	5	5	1	8	
	Coal (fresh)	5.0%	unkn.	unkn.	5.0%	77%	Approximately 77% of the 26 fresh, coal samples were classified as 'PAF' (data from geochemical database). Water table information unknown. Assume 50% of this material lies above the water table and would be potentially subject to oxidation.	3.9%	Expected to comprise about 5% of the void wall material by meterage and about 4% of the highwall is expected to be 'PAF' coal. The 75th %ile S value for all coal samples is 0.40%. AMD capacity based on PAF samples 75th %ile total S of 0.44%. With regard to the coal quality database (n=7011 samples), the 75th %ile total S value is 0.58% - higher, but generally consistent with the smaller geochemical database.	7	5	1	10	
	Unknown	0.0%	n/a	n/a	0.0%	0%	No material of unknown type.	0%	No material of unknown type.	n/a	n/a	n/a	**n/a**	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							6.6%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Ramp 32 East void floor	
Ramp 32 East Void Floor	Coal: GLS (Goonyella Lower Seam)	100%	0%	100%	100%	98%	PAF proportion estimated by applying a total S 'cut-off' of 0.42% to the coal quality data for GLS seam samples (3372 samples). 3303 out of 3372 GLS samples (ie. 98% of samples) had total S ≥0.42%. The S cut-off was based on the median total S value for 'PAF' coal and rejects samples (combined) from the geochemical database. 'PAF' comprises samples classified as PAF, PAF-LC, UC(PAF) and NAF-S. Based on the geochemical database, 77% of 26 coal samples (from all seams) were conservatively classified as 'PAF' of some type. Whereas, based on the much larger coal quality database (3372 samples), almost all of the void floor is estimated to be PAF. The assessment assumes the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining.	98%	The floor of Ramp 32 East void is expected to be GLS seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.57% (based on 3372 GLS samples in the coal quality database). AMD capacity is based on 75th percentile total S value of 0.44% for PAF coal samples from the geochemical database. Almost all of GLS seam coal samples from GRBM have been classified as PAF and, combined with the relatively low ANC in coal itself, the potential for AMD generation from essentially all of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	7	5	7	13	Almost alll of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is moderate if the entire void 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. The likelihood for AMD generation from exposed Ramp 32 East void floor = **PROBABLE/LIKELY**

Table B17. AMD hazard scoring for source materials and likelihood for AMD generation from Ramp 32 South residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal 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 Ramp 32 South void highwall
Ramp 32 South Void Highwall	Weathered, non-carbonaceous	23%	unkn.	unkn.	0%	3.2%	Five out of 154 weathered non-carbonaceous samples were 'PAF' (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF. Water table information unknown - assume all above the water table.	0.7%	Expected to comprise approximately 34% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Very low proportion of PAF material. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.05%. AMD capacity is based on PAF samples 75th %ile total S of 0.58%.	1	5	1	4	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. The potential exposure of PAF materials on the highwall is estimated to represent approximately 7% (vertical meterage). PAF domains are expected to be largely confined to coal horizons/seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Overall, void wall run-off reporting to the residual void is unlikely to produce significant acidity. The hazard for AMD generation from void highwall = **LOW-MODERATE**. The likelihood for AMD generation from void highwall (generally) = **UNLIKELY**
	Weathered, carbonaceous & coaly	2.0%	unkn.	unkn.	0%	23%	Seven out of 31 weathered carbonaceous samples were 'PAF' (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF. Water table information unknown - assume all above the water table.	0.5%	Expected to comprise approximately 2.6% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Significant proportion of PAF material, however all predominantly oxidised and generally low S. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.23%. AMD capacity is based on PAF samples 75th %ile total S of 0.63%.	5	5	1	8	
	Fresh, non-carbonaceous	63%	unkn.	unkn.	63%	1.3%	Approximately 1.3% of the 1015 fresh, non-carbonaceous samples were classified as 'PAF' (data from geochemical database). Water table information unknown. Assume 50% of this material lies above the water table and would be potentially subject to oxidation.	0.8%	Estimated to comprise approximately 53% of the void wall material by meterage. Overall, fresh, non-carb. spoil is overwhelmingly NAF with excess ANC. Likely to be an important source of ANC. Approximately 1.3% of samples were PAF (of some type). This material is overwhelmingly NAF. The 75th %ile total S value is 0.05%. AMD capacity based on PAF samples 75th %ile total S of 0.47%.	1	5	1	4	
	Fresh, carbonaceous	6.0%	unkn.	unkn.	6.0%	7.1%	Approximately 7% of the 112 fresh, carbonaceous samples were classified as 'PAF' (data from geochemical database). Water table information unknown. Assume 50% of this material lies above the water table and would be potentially subject to oxidation.	0.4%	Generation of AMD from fresh carbonaceous units cannot be excluded as approximately 7% of the samples tested were classed as PAF (of some type), however most were closely associated with seams. Estimated to comprise approximately 5% of the void wall material. The 75th %ile total S value is 0.13%. AMD capacity based on PAF samples 75th %ile total S of 0.51%.	5	5	1	8	
	Coal (fresh)	6.0%	unkn.	unkn.	6.0%	77%	Approximately 77% of the 26 fresh, coal samples were classified as 'PAF' (data from geochemical database). Water table information unknown. Assume 50% of this material lies above the water table and would be potentially subject to oxidation.	4.6%	Expected to comprise about 5% of the void wall material by meterage and about 4% of the highwall is expected to be 'PAF' coal. The 75th %ile S value for all coal samples is 0.40%. AMD capacity based on PAF samples 75th %ile total S of 0.44%. With regard to the coal quality database (n=7011 samples), the 75th %ile total S value is 0.58% - higher, but generally consistent with the smaller geochemical database.	7	5	1	10	
	Unknown	0.0%	n/a	n/a	0.0%	0%	No material of unknown type.	0%	No material of unknown type.	n/a	n/a	n/a	**n/a**	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							7.1%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Ramp 32 South void floor	
Ramp 32 South Void Floor	Coal: GLS (Goonyella Lower Seam)	100%	0%	100%	100%	98%	PAF proportion estimated by applying a total S 'cut-off' of 0.42% to the coal quality data for GLS seam samples (3372 samples). 3303 out of 3372 GLS samples (ie. 98% of samples) had total S ≥0.42%. The S cut-off was based on the median total S value for 'PAF' coal and rejects samples (combined) from the geochemical database. 'PAF' comprises samples classified as PAF, PAF-LC, UC(PAF) and NAF-S. Based on the geochemical database, 77% of 26 coal samples (from all seams) were conservatively classified as 'PAF' of some type. Whereas, based on the much larger coal quality database (3372 samples), almost all of the void floor is estimated to be PAF. The assessment assumes the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining.	98%	The floor of Ramp 32 South void is expected to be GLS seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.57% (based on 3372 GLS samples in the coal quality database). AMD capacity is based on 75th percentile total S value of 0.44% for PAF coal samples from the geochemical database. Almost all of GLS seam coal samples from GRBM have been classified as PAF and, combined with the relatively low ANC in coal itself, the potential for AMD generation from essentially all of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	7	5	7	13	Almost alll of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is moderate if the entire void 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. The likelihood for AMD generation from exposed Ramp 32 South void floor = **PROBABLE/LIKELY**

Table B18. AMD hazard scoring for source materials and likelihood for AMD generation from Broadmeadow-Isaac residual void walls and floor

Material domain	Material type	Proportion of drill-hole meterage on highwall by material type %	Above current water table (where known)	Below current water table (where known)	Proportion of drill-hole meterage (below base of weathering)	% of PAF sample by material type (environmental and/or coal 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 Broadmeadow-Isaac void highwall
Broadmeadow-Isaac Void Highwall	Weathered, non-carbonaceous	26%	99%	1%	0%	3.2%	Five out of 154 weathered non-carbonaceous samples were 'PAF' (data from geochemical database). It is expected that weathered material is completely or predominantly oxidised and, as such, this material is overwhelmingly NAF. Almost all of this material lies above the water table.	0.8%	Expected to comprise approximately 26% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Very low proportion of PAF material. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.05%. AMD capacity is based on PAF samples 75th %ile total S of 0.58%.	1	5	1	4	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. The potential exposure of PAF materials on the highwall is estimated to represent approximately 7% (vertical meterage). PAF domains are expected to be largely confined to coal horizons/seams. However, these will be embedded in a matrix of NAF and ANC-rich materials. Overall, void wall run-off reporting to the residual void is unlikely to produce significant acidity. The hazard for AMD generation from void highwall = **LOW-MODERATE**. The likelihood for AMD generation from void highwall (generally) = **UNLIKELY**
	Weathered, carbonaceous & coaly	0.8%	100%	0%	0%	23%	Seven out of 31 weathered carbonaceous samples were classified as 'PAF' (data from geochemical database). It is expected that weathered material is prodominantly oxidised and, as such, this material is predominantly NAF or would pose a low AMD hazard. All of this material lies above the water table.	0.2%	Expected to comprise less than 1% of the void wall material by meterage. Assumed to be non-mineralised, with very low sulphide concentration. Significant proportion of PAF material, however all predominantly oxidised and generally low S. The potential for AMD from acid sulphate minerals is very low. Likely source of ANC. The 75th %ile total S value is 0.23%. AMD capacity is based on PAF samples 75th %ile total S of 0.63%.	5	5	1	8	
	Fresh, non-carbonaceous	61%	46%	54%	61%	1.3%	Approximately 1.3% of the 1015 fresh, non-carbonaceous samples were classified as 'PAF' (data from geochemical database). Available drill-hole data indicates that approximately 46% of this material lies above the water table and would be potentially subject to oxidation.	0.8%	Estimated to comprise approximately 61% of the void wall material by meterage. Overall, fresh, non-carb. spoil is overwhelmingly NAF with excess ANC. Likely to be an important source of ANC. Approximately 1.3% of samples were PAF (of some type). This material is overwhelmingly NAF. The 75th %ile total S value is 0.05%. AMD capacity based on PAF samples 75th %ile total S of 0.47%.	1	5	1	4	
	Fresh, carbonaceous	1.5%	43%	57%	1.5%	7.1%	Approximately 7% of the 112 fresh, carbonaceous samples were classified as 'PAF' (data from geochemical database). Available drill-hole data indicates that approximately 43% of this material lies above the water table and would be potentially subject to oxidation.	0.1%	Generation of AMD from fresh carbonaceous units cannot be excluded as approximately 7% of the samples tested were classed as PAF (of some type), however most were closely associated with seams. Estimated to comprise approximately 1.5% of the void wall material. The 75th %ile total S value is 0.13%. AMD capacity based on PAF samples 75th %ile total S of 0.51%.	5	5	1	8	
	Coal (fresh)	6.7%	35%	65%	6.7%	77%	Approximately 77% of the 26 fresh, coal samples were classified as 'PAF' (data from geochemical database). Available drill-hole data indicates that approximately 35% of this material lies above the water table and would be potentially subject to oxidation.	5.2%	Expected to comprise about 7% of the void wall material by meterage and about 5% of the highwall is expected to be 'PAF' coal. The 75th %ile S value for all coal samples is 0.40%. AMD capacity based on PAF samples 75th %ile total S of 0.44%. With regard to the coal quality database (n=7011 samples), the 75th %ile total S value is 0.58% - higher, but generally consistent with the smaller geochemical database.	7	5	1	10	
	Unknown	4.0%	96%	4%	2.8%	7.1%	Lithology unknown. Majority of material is below base of weathering and above water table. Conservatively assume PAF samples based on fresh carb spoil.	0.3%	Very low proportion and over two-thirds is 'fresh'. Conservatively assume 'Moderate' AMD capacity rating - consistent with fresh carbonaceous material.	5	5	1	8	
	Estimated frequency of occurrence of PAF drill-hole intervals - assuming representativeness of surface exposure by drill-hole data							7.4%						

Material domain	Material type on void floor	Proportion of exposure on void floor % (assumed)	Above current water table	Below current water table	% Exposure (below base of weathering)	% of PAF sample by material type (environmental and/or coal database)	Comment	Estimated % PAF exposure on void floor	Comment	Geochemical Propensity for AMD	AMD Capacity Rating	AMD Quantity Rating	Likelihood for AMD generation from exposed Broadmeadow-Isaac void floor	
Broadmeadow-Isaac Void Floor	Coal: GMS (Goonyella Middle Seam)	100%	0%	100%	100%	98%	PAF proportion estimated by applying a total S 'cut-off' of 0.42% to the coal quality data for GMS seam samples (2227 samples). 2175 out of 2227 GMS samples (ie. 98% of samples) had total S ≥0.42%. The S cut-off was based on the median total S value for 'PAF' coal and rejects samples (combined) from the geochemical database. 'PAF' comprises samples classified as PAF, PAF-LC, UC(PAF) and NAF-S. Based on the geochemical database, 77% of 26 coal samples (from all seams) were conservatively classified as 'PAF' of some type. Whereas, based on the much larger coal quality database (2227 samples), almost all of the void floor is estimated to be PAF. The assessment assumes the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining.	98%	The floor of Broadmeadow-Isaac void is expected to be GMS seam group materials (coaly and carbonaceous materials), which has a 75th percentile total S value of 0.53% (based on 2227 GMS samples in the coal quality database). AMD capacity is based on 75th percentile total S value of 0.44% for PAF coal samples from the geochemical database. Almost all of GMS seam coal samples from GRBM have been classified as PAF and, combined with the relatively low ANC in coal itself, the potential for AMD generation from essentially all of the void floor cannot be excluded - assuming the entire void floor comprises purely coal material - which is highly unlikely, given that the entire seam (coal) is taken during mining. No allowance for pit flooding has been taken into account in this hazard assessment. Refer to report body for discussion regarding pit flooding.	7	5	7	13	Almost alll of the void floor may comprise PAF coal. The geochemical hazard for the void floor to develop AMD is moderate if the entire void 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. The likelihood for AMD generation from exposed Broadmeadow-Isaac void floor = **PROBABLE/LIKELY**

Attachment C – SPR Assessment Tables

SPR assessment of post-closure spoil landform (source) to surface water (receptor)

- Table C1 Goonyella spoil landform
- Table C2 Thiess spoil landform
- Table C3 Airstrip spoil landform
- Table C4 Broadmeadow-Isaac spoil landform

SPR assessment of post-closure TSF and rejects landform (source) to surface water (receptor)

- Table C5 GS1 TSF landform
- Table C6 RS1 TSF landform
- Table C7 Riverside rejects landform
- Table C8 GS2 rejects landform
- Table C9 GS11 rejects landform
- Table C10 R22 in-pit rejects landform

SPR assessment of post-closure spoil landform (source) to residual void (receptor)

- Table C11 Airstrip spoil landform
- Table C12 Goonyella, Thiess and Broadmeadow-Isaac spoil landforms

SPR assessment of post-closure TSF and rejects landform (source) to residual void (receptor)

- Table C13 TSF landforms
- Table C14 Rejects landforms

SPR assessment of residual void highwall and floor (source) to residual void (receptor)

- Table C15 All voids

Table C1. Source-Pathway-Receptor (SPR) assessment of Goonyella post-closure spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Goonyella spoil landform (post-closure) Comprised of approximately 91% non-carbonaceous spoil; approximately 9% carbonaceous spoil; and approximately 0.1% rejects (historic rejects disposed in the Lenton pit area). No tailings *AMD source hazard of the spoil landform is **Low*** *Salinity (non-oxidative) source hazard of the spoil landform is **Low***	From Goonyella spoil landform via surface water run-off into ephemeral creeks: • Goonyella Ck tributary. Distance <300m northeast. • Eureka Ck. Distance ~150m south. • Isaac River. Distance ~250m southeast. *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creeks (via surface water run-off): • Goonyella Ck tributary @ northeast. • Eureka Ck @ south. • Isaac River @ southeast. *Potential for AMD to reach either of these creeks: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach either of these creeks: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Goonyella Ck, Eureka Ck and/or Isaac River [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Goonyella Ck, Eureka Ck and/or Isaac River [via run-off]	Unlikely	S1	**Low**
			Saline drainage (sulphide oxidation): Salt (sulphate) impacting Goonyella Ck, Eureka Ck and/or Isaac River [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Goonyella Ck, Eureka Ck and/or Isaac River [via run-off]	Unlikely	S1	**Low**
	From Goonyella spoil landform via seepage into shallow permeable strata then into ephemeral creeks: • Goonyella Ck tributary. Distance <300m northeast. • Eureka Ck. Distance ~150m south. • Isaac River. Distance ~250m southeast. *Potential for AMD to enter shallow permeable strata: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow permeable strata: **Unlikely***	Ephemeral creeks (via shallow permeable strata): • Goonyella Ck tributary. Distance <300m northeast. • Eureka Ck. Distance ~150m south. • Isaac River. Distance ~250m southeast. *Potential for AMD to reach either of these creeks: **Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach either of these creeks: **Highly Unlikely***	**Acid/acidic drainage:** Low pH & metalliferous water impacting Goonyella Ck, Eureka Ck and/or Isaac River [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals/metalloids impacting Goonyella Ck, Eureka Ck and/or Isaac River [via seepage]	Unlikely	S1	**Low**
			Saline drainage (sulphide oxidn.): Salt (sulphate) impacting Goonyella Ck, Eureka Ck and/or Isaac River [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Goonyella Ck, Eureka Ck and/or Isaac River [via seepage]	Unlikely	S1	**Low**

Table C2. Source-Pathway-Receptor (SPR) assessment of Thiess post-closure spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Thiess spoil landform (post-closure) Comprised of approximately 91% non-carbonaceous spoil; approximately 9% carbonaceous spoil; and less than 0.5% rejects (R23 rejects). [R22 rejects dump assessed separately] No tailings [DRE5 TSF addressed separately] *AMD source hazard of the spoil landform is **Low*** *Salinity (non-oxidative) source hazard of the spoil landform is **Low***	From Thiess spoil landform via surface water run-off into ephemeral Eureka Creek. Distance ~150m to receptor @ west; and <100m to receptor @ south. *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Eureka Creek @ western and southern sides of Thiess spoil landform. *Potential for AMD to reach Eureka Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH water and metalliferous impacting Eureka Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Eureka Creek [via run-off]	Unlikely	S1	**Low**
	From Thiess spoil landform via seepage into shallow permeable strata then into ephemeral Eureka Creek. Distance ~150m to receptor @ west; and <100m to receptor @ south. *Potential for AMD to enter shallow permeable strata: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Unlikely***	Ephemeral creek (via shallow permeable strata): Eureka Creek @ western and southern sides of Thiess spoil landform. *Potential for AMD to reach Eureka Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Eureka Creek [via seepage]	Unlikely	S1	**Low**

DRE5 in-pit TSF and R22 in-pit rejects dump are both within the footprint and pit shell of Thiess spoil landform, but are conservatively assessed as stand-alone TSF and rejects landforms due to the concentrated nature of tailings and rejects within the landform (i.e. the SPR assessments for DRE5 TSF and R22 rejects dump have been undertaken separate to Thiess spoil landform). DRE5 in-pit TSF is below ground and will be mostly backfilled with spoil such that the backfilled facility will free drain into the Thiess landform. R22 rejects dump will be covered by spoil to manage the AMD hazard. Refer to **Figure 26** for the CFM for DRE5 TSF and **Figure 27** for the CFM for R22 rejects dump. Refer to **Table C10** for the SPR for surface water receptors associated with R22 rejects dump. There are no plausible surface water receptors associated with DRE5 TSF.

Table C3. Source-Pathway-Receptor (SPR) assessment of Airstrip post-closure spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Airstrip spoil landform (post-closure) Comprised of approximately 91% non-carbonaceous spoil; approximately 8% carbonaceous spoil; and approximately 1% rejects [broadly distributed]. No tailings *AMD source hazard of the spoil landform is **Low*** *Salinity (non-oxidative) source hazard of the spoil landform is **Low***	From Airstrip spoil landform via surface water run-off into ephemeral Holding Paddock Creek. Distance <100m to receptor @ west and southwest. *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Holding Paddock Creek @ western and southwestern sides of Airstrip spoil landform. *Potential for AMD to reach Holding Paddock Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Holding Paddock Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Holding Paddock Creek [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Holding Paddock Creek [via run-off]	Unlikely	S1	**Low**
			Saline drainage (sulphide oxidation): Salt (sulphate) impacting Holding Paddock Creek [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Holding Paddock Creek [via run-off]	Unlikely	S1	**Low**
	From Airstrip spoil landform via seepage into shallow permeable strata then into ephemeral Holding Paddock Creek. Distance <100m to receptor @ west and southwest. *Potential for AMD to enter shallow permeable strata: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Unlikely***	Ephemeral creek (via shallow permeable strata): Holding Paddock Creek @ western and southwestern sides of Airstrip spoil landform. *Potential for AMD to reach Holding Paddock Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Holding Paddock Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Holding Paddock Creek [via seepage]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Holding Paddock Creek [via seepage]	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Holding Paddock Creek [via seepage]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Holding Paddock Creek [via seepage]	Unlikely	S1	**Low**

Ramp 32 in-pit TSF (Airstrip pit) is within the footprint and pit shell of Airstrip spoil landform, but is conservatively assessed as a stand-alone TSF landform due to the concentrated nature of tailings in one area of the landform (i.e. the SPR assessment of Ramp 32 in-pit TSF has been undertaken separate to Airstrip spoil landform). Ramp 32 in-pit TSF is below ground and will be backfilled with spoil, therefore there are no plausible surface water receptors. Refer **Figure 28** for the CFM.

Table C4. Source-Pathway-Receptor (SPR) assessment of Broadmeadow-Isaac post-closure spoil landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Broadmeadow-Isaac spoil landform (post-closure) Comprised of approximately 92% non-carbonaceous spoil; approximately 5% carbonaceous spoil; and approximately 3% rejects (rejects mostly disposed at northern end of the landform). No tailings *AMD source hazard of the spoil landform is **Low*** *Salinity (non-oxidative) source hazard of the spoil landform is **Low***	From Broadmeadow-Isaac spoil landform via surface water run-off into ephemeral creeks: • Eureka Creek. Distance <100m north. • Isaac River. Distance ~250m southeast. *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creeks (via surface water run-off): • Eureka Creek @ northern side of landform. • Isaac River @ southeast *Potential for AMD to reach either of these creeks: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach either of these creeks: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Creek and/or Isaac River [via run-off]	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Creek and/or Isaac River [via run-off]	Unlikely	S1	**Low**
			Saline drainage (sulphide oxidation): Salt (sulphate) impacting Eureka Creek and/or Isaac River [via run-off]	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Eureka Creek and/or Isaac River [via run-off]	Unlikely	S1	**Low**
	From Broadmeadow-Isaac spoil landform via seepage into shallow permeable strata then into ephemeral creeks: • Eureka Creek. Distance <100m north. • Isaac River. Distance ~250m southeast. *Potential for AMD to enter shallow permeable strata: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow permeable strata: **Unlikely***	Ephemeral creeks (via shallow permeable strata): • Eureka Creek. Distance <100m north. • Isaac River. Distance ~250m southeast *Potential for AMD to reach either of these creeks: **Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach either of these creeks: **Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Creek and/or Isaac River [via seepage]	Highly Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Creek and/or Isaac River [via seepage] Risk lies with the rejects disposed at northern end of the spoil landform, approximately 500m from the edge of the rejects to Eureka Creek]	Highly Unlikely	S2	**Low**
			Saline drainage (from sulphide oxidn.): Salt (sulphate) impacting Eureka Creek and/or Isaac River [via seepage] Risk lies with the rejects disposed at northern end of the spoil landform, approximately 500m from the edge of the rejects to Eureka Creek]	Highly Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Eureka Creek and/or Isaac River [via seepage]	Unlikely	S1	**Low**

Table C5. Source-Pathway-Receptor (SPR) assessment of GS1 TSF post-closure landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
GS1 TSF landform (post-closure) Excluding cover, the TSF is comprised of approximately 95% tailings and approximately 5% rejects. It is assumed that the TSF may contain up to 0.5% fill. *AMD source hazard of the unrehabilitated landform is **Moderate-High*** *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Moderate*** TSF will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	From rehabilitated GS1 TSF landform via surface water run-off into ephemeral creeks: • Holding Paddock Ck. Distance <100m south and west. • Eureka Ck. Distance ~500m northeast. *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creeks (via surface water run-off): • Holding Paddock Ck. Distance <100m south and west. • Eureka Ck. Distance ~500m northeast *Potential for AMD to reach these creeks: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach these creeks: **Unlikely***	**Acid drainage:** Low pH and metalliferous water impacting Holding Paddock Ck and/or Eureka Ck [via run-off]	Unlikely	S2	Low
			Neutral metal. drainage: Metals and metalloids impacting Holding Paddock Ck and/or Eureka Ck [via run-off]	Unlikely	S2	Low
			Saline drainage. (sulphide oxdn.): Salt (sulphate) impacting Holding Paddock Ck and/or Eureka Ck [via run-off]	Unlikely	S2	Low
			Saline drainage (non-oxidative): Salt impacting Holding Paddock Ck and/or Eureka Ck [via run-off]	Unlikely	S2	Low
	From rehabilitated GS1 TSF landform via seepage into shallow permeable strata then into ephemeral creeks: • Holding Paddock Ck. Distance <100m south and west. • Eureka Ck. Distance ~500m northeast. *Potential for AMD to enter shallow permeable strata: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow permeable strata: **Unlikely***	Ephemeral creeks (via shallow permeable strata): • Holding Paddock Ck. Distance <100m south and west. • Eureka Ck. Distance ~500m northeast *Potential for AMD to reach these creeks: **Probable** (for Holding Paddock Ck) **Unlikely** (for Eureka Creek)* *Potential for salt (non-oxidative) >900 µS/cm to reach these creeks: **Unlikely***	**Acid drainage:** Low pH and metalliferous water impacting Holding Paddock Ck and/or Eureka Ck [via seepage] Risk primarily lies with seepage to Holding Paddock Creek, located very close to the TSF.	Unlikely	S3	Low to Medium
			Neutral metal. drainage: Metals and metalloids impacting Holding Paddock Ck and/or Eureka Ck [via seepage] Risk primarily lies with seepage to Holding Paddock Creek, located very close to the TSF.	Unlikely	S3	Low to Medium
			Saline drainage (sulphide oxdn.): Salt (sulphate) impacting Holding Paddock Ck and/or Eureka Ck [via seepage]. Risk primarily lies with seepage to Holding Paddock Creek, located very close to the TSF.	Unlikely	S3	Low to Medium
			Saline drainage (non-oxidative): Salt impacting Holding Paddock Ck and/or Eureka Ck [via seepage]	Unlikely	S2	Low

Table C6. Source-Pathway-Receptor (SPR) assessment of RS1 TSF post-closure landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
RS1 TSF landform (post-closure) Excluding cover, the western compartment comprises rejects only. The eastern compartment comprises approximately 85% tailings and 15% rejects. The eastern compartment may contain up to 0.5% fill. *Overall, the unrehabilitated TSF landform has a **Moderate-High** AMD source hazard. The hazard primarily lies with the tailings.* *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Moderate*** The TSF will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	From rehabilitated RS1 TSF landform via surface water run-off into ephemeral tributary of Eureka Creek. Distance ~800m to receptor @ west and southwest. *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Eureka Creek tributary @ western and southwestern sides of RS1 TSF landform. *Potential for AMD to reach Eureka Creek: **Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via run-off]	Highly Unlikely	S2	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via run-off]	Highly Unlikely	S2	Low
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via run-off]	Highly Unlikely	S2	Low
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via run-off]	Highly Unlikely	S2	Low
	From rehabilitated RS1 TSF landform via seepage into shallow permeable strata then into ephemeral tributary of Eureka Creek. Distance ~800m to receptor @ west and southwest. *Potential for AMD to enter shallow permeable strata: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow permeable strata: **Unlikely***	Ephemeral creek (via shallow permeable strata): Eureka Creek tributary @ western and southwestern sides of RS1 TSF landform. *Potential for AMD to reach Eureka Creek: **Highly Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Highly Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via seepage] Eureka Creek tributary is located a significant distance (~800m) from the TSF.	Highly Unlikely	S3	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via seepage] Eureka Creek tributary is located a significant distance (~800m) from the TSF.	Highly Unlikely	S3	Low
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via seepage] Eureka Creek tributary is located a significant distance (~800m) from the TSF.	Highly Unlikely	S3	Low
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via seepage]	Highly Unlikely	S2	Low

Table C7. Source-Pathway-Receptor (SPR) assessment of Riverside rejects post-closure landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Riverside rejects landform (post-closure) Excluding cover, the facility is essentially comprised of rejects only. It is assumed that the facility may contain up to 0.5% fill. *AMD source hazard of the unrehabilitated landform is **Moderate*** *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Low***	From rehabilitated Riverside rejects landform via surface water run-off into ephemeral Eureka Creek (+/- via tributaries). Distance ~350m to receptor (south). *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Eureka Creek tributary @ southern side of Riverside rejects landform. *Potential for AMD to reach Eureka Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via run-off]	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via run-off]	Unlikely	S2	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via run-off]	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via run-off]	Unlikely	S2	**Low**
The rejects landform already has a spoil cover. The facility may be subject to additional rehabilitation to manage the AMD hazard of the landform. *AMD source hazard of the spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	From rehabilitated Riverside rejects landform via seepage into shallow permeable strata then into ephemeral Eureka Creek (+/- via tributaries). Distance ~350m to receptor (south). *Potential for AMD to enter shallow permeable strata: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Unlikely***	Ephemeral creek (via shallow permeable strata): Eureka Creek tributary @ southern side of Riverside rejects landform. *Potential for AMD to reach Eureka Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via seepage]	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via seepage]	Unlikely	S2	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via seepage]	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via seepage]	Unlikely	S2	**Low**

Table C8. Source-Pathway-Receptor (SPR) assessment of GS2 rejects post-closure landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
GS2 rejects landform (post-closure) Excluding cover, the facility is essentially comprised of rejects only. It is assumed that the facility may contain up to 0.5% fill. *AMD source hazard of the unrehabilitated landform is **Low-Moderate*** *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Low***	From rehabilitated GS2 rejects landform via surface water run-off into ephemeral Eureka Creek. Distance <150m to receptor (east). *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Eureka Creek @ eastern side of GS2 rejects landform. *Potential for AMD to reach Eureka Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via run-off]	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via run-off]	Unlikely	S2	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via run-off]	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via run-off]	Unlikely	S2	**Low**
The rejects landform will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	From rehabilitated GS2 rejects landform via seepage into shallow permeable strata then into ephemeral Eureka Creek. Distance <150m to receptor (east). *Potential for AMD to enter shallow permeable strata: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Unlikely***	Ephemeral creek (via shallow permeable strata): Eureka Creek @ eastern side of GS2 rejects landform. *Potential for AMD to reach Eureka Creek: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via seepage]	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via seepage]	Unlikely	S2	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via seepage]	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via seepage]	Unlikely	S2	**Low**

Table C9. Source-Pathway-Receptor (SPR) assessment of GS11 rejects post-closure landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
GS11 rejects landform (post-closure) Excluding cover, the facility is essentially comprised of rejects only. It is assumed that the facility may contain up to 0.5% fill. *AMD source hazard of the unrehabilitated landform is **Low-Moderate*** *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Low***	From rehabilitated GS11 rejects landform via surface water run-off into ephemeral Eureka Creek. Distance ~400m to receptor (north). *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Eureka Creek @ northern side of GS11 rejects landform. *Potential for AMD to reach Eureka Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via run-off]	Unlikely	S2	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via run-off]	Unlikely	S2	Low
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via run-off]	Unlikely	S2	Low
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via run-off]	Unlikely	S2	Low
The rejects landform will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	From rehabilitated GS11 rejects landform via seepage into shallow permeable strata then into ephemeral Eureka Creek. Distance ~400m to receptor (north). *Potential for AMD to enter shallow permeable strata: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Unlikely***	Ephemeral creek (via shallow permeable strata): Eureka Creek @ northern side of GS11 rejects landform. *Potential for AMD to reach Eureka Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via seepage]	Unlikely	S2	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via seepage]	Unlikely	S2	Low
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via seepage]	Unlikely	S2	Low
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via seepage]	Unlikely	S2	Low

Table C10. Source-Pathway-Receptor (SPR) assessment of R22 rejects post-closure landform: surface water receptors via run-off and via shallow permeable strata (shallow groundwater)

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
R22 rejects landform (post-closure) Excluding cover, the facility is essentially comprised of rejects only. It is assumed that the facility may contain up to 0.5% fill. *AMD source hazard of the unrehabilitated landform is **Low-Moderate*** *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Low***	From rehabilitated R22 rejects landform via surface water run-off into ephemeral Eureka Creek. Distance ~250m to receptor (south and west). *Potential for AMD to enter surface water run-off: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off: **Unlikely***	Ephemeral creek (via surface water run-off): Eureka Creek @ southern and western side of R22 rejects landform. *Potential for AMD to reach Eureka Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via run-off]	Unlikely	S2	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via run-off]	Unlikely	S2	Low
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via run-off]	Unlikely	S2	Low
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via run-off]	Unlikely	S2	Low
The rejects landform will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	From rehabilitated R22 rejects landform via seepage into shallow permeable strata then into ephemeral Eureka Creek. Distance ~250m to receptor (south and west). *Potential for AMD to enter shallow permeable strata: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter shallow groundwater: **Unlikely***	Ephemeral creek (via shallow permeable strata): Eureka Creek @ southern and western side of R22 rejects landform. *Potential for AMD to reach Eureka Creek: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach Eureka Creek: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Eureka Ck [via seepage]	Unlikely	S2	Low
			Neutral metalliferous drainage: Metals and metalloids impacting Eureka Ck [via seepage]	Unlikely	S2	Low
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Eureka Ck [via seepage]	Unlikely	S2	Low
			Saline drainage (non-oxidative): Salt impacting Eureka Ck [via seepage]	Unlikely	S2	Low

Table C11. Source-Pathway-Receptor (SPR) assessment of Airstrip post-closure spoil landform: Ramp 32 East and Ramp 32 South residual void receptors

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Airstrip spoil landform (post-closure) Comprised of approximately 91% non-carbonaceous spoil; approximately 8% carbonaceous spoil; and approximately 1% rejects [broadly distributed]. No tailings *AMD source hazard of the spoil landform is* ***Low*** *Salinity (non-oxidative) source hazard of the spoil landform is* ***Low***	Seepage / percolation from Airstrip spoil landform into groundwater, which flows into Ramp 32 East and/or Ramp 32 South residual voids. Residual voids are expected to intersect the water table. Residual voids are groundwater 'sinks', drawing all groundwater within the groundwater catchment of these two voids towards the residual voids. *Potential for AMD to enter groundwater:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater:* ***Unlikely***	Ramp 32 East and Ramp 32 South residual voids (both NUMAs). *Potential for AMD to reach residual voids:* ***Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual voids:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Ramp 32 East and/or Ramp 32 South residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Ramp 32 East and/or Ramp 32 South residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Ramp 32 East and/or Ramp 32 South residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Ramp 32 East and/or Ramp 32 South residual void water quality	Unlikely	S1	**Low**

Ramp 32 in-pit TSF (Airstrip pit) is within the footprint and pit shell of Airstrip spoil landform, but is conservatively assessed as a stand-alone in-pit TSF landform due to the concentrated nature of tailings in one area of the landform (i.e. the SPR assessment of Ramp 32 in-pit TSF has been undertaken separate to Airstrip spoil landform). Refer **Table C13** for Ramp 32 in-pit TSF landform residual void receptor.

Table C12. Source-Pathway-Receptor (SPR) assessment of Goonyella, Thiess and Broadmeadow-Isaac post-closure spoil landforms: Goonyella residual void receptor

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Goonyella spoil landform (post-closure) Comprised of approximately 91% non-carbonaceous spoil; approximately 9% carbonaceous spoil; and approximately 0.1% rejects (historic rejects disposed in the Lenton pit area). No tailings *AMD source hazard of the spoil landform is **Low*** *Salinity (non-oxidative) source hazard of the spoil landform is **Low***	Seepage / percolation from Goonyella spoil landform into groundwater, which flows into Goonyella residual void. Residual void will intersect the water table. Goonyella residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Goonyella residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Goonyella residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Goonyella residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Goonyella residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Goonyella residual void water quality	Unlikely	S1	**Low**
Thiess spoil landform (post-closure) Comprised of approximately 91% non-carbonaceous spoil; approximately 9% carbonaceous spoil; and less than 0.5% rejects (disposed @ Ramp 23). [Essentially all rejects within Thiess landform are disposed at R22 rejects dump, which is assessed as a separate facility.] No tailings (excluding DRE5 in-pit TSF) *AMD source hazard of the spoil landform is **Low*** *Salinity (non-oxidative) source hazard of the spoil landform is **Low***	Seepage / percolation from Thiess spoil landform into groundwater, which flows into Goonyella residual void [via Thiess residual void]. Both voids are expected to intersect the water table. Goonyella residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Goonyella residual void (NUMA) via Thiess residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Goonyella [and Thiess] residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Goonyella [and Thiess] residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Goonyella [and Thiess] residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Goonyella [and Thiess] residual void water quality	Unlikely	S1	**Low**
Broadmeadow-Isaac spoil landform (post-closure) Comprised of approximately 92% non-carbonaceous spoil; approximately 5% carbonaceous spoil; and approximately 3% rejects (rejects mostly disposed at northern end of the landform). No tailings *AMD source hazard of the spoil landform is **Low*** *Salinity (non-oxidative) source hazard of the spoil landform is **Low***	Seepage / percolation from Goonyella spoil landform into groundwater, which flows into Goonyella residual void [via Broadmeadow-Isaac residual void]. Both voids are expected to intersect the water table. Goonyella residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Goonyella residual void (NUMA) via Broadmeadow-Isaac residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Goonyella [and Broadmeadow-Isaac] residual void water quality	Highly Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Goonyella [and Broadmeadow-Isaac] residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Goonyella [and Broadmeadow-Isaac] residual void water quality	Highly Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Goonyella [and Broadmeadow-Isaac] residual void water quality	Unlikely	S1	**Low**

DRE5 in-pit TSF and R22 in-pit rejects dump are both within the footprint and pit shell of Thiess spoil landform, but are conservatively assessed as stand-alone TSF and rejects landforms due to the concentrated nature of tailings and rejects within the landform (i.e. the SPR assessments for DRE5 TSF and R22 rejects dump have been undertaken separate to Thiess spoil landform). Refer to **Table C13** for the SPR for DRE5 in-pit TSF landform residual void receptor and **Table C14** for the SPR for R22 in-pit rejects landform residual void receptor.

Table C13. Source-Pathway-Receptor (SPR) assessment of post-closure TSF landforms: residual void receptors

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
RS1 TSF landform (post-closure) Excluding cover, the western compartment comprises rejects only and the eastern compartment comprises approximately 85% tailings and 15% rejects. The eastern compartment may contain up to 0.5% fill. *Overall, the unrehabilitated TSF landform has a **Moderate-High** AMD source hazard. The hazard primarily lies with the tailings.* *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Moderate**.* The TSF will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	Seepage / percolation from RS1 TSF landform into groundwater, which flows into Goonyella residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Probable***	Goonyella residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Goonyella residual void water quality	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Goonyella residual void water quality	Unlikely	S2	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Goonyella residual void water quality	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Goonyella residual void water quality	Unlikely	S2	**Low**
DRE5 in-pit TSF landform (post-closure). Located at the base of Thiess spoil landform. Excluding cover, the TSF is comprised of tailings only. *AMD source hazard of the unrehabilitated landform is **Moderate**.* *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Moderate**.* TSF will be partially (mostly) backfilled with spoil to allow free-drainage onto the Thiess spoil landform. The backfill cover will be installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	Seepage / percolation from DRE5 in-pit TSF landform into groundwater, which flows into Goonyella residual void [via Thiess residual void]. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Probable***	Goonyella residual void (NUMA) via Thiess residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Goonyella [and Thiess] residual void water quality	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Goonyella [and Thiess] residual void water quality	Unlikely	S2	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Goonyella [and Thiess] residual void water quality	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Goonyella [and Thiess] residual void water quality	Unlikely	S2	**Low**
Ramp 32 in-pit TSF landform (post-closure). Located at the base of Airstrip spoil landform. Excluding cover, the TSF is comprised of tailings only. *AMD source hazard of the unrehabilitated landform is **Moderate**.* *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Moderate**.* TSF will be backfilled with spoil. The backfill cover will be installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the likely spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	Seepage / percolation from Ramp 32 in-pit TSF landform into groundwater, which flows into Ramp 32 East and/or Ramp 32 South residual voids. Residual voids are expected to intersect the water table. Residual voids are a groundwater 'sink', drawing groundwater within the void groundwater catchment towards the residual voids. *Potential for AMD to enter groundwater: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Probable***	Ramp 32 East and Ramp 32 South residual voids (both NUMAs). *Potential for AMD to reach residual voids: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual voids: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Ramp 32 East and/or Ramp 32 South residual void water quality	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Ramp 32 East and/or Ramp 32 South residual void water quality	Unlikely	S2	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Ramp 32 East and/or Ramp 32 South residual void water quality	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Ramp 32 East and/or Ramp 32 South residual void water quality	Unlikely	S2	**Low**

GS1 TSF landform (post-closure)

Groundwater modelling indicates there are no groundwater (or residual void) receptors associated with GS1 TSF landform. Seepage from GS1 TSF landform would remain within the low-permeability Tertiary sediments beneath the landform. Migration to groundwater (>50 m depth) is implausible.

Table C14. Source-Pathway-Receptor (SPR) assessment of post-closure rejects landforms: residual void receptors

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Riverside rejects landform (post-closure) Excluding cover, the facility is essentially comprised of rejects only. It is assumed that the facility may contain up to 0.5% fill. *AMD source hazard of the unrehabilitated landform is **Moderate*** *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Low*** The rejects landform already has a spoil cover. The facility may be subject to additional rehabilitation to manage the AMD hazard of the landform. *AMD source hazard of the spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	Seepage / percolation from Riverside rejects landform into groundwater, which flows into Goonyella residual void. Residual void will intersect the water table. Goonyella residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Goonyella residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Goonyella residual void water quality	Unlikely	S2	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Goonyella residual void water quality	Unlikely	S2	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Goonyella residual void water quality	Unlikely	S2	**Low**
			Saline drainage (non-oxidative): Salt impacting Goonyella residual void water quality	Unlikely	S1	**Low**
GS11 rejects landform (post-closure) Excluding cover, the facility is essentially comprised of rejects only. It is assumed that the facility may contain up to 0.5% fill. *AMD source hazard of the unrehabilitated landform is **Low-Moderate*** *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Low*** The rejects landform will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	Seepage / percolation from GS11 rejects landform into groundwater, which flows into Ramp 32 East residual void. Residual void is expected to intersect the water table. Residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Ramp 32 East residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Ramp 32 East residual void water quality	Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Ramp 32 East residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Ramp 32 East residual void water quality	Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Ramp 32 East residual void water quality	Unlikely	S1	**Low**
R22 in-pit rejects landform. Located within Thiess spoil landform. (post-closure) Excluding cover, the facility is essentially comprised of rejects only. It is assumed that the facility may contain up to 0.5% fill. *AMD source hazard of the unrehabilitated landform is **Low-Moderate*** *Salinity (non-oxidative) source hazard of the unrehabilitated landform is **Low*** The rejects landform will have a spoil cover installed at an appropriate thickness to manage the AMD hazard of the landform. *AMD source hazard of the spoil cover is **Low**. Salinity (non-oxidative) source hazard of the likely spoil cover is **Low***	Seepage / percolation from R22 in-pit rejects landform into groundwater, which flows into Goonyella residual void [via Thiess residual void]. Both voids are expected to intersect the water table. Goonyella residual void is a groundwater 'sink', drawing all groundwater within the void groundwater catchment towards the residual void. *Potential for AMD to enter groundwater: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to enter groundwater: **Unlikely***	Goonyella residual void (NUMA) via Thiess residual void (NUMA). *Potential for AMD to reach residual void: **Unlikely*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual void: **Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting Goonyella [and Thiess] residual void water quality	Unlikely	S1	**Low**
			Neutral metalliferous drainage: Metals and metalloids impacting Goonyella [and Thiess] residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting Goonyella [and Thiess] residual void water quality	Unlikely	S1	**Low**
			Saline drainage (non-oxidative): Salt impacting Goonyella [and Thiess] residual void water quality	Unlikely	S1	**Low**

<u>GS2 rejects landform (post-closure)</u>

Groundwater modelling indicates there are no groundwater (or residual void) receptors associated with GS2 rejects landform. Seepage from GS2 rejects landform would remain within the low-permeability Tertiary sediments beneath the landform. Migration to groundwater (>50 m depth) is implausible.

Table C15. Source-Pathway-Receptor (SPR) assessment of residual void highwall and floor: residual void receptors

Source	Pathway	Receptor	Event / potential harm	Likelihood of Event	Severity of Event	Risk Rating
Highwall and floor of residual voids (post-closure) Highwalls of the residual voids are comprised of approximately: • 83% to 90% non-carbonaceous overburden/interburden; • 2% to 8% carbonaceous overburden/interburden; • 5% to 10% coal (residual coal seams). 'PAF' and NAF-S exposure on highwalls conservatively estimated at approximately 8% (vertical meterage). A proportion of this will be in lower seams, which will be submerged. 'PAF' and NAF-S exposure on pit floors conservatively estimated at approximately 98% (ie. essentially all of the pit floor), however all pit floors will be submerged by water. *AMD source hazard from exposed highwalls and submerged pit floors is* ***Moderate*** *Salinity (non-oxidative) source hazard of the exposed highwalls and submerged pit floors is* ***Low***	Surface water run-off from highwall into residual voids. *Potential for AMD to enter surface water run-off from highwall:* ***Probable*** *Potential for salt (non-oxidative) >900 µS/cm to enter surface water run-off from highwall:* ***Unlikely***	Residual voids (NUMA). *Potential for AMD to reach residual voids:* ***Probable*** *Potential for salt (non-oxidative) >900 µS/cm to reach residual voids:* ***Unlikely***	**Acid/acidic drainage:** Low pH and metalliferous water impacting residual void water quality. Risk primarily lies with coal seams exposed in the highwall, of which PAF coal is broadly distributed throughout all likely exposed seams. Coal seams comprise between 5 to 10% of the vertical meterage of the highwall. Most 'PAF' coal is low S and is classified as PAF-LC.	Probable	S2	**Low to Medium**
			Neutral metalliferous drainage: Metals and metalloids impacting residual void water quality	Unlikely	S1	**Low**
			Saline drainage (from sulphide oxidation): Salt (sulphate) impacting residual void water quality. Risk primarily lies with coal seams exposed in the highwall, of which PAF coal is broadly distributed throughout all likely exposed seams. Coal seams comprise between 5 to 10% of the vertical meterage of the highwall. Most 'PAF' coal is low S and is classified as PAF-LC.	Probable	S2	**Low to Medium**
			Saline drainage (non-oxidative): Salt impacting residual void water quality	Unlikely	S1	**Low**

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BMA

PRCP Concept Design Report

Holding Paddock Creek Diversion

QC1000_051-REP-003-2

1 OCTOBER 2024

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1. INTRODUCTION

1.1 Context

The purpose of this report is to detail the concept design developed for the closure and ultimate relinquishment of the Holding Paddock Creek (HPC) Diversion which must satisfy the conditions within EA EPML00853413 located at Goonyella Riverside Mine (GRM). The watercourse diversion is required to achieve a state of dynamic equilibrium enabling its relinquishment in the post closure landform of the GRM.

The long-term performance of the diversion under both operating and closure scenarios is assessed within the following objectives, based on requirements from relevant licences and approvals:

- The diversion demonstrates to be in a safe, stable, non-polluting, and self-sustaining state (As per Environmental Authority requirements).
- Rehabilitation requirements (acceptance criteria) include goals, objectives and acceptance criteria for the post mining land use of the 'Watercourse' which is applicable for the watercourse diversion.
- Achieves the key outcomes identified in the Department of Natural Resources, Mines and Energy (DNRME) *Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (DNRME, 2019).*

This report details the design requirements for the rehabilitation of the diversion for incorporation into the Progressive Rehabilitation and Closure Plan (PRCP) for GRM as described in the Queensland Department of Environment, Science (DES) *Guideline: Progressive rehabilitation and closure plans (ESR/2019/4964, Version 3- 4 April 2023).*

1.2 Purpose and Scope

The scope of work for each diversion is comprised of two stages:

- Stage 1: Options identification, assessment, and selection.
- Stage 2: Concept Design on the preferred option outcome from Stage 1.

The purpose of this document is to outline the concept design developed for the preferred diversion option (outcome from Stage 1) to achieve a state of dynamic equilibrium resulting in a relinquishable state for the diversion. The following methodology was conducted:

- A desktop geomorphic assessment of the creek was undertaken using historical aerial imagery and survey to identify options for the closure alignment.
- Review of existing flood studies to determine peak flow rates for design flow events to assess hydraulic performance.
- Hydraulic assessment of the diversion option against the criteria in the *DNRME 2019 Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (DNRME, 2019)*.
- Develop concept design sketches and watercourse diversion spatial polygons for presentation in the PRCP.
- Develop concept design report summarising the design and key information required for inclusion in the PRCP.

1.3 Design Process

1.3.1 Concept Design Considerations

The design is concept only, and not at functional level which would be required for approval and construction. The concept design is developed exclusively for PRCP purposes within the limitations of the PRCP, with only permanent design options considered.

To progress the concept design to a functional design level, detailed site-specific information is required including:

- Soil surveys and geotechnical studies.
- Material characterisation for use in erosion protection cover (i.e. rock sizing and composition).
- Site specific revegetation studies.
- Groundwater studies.

2. OVERVIEW

2.1 Location

GRM is located approximately 150 km southwest of Mackay and 25 km north of Moranbah within the Bowen Basin. The HPC diversion begins at the western boundary of the GS1 Tailings Storage Facility (TSF) located on ML 70287 and flows southeast towards the southern end of the GRM. It was constructed parallel to but further south of the pre-mining alignment and joins with Fisher Creek to continue the diversion downstream. The diversion is approximately 6.1 km in length compared to the pre-mining length of 4.7 km. The location of the HPC diversion is shown in Figure 2.1.

2.2 Pre-Mining Condition

HPC is an ephemeral tributary within the Isaac River sub catchment which is part of the wider Fitzroy River catchment. It has a catchment area of approximately 32 km^2 and watercourse flowing directly into the Isaac River.

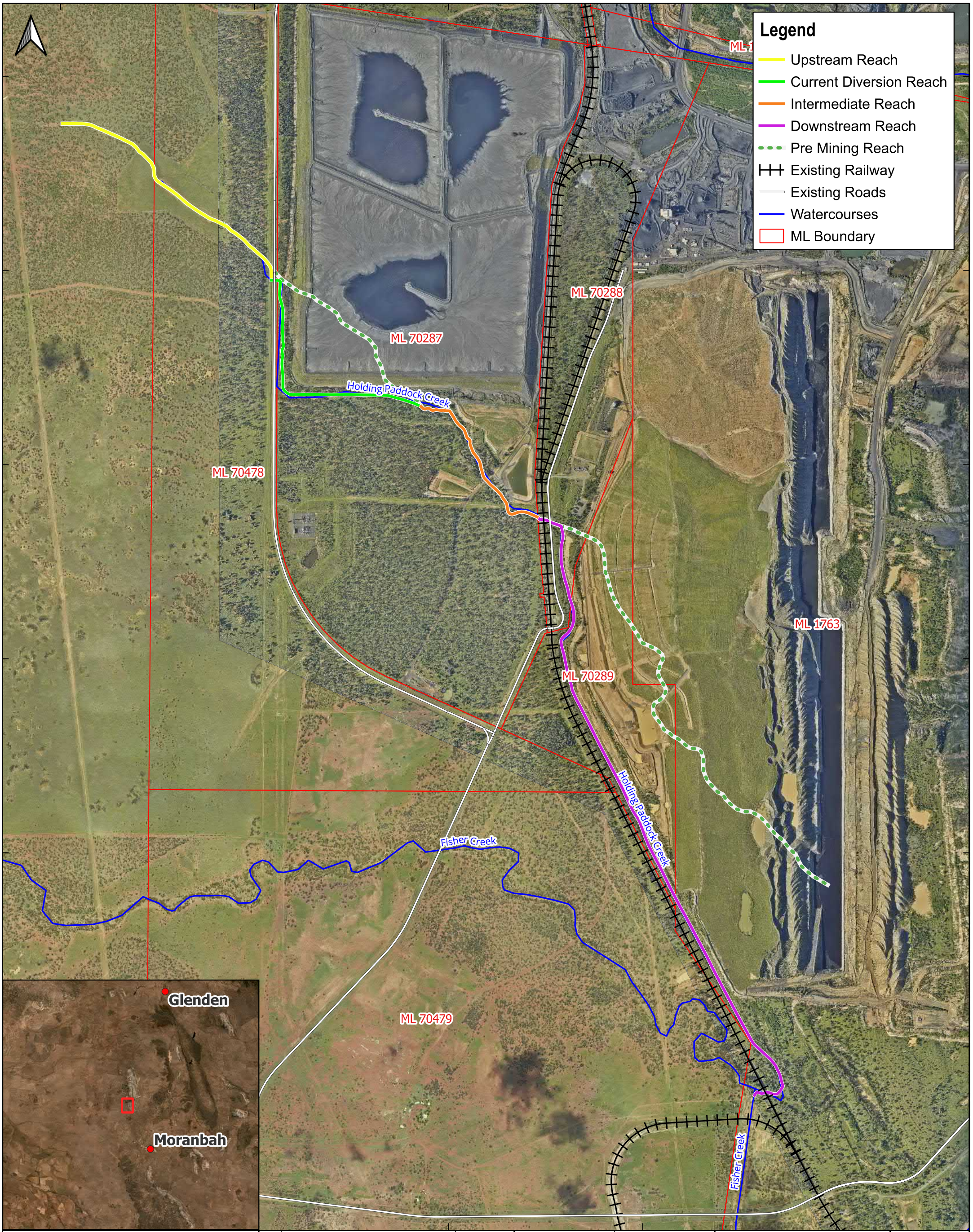
- **Upstream reach** – The upstream reach is located west of the mine and is situated amongst open woodland. As the vegetation was mostly cleared in 2011 due to some erosion prevention works, the pre-mining condition had significantly more vegetation as can be also seen in historical imagery.
- **Downstream reach** – Fisher Creek acts as the downstream reach of the HPC diversion and is described in the Fisher Creek Diversion report (Engeny, 2024).
- **Diversion reach (pre-mining)** – The pre-mining reach flowed north of the current alignment and was shorter at 4.7 km. There is little historical imagery before diversion was constructed however, consistent to the surrounding vegetation, dense and open woodland and native plants would have surrounded the waterways and HPC. The reach originally flowed through the middle of the GS1 TSF.

2.3 Current Conditions

The last major monitoring effort and report at the time of writing was completed in 2022 by Alluvium. As part of the major monitoring, the latest condition of the HPC diversion has been described as follows (Alluvium, 2022):

- The upstream reach of the HPC channel is not well defined and is assumed to have been that way prior to mining activity. Over the length of the natural upstream reach, the natural geomorphic conditions are assumed to have been similar to the diversion reach (alluvial, low flow channel).
- Limited information is available on the natural geomorphic conditions of the diversion reach. Over the length of the natural diversion reach, the natural geomorphic conditions are assumed to have been similar to the upstream reach (alluvial, low flow channel).

It is important to note the current diversion arrangement has no defined downstream reach as it directly discharges into Fisher Creek. Due to this current condition, it is considered unlikely that the existing diversion will achieve a state of dynamic equilibrium and be suitable for relinquishment following closure of the GRM.



BMA PRCP GRM Holding Paddock Creek Diversion

Figure 2.1
Location of Holding Paddock Creek diversion

REV.	DETAILS	DATE
0		

DRAWN: CH
CHECKED: BK
APPROVED: BK
DATE: 08/08/2024

GENERAL NOTES:

0 250 500 m
Scale @ A3: 1:17500

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3. BASIS FOR CONCEPT DESIGN

There are currently two recognised guidelines for design of watercourse diversions within Queensland:

- *Guideline: Works that interfere with water in a watercourse for a resource activity – watercourse diversions authorised under the Water Act 2000 (Department of Natural Resources, Mines and Energy (DNRME), 2019).*
- *Criteria for functioning river landscape units in mining and post mining landscapes (Australian Coal Association Research Program (ACARP), 2014).*

Both the DNRME and ACARP Guidelines were developed based on previous research completed by ACARP in the early 2000s which included assessment of existing diversion performance and the development of design and rehabilitation criteria for watercourse diversions.

The DNRME and ACARP Guidelines have both been used to inform the basis of design for the diversion, as summarised in Table 3.1.

TABLE 3.1: DNRME AND ACARP GUIDELINES USED FOR DESIGN BASIS

Guideline	Design Parameter
DNRME	Diversion Design Outcomes and Design Recommendations.
	Velocity, shear stress, stream power (39% AEP) guidelines.
ACARP	General Design Process.
	Stream power (2% AEP event Guideline).

3.1 DNRME Guidelines

3.1.1 Diversion Design Outcome Requirements (Permanent Watercourse Diversions)

The diversion design outcome requirements are nominated by DNRME for permanent watercourse diversions and have been used to develop the design for the HPC diversion:

- Outcome 1 – The permanent watercourse diversion incorporates natural features (including geomorphic and vegetation) present in the landscape and in local watercourses.
- Outcome 2 – The permanent watercourse diversion maintains the existing hydrologic characteristics of surface water and groundwater systems.
- Outcome 3 – The hydraulic characteristics of the permanent watercourse diversion are comparable with other local watercourses and suitable for the region in which the watercourse diversion is located.
- Outcome 4 – The permanent watercourse diversion maintains sediment transport and water quality regimes that allow the watercourse diversion to be self-sustaining, while minimising any impacts on upstream and downstream reaches.
- Outcome 5 – The permanent watercourse diversion and associated structures maintain equilibrium and functionality and are appropriate for all substrate conditions they encounter.

3.1.2 Design Criteria

DNRME recommend the following design criteria in development of permanent watercourse diversions and have been considered in development of the HPC diversion:

- The watercourse diversion should tie-in with the existing or receiving watercourse within the resource tenure boundary.
- The stability and performance of a watercourse diversion is assisted by vegetation within the watercourse diversion and adjoining floodplain and does not include artificial structures for grade control that requires ongoing maintenance.
- The channel capacity must be at least equivalent to the natural stream channel capacity existing in that vicinity.
- The length of the channel should be equivalent to the length of the watercourse it replaces.
- Bed grade/slope should be equivalent to the existing watercourse.
- Batter slopes should be designed to maintain stability through different substrates.

The DNRME Guideline also nominates a set of hydraulic design criteria which have been adapted from the original ACARP research. These hydraulic design criteria were developed based on assessment of existing Bowen Basin streams and watercourse diversions and are considered reflective of stable hydraulic conditions for ephemeral systems in central Queensland. The hydraulic design criteria are summarised in Table 3.2 and include the following:

- Shear stress which is a function of discharge, flow depth and hydraulic gradient and represents the tractive force acting on sediment particles and is used to determine the threshold of motion for sediment. High shear stress provides an indication of potential erosion in cohesive sediments or movement of non-cohesive sediments. It also provides a measure of the ability of vegetation to withstand flow.
- Stream power which is a function of hydraulic gradient, flow width and flow rate and represents the energy available to do work on the channel. High stream power values generally result in elevated erosion potential.
- Velocity which is a function of flow rate and cross-sectional area and is a simplified measure of erosion potential. Generally higher velocities result in higher erosion potential; however, stream power and shear stress are more reliable indicators of erosion and sediment transport potential.

TABLE 3.2: DNRME 2019 HYDRAULIC DESIGN CRITERIA

Design Flow Event	Stream Power (W/m^2)	Velocity (m/s)	Shear Stress (N/m^2)
39% AEP (previously 2-year ARI) - no vegetation	<35	<1.0	<40
39% AEP (previously 2-year ARI) - vegetated	<60	<1.5	<40
2% AEP (previously 50-year ARI)	<150	<2.5	<80[1]

[1] DNRME values are extracted from ACARP 2002, however the value reported for the 2% AEP shear stress (<50 N/m^2) in the DNRME 2014 is incorrect. The ACARP value of <80 N/m^2 has been adopted.

The DNRME hydraulic design criteria summarised in Table 3.2 were adopted as the basis for the concept design. The ACARP value described in Section 3.2 are provided for information only. The ACARP values were referenced when considering stable stream powers and shear stresses during the vegetation establishment phase of the construction.

3.2 ACARP Guidelines

ACARP (2014) outlined several approaches to the design of diversion channel dimensions, including:

- The analogous approach, where channel dimensions are selected from a reference reach.
- The hydraulic geometry approach, where dimensions are determined from regression relationships; and,
- The analytical approach, where equations are used to calculate continuity, hydraulic resistance, and sediment transport and channel characteristics are determined from field inspection of a reference reach.

In addition to the analogous approach, ACARP (2014) also provides guidance on alluvial channel design parameters which were adapted from ACARP (2002). These hydraulic parameters are intended to be representative of stable watercourses within the Bowen Basin and are summarised in Table 3.3.

TABLE 3.3: ACARP 2014 ALLUVIAL CHANNEL DESIGN PARAMETERS

Stream Type	Sediment Scenario	Stream Power 39% AEP (W/m²)	Stream Power 2% AEP (W/m²)
Alluvial	Supply limited	15-35	50-100
	Transport limited	35-60	80-150
Bedrock Controlled	n/a	50-100	100-350

ACARP (2014) also provides recommendations on shear stress thresholds for vegetation used as part of rehabilitation activities. These thresholds are summarised in Table 3.4.

TABLE 3.4: ACARP 2014 RECOMMENDED VEGETATION SHEAR STRESS THRESHOLDS

Vegetation Type	Design Shear Stress (N/m²)
Buffel Grass *(Cenchrus ciliaris)*	40
Structurally Diverse Suite of Established Native Vegetation	120

4. OPTIONS IDENTIFICATION

Engeny identified four potential options for the diversion as part of stage 1 (summarised below in Table 4.1). The following criteria were also considered during the development of the concept design:

- Geomorphic features of the pre mining drainage path.
- Upstream and downstream channel geometry and grade.
- Remaining within the mining lease (ML) boundary.
- Impacts to, and from, the final landform.
- Impacts to surrounding drainage paths and catchments.
- Permanent options only.

The objective was to identify suitable options for the rehabilitation of the Diversion, and select a preferred option informed by multi-criteria analysis (MCA) to progress to concept design.

Each option was defined with a concept cross section and longitudinal profile. Civil earthworks modelling was undertaken to confirm the following:

- Alignment of the diversion options.
- The need for potential flood levees (during operations).
- Final landform reconfiguration.
- Reinstatement of the floodplain.
- Proposed tie-in locations to the existing waterway.
- Development of a Class 5 capital cost estimate for construction.

The options identification also included assessment of key risks and opportunities regarding construction staging, potential for impacts to downstream infrastructure and post mining land-use risks in the context of closure.

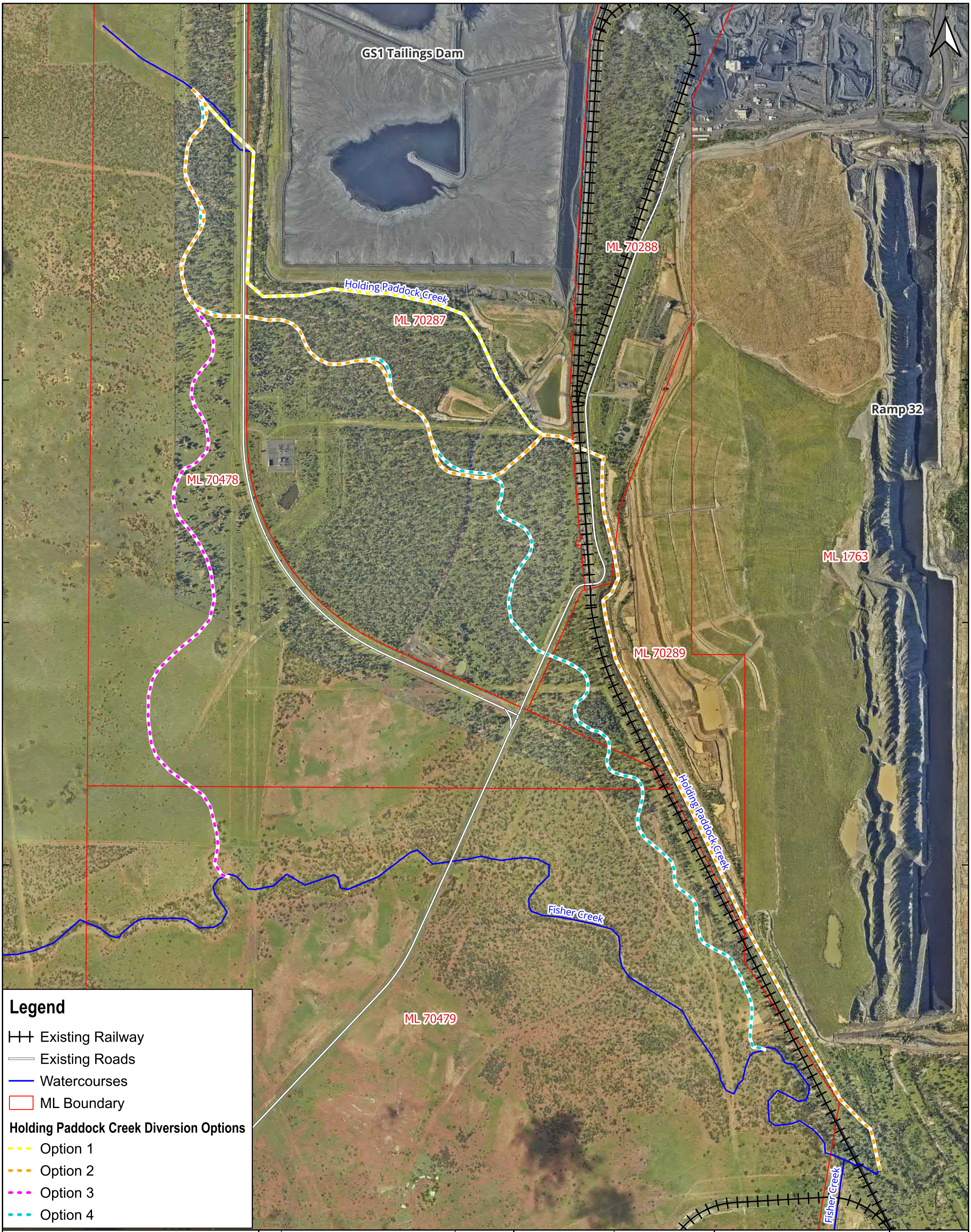
The four options assessed are shown in Figure 4.1 and summarised in Table 4.1.

TABLE 4.1: OPTIONS IDENTIFICATION DETAILS

Statistic	Option 1	Option 2	Option 3	Option 4
Description	Retain existing diversion alignment (6.1 km)	The diversion would cross Riverside Mine Road between GS1 and the sub-station, then travels east to a downstream tie in location in the existing HPC, on the western extent of GS15. The total length of the diversion is approximately 6.5 km with the new diversion extent being the initial 2.9 km prior to the downstream tie in on the western extent of GS15 with a grade of 0.38%.	Option 3 runs north-south on the west of Riverside Mine Road. The intent of Option 3 is to assess the benefit of removing road/service crossings. The downstream tie in location is to the existing Fisher Creek, approximately 2.5km south of GS1. The total length of the diversion is approximately 3.8 km.	Option 4 crosses Riverside Mine Road at a similar location to Option 2, however, continues south to Fisher Creek, without crossing the rail line. The total length of the diversion is approximately 5.6 km.
Likelihood that diversion will achieve state of dynamic equilibrium	Low – Retain existing alignment - length 6.1 km and grade 0.34%. Potential seepage from the GS1 TSF could impact diversion performance. Reshaping of GS1 embankment at closure will likely toe out into the current diversion alignment.	High – Total diversion length is 6.5 km with the new diversion extent being the initial 2.9 km prior to the downstream tie in on the western extent of GS15 with a grade of 0.38%.	Moderate - Diversion length is 3.8 km with a grade of 0.31%. Option 3 will result in increasing the catchment area of HPC.	High - Diversion length is 5.6 km with a grade of 0.39%.
Order of magnitude cost estimate*	$1.38 M	$25.4 M	$38.7 M	$47.7 M

Statistic	Option 1	Option 2	Option 3	Option 4
Ability to isolate diversion from flows during establishment period	No – Will be constructed on the existing diversion alignment.	Partially – Option 2 cuts across the existing alignment. It is possible but there is some engineering risk.	Yes – The entire of the diversion can be constructed offline from the existing diversion	Yes – The entire of the diversion can be constructed offline from the existing diversion

* Costs estimated based on average $10/m^3.



BMA PRCP GRM Holding Paddock Creek Diversion

Figure 4.1
Holding Paddock Creek Diversion Realignment Options

REV.	DETAILS	DATE
0		

DRAWN: CH | CHECKED: BK
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GENERAL NOTES:

0 100 200 300 400 m
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5. OPTIONS ANALYSIS

5.1 Multi-Criteria Analysis Framework

A high-level multi-criteria analysis (MCA) was undertaken to rank the identified options for individual criteria as per Figure 5.1 below and determine a preferred option. The weighting of each criterion was determined and agreed upon with a BMA and Engeny collaborative decision group. The individual weightings are summarised in Table 5.1. Based on the score for each criterion against each option, a preferred option is identified.

-3	-2	-1	0	1	2
Fatal Flaw	Strongly Negative	Mildly Negative	Neutral	Mildly Positive	Strongly Positive

Figure 5.1: Ranking Scores for MCA

TABLE 5.1: WEIGHTING FOR INDIVIDUAL SCREENING CRITERIA

Criteria	Weight
Likelihood that diversion will achieve state of dynamic equilibrium	50%
Order of magnitude cost estimate	30%
Ability to isolate diversion from flows during establishment period	20%

5.2 Multi-Criteria Analysis

The MCA resulted in Option 2 to be carried forward into concept design as a preferred option, since it scored highest out of the four options and resulted in the lowest relative risk (see Table 5.2). Refer to Appendix A for the detailed MCA and scoring.

TABLE 5.2: MULTI-CRITERIA ANALYSIS OUTCOMES

Item	Option 1	Option 2	Option 3	Option 4
Overall Weighted Score	-0.9	1.2	0.6	0.8
Relative Risk	Highest Risk	Lowest Risk	Low Risk	Low Risk
Fatal Flaw	Yes	No	No	No

6. CONCEPT DESIGN

6.1 Design Parameters and Plan

Table 6.1 details the parameters for each outcome in Section 3, forming the design plan for the permanent diversion, aligning with DNRME and ACARP Guideline requirements.

TABLE 6.1: DNRME AND THE AUSTRALIAN COAL ASSOCIATION RESEARCH PROGRAM (ACARP) PARAMETERS ADOPTED

DNRME Parameters (DNRME, 2019)		Equivalent ACARP Parameters (ACARP, 2014)	
Outcome 1 – The design plan should include a detailed description of: a) the location, function, and description of geomorphic features within the proposed watercourse diversion as well as a revegetation and vegetation management plan.	☒	*Outcome 1 –* Geomorphic and riparian vegetation features of the diverted watercourse and connecting reaches (minimum of 1 km upstream and downstream of proposed tie ins). Vegetation characteristics along the proposed optional watercourse diversions should also be noted.	☒
Outcome 2 – The design plan should include a detailed description of: a) the development and calibration, or sensitivity analysis, of the hydrologic model, including the referencing of methodologies used to generate flood frequency analysis[1] b) any design implications and construction processes that necessitate a lateral disconnectivity of sub-surface flow between the watercourse and an adjacent final void (if proposed). [1] A hydrologic model for the southern extent of GRM inclusive of HPC was originally developed as part of the Eureka Flood Study (Engeny, 2024).	☒ ☐	*Outcome 2 –* Summary of hydrological characteristics including surface water-groundwater interactions and water use. Flow changes along the reach should also be clearly noted.	☒
Outcome 3 – The design plan should include hydraulic modelling results (benchmarked against guideline values for stream power, shear stress and velocity adopted from ACARP, 2002) and analysis identifying depth of inundation. The design plan should include a floodplain of sufficient capacity.	☒	*Outcome 3 –* Summary of hydraulic characteristics along the waterway length. Longitudinal section of stream power with standard cross section increments. A higher frequency of cross sections is required at stream junctions and bifurcations. A table summarising stream powers (in channel and floodplain) at each cross section is also required, along with statistics for the reach. This specifically includes the reach minimum, low quartile, median, mean, upper quartile and maximum values[2]. [2] Only mean stream power values were calculated for comparison with the adopted criteria.	☒ ☐
Outcome 4 – The design plan should include a sediment transport analysis that identifies how the watercourse diversion will manage erosion or deposition events such that they are consistent with the existing sediment regime.	☒	*Outcome 4 –* Sedimentation characteristics. Where the existing reach is aggrading, degrading, or is in equilibrium. Note presence of sediment sources (e.g., main channel bed or bank instabilities, floodplain contributions) and sinks (e.g., flood outs or sediment splays along low gradient sections of the reach, and infilling pools).	☒
Outcome 5 – The design plan should include the specification of spoil placement and sequencing and the settlement process and timing of operation that will ensure the watercourse diversion, once constructed, operates in a stable manner.	☒	Outcome 5 – Interaction between watercourse diversion options and mine infrastructure (pipes, pits, culverts, access, etc.) and planning over the life of mine	☒

It is important to note only benchmark values for shear stress and velocity were adopted from DNRME (2019). Stream power benchmark values were adopted from ACARP (2014) due to it being a more contemporary standard that considers impacts of sediment transport.

6.2 Concept Design Diversion Alignment

The alignment of Option 2 was determined to be the preferred option using the MCA. Option 2 was chosen due to a high likelihood of achieving a state of dynamic equilibrium. The full concept drawing package for the permanent HPC diversion is included in Appendix E and the interaction of the design with the concept PRCP landform 2 in Appendix F.

6.3 Channel Geometry and Grade

The location of the reference cross sections is shown in Figure 6.1. The typical intermediate reach channel cross sections are presented in Figure 6.2. This reach represents the original pre-mining alignment which joins the upstream and downstream diversion reaches for HPC. These dimensions were based on the average natural downstream channel geometry and grade as assessed in the options identification phase.

Table 6.2 summarises the typical channel cross section selected for the concept design. The concept design drawings in Appendix E show the typical cross sections, longitudinal profile, and footprint of the proposed channel works.

TABLE 6.2: DETAILED CHANNEL CROSS SECTION GEOMETRY FOR CONCEPT DESIGN

Channel Geometry	Quantity	Comments
Channel Bed Width	4 m	Based on the current upstream HPC representative cross sections
Channel Depth	1.5 m	Consistent depth of low flow channel at 1.5 m
Batter Slope	1V:4H (Low Flow Channel) 1V:8H (High Flow Channel)	Based on the existing upstream HPC representative cross sections. The batters will be covered with topsoil, hydromulch, and hydroseed (Appendix E) to ensure stability and prompt revegetation of the channel batters.

BMA PRCP GRM Holding Paddock Creek Diversion

Figure 6.1
Location of Reference Cross-Sectional Areas

REV.	DETAILS	DATE
0		

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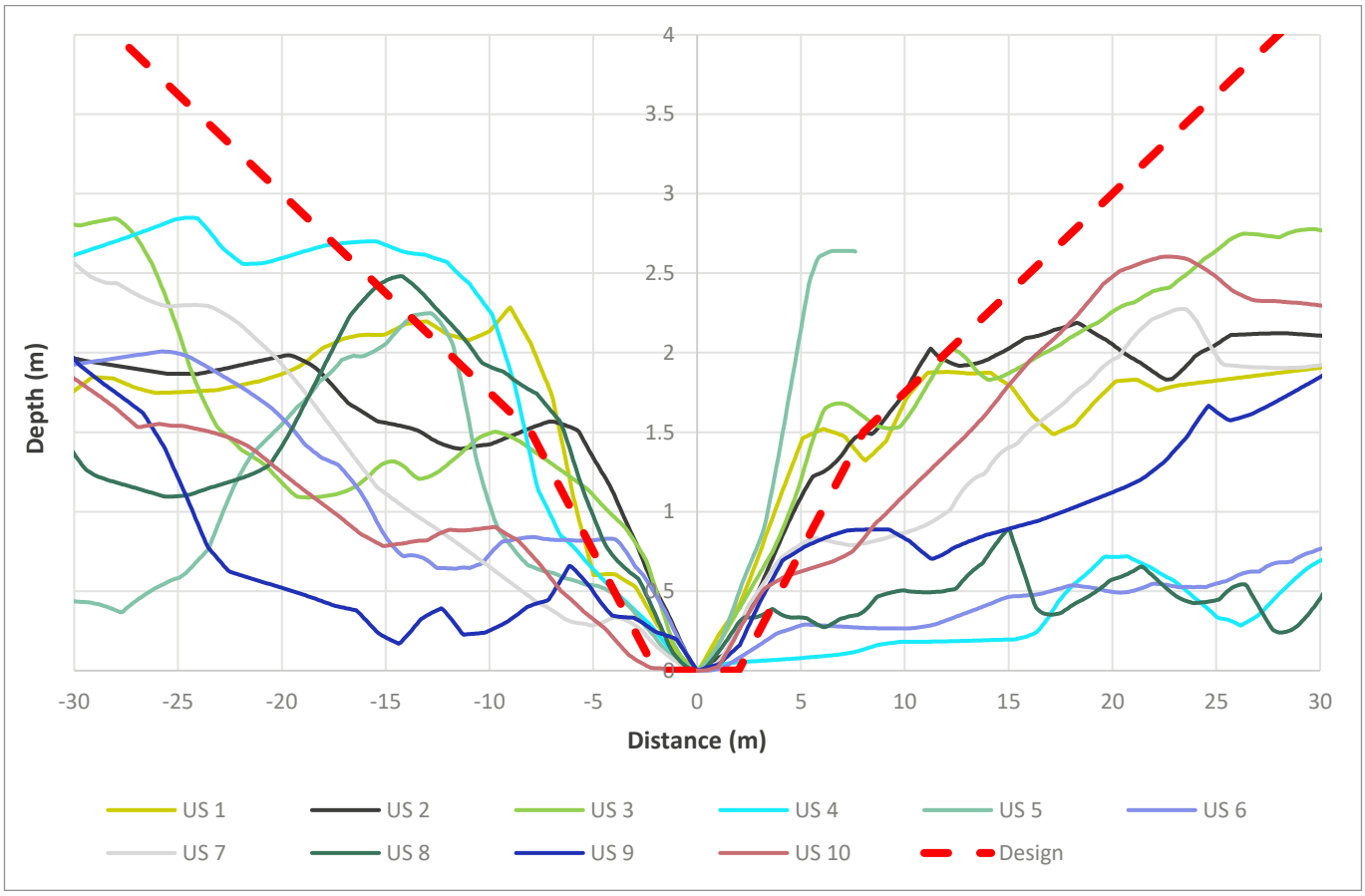
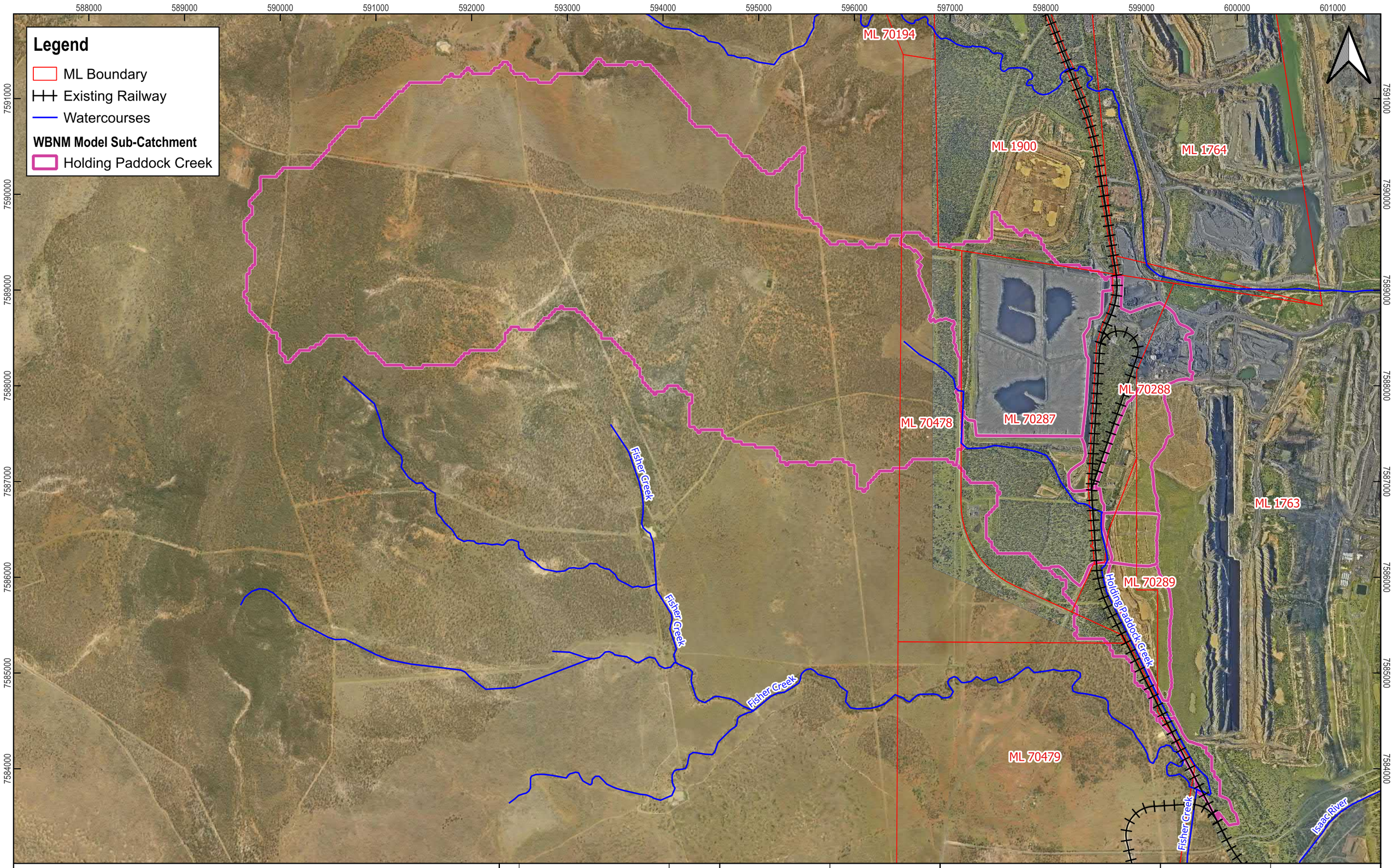


Figure 6.2: Typical Downstream Channel Cross Section of Holding Paddock Creek

The grade of the proposed diversion is 0.38% while the grade of the current diversion is 0.34%. The total proposed diversion is approximately 6.5 km in length, which is a 7% increase from the current alignment which is approximately 6.1 km in length. This change in alignment allows the diversion to be further away from the GS1 but is not expected to adversely impact sediment transport/deposition within the channel. A longitudinal section for the diversion alignment is included in the concept design drawings in Appendix E.

6.4 Hydrology

A hydrologic model for the southern extent of GRM inclusive of HPC was developed for the Eureka Creek Diversion using WBNM software and was validated against the Isaac River Gauge. The model was also used for the HPC (concept design) to estimate flows for the 0.1% AEP (1 in 1000 year) flood event. The details of the hydrologic model development are presented in Appendix B. Peak flows for frequent events (39% AEP and 2% AEP) for the HPC diversion were estimated using the ACARP (2002) methods and are presented in Table 6.3. The HPC catchment is presented in Figure 6.3.



BMA PRCP GRM Holding Paddock Creek Diversion

Figure 6.3
Catchment Map

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6.4.1 Frequent Events

Peak flows for frequent events (39% AEP and 2% AEP) for the HPC diversion were estimated using the ACARP (2002) methods and are presented in Table 6.3. The ACARP (2002) assessment included a regional flood frequency analysis for a selection of gauged catchments in the Bowen Basin region. From this, a method was developed to estimate flood magnitudes for ungauged catchments, based on catchment area and rainfall intensity. The calculated flood magnitudes for the 39% and 2% AEP events were then used to determine diversion design limits for shear stress, stream power and velocity to provide a conservative estimate. This approach has been adopted to determine the flows within the proposed HPC diversion concept design and have been compared to the ACARP (2002) diversion channel design parameters.

TABLE 6.3: ACARP DESIGN FLOWS

Rainfall Event	Diversion Channel Design Flows (ACARP, 2002) m3/s
2% AEP (50-year ARI)	52.6
39% AEP (2-year ARI)	27.3

6.4.2 Rare Events

The interaction of a 0.1% AEP flood event and the concept PRCP landform 2 has been assessed as part of the rehabilitation flood modelling completed for the PRCP. This informs the interaction between the diversion and final voids landform. The 0.1% AEP peak flow rate at the end of the diversion is estimated at 172 m^3/s.

6.5 Hydraulics

A two-dimensional TUFLOW flood model was developed to assess the compliance with the DNRME and ACARP hydraulic performance criteria for the 39% and 2% AEP events.

Average values were derived from the TUFLOW model for the stream powers, stream velocity and shear stress in the 39% and 2% AEP event (refer to Table 6.4). The proposed diversion values have been compared to the DNRME (2019) diversion channel design parameters. The detailed results for the DNRME guideline design criteria (stream power, velocity, and shear stress) as they vary along the length of the channel are presented graphically in Appendix D.

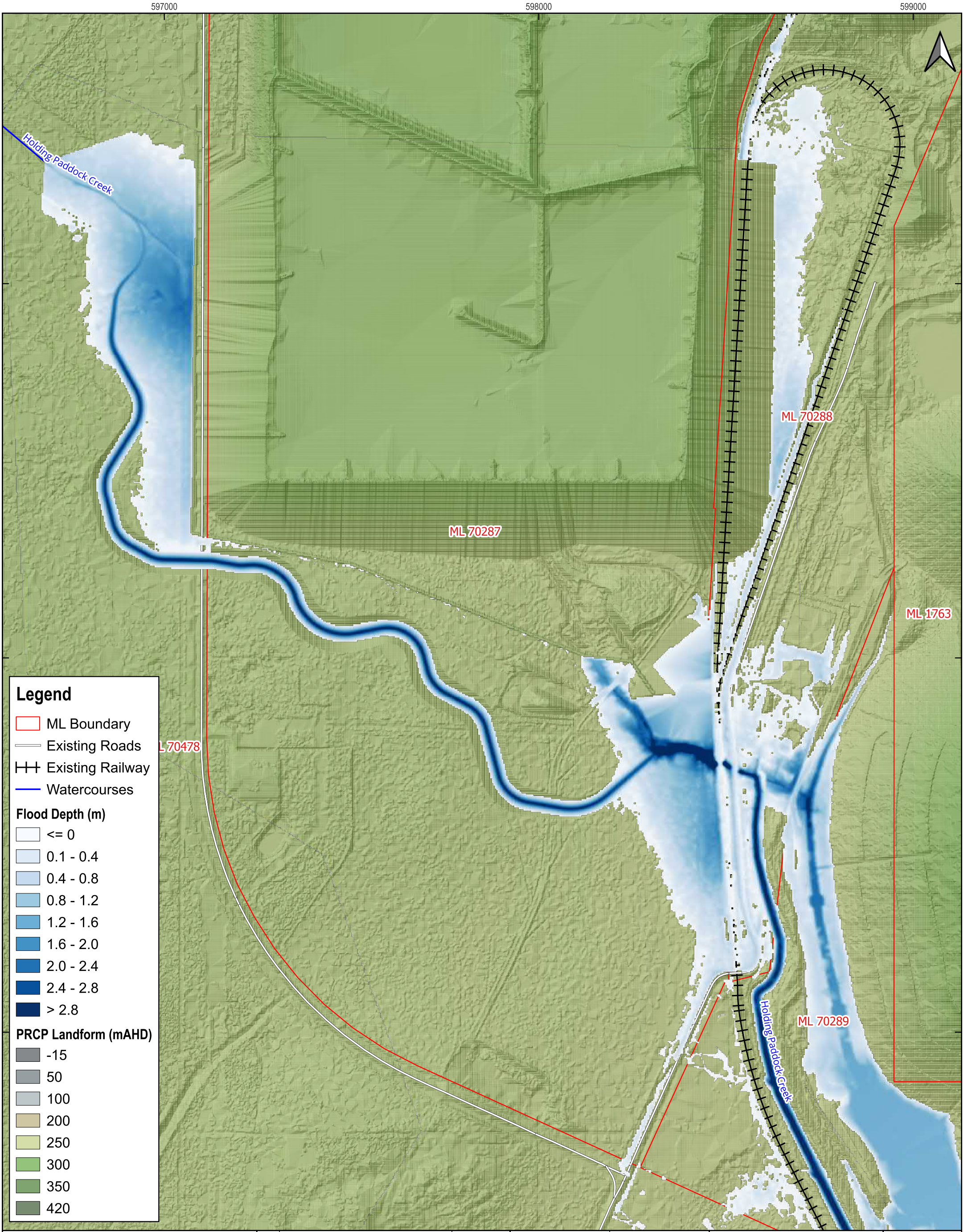
TABLE 6.4: DIVERSION DESIGN CRITERIA COMPARED TO DNRME (2019) GUIDELINE PARAMETERS

	39% AEP (2-year ARI)		2% AEP (50-year ARI)	
Design Criteria	**Diversion**	**DNRME Design Parameter (2019)**	**Diversion**	**DNRME Design Parameter (2019)**
Stream Power (W/m^2)	28	<60	36	<150
Stream Velocity (m/s)	0.77	<1.5	0.84	<2.5
Shear Stress (N/m^2)	24	<40	28	<80[1]

[1] DNRME values are extracted from ACARP 2002, however the value reported for the 2% AEP shear stress (<50 N/m^2) in the DNRME 2014 is incorrect. The ACARP value of <80 N/m^2 has been adopted.

It can be seen from Table 6.4 that all the average diversion hydraulic results are below the design parameters for both the 39% and 2% AEP events. Moreover, 39% AEP (2yr ARI) stream power and velocities meet the DNRME design criteria for stability if the channel remains unvegetated. The detailed results for the DNRME guideline design criteria (stream power, velocity, and shear stress) as they vary along the length of the channel are presented graphically in Appendix D.

The extents and depths of the 0.1% AEP design flood event with the concept PRCP landform 2 and the concept diversion design are depicted in Figure 6.4. The result shows that there is no risk of flood ingress to any final voids.



BMA PRCP GRM Holding Paddock Creek Diversion

Figure 6.4
0.1% AEP Flood Event with Concept PRCP Landform 2

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6.6 Risks and Mitigation Measures

Table 6.5 summarises the main risks for the diversion design and its ability to achieve a state of dynamic equilibrium suitable for relinquishment. The consequence and likelihood matrix utilised for this risk assessment align with the BMA risk tables.

TABLE 6.5: DIVERSION RISKS AND MITIGATION MEASURES

Risks	Likelihood	Consequences	Risk Rating and Score	Mitigation Measures	Residual Likelihood	Residual Consequences	Residual Risk Rating and Score
Damage to new diversion channel due to frequent (up to 20% AEP / 5 year ARI) flood events.	Probable	2	9	Diversion channel constructed during dry season. Entire diversion able to be constructed while offline. Detailed revegetation plan to be implemented to promote rapid establishment. Seed mix to include fast establishing species to rapidly stabilise diversion.	Unlikely	1	1
Damage to the new diversion channel due to extreme/rare (0.1% AEP / 1000 year ARI) flood event (mainly overland flow and bank erosion)	Unlikely	2	3	Revegetation plan to include large species capable of withstanding shear stresses associated with rare events.	Highly Unlikely	2	0.9
Construction program impacted by frequent flow event (up to 20% AEP / 5 year ARI).	Unlikely	1	1	Diversion construction to be timed to minimise risk of large flows while still maintaining enough watering to promote vegetation establishment and growth. Entire diversion able to be constructed while offline.	Highly Unlikely	1	0.3
Constructability of diversion channel – encountering bedrock, material availability and access	Unlikely	2	3	Geotechnical and soil investigations as part of functional design.	Highly Unlikely	1	0.3
Flood ingress into final voids	Highly Unlikely	2	0.9	Final landform design to provide flood protection to ensure no flooding ingress in 0.1% AEP flood with 1.0 m freeboard.	Highly Unlikely	2	0.9
Upstream rehabilitation of mining areas unsatisfactory leading to increase in sediments loads to the final diversion channel	Unlikely	2	3	Additional upstream controls could be considered during functional design. Diversion able to be constructed offline so no offline flows through diversion.	Unlikely	2	3

6.7 Additional Design and Construction Considerations

6.7.1 Infrastructure

A landform to direct flow into the concept diversion design may be required along the western side of Riverside Mine Road heading south which the upstream section of the existing diversion crosses, dependent on the closure scenario of the Riverside Mine Road. This landform will require review as part of the detailed design work for the HPC diversion and will need to be tied in with the final landform for GS1 to the east. Appendix E shows the concept design drawings with the current alignment of Riverside Mine Road and a landform design based on this current road alignment and its interaction with the proposed concept design of HPC.

6.7.2 Roads and Culverts

Riverside Mine Road runs parallel to the western side of the diversion heading south. The current alignment of Riverside Mine Road may be impacted by the HPC diversion and if it were to remain would have the requirement for a culvert as part of the closure design. This will require review as part of the detailed design work for the HPC diversion. Appendix E shows the concept design drawings with the current alignment of Riverside Mine Road and its interaction with the proposed concept design of HPC.

6.7.3 Soils

The channel bed and banks are expected to be comprised largely of the surrounding soils, potentially dominated by dispersive sandy to loamy duplex soils. Erosion of the diversion channel is a key risk to the diversion not achieving a state of dynamic equilibrium. Key actions which should be undertaken in detailed design and construction to further quantify and mitigate this risk include:

- A detailed soil survey should be conducted in the functional design stage to determine characteristics of topsoil and subsoil within the diversion alignment.
- The detailed engineering in functional design should specify requirements for cover materials, including rock and rock mulch, to protect diversion batters from erosion.
- Temporary erosion sediment controls should be designed to minimise risk of erosion until vegetation establishment. This plan should be developed and approved by an appropriately qualified person informed by site specific soils data.
- An appropriately qualified person to assess the growth media for the diversion banks and recommend required ameliorants, fertilisers, and surface treatments.
- Excess supply of sediment from upstream and adjacent mining activities (spoil dumps, haul roads, coal stockpiles etc.) can impact vegetation establishment within the new diversion. Controls should be established to reduce sediment influx from surrounding landforms during the establishment of the diversion channel.

6.7.4 Revegetation

Hydraulic modelling has demonstrated that the design criteria values for stream power, stream velocity and shear stress for both 39% AEP and 2% AEP storm events, are within the ACARP (2002) diversion channel design parameters (refer Table 3.2). Effective revegetation will be crucial for the long-term stability of the diversion reach. A detailed revegetation plan should be developed as part of the functional design for HPC as it will be critical to prevent uncontrolled erosion in the early years following construction.

The revegetation for the diversion should be done in accordance with the revegetation plan informed by baseline vegetation surveys. The plan should:

- Specify the method for revegetation considering direct seeding, mulch blanket, direct planting etc. and be informed by the erosion potential, expected velocities of flows and the cover material in selecting the appropriate method.

The watercourse revegetation species should be based on selecting key framework trees, woody understorey, and groundcover species associated with the predominant natural watercourse regional ecosystems occurring upstream and/or downstream of the site as prescribed in the Goonyella Riverside Mine Progressive Rehabilitation and Closure Plan.

- Revegetation design should focus on re-establishing riparian vegetation for upper banks, mid banks and lower banks (including bank toe) revegetation zones.
- Include geomorphic and vegetation features like those in the local landscape.

- Consider irrigation and other controls required to promote vegetation establishment in response to changing climatic conditions.
- Achieve sufficient ground cover to mitigate erosion risk on beds and banks.
- Maintain a sediment transport regime that does not directly impact on upstream and downstream reaches.
- Not require ongoing maintenance.

6.7.5 Monitoring and Maintenance

Monitoring and maintenance of the diversion during the operational phase should be conducted in accordance with BMAs watercourse diversion monitoring program, and following construction and rehabilitation of the new diversion alignment is required to be conducted in accordance with the PRCP. The monitoring and maintenance of the diversion during the establishment phase should be done routinely and consider the following (at least):

- Identifying introduced species and weeds for control.
- Success of vegetation establishment and identifying the need for subsequent seeding or planting.
- Climatic conditions which may impact the success of vegetation establishment (i.e., drought).
- Unplanned events which may impact the success of vegetation establishment (i.e., bushfire).
- Monitoring for erosion of beds and banks.
- Sediment transport under low flow conditions to ensure no excess sedimentation.
- Success of temporary erosion and sediment control measures.

The frequency of inspections should be aligned to risk (i.e. increase where control implementation is not suitable), and also following periods of high flow in the diversion.

7. CONCLUSION

The existing diversion is experiencing increasing bank erosion, lack of geomorphic and vegetation features like those in the local landscape, sediment aggradation and sediment deposition downstream.

The concept design has been developed to meet the requirements of the PRCP and achieve a state of dynamic equilibrium enabling its relinquishment in the post closure landform of GRM.

Four options for rehabilitation of the diversion were identified and assessed using the BMA MCA outlined in Section 5. Option 2 was selected to proceed as the preferred concept design as it had a high likelihood of achieving a state of dynamic equilibrium due to the length and grade of the diversion and maintaining the current catchment area for HPC. The chosen concept design, typical cross sections and longitudinal section are presented in Appendix E.

The concept design demonstrates that the watercourse diversion will satisfy the closure objectives identified in the guidelines, for PRCP purposes.

8. QUALIFICATIONS

(a) In preparing this document, including all relevant calculation and modelling, Engeny Australia Pty Ltd (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

(b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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   (ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

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(g) This Report does not provide legal advice.

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APPENDIX A: MULTI-CRITERIA ANALYSIS DETAILS

Multi-Criteria Analysis - Holding Paddock Creek Diversion

Project: PRCP GRM Diversions
Workshop Date:

-3	-2	-1	0	1	2
Fatal Flaw	Strongly Negative	Mildly Negative	Neutral	Mildly Positive	Strongly Positive

Criteria	Assumptions/Considerations	Weight	Option 1	Option 2	Option 3	Option 4	Comments
Likelihood that diversion will achieve state of dynamic equilibrium	Considers the difference between diversion length and grade to natural stream length and grade. Ideally diversion length/grade = natural stream length/grade.	50%	-3	2	1	2	Option 1: Retain existing alignment - length 6.1 km and grade 0.34%. Potential seepage from GS1 tailings storage facility could impact diversion performance. Reshaping of GS1 embankment at closure will likely toe out into the current diversion alignment. Option 2: Total diversion length is 6.5 km with a grade of 0.32%. Option 3: Diversion length is 3.8 km with a grade of 0.31%. Option 3 will result in increasing the catchment area of HPC. Option 4: Diversion length is 5.6 km with a grade of 0.39%.
Order of magnitude cost estimate	Assumes $10/m3 of cut.	30%	2	0	-1	-2	Option 1: Compared based on direct diversion cut requirement costs only. Option 2, Option 3 & Option 4: Compared based on the 'HPC Diversion Alignment Trade-Off' project completed by Engeny (Engeny, 2023).
Ability to isolate diversion from flows during establishment period	Diversion can be isolated from flows if it is constructed offline of the existing diversion.	20%	0	1	2	2	Option 1: Will be constructed on the existing diversion alignment. Option 2: Cuts across the existing alignment. It is possible but there is some engineering risk. Option 3 & Option 4: The entire of the diversion can be constructed offline from the existing diversion
		Overall Weighted Score	-0.9	1.2	0.6	0.8	

Is there a Fatal Flaw?	**Fatal Flaw**	**No**	**No**	**No**
Relative Risk	**Highest Risk**	**Lowest Risk**	**Low Risk**	**Low Risk**

APPENDIX B: HYDROLOGIC MODEL DEVELOPMENT

HYDROLOGIC MODEL SETUP

The WBNM (Watershed Bound Network Model) runoff routing software (2021 version) was used to develop the hydrology model. WBNM automatically calculates catchment routing based on the sub-catchment area, pervious/impervious areas and parameters, and the sub-catchment flow paths.

Catchment Inputs

Sub-catchment delineation for GRM was developed using the PRCP landform (Version 2) topography displayed in Figure B.1. The hydrological model includes the total catchment for the Isaac River (inclusive of Eureka, HPC, and Fisher creeks) extending downstream past the Goonyella mine, covering a total area of approximately 1180 km^2.

Three open water bodies are located in the upper catchment: Lake Elphinstone, Teviot Dam and Burton Gorge Dam. Lake Elphinstone is a natural lake formed behind the Carborough Range whereas Teviot Dam and Burton Gorge Dam are man-made structures that supply water to Burton and North Goonyella mines in the upper catchment.

The design life of the Teviot Creek Dam and Burton Gorge Dam, as part of mining closure operations, could impact design flow estimates. For this study, the WBNM model did not include the Burton Gorge Dam, Teviot Dam, and Lake Elphinstone located upstream of the study area, considering a worst-case scenario.

Figure B.1 provides the sub-catchment extents used for the WBNM.

Model Parameters

The final landform is proposed to be rehabilitated; therefore, the hydrology model has assumed no impervious surfaces remain and a 0% impervious fraction (Fi) for all catchments including the remaining spoil areas and voids.

The default routing parameter of 1, pervious lag parameter of 1.8 and impervious lag parameter of 0.1 have been adopted for the WBNM.

Design Rainfall

The 0.1% AEP (1000yr) was sourced using the Australian Rainfall and Runoff 2019 IFD generation tool available on the Bureau of Meteorology (BoM) website (www.bom.gov.au), at Latitude 21.6652 (S), Longitude 148.0792 (E). Aerial Reduction Factors (ARFs) have been used for all design events to convert point rainfall estimates to areal rainfall estimates.

Temporal Patterns

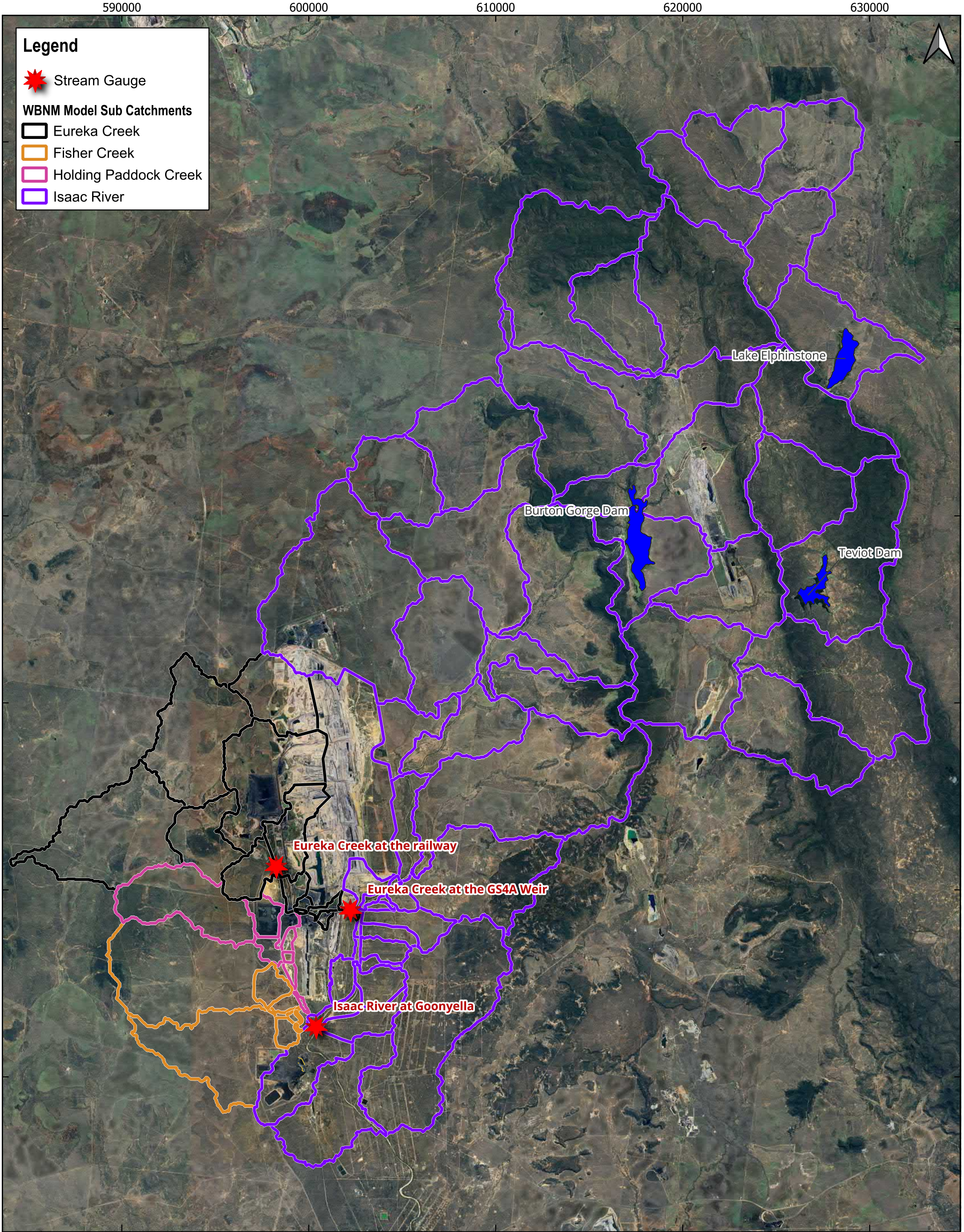
Design events (1% - 0.1% AEP) have utilised the 'East Coast North' areal temporal patterns, as the total catchment area for the model exceeds 75 km^2. All ten temporal patterns were simulated for storm durations ranging from the 3 hours to 168 hours.

Design Rainfall Losses

The initial and continuing losses obtained from the ARR Datahub for Isaac River catchment to Goonyella gauge are 36 mm and 2.7 mm/h, respectively.

The adopted design rainfall losses were selected to achieve the best match between the XP-RAFTS design discharges with the design discharges estimated by the FFA at the Isaac River Goonyella gauge. The following is of note:

- For the 50%, 20%, 10%, 5%, 2% and 1% AEP events, the default ARR initial losses of 36 mm and continuing losses of 2.7 mm/h were adopted, respectively. The initial loss will decrease for larger events as the catchment is likely to be more saturated prior to the design rainfall burst.
- For the 0.1% AEP design event, a conservative 0 mm initial loss was adopted. A continuing loss of 2.5 mm/h was adopted as per the flood assessment done by WRM in 2019 (WRM, 2019).



BMA PRCP GRM Holding Paddock Creek Diversion

Figure B.1
WBNM Hydrologic Model Layout

REV.	DETAILS	DATE
0		

DRAWN: CH | CHECKED: BK
APPROVED: BK | DATE: 08/08/2024

GENERAL NOTES:

0 2 4 km
Scale @ A3: 1:180,000

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MODEL VALIDATION

The 50%, 20%, 10%, 5%, 2% and 1% AEP peak flows estimated from the hydrology model were validated using the following methods:

- **Regional Flood Frequency Estimation Model (RFFE)** - is a recommended peak flow validation method from the ARR 2019 guidelines (Ball, et al., 2019). The RFFE provides peak flow estimations based on the catchment area and a catchment shaping factor, determined using the catchment centroid and outlet coordinates. The RFFE peak flow estimates were calculated using the ARR RFFE Model online tool (http://rffe.arr-software.org/).

- **Flood Frequency Analysis (FFA)** - provides peak flow estimates for different AEPs by developing a fitted distribution from recorded peak flows from historical flood events.

  There is no gauge station for HPC, while the Eureka Creek gauges (Eureka Creek at the railway and GS4A) had an insufficient monitoring duration to conduct a reliable Flood Frequency Analysis (FFA). As a result, the FFA for the nearby Isaac River at the Goonyella gauge, located 7 km downstream of Eureka, was used for validation purposes. This analysis was completed as part of the Isaac River Flood Model by Engeny in March 2021.

  Isaac River FFA was undertaken on the peak annual (water year from October to September) discharges recorded at Isaac River at Goonyella (130414A) streamflow gauge by Queensland Department of Natural Resources Mines and Energy (DNRME) between 1982 and 2020. A Log Pearson Type 3 (LPIII) distribution was fitted to an annual maximum series of peak flows from the gauge (Engeny, 2021). To adapt the Isaac River FFA to Eureka Creek (as there was no gauge station data for HPC nor was it covered as part of the WRM 2019 flood modelling report), peak flows were scaled based on the catchment area using the QRT method. The formula used for this adjustment is:

$$\boldsymbol{Q_u = \left(\frac{A_u}{A_g}\right)^n Q_g}$$

  Where,

  Q_u is the estimated peak flow for the ungauged catchment.

  A_u is the area for the ungauged catchment.

  A_g is the catchment area for the stream gauging station.

  Q_g is the peak flow for the gauging station determined from the flood frequency analysis.

  The exponent n has been determined from the regional flood frequency regression analysis (RFFE) undertaken by the Queensland Department of Transport and Main Roads (Palmen & Weeks, 2008).

- **Peak Flow Estimates from Previous Flood Studies** –

  - A hydrologic modelling of the Isaac River catchment including the Grosvenor Mine (GRV) and Moranbah North Mine (MNM) using the XPRAFTS runoff-routing model was developed to estimate the 39%, 10%, 5%, 2%, 1%, 0.2% and 0.1% annual exceedance probability (AEP) and probable maximum flood (PMF) design discharges for the Isaac River and its tributaries (Engeny, 2021). The estimated peak flows at the Isaac River at Goonyella Streamflow Gauge were compared to the WBNM and RFFE peak flows (refer to Figure B.2). It is to be noted that The Burton Gorge Dam, Teviot Dam and Lake Elphinstone upstream of the study area were modelled as detention basins in the XPRAFTS model.

  - Design peak discharges in the Isaac River at Goonyella, Eureka Creek upstream of the railway and Eureka Creek at the GS4A for the 10%, 5%, 2%, 1%, 0.1% were estimated using the XP-RAFTS model by WRM in 2019. These flows were compared to the WBNM model design peak discharges at these three gauge locations.

Model Validation Results

Table B.1 shows the WBNM estimated design discharges at the Isaac River at Goonyella, Eureka Ck at the Railway and Eureka Ck at the GS4A for design events between 10% to 0.1% AEP, and the comparison to the WRM design discharges. This was due to there being no WRM design discharges for HPC. A visual comparison of the WBNM design peak discharges at the Isaac River streamflow gauge (130414A) against the flood frequency distribution curve, XP-RAFTS estimated peak flows by Engeny in 2021 and RFFE is provided in Figure B.2.

Validation of the design hydrology peak flow estimates indicates the following.

- **Isaac River Gauge**
  - Modelled peak flows for all design events are higher (3%-26%) than the LPIII expected quantile from the FFA. This is expected considering the exclusion of Burton Gorge Dam, Teviot Dam and Lake Elphinstone (Figure B.2).
  - Modelled peak flows compared to the RFFE method were higher for events rarer than the 10% AEP and lower for events more frequent than the 10% AEP. This irregularity is not concerning as the RFFE can provide irregular results if catchment characteristics are mostly different from the nearby gauged waterways used to derive the RFFE. Additionally, the Isaac gauge catchment (1071.21 km^2) is outside the RFFE recommended catchment size of 0.5-1000 km^2, hence results have lower accuracy (Figure B.2).
  - WBNM estimated peak flows for all design events are higher (11%-28%) than the WRM 2019 flood modelling report (Table B.1).
- **Eureka Ck Gauge**
  - WBNM estimated peak flows for all design events are higher (10%-37%) than the WRM 2019 flood modelling report. This is expected considering the 37% increase of the Eureka catchment (Table B.1).

TABLE B.1: COMPARISON OF WBNM DESIGN DISCHARGES TO THE WRM 2019 FLOWS

		WRM (2019) Peak Discharge (m3/s)	WRM (2019) Critical duration (hours)	WBNM Peak Discharge (m3/s)	WBNM Critical duration (hours)	Difference (%)
Isaac River at Goonyella	Catchment Area (km^2)	-		1071.12 km^2		-
	Design event (AEP%)					
	10	830	18 hr	932	18 hr	11%
	5	1167	18 hr	1363	18 hr	14%
	2	1707	18 hr	2061	18 hr	17%
	1	2079	24 hr	2616	18 hr	21%
	0.1	3808	24 hr	5291	18 hr	28%
Eureka Creek at the railway	Catchment Area (km^2)	76.4 km^2		113.78 km^2		33%
	Design event (AEP%)					
	10	140	6 hr	159	18 hr	12%
	5	180	6 hr	217	18 hr	17%
	2	256	6 hr	299	18 hr	14%
	1	299	6 hr	374	18 hr	20%
	0.1	499	6 hr	692	12 hr	28%
Eureka Creek at the GS4A	Catchment Area (km^2)	80.7 km^2		129.05 km^2		37%
	Design event (AEP%)					
	10	147	6 hr	163	18 hr	10%
	5	189	6 hr	225	18 hr	16%
	2	267	6 hr	320	18 hr	17%
	1	311	6 hr	400	18 hr	22%
	0.1	521	6 hr	728	18 hr	28%

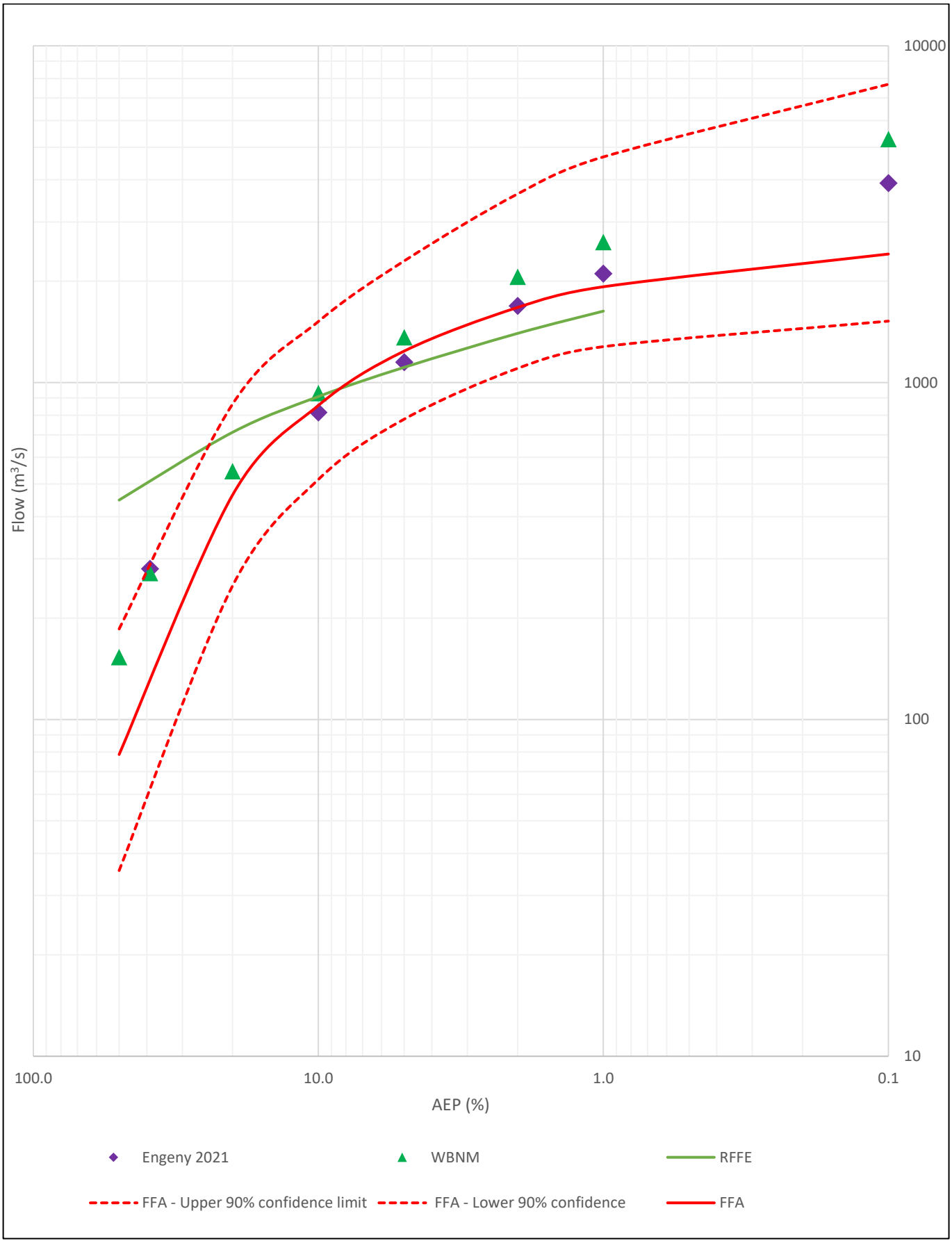


FIGURE B.2: COMPARISON OF WBNM DESIGN DISCHARGES TO THE FFA AND RFFE DESIGN DISCHARGES TO THE ISAAC RIVER GAUGE

APPENDIX C: HYDRAULIC MODEL DEVELOPMENT

MODEL EXTENT AND TOPOGRAPHY

The hydraulic model utilised the TUFLOW HPC solver. The Digital Elevation Model (DEM) used in the hydraulic model was based on the most recent PRCP landform (Version 2) provided by BMA.

A grid cell size of 4 m was selected for the TUFLOW model, which is suitable for representing the width of the diversion across multiple modelling cells.

The selected extent for the HPC TUFLOW model covers upstream of where both HPC and Eureka Creek starts to the Isaac River, downstream of where HPC, Fisher Creek, and Platypus Creek join into the Isaac River from the west which are all in the extent of the ML Goonyella Riverside. This was chosen to maintain a consistent modelling extent for the 0.1% AEP runs for all the GRM diversions across each of the hydraulic models. The modelling layout is shown in Figure C.1 and Figure C.2.

The proposed diversion design option was included in the model using design tins produced by 12D and merging it to the PRCP landform (Version 2) as well as the addition of the proposed landform to provide flood protection and battering of the GS1 Tailings Dam dump top outer extents.

HYDRAULIC ROUGHNESS

The hydraulic roughness has been selected based on the inspection of aerial imagery and expected treatments within the diversion as well as historical investigations into hydraulic roughness values for existing watercourse channels at GRM. The rail, which is not owned by BMA and goes to Moranbah North, was considered in the base land use mapping of the site. The adopted Manning's 'n' roughness values are summarized in TABLE C.1 below.

TABLE C.1: ADOPTED MANNING'S N ROUGHNESS

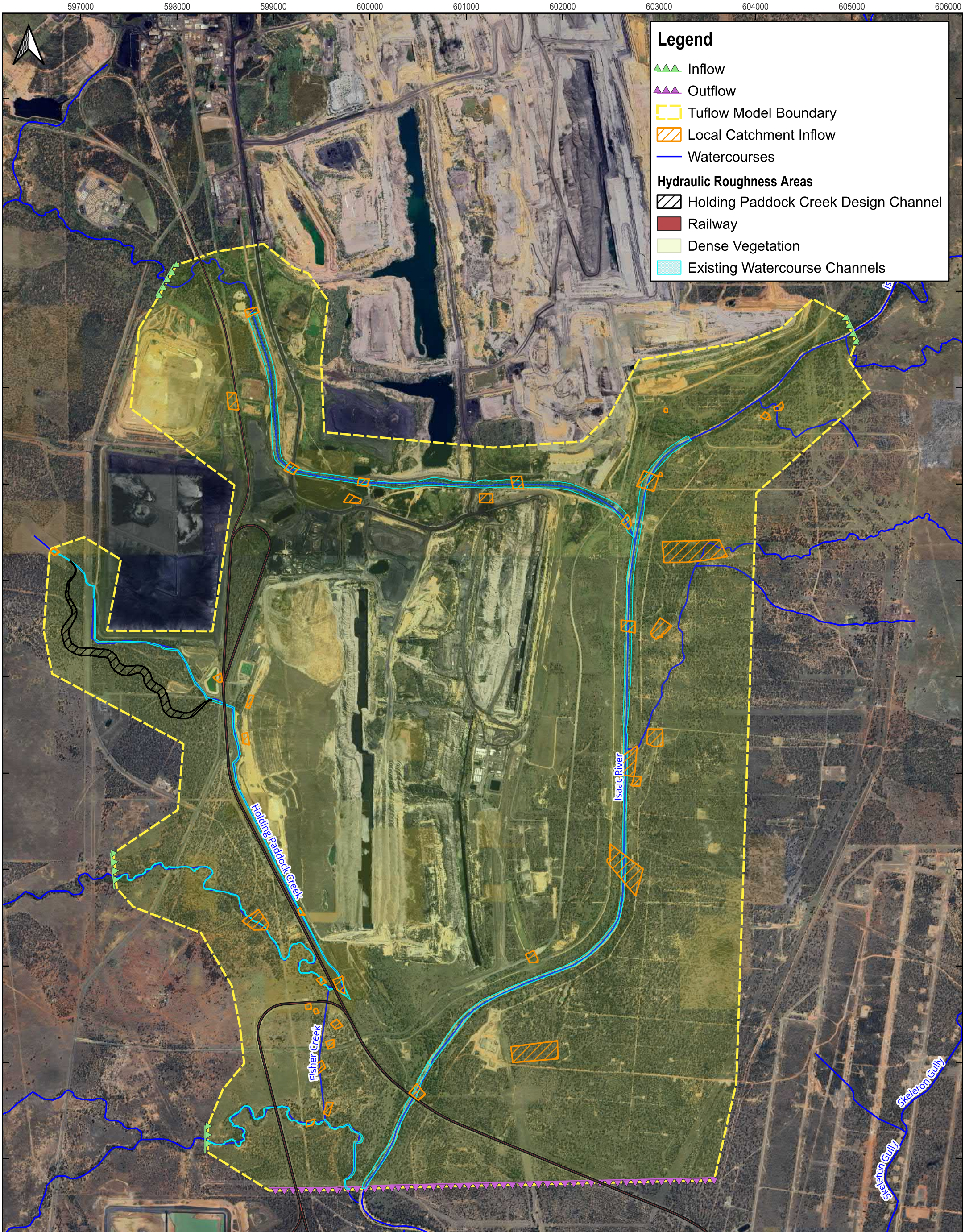
Land Use	Manning's' 'n'
Railway	0.015
Constructed Channel	0.050
Dense Vegetation	0.080
Isaac River Existing Channel	0.020
Platypus Creek Existing Channel	0.030
Holding Paddock Creek and Fisher Creek Existing Channel	0.050

MODEL INFLOWS AND BOUNDARY CONDITIONS

Boundary conditions are required in the model to define hydrology inflows, flow leaving the model domain and interfaces between the one dimensional and two-dimensional model domains. The following boundary conditions used in the models are:

- Upstream: The upstream boundary condition used a combination of 'SA' and 'BC' type boundaries, allocating flow to the defined model grid cells based on the design hydrograph from the hydrologic model (flow per unit of time) input. Total inflow hydrographs were applied to HPC, Fisher Creek, Isaac River, and Platypus Creek at the upstream boundaries.
- Downstream: A normal depth outflow boundary was adopted with a hydraulic grade based on the Isaac River channel grade at the downstream extent of the model. The boundary was located a sufficient distance downstream to not influence the flood behaviour near the areas of interest.

Peak flows as estimated by the WBNM hydrologic model (only for 0.1% AEP event) have been applied at various locations dependent on the diversion being assessed. The location of the model inflows (0.1% AEP) can also be seen in Figure C.1**.** As mentioned in section 6.4.1, for the 39% and 2% AEP event, constant ACARP flows were applied throughout the diversion as shown in Figure C.2**.**



BMA PRCP GRM Holding Paddock Creek Diversion

Figure C.1
Hydraulic Model Layout - 0.1% AEP

REV.	DETAILS	DATE
0		

DRAWN: CH | CHECKED: BK
APPROVED: BK | DATE: 28/08/2024

GENERAL NOTES:

0 250 500 750 1,000 m
Scale @ A3: 1:35000

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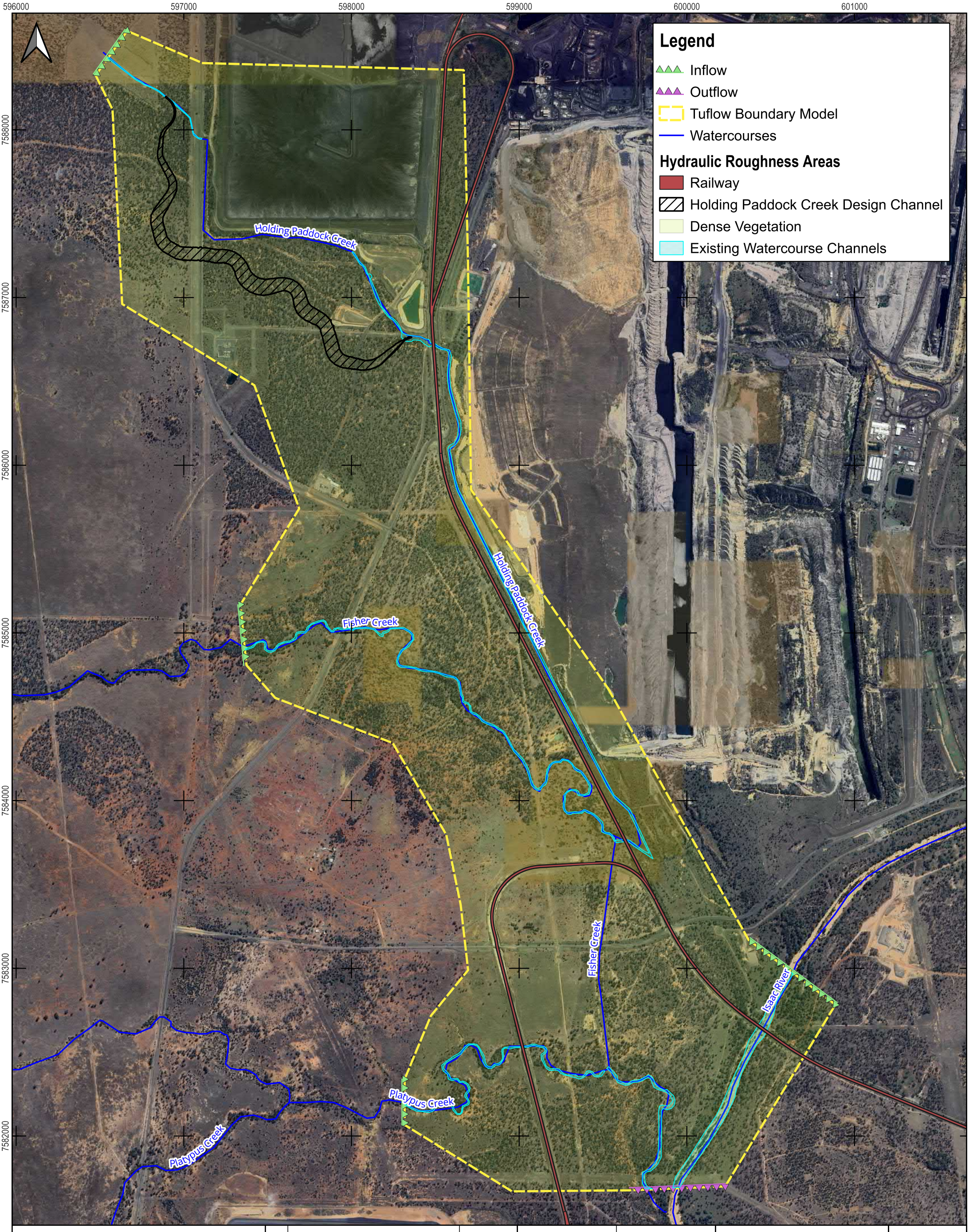

BMA PRCP GRM Holding Paddock Creek Diversion

Figure C.2
Hydraulic Model Layout - 39% and 2% AEP

REV.	DETAILS	DATE
0		

DRAWN: CH | CHECKED: BK
APPROVED: BK | DATE: 28/08/2024

GENERAL NOTES:

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Scale @ A3: 1:20000

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APPENDIX D: HYDRAULIC PARAMETER MODELLING RESULT

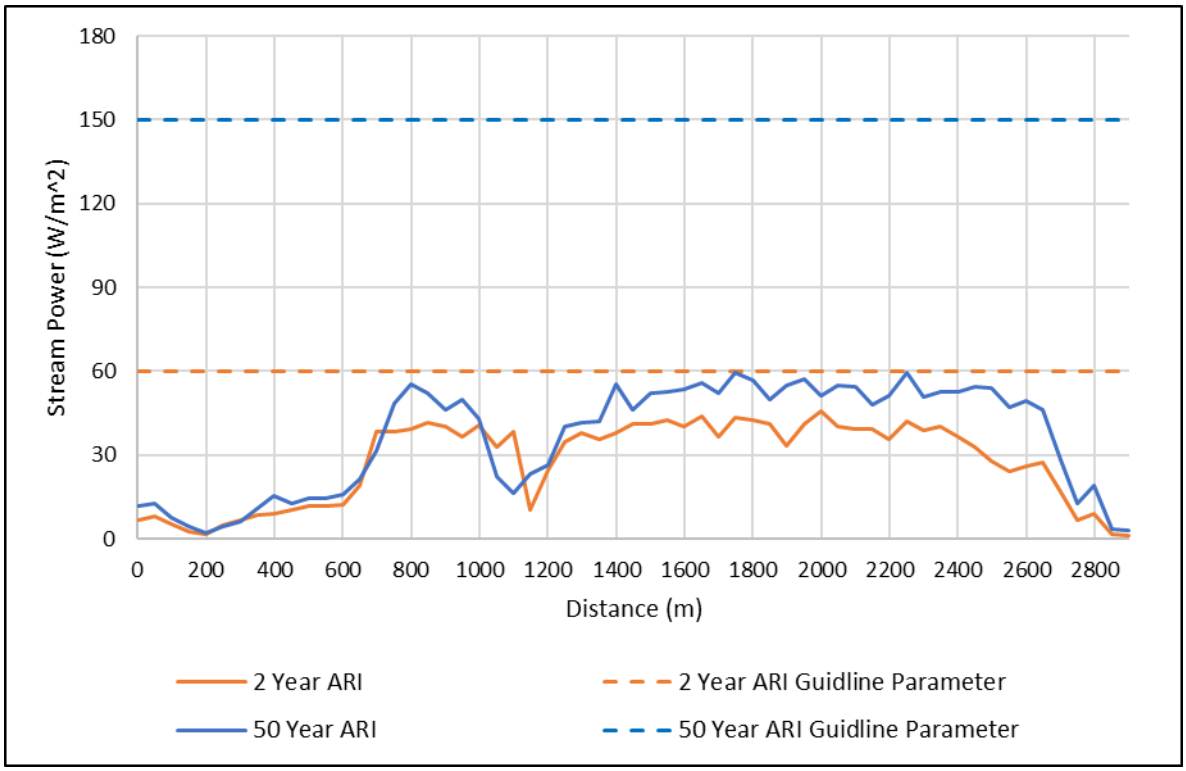

FIGURE D.1: STREAM POWER TUFLOW MODEL RESULTS

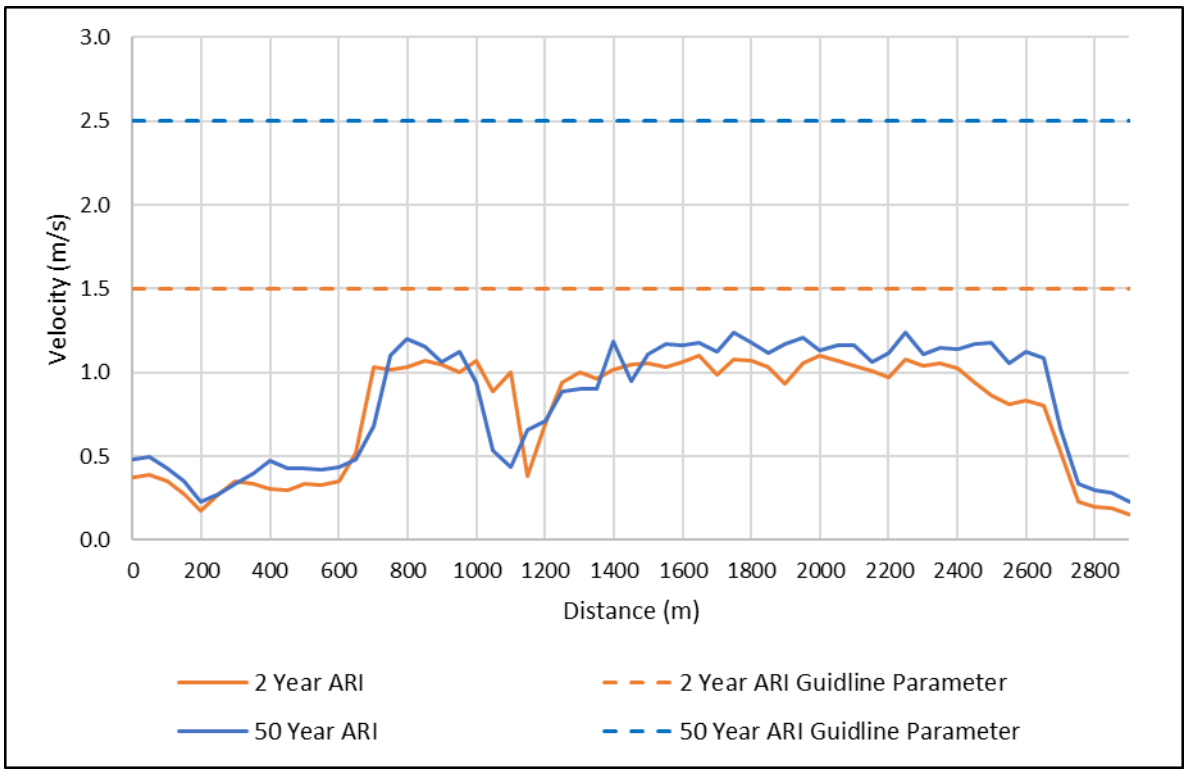

FIGURE D.2: VELOCITY TUFLOW MODEL RESULTS

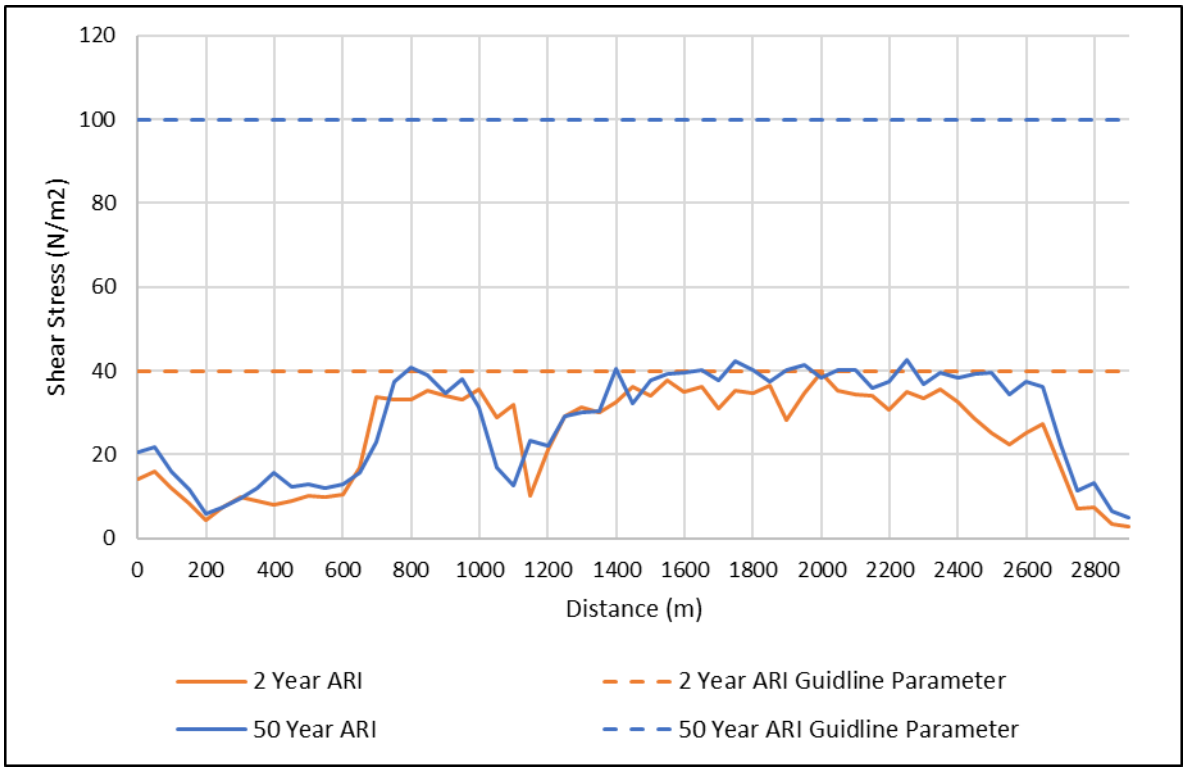

FIGURE D.3: SHEAR STRESS TUFLOW MODEL RESULTS

APPENDIX E: PREFERRED OPTION CONCEPT DESIGN DRAWINGS

NOT FOR CONSTRUCTION

CONTROL MCE01
(LANDFORM)

CONTROL MCD01
(HOLDING PADDOCK CREEK DIVERSION)

GS1 TSF

HOLDING PADDOCK CREEK

RIVERSIDE MINE ROAD

ROAD CROSSING DETAILS TO BE CONFIRMED DURING FUTURE PHASES OF STUDY

1093.745

0.000 250 500 750 1000 1250 1500 1750 2000 2250 2500 2750 2928.211

LEGEND - EXISTING

- BURIED WATER LINE
- POWER LINE
- PROPERTY BOUNDARY
- WATERCOURSE
- PIT DEWATERING LINE
- UNKNOWN BURIED SERVICE
- RAILWAY TRACK

LEGEND - DESIGN

- DIVERSION EXTENTS
- BATTER TICK
- CONTROL LINE
- DIRECTION OF FLOW

0 50 100 150 200 250m
SCALE 1:5000 (A1)
SCALE BEFORE REDUCTION

VENDOR DRG NUMBER QC1000-098-DWG-0101							
VENDOR LOGO ENGENY	A						
	REV	DATE	DESCRIPTION	DRN	ENG	APP	
			REVISION				

DRAWING No.	TITLE
REFERENCE DRAWINGS	

UNCONTROLLED IF PRINTED OR DOWNLOADED

BMA BHP Mitsubishi Alliance

VENDOR APPROVALS	SIGNATURE	DATE
DRAWN		
DRN. CHK		
ENGINEER		
ENG. CHK (QA)		
APPROVED		

RPEQ APPROVAL	BMA REVIEW
RPEQ ENGINEER	SIGNATURE
RPEQ No. DATE	
PROJECT No.	DATE
EQUIPMENT TAG	

GOONYELLA MINE
HOLDING PADDOCK CREEK DIVERSION
GENERAL ARRANGEMENT PLAN

DRG. No.	LEGACY DRG No.
STATUS: NOT FOR CONSTRUCTION - FOR REVIEW	DISCIPLINE:

Sht
Sht Size A1
Scale -
Rev. No. A

CAD FILE: QC1000-098-DWG-0101.dwg

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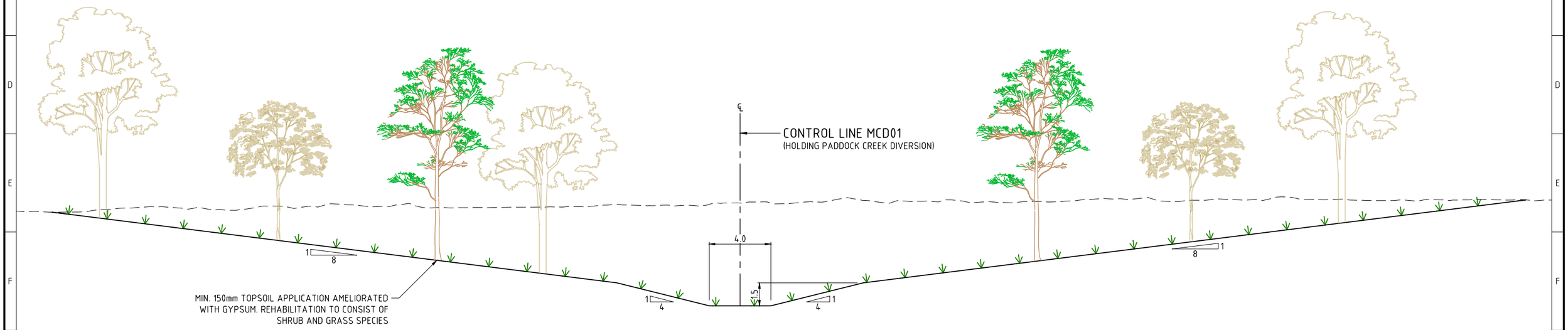

HOLDING PADDOCK CREEK DIVERSION TYPICAL SECTION

SCALE 1:125

LEGEND

EXISTING SURFACE

DESIGN SURFACE

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SCALE 1:125 (A1)
SCALE BEFORE REDUCTION

VENDOR DRG NUMBER	REV	DATE	DESCRIPTION	DRN	ENG	APP	DRAWING No.	TITLE
QC1000-098-DWG-0201	A							

VENDOR LOGO: ENGENY

REVISION — REFERENCE DRAWINGS

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VENDOR APPROVALS	SIGNATURE	DATE
DRAWN		
DRN. CHK		
ENGINEER		
ENG. CHK (QA)		
APPROVED		

RPEQ APPROVAL: RPEQ ENGINEER; RPEQ No. DATE; PROJECT No.; EQUIPMENT TAG

BMA REVIEW: SIGNATURE; DATE

GOONYELLA MINE
HOLDING PADDOCK CREEK DIVERSION
TYPICAL SECTIONS AND DETAILS

DRG. No.

LEGACY DRG No.

STATUS: NOT FOR CONSTRUCTION - FOR REVIEW

DISCIPLINE:

Sht

Sht Size: A1

Scale: –

Rev. No.: A

CAD FILE: QC1000-098-DWG-0201.dwg

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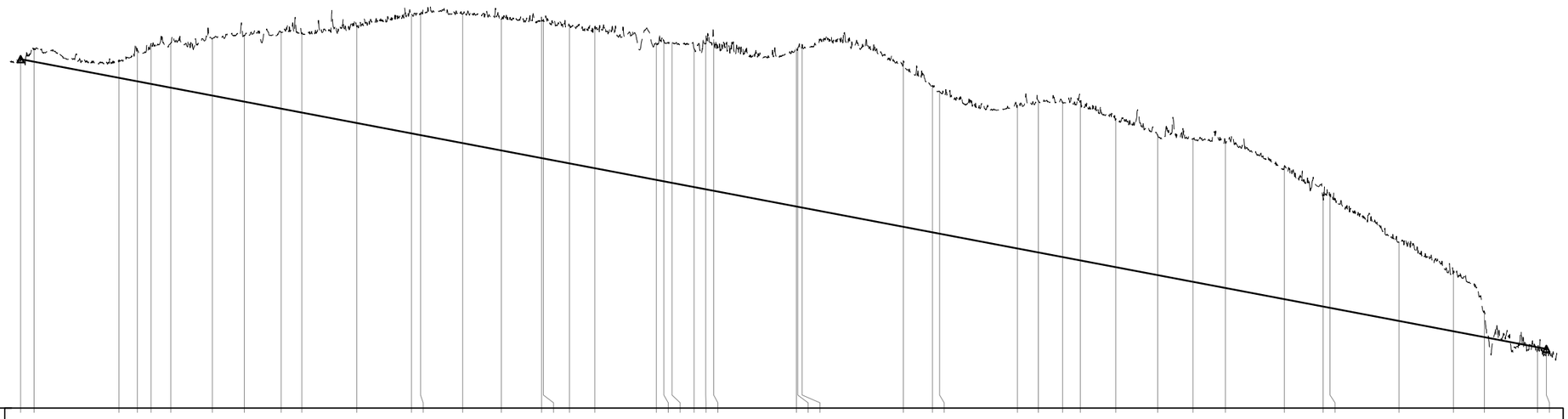

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CHAINAGES	NORTHING	EASTING	DEPTHS	DESIGN LEVELS	EXISTING LEVELS
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25.963	7588180.645	596911.109	0.474	260.286	260.760
189.006	7588035.310	596919.467	0.679	259.667	260.346
223.937	7588009.937	596895.459	1.225	259.535	260.759
250.000	7587988.899	596880.201	1.525	259.436	260.961
288.339	7587952.557	596868.742	1.716	259.290	261.006
367.876	7587873.535	596859.715	2.180	258.988	261.168
429.143	7587814.336	596871.259	2.537	258.756	261.293
500.000	7587752.117	596905.163	2.919	258.487	261.406
539.644	7587717.306	596924.132	3.065	258.336	261.401
645.279	7587616.558	596921.185	3.692	257.935	261.627
750.000	7587527.689	596865.787	4.520	257.537	262.057
767.672	7587512.692	596856.439	4.633	257.470	262.103
848.527	7587434.942	596844.438	4.956	257.163	262.119
922.480	7587363.309	596862.815	5.029	256.882	261.912
1000.000	7587302.618	596907.882	5.257	256.588	261.845
1003.219	7587300.996	596910.662	5.315	256.576	261.891
1053.209	7587276.492	596954.235	5.302	256.386	261.688
1101.836	7587263.689	597000.651	5.433	256.201	261.634
1220.246	7587260.610	597119.021	5.210	255.752	260.962
1234.474	7587259.232	597133.170	5.402	255.698	261.100
1250.000	7587256.631	597148.477	5.373	255.639	261.012
1292.619	7587249.493	597190.494	5.315	255.477	260.792
1314.837	7587248.226	597212.630	5.586	255.393	260.978
1330.323	7587249.060	597228.093	5.805	255.334	261.138
1488.723	7587165.235	597349.031	6.085	254.732	260.818
1491.260	7587162.815	597349.792	6.020	254.723	260.742
1500.000	7587154.564	597352.672	6.266	254.690	260.956
1694.352	7587067.193	597509.035	6.362	253.952	260.313
1750.000	7587077.405	597563.738	5.635	253.740	259.376
1763.853	7587079.947	597577.356	5.458	253.688	259.146
1913.209	7587007.528	597692.300	5.476	253.121	258.596
1953.434	7586968.673	597702.711	5.822	252.968	258.790
2000.000	7586928.057	597724.617	5.945	252.791	258.736
2033.758	7586907.074	597750.856	6.081	252.663	258.743
2102.060	7586873.984	597810.607	5.693	252.403	258.096
2182.190	7586812.571	597858.702	5.374	252.099	257.473
2250.000	7586747.106	597876.379	5.490	251.842	257.331
2312.225	7586687.033	597892.600	5.612	251.605	257.218
2425.490	7586614.618	597971.789	5.109	251.175	256.284
2500.000	7586601.688	598045.169	4.110	250.893	255.003
2513.015	7586599.429	598057.986	4.284	250.843	255.127
2645.609	7586633.354	598181.739	3.022	250.340	253.362
2750.000	7586701.364	598260.937	2.277	249.943	252.220
2809.470	7586740.107	598306.054	0.974	249.717	250.691
2911.512	7586759.448	598401.792	-0.101	249.330	249.229
2928.211	7586754.340	598417.691	-0.000	249.267	249.267

CONTROL LINE MCD01 (HOLDING PADDOCK CREEK DIVERSION)

SCALE 1:5000 HORZ.
SCALE 1:100 VERT.

LEGEND

EXISTING SURFACE
DESIGN SURFACE

0 1 2 3 4 5m
SCALE 1:100 (A1)
SCALE BEFORE REDUCTION

0 50 100 150 200 250m
SCALE 1:5000 (A1)
SCALE BEFORE REDUCTION

VENDOR DRG NUMBER
QC1000-098-DWG-0301

VENDOR LOGO
ENGENY

REV	DATE	DESCRIPTION	DRN	ENG	APP
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REVISION

DRAWING No.	TITLE

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BMA
BHP Mitsubishi Alliance

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RPEQ No. DATE
PROJECT No.
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SIGNATURE
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GOONYELLA MINE
HOLDING PADDOCK CREEK DIVERSION
LONGITUDINAL SECTIONS

DRG. No.
LEGACY DRG No.
STATUS: NOT FOR CONSTRUCTION - FOR REVIEW
DATE:

Sht
Sht Size A1
Scale -
Rev. No. A

CAD FILE: QC1000-098-DWG-0301.dwg

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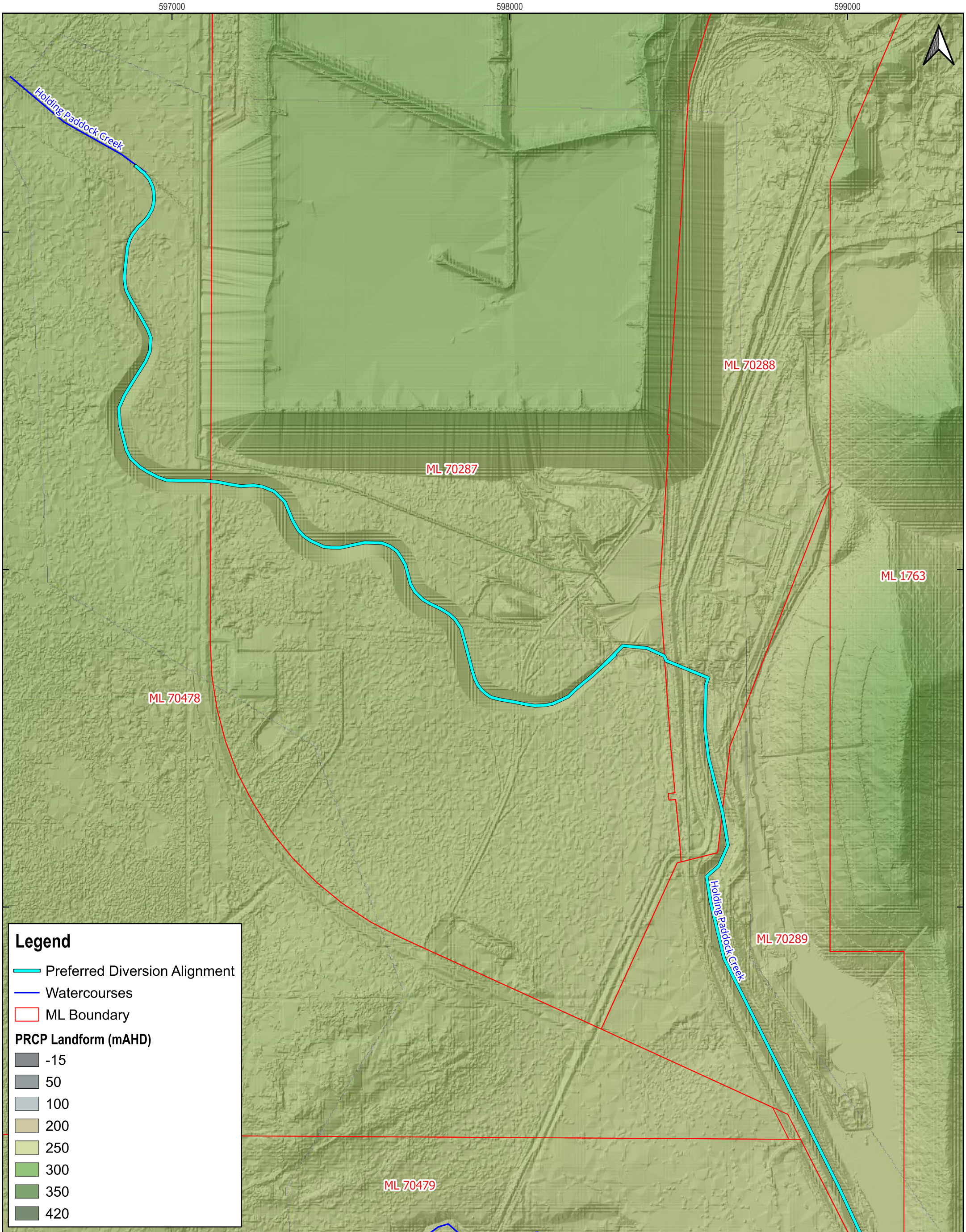
APPENDIX F: CONCEPT DESIGN WITH CONCEPT PRCP LANDFORM 2 INTERACTION



BMA PRCP GRM Holding Paddock Creek Diversion

REV.	DETAILS	DATE
0	Client Issue	

DRAWN: CH | CHECKED: BK

APPROVED: BK | DATE: 24/09/2024

0 100 200 300 400 m

Scale @ A3: 1:10000

BMA
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Figure F.1
Holding Paddock Creek Concept Design with Concept PRCP Landform 2

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BYRNES GEOTECHNICAL

ACN 633 507 623

BMA TECHNICAL SERVICES

Geotechnical considerations for closure of underground mines at BMA Broadmeadow.

REPORT: BMA-13 GRB

Date:17 October 2024

Prepared by:

Dr Ross Seedsman RPEQ

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1 INTRODUCTION

Broadmeadow Mine currently extracts the Goonyella Middle Seam (GMS) and at some time in the future will extract the Goonyella Lower Seam (GLS) (Figure 1).

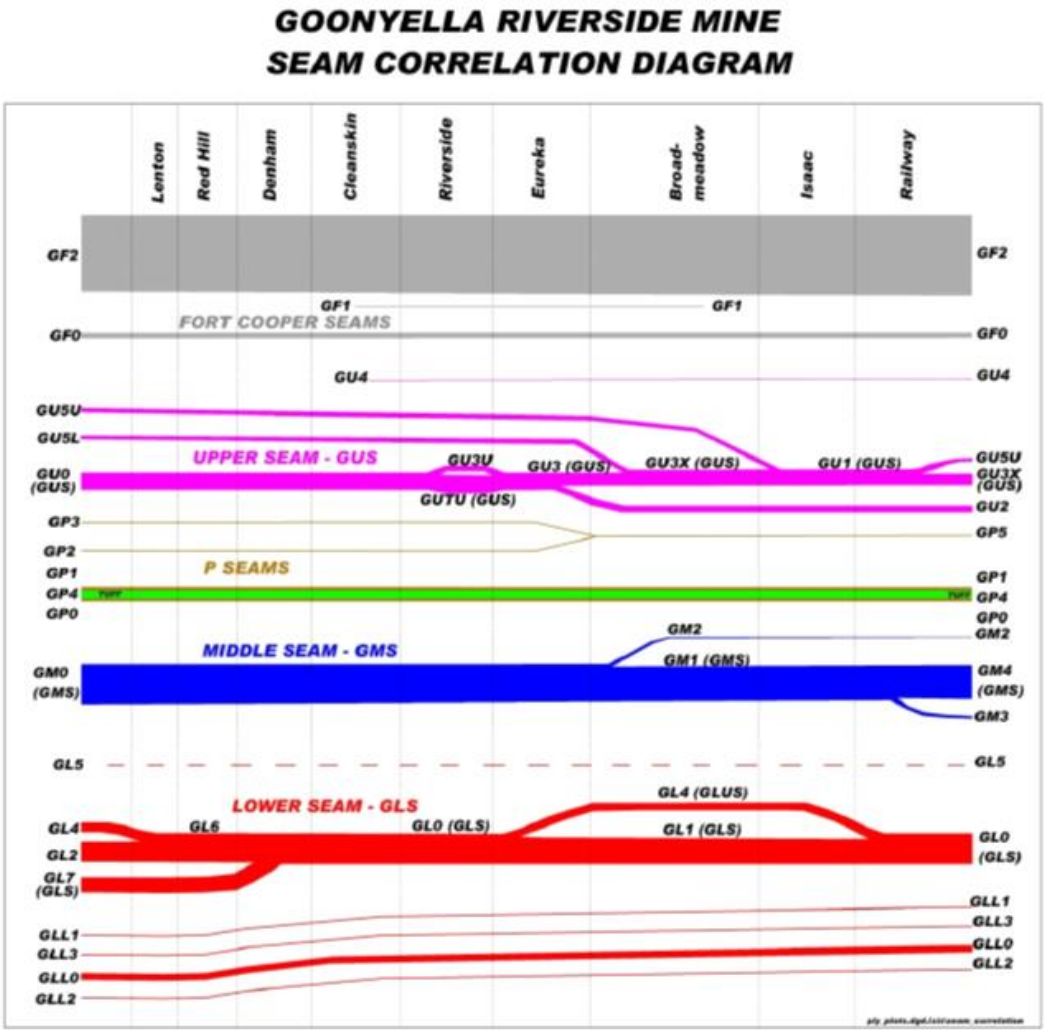


Figure 1 Seam Correlation Diagram

Broadmeadow Mine commenced longwall operations in the GMS in 2005, initially with a conventional longwall but later with a top coal caving system (TCC). The initial extracted thickness was 3.8 m but increased to a nominal 5.5 m with the TCC system (noting the thickness varies due to the caving process). The Broadmeadow longwall panels are 330 m wide (320 m wide wall plus 2 of 5 m roadway widths) and typically 2-3 km in length with chain pillars having widths that have ranged between 35 m and 45 m.

The longwalls in the GMS have retreated to the west with the mining depth decreasing from 320 m to 100 m (Figure 2). LW1-LW12 (northern panels) were punch longwalls with the gate roads driven from the Goonyella and Broadmeadow open cuts (Ramps 4 and 3). LW13 onwards (progressing to the south) are accessed by a 5-heading set of Mains. A total of 27 longwall panels are currently proposed for the GMS.

There are plans to then extract 29 longwall panels in the GLS seam with mining depths of 410 m to 110 m (Figure 3).

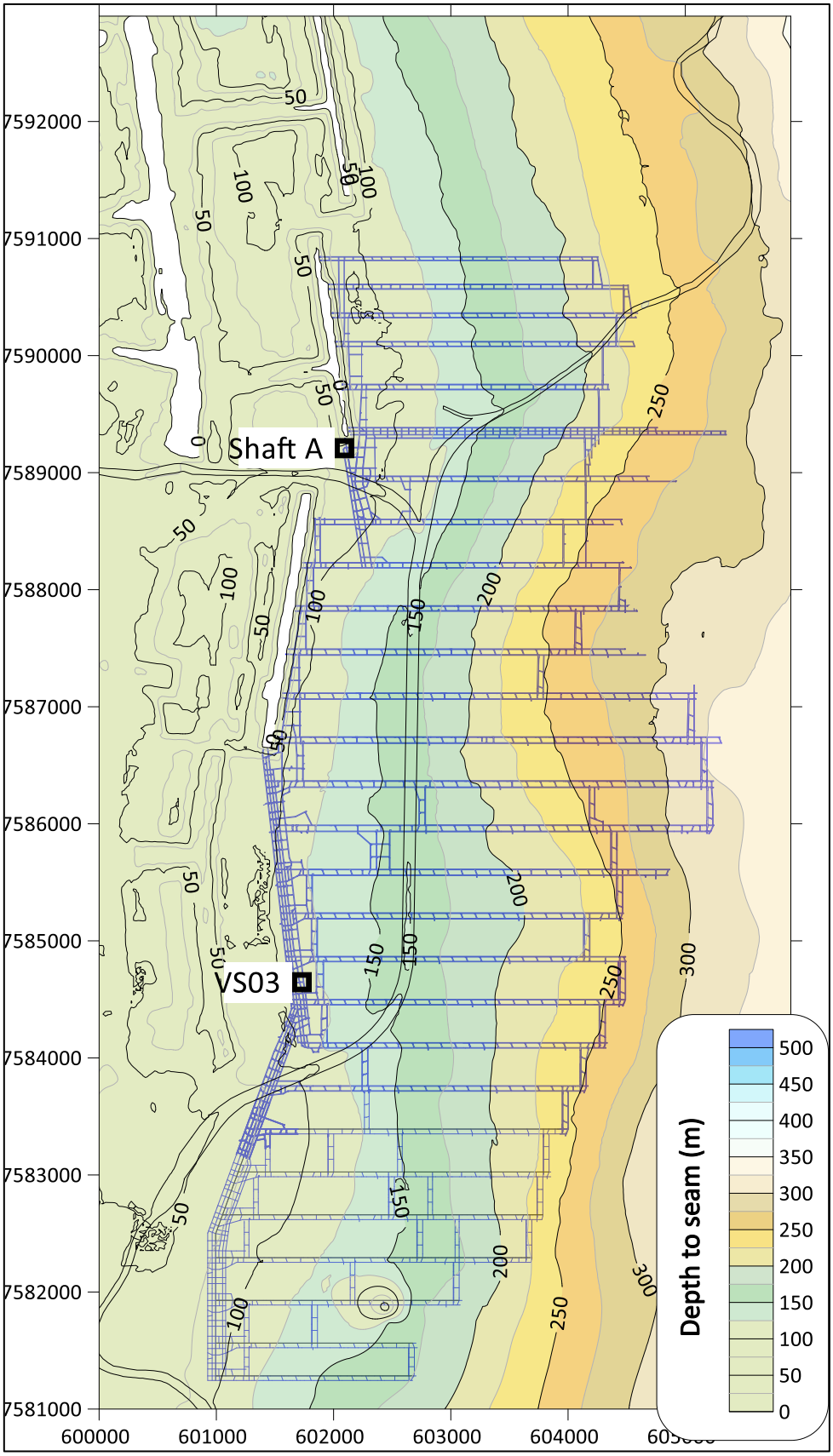


Figure 2 Mining layout for GMS with depths of cover

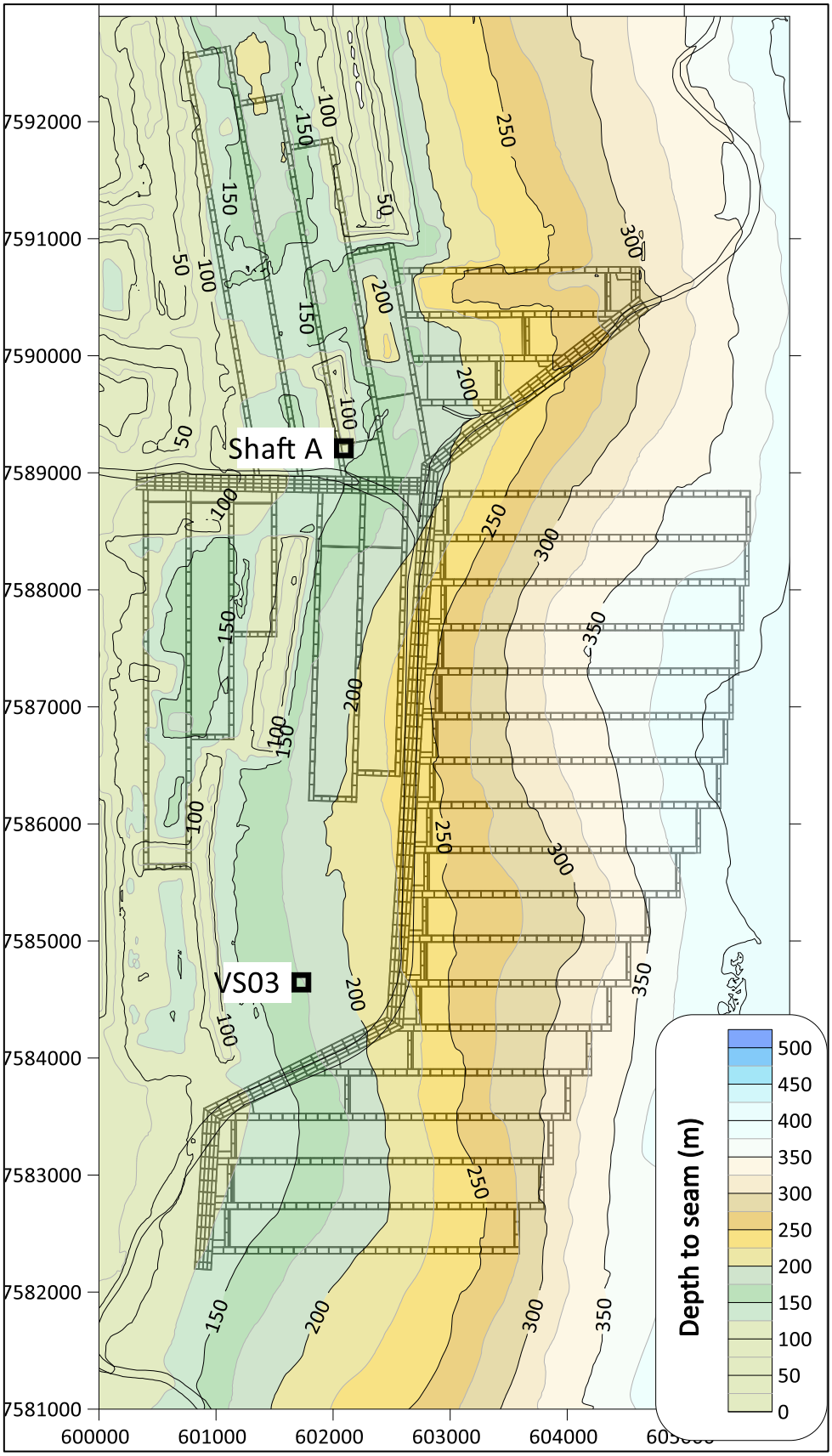


Figure 3 Mining layout for GLS with depths of cover

2 ENGINEERING GEOLOGY

2.1 Regional geology

Broadmeadow Mine is located at the mid-western fringe of the Bowen Basin in Central Queensland. In this area the late Permian coal bearing formations (Moranbah Coal Measures and overlying Fort Cooper Coal measures) are unconformably overlain by Tertiary aged sediments and basalt flows.

The Permian formations consist of fine to coarse grained sandstone of moderate to high strength, with interbeds of mudstone, siltstone and coal seams. The Tertiary sediments consist of poorly lithified sands and clays with poorly cemented sand and minor gravel lenses intercalated within widespread basalt flows. The flows infill old paleo channel drainage systems with the main channel running through the Wards Well, North Goonyella, Moranbah North and Grosvenor Coal leases, east and southeast of Broadmeadow Mine.

2.2 Surface geology

Quaternary sands and clays overlie the Tertiary deposits and are associated with more recent drainage systems (Figure 4). The main units are:

- Qrc: Colluvium and/or residual deposits, talus, scree, sheet wash; boulder, gravel, sand; may include minor alluvial or sand plane deposits.
- Czs: Sand plain, may include some residual alluvium; sand dominant, gravel, clay.

Site investigations[1] for ventilation Shaft A (Figure 2) intercepted clays and sands to a depth of 9.2 m. Both the clay and clayey sand, down to a depth of 4.2 m, were logged as being plastic with clayey properties. The silty sand, between depths of 4.4 and 9.2 m was medium dense, only had minor clay and was essentially non-plastic, collapsing following drilling and required casing.

Site investigations for ventilation shaft VS03 did not separate the Quaternary from the underlying Tertiary sediments (Figure 5). There was a large amount of core loss over the upper 16 m of the hole. Soil materials (soil clay gravel) were logged to 16.07 m and then sandstones and siltstones. The change in colour from browns to greys would appear to have been used to indicate the base of the Tertiary sequence at 16.07 m.

The compiled thickness of the Tertiary alluvials varies between 10-20 m over the Broadmeadow Mine area.

2.3 Coal Measures

The Permian coal measure rocks are interbedded sandstones mudstones and coals with laterally extensive bedding partings and orthogonal jointing whose continuity is limited by lithological units. A Geological Strength Index (GSI) of approximately 40 applies (sandstone and siltstone in similar amounts, smooth bedding planes[2]).

At Ventilation Shaft A, coal measure rocks were first encountered at a depth of approximately 14m, comprising of 11 m of extremely low strength, extremely weathered clayey sandstone with the first coal seam being intersected between depths of 25.48 - 27.0 m. Below the coal seam a further 7.6 m of generally very low strength siltstone and sandstone was intersected before medium strength siltstone was encountered at a depth of 34.65 m. Between this depth and the top of the GMS at a

[1] Douglas Partners 2014. Geotechnical Investigation, 3.6 m Diameter Ventilation Shaft. Project 80543.00.

[2] Hoek E, Marinos PG, Marinos VP.2005 Characterisation and engineering properties of tectonically undisturbed but lithologically varied sedimentary rock masses. IJRMMS, 4, 277-285.

depth of 109.68 m, there was interbedded, generally low to medium strength siltstone and high strength silty sandstone (15 - 35 MPa). Similar results are reported in analyses conducted for the underground mining operations.

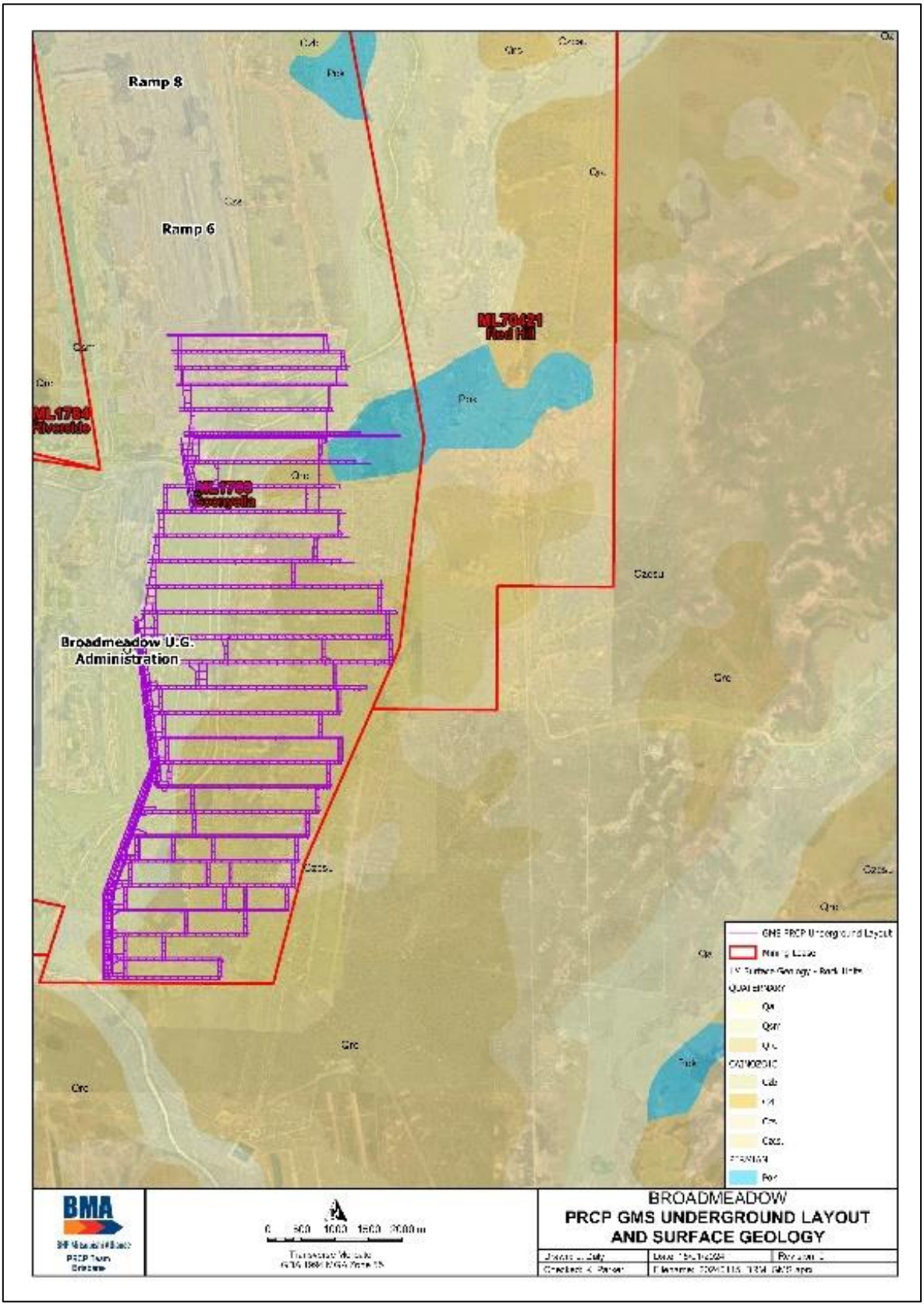


Figure 4 Surficial geology

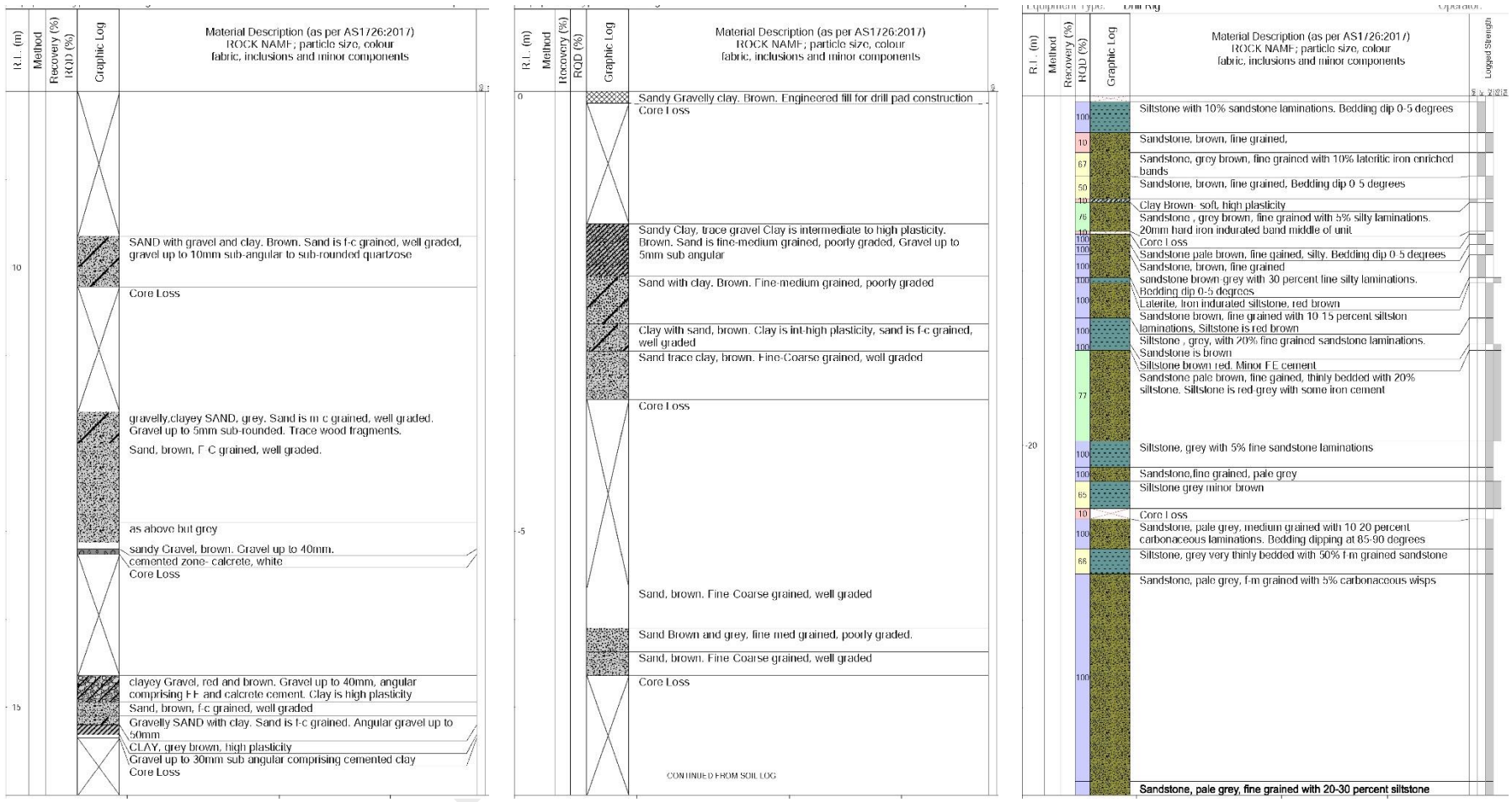


Figure 5 Quaternary and Tertiary sediments at VS03 – note large amount of core loss.

2.4 Goonyella Middle Seam

2.4.1 Coal

The working section for gate road development is 3.6-3.7 m high (Figure 6) and is located specifically to maintain a certain thickness of Ply 2 as the immediate roof. The TCC system seeks to extract a nominal thickness of 5.5 m.

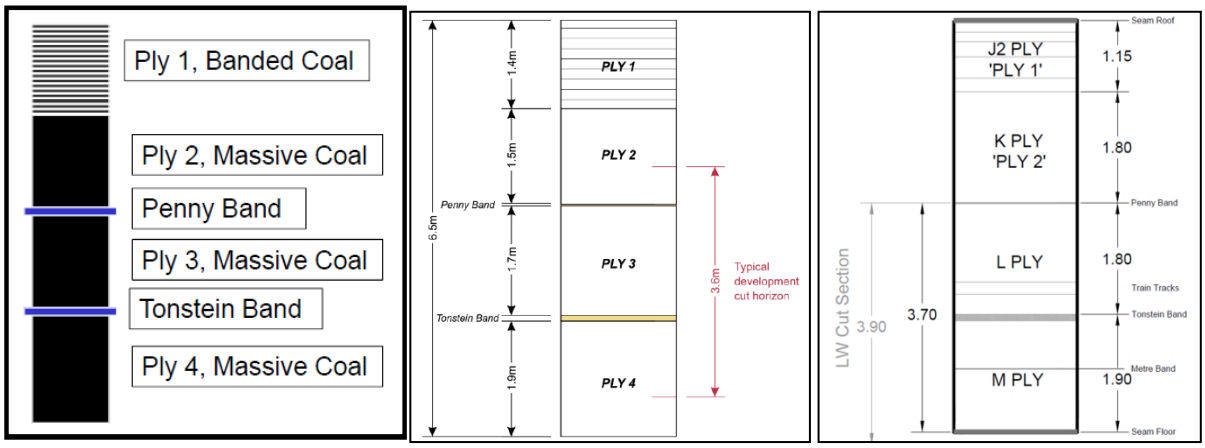


Figure 6 Details of the Goonyella Middle Seam.

2.4.2 Roof rocks

Fine grained rocks such as mudstones and siltstones have a Uniaxial Compressive Strength (UCS) of about 30 MPa. Sandstones are stronger with a UCS of about 40 MPa and with a wider range of variation (Figure 7).

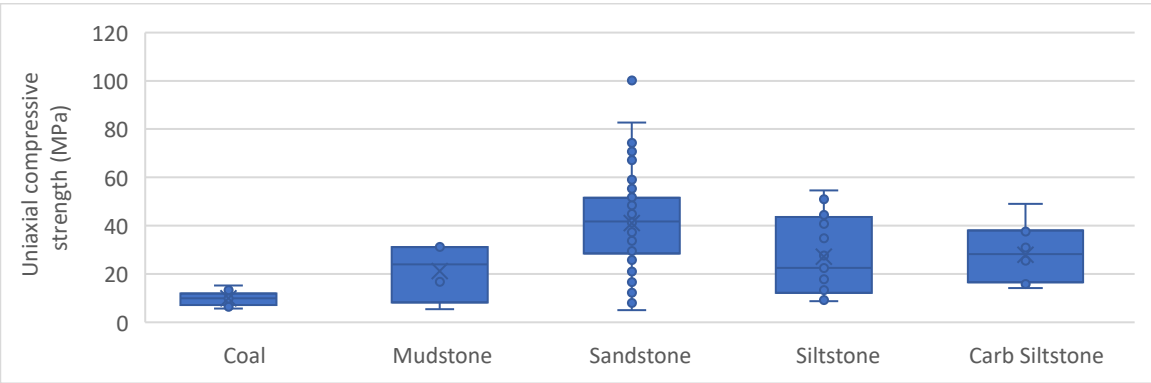


Figure 7 Range of UCS values for different lithologies.

The areal distribution of immediate roof strengths is presented in Figure 8 which is based on estimates of rock strength derived from geophysical logs. There are no low strength clayey units in the immediate roof or floor of the GMS.

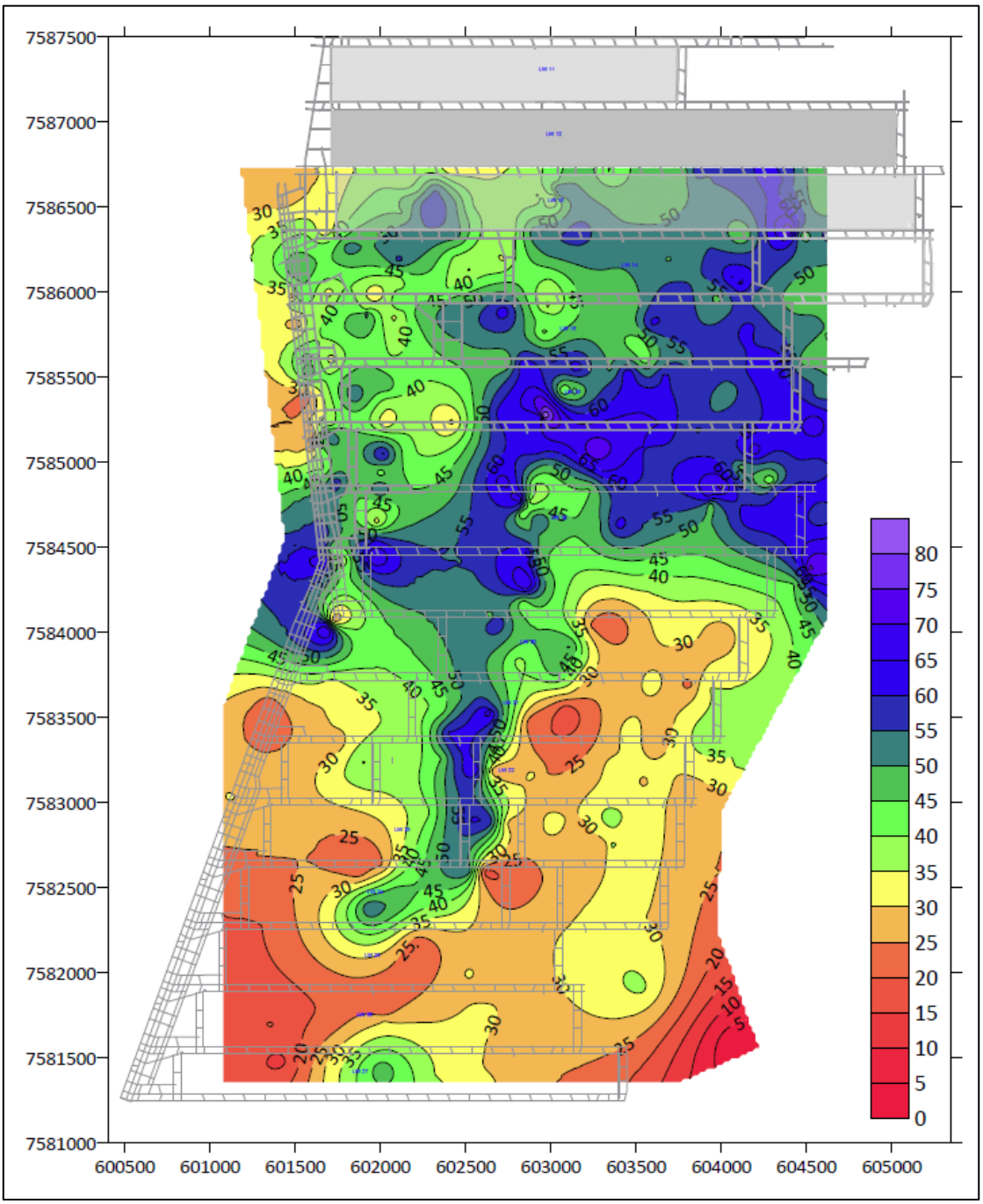


Figure 8 Sonic derived strength of the roof of GMS 2-6 m above

2.4.3 Immediate floor

The floor of the GMS consists of mudstones with no puggy clay horizons present. The compressive strengths are about 25-35 MPa.

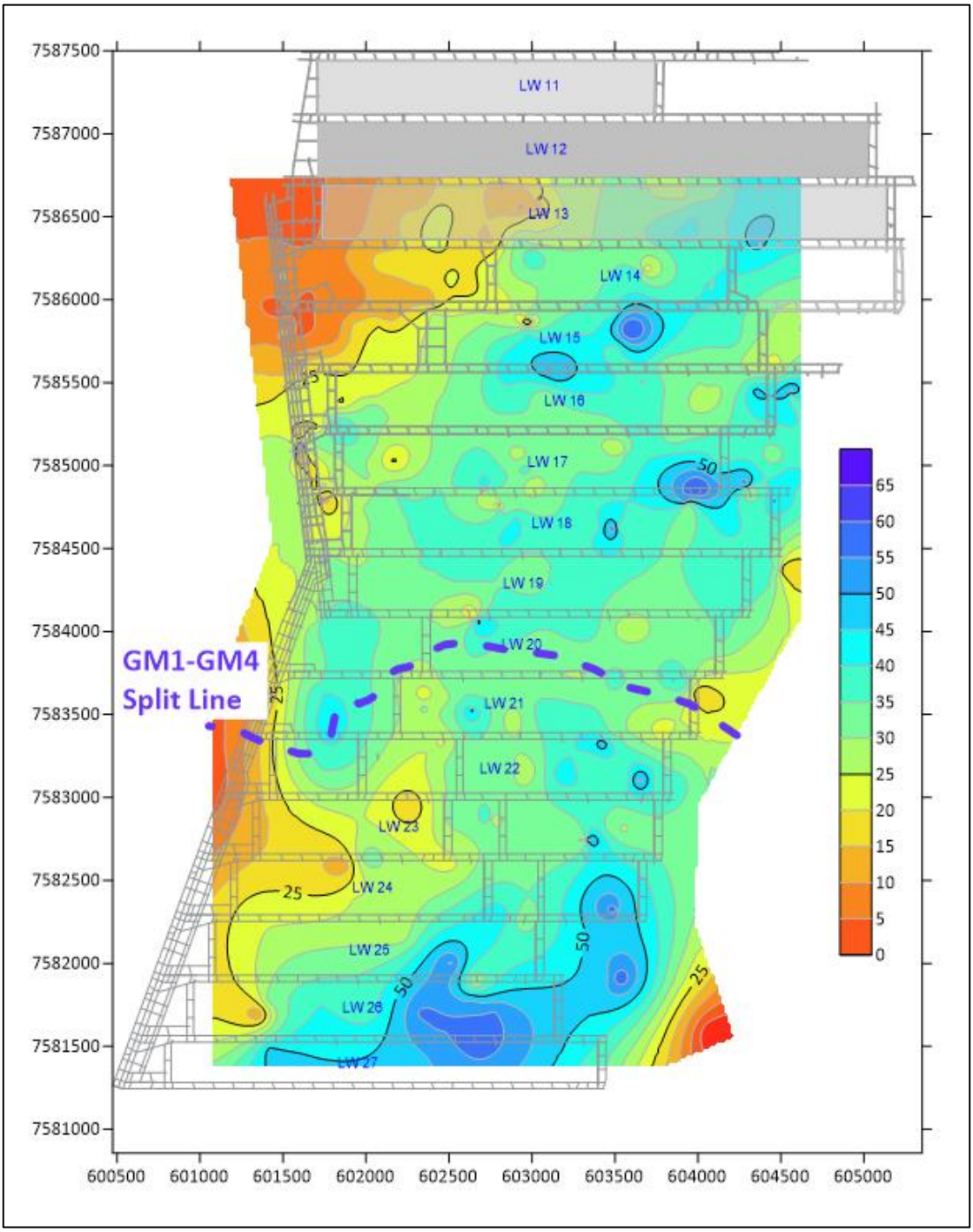


Figure 9 Sonic- derived floor strength for 1.0-2.0m interval below GM Seam

2.5 Goonyella Lower Seam

As of 2024, the geotechnical information available for the GLS has not been presented in the same way as for the GMS. There is information that compares the immediate roof and floor of the two seams which indicates that the GLS roof and floor is slightly stronger than the GMS (Table 1). It is assessed that the strength differences between the two seams are not significant and that the subsidence prediction method for the GMS seam can be validly applied to the GLS seam.

Table 1 Comparison of GMS and GLS lithologies and strengths

	Comments in BMM511c[3]
GMS roof	Siltstones – 25 MPa Sandstone 25-30 MPa Siltstone laminate sandstone 25-50 MPa Interbedded sandstone >35 MPa
GLS roof	Interbedded siltstone/sandstone 30-75 MPa Interbedded sandstone and siltstone 30-75 MPa
GMS floor	Moderate strength sandy floor Siltstone mudstone – 25-35 MPa Carbonaceous siltstone 25-35 MPa
GLS floor	Siltstone – 25-30 MPa Sandy floor 30-35 MPa Shale/sandstone floor 35-40 MPa Carbonaceous siltstone 30 MPa

3 SURFACE DEFORMATIONS DURING MINING OPERATIONS

3.1 Longwall mining

Inherent in safe and productive longwall mining is the collapse of the rock mass above the extracted coal. The geotechnical parameters of the local and regional geology (Section 2) are critical in understanding the way in which the strata above the underground mine will collapse. The collapse may extend to the surface if the width of the extraction relative to the depth of mining exceeds about 0.5. The width:depth ratio for the current and legacy longwall mines in Queensland means that the collapse extends to the surface and vertical subsidence develops progressively as the longwall advances. Maximum subsidence develops above the extraction within about 100 m of the active longwall mining face: there is also a lesser amount of vertical subsidence above the chain pillars (between the longwall panels) that develops independently of that above the longwall panel extraction (Figure 10).

There are 2 types of pillars in a longwall mining layout: mains pillars that provide access to the longwall panels and chain pillars that separate consecutive longwall panels. The mains pillars and the associated roadways are designed to be stable during the operations – both in terms of roof collapse in the roadways and stability of the pillars. The mains pillars are designed with high stability factors such that failure over the long term is unlikely and the vertical subsidence on the surface is expected to be minimal, if any. The chain pillars have lesser levels of stability and while they are designed not to collapse during longwall extraction may deform significantly and result in measurable subsidence. The collapse of the rock mass above the extracted longwalls results in the

[3] SCT 2016 Development of GMS and GLS Roadway Models for the Selection Phase of the GCOS Project.

chain pillars being confined such that on-going subsidence does not develop – subsidence is effectively complete after a few months but this depends on the rate of longwall extraction.

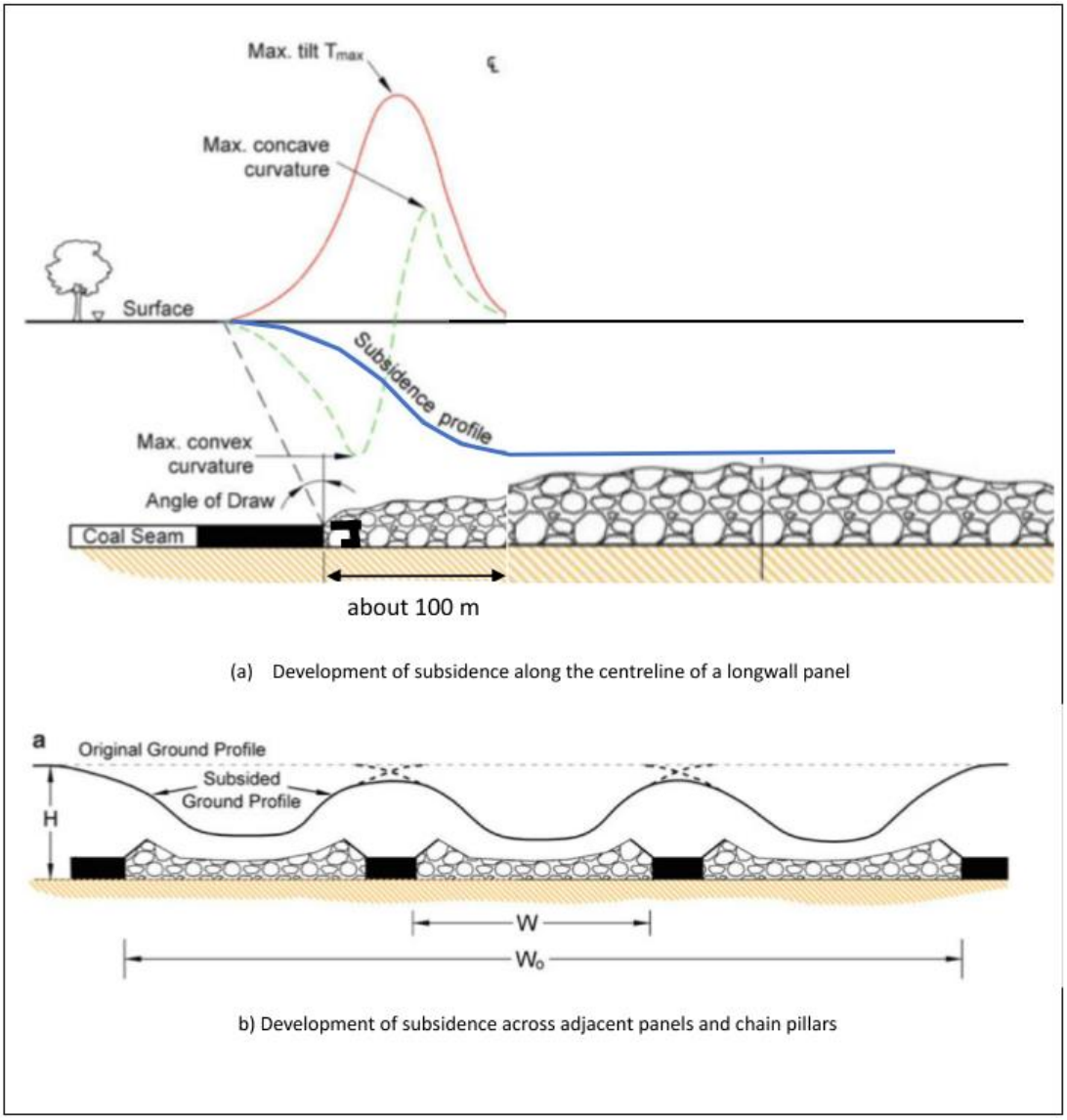


Figure 10 – Subsidence deformations (Modified from Galvin (2016)[4] Figure 10.1 and Figure 10.16)

Mining subsidence results in the following deformations and associated impacts at the surface:

- Downward vertical movements
- Change in surface slope angles
- Vertical steps and compression humps
- Surface cracking

[4] Galvin JM 2016. Ground engineering Principles and Practice for Underground Coal Mining.

3.2 Subsidence at Broadmeadow Mine

3.2.1 Above the longwall panels

The magnitude of surface subsidence directly above the longwall extraction at Broadmeadow has been well established using conventional terrestrial surveys. Surveys are completed down the centreline of each longwall panel and 3 cross lines. A peg spacing of 10 m has been used.

The crossline data for LW15 (Figure 11) shows the expected patterns for the longwall panels at Broadmeadow Mine, with the maximum vertical subsidence being 3.44m, the maximum tilt being 7.4 mm/m and the maximum tensile strain being 22.5 mm/m.

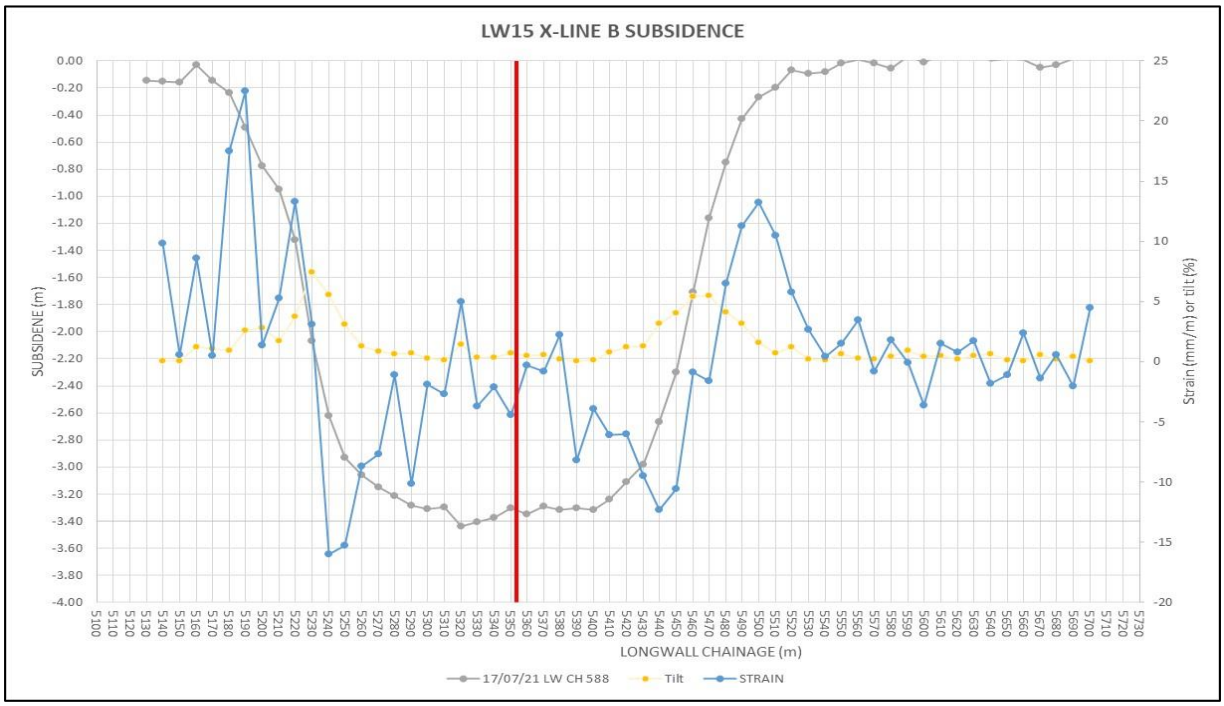


Figure 11 Example of crossline survey data used to derive prediction inputs

There are variations in the vertical subsidence measured along the centrelines of the longwalls (Figure 12). The maximum vertical subsidence recorded along LW15 centreline is 3.77 m. The bottom of the subsidence trough is not smooth – for LW15 the average subsidence between chainage 1780 and 410 is 3.4 m with a range between 3.0 - 3.77 m, with a standard variation of 0.16 m, and a coefficient of variation of 4.7%.

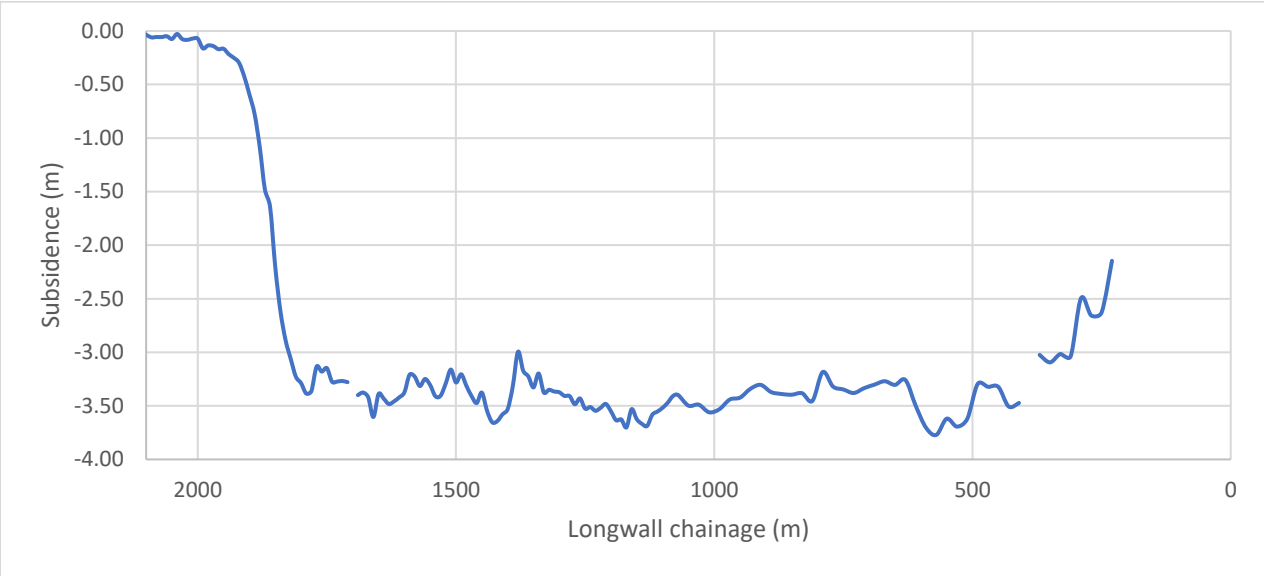


Figure 12 Example of vertical subsidence along the centreline survey of LW15

Figure 13 compiles data on the maximum vertical subsidence recorded along the surveyed centrelines for all longwalls to date. This plot highlights the fact that maximum subsidence is related to extraction thickness with the earlier conventional longwall extracting 3.8 m coal section and the TCC system extracting a thicker but variable section. There is more variability in the TCC data possibly related to variations in the amount of coal recovered in the caving process.

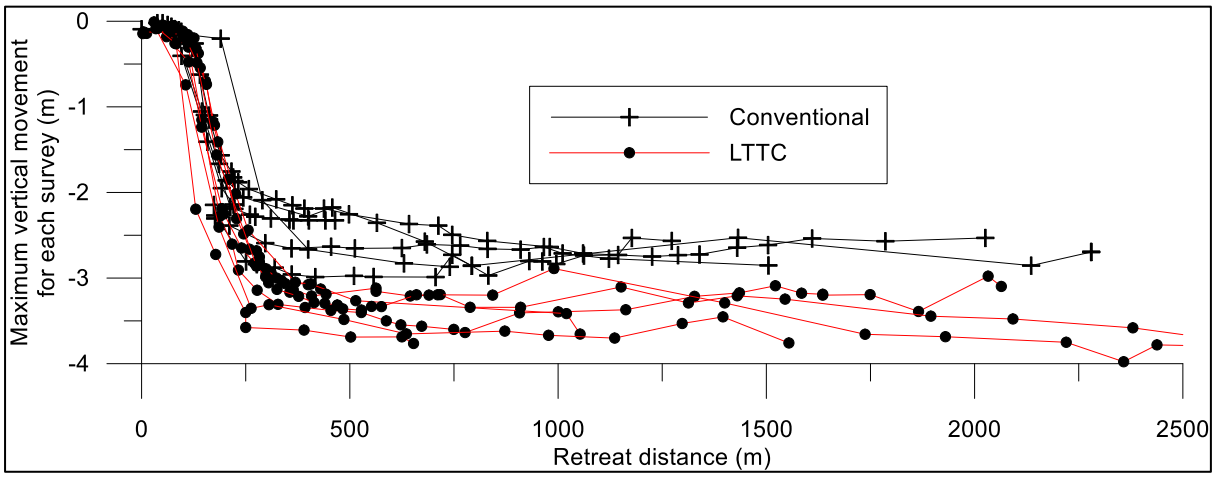


Figure 13 Compilation of centreline survey data

3.2.2 Above the chain pillars

The terrestrial surveys do not provide adequate coverage of the subsidence above the chain pillars. LIDAR surveys have given the general indication that subsidence above the chain pillars increases to the east with the greater mining depths (Figure 14). The resolution of these surveys could not detect vertical subsidence above pillars formed at depths less than about 250 m.

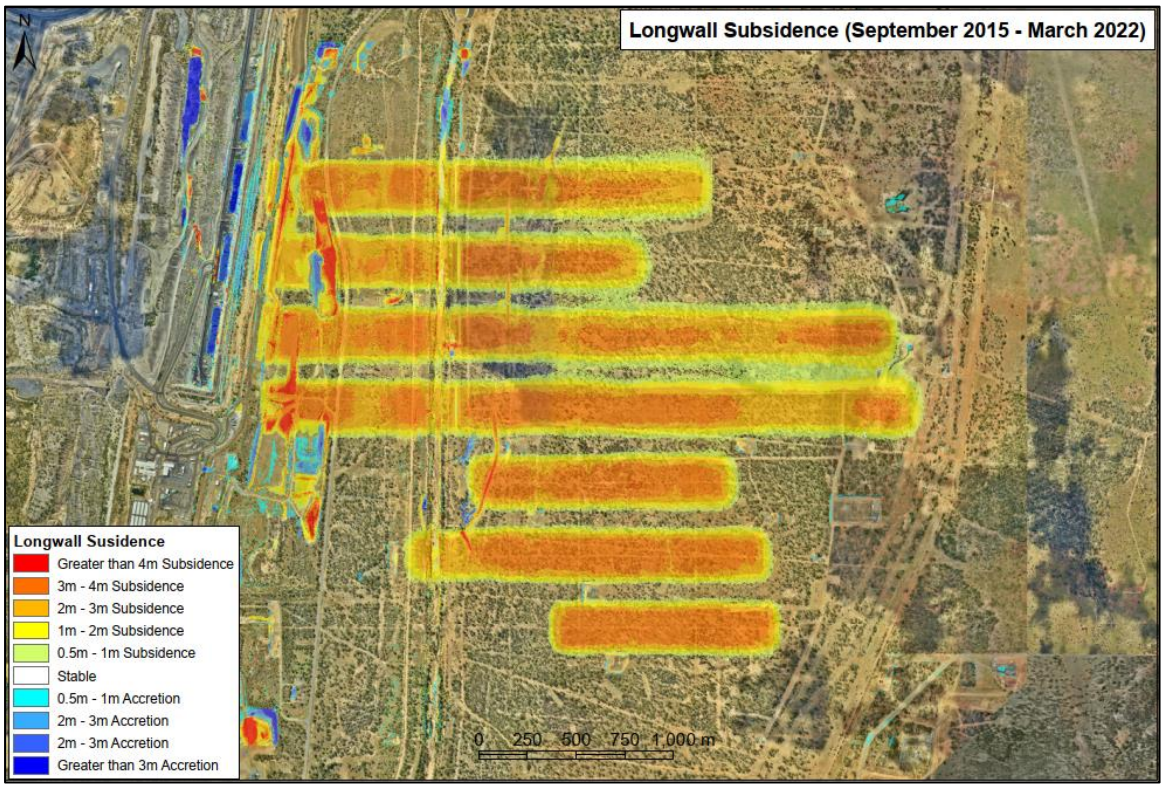


Figure 14 Example of Lidar data

3.3 Prediction and visualisation of subsidence

Inspection of the terrestrial surveys indicate that the shape of the subsidence bowl can be modelled with a gaussian influence function. The average maximum vertical subsidence over the initial longwalls was 2.8 m and this has increased to 3.4 m for the TCC panels. Relative to the extracted thickness, the maximum subsidence (Smax/T) is 0.75. The location of the maximum tilt (also the point of inflexion in the subsidence profile) relative to the extraction edge is 0.2 times the mining depth.

The prediction of future subsidence is based on the view that the overburden geology (Section 2) will not be materially different to that already encountered for GMS and that ratio of the mining depth to extraction width remains greater than 1.0.

In this report the Surface Deformation Prediction System (SDPS) influence function method[5] has been used to visualise subsidence deformations. SDPS provides 2 ways of modelling subsidence above chain pillars (Figure 15):

- One way involves the simple addition of the predicted subsidence for each longwall panel. Without calibration data, the panel addition method is more applicable for deeper mines and has been adopted for Broadmeadow. This method tends to underestimate pillar subsidence but gives a better representation of the subsidence above the extraction. Predictions were made on 20 m centres.
- The alternative way is to assume the maximum subsidence is developed over all panels and then the chain pillars are specifically introduced. This pillar reduction method works

[5] Surface Deformation Prediction System (SDPS) Software | Office of Surface Mining Reclamation and Enforcement (osmre.gov)

reasonably well for longwalls at shallow depths (individual panels are supercritical) but becomes more complicated for deeper mines (individual panels are subcritical).

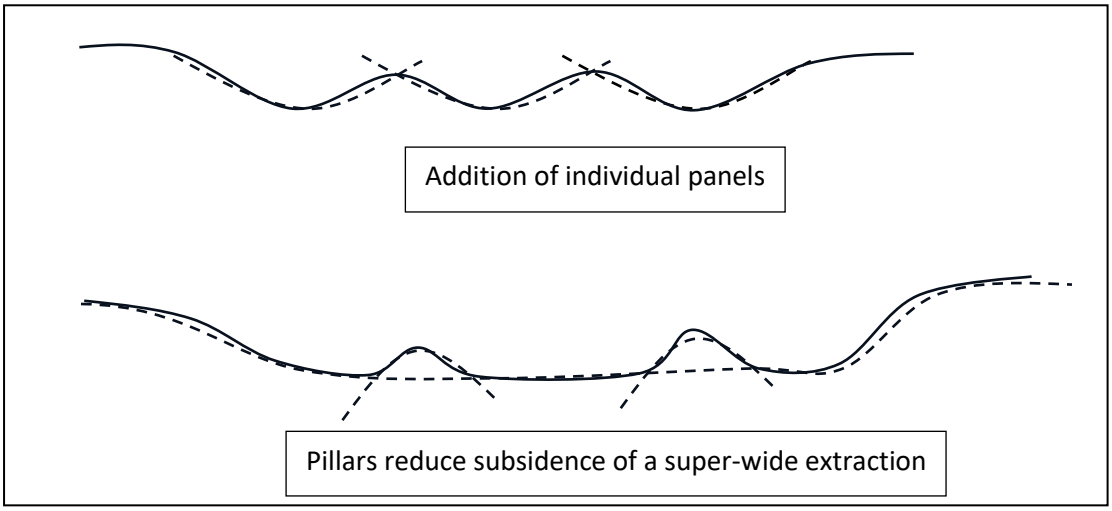


Figure 15 Two ways of modelling pillar subsidence in SDPS

SDPS has been used to visualise the vertical subsidence, tilts, and strains for both the GMS and GLS using the parameters detailed in Table 2. Note that the mathematics invoked in SDPS produces deformations down to 1 mm. A cut-off vertical deformation of 20 mm was adopted to define the onset of mining-induced displacement. As will be discussed below, there may be additional subsidence deformations when the abandoned underground workings are flooded.

Table 2 Default parameters for subsidence prediction at BMA mines

Smax/T	0.75
Edge-effect offset (distance from panel edge to inflexion point normalised to mining depth)	0.2
Angle of influence	63.4°
Factor to convert curvature to strain (metric system)	0.2

The visualisation for the end of mining of both the GMS and GLS is obtained by the addition of the vertical subsidence and horizontal strain grids. The tilts for the combined subsidence were determined by a calculus manipulation of the vertical deformations. It is recognized that the addition of the subsidence prediction for each seam may result in an underestimation of the maximum vertical subsidence and associated tilts and strains (possibly in the order of 10%). However, until calibration data is available the addition method is assessed to be suitable for the planning for mine closure.

Visualisations of vertical subsidence, tilts, and horizontal strains after the extraction of both the GMS and GLS are presented in Figure 16, Figure 17, and Figure 18 respectively. Figure 19 presents overall frequency plots of each parameter noting that there is 30.8 km^2 subsided ground. The maximum vertical subsidence is 6.75 m, the maximum change in slope is 8.25% (4.7°) and the strains range from -35 mm/m to +35 mm/m. About 30% of the subsidence area may have tensile strains in excess of 5 mm/m.

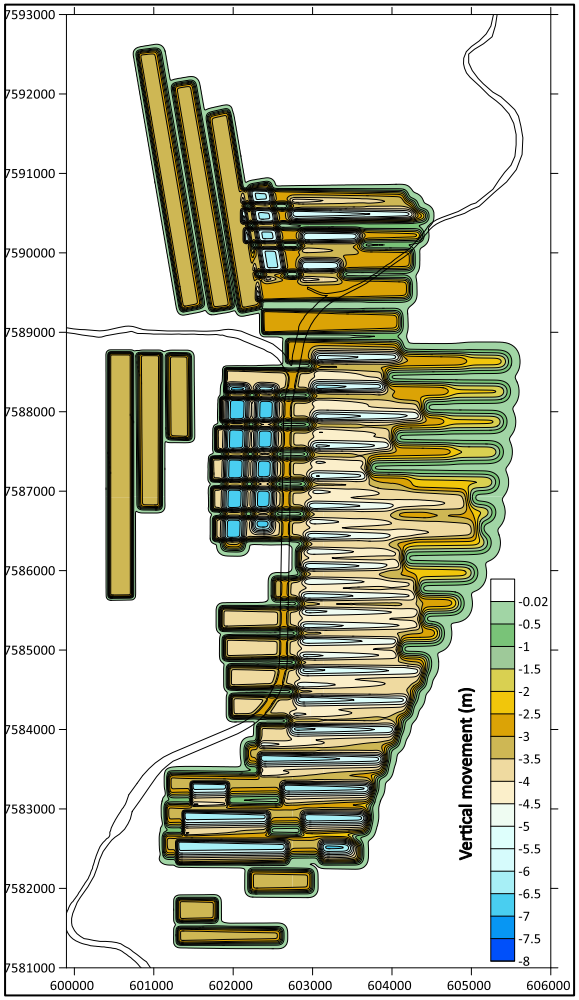


Figure 16 Visualisation of modelled vertical subsidence - both seams dry.

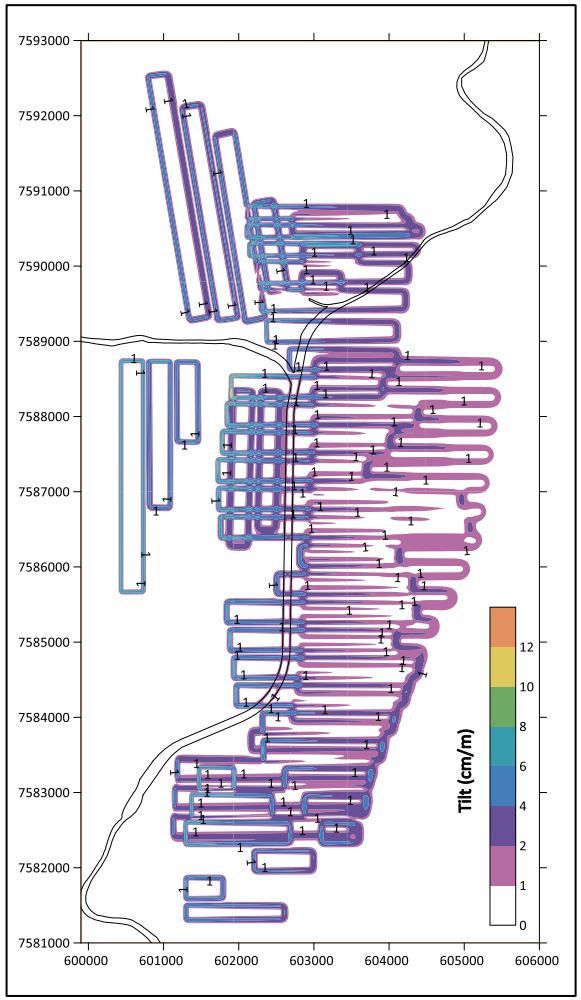


Figure 17 Visualisation of modelled tilts - both seams dry.

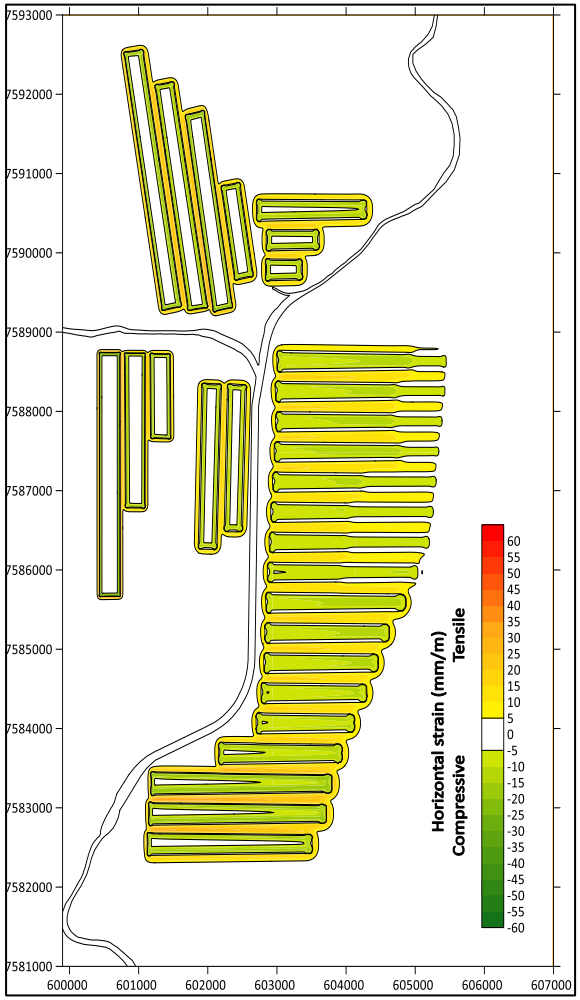


Figure 18 Visualisation of modelled strain - both seams.

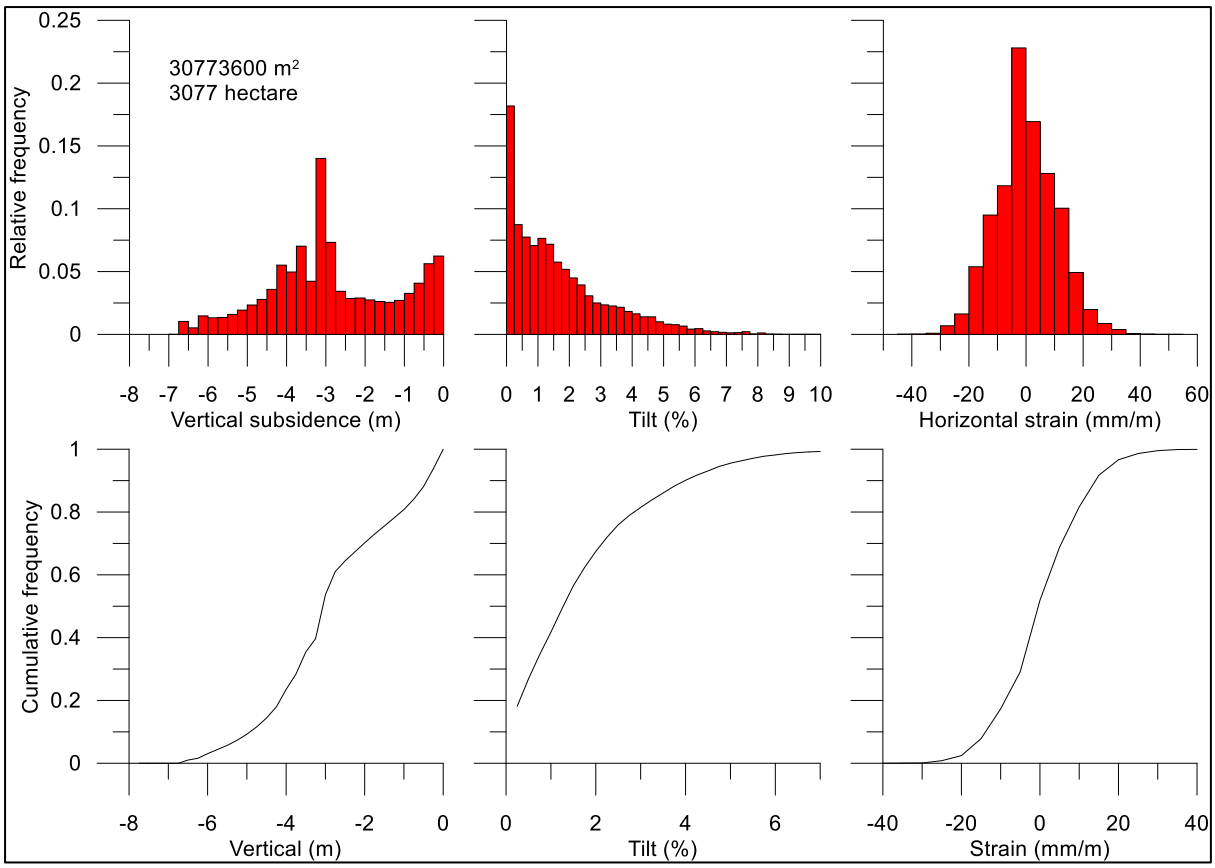


Figure 19 Frequency statistics on total area exposed to mine subsidence as defined by a prediction of vertical subsidence in excess of 20 mm both seams.

3.4 Impact of flooding of the underground workings

When the underground workings are flooded there may be a small amount of additional vertical subsidence related to the softening and consolidation of the caved rock in the presence of water. This additional subsidence after flooding is not included in the modelled results in Section 3.3.

The potential for consolidation has been identified in laboratory studies but there have been no controlled studies at the mine scale to confirm and quantify the scale of this effect. Until such information is available, it is recommended that the Smax/T values used in Table 2 be increased from 0.75 to 0.85. Figure 20 suggests that flooding will have a relatively small impact on tilts and strains.

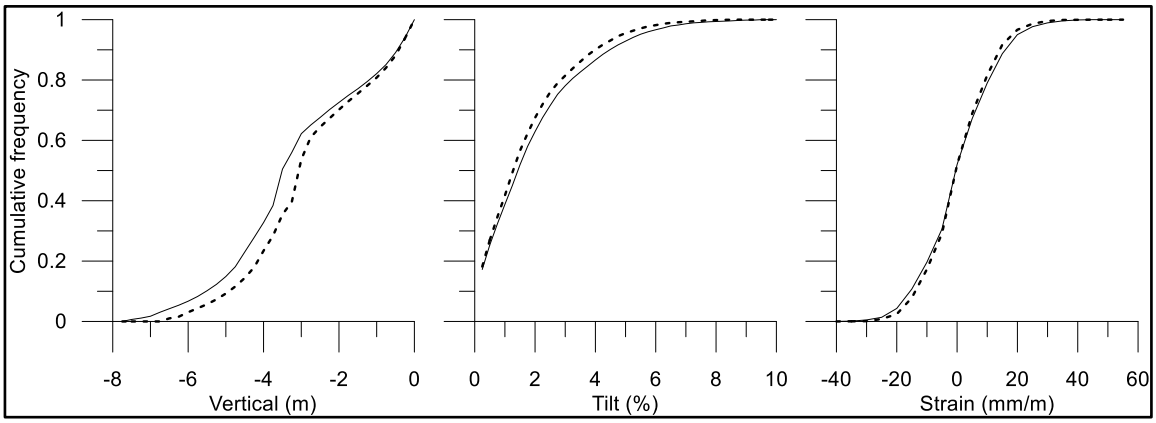


Figure 20 Impact of flooding (flooded – solid line, at mine closure -dashed line)

Flooding of the undergrounds can occur as a direct result of the mine being purposefully flooded, or over time as the groundwater recovers from operational dewatering. Flooding of the mine may temporarily reduce the stability of the pillars, but eventually their stability will be increased due to a buoyancy effect reducing the loads on the pillars.

Additional post-flooding subsidence will not occur until mining in the GLS is complete and the workings are flooded. Once the workings are flooded, any additional subsidence impacts should have developed within 12 months.

4 SUBSIDENCE DAMAGE – CRACKING

The hazards presented by subsidence at closure of longwall mines need to be considered in the context of the post-mining land use. The most problematic hazard is likely to be cracking resulting from subsidence. It is noted that the remediation of vertical steps, humps, and cracking is now addressed to some degree in progressive rehabilitation and forms a part of the day-to-day operational mining rehabilitation activities.

For longwalls such as those at Broadmeadow Mine with high width/depth ratios, cracking is to be expected at the surface (Figure 21). Open cracking may be parallel and close to the panel edges (longitudinal fracture) or parallel to the face line (arcuate fractures). There may be other longitudinal fractures distant from the panel edges.

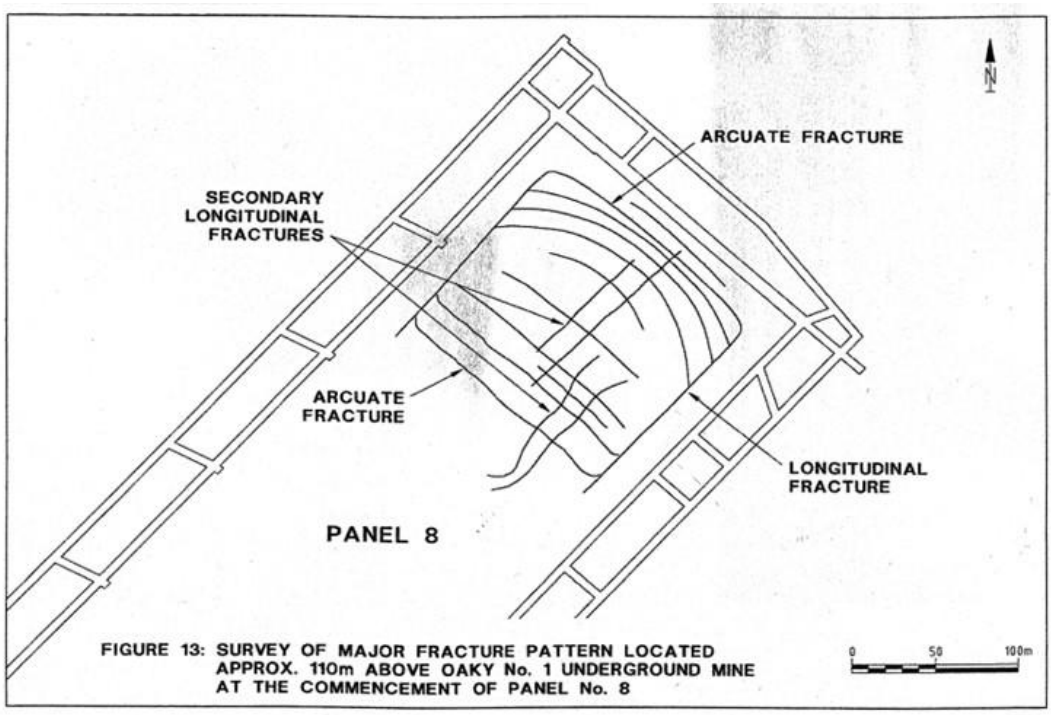


Figure 21 Longwall cracking (ACARP 2000[6])

A reconnaissance survey of subsidence cracking was conducted in July 2023 on site at Broadmeadow Mine.

[6] ACARP Project C5016 (2000) The influence of subsidence cracking on longwall extraction. Prepared by Australian Mining Engineering Consultants.

4.1 Longitudinal cracking

Longitudinal cracking was observed above LW16. The cracks can be considered to result from the onset of block rotations in response to tensile subsidence deformations. During field inspection of LW16 cracking was observed – up to 400 mm wide and at least 2.9 m deep (Figure 22).

The relationship between the width of longitudinal cracks and the predicted tensile strain depends on the spacing of the cracks. The predicted tensile strains are in part related to the spacing of the survey pegs (10 m) used in the calibration of SDPS. An upper bound estimate of the crack width (in millimeters) can be derived from tensile strain predictions (Figure 18 and Figure 19) multiplied by 10.

Assuming rigid body movements, the survey data can be used to obtain an estimate of the depth of cracking. Referring to Figure 23, the maximum strain of 13 mm/m implies a crack width of 130 mm, and this is associated with a differential tilt of 19 mm/m. The possible depth extent of the crack would be 6.8 m (0.130/0.019) at LW15. In the absence of better information, assume a crack depth of 10 m for all surfaces affected by subsidence. Adopting this depth means that the surface cracking extends through plastic clays and silty sands (Section 2.2). The silty sands would be anticipated to immediately collapse into subsidence cracks but the subsidence cracks in the clays would be metastable are only likely to collapse after rainfall.

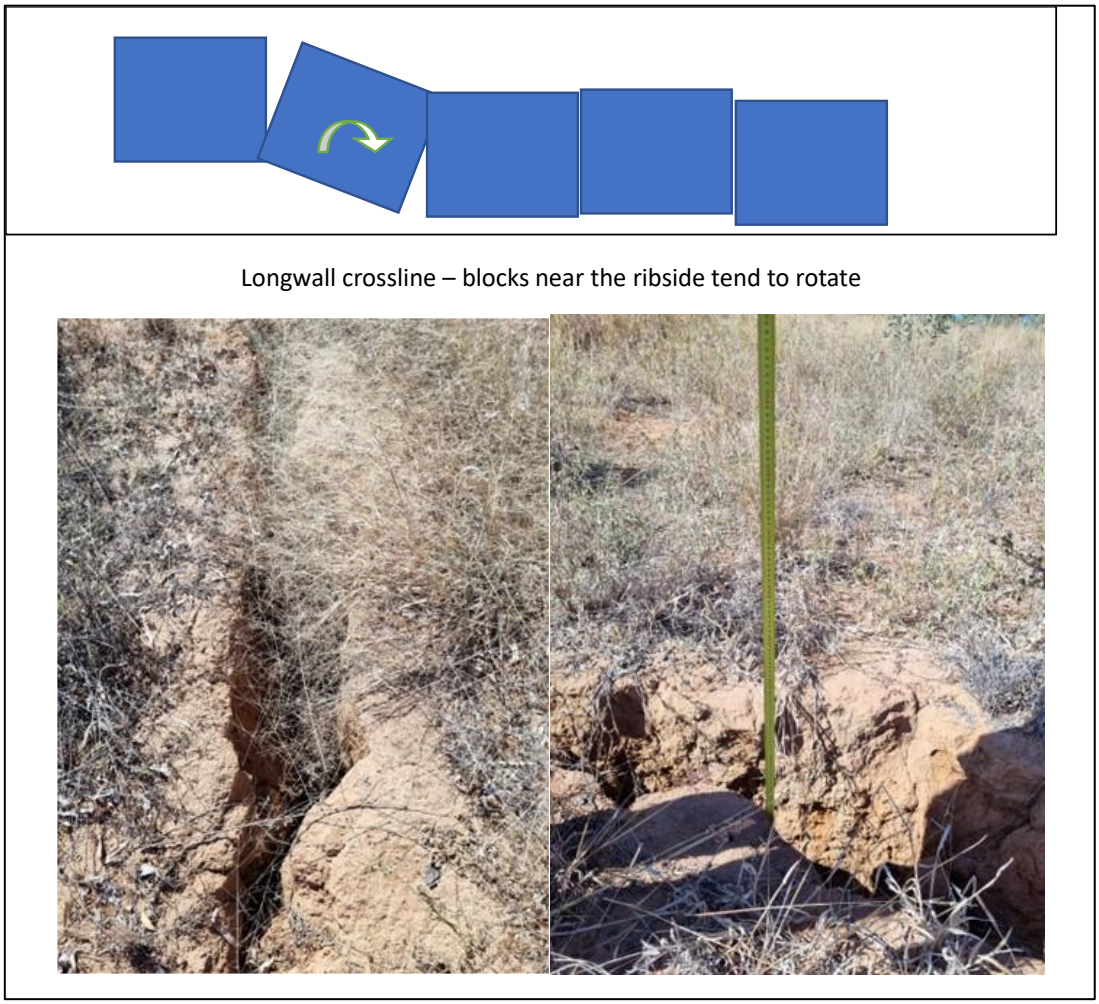


Figure 22 Longitudinal cracks

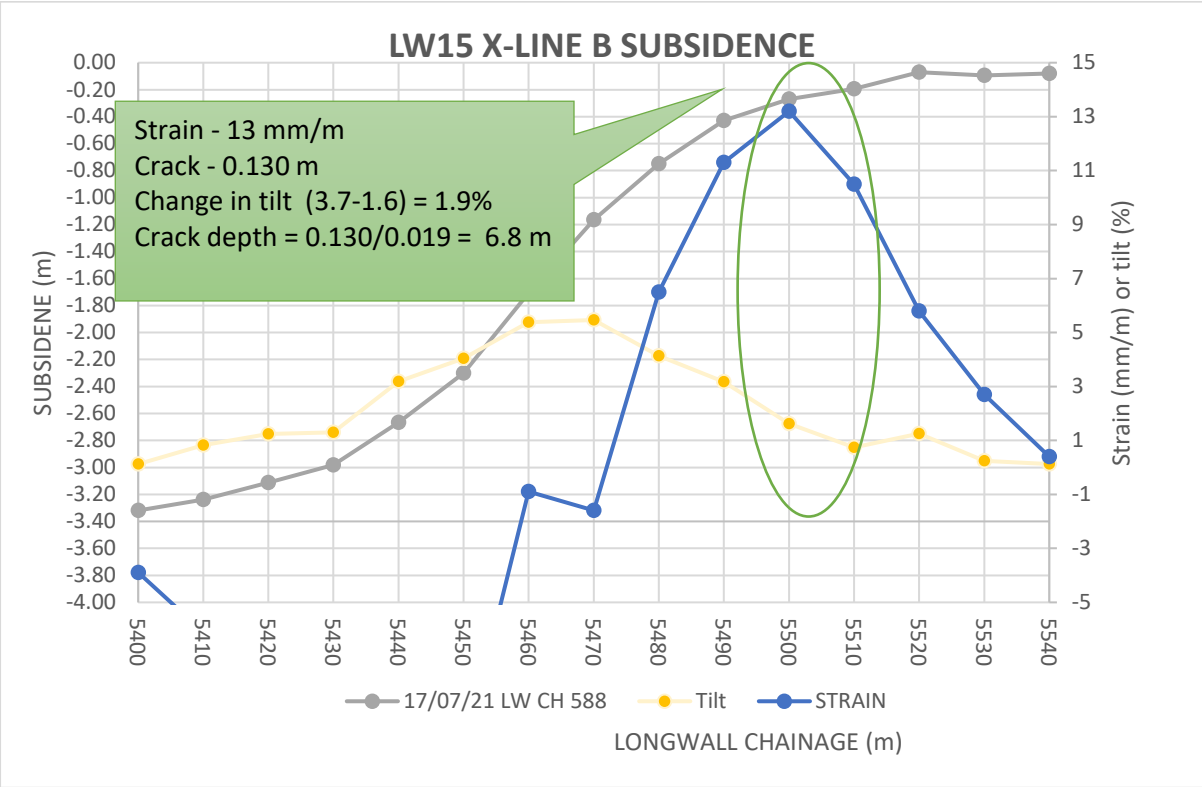


Figure 23 Detail of high strain and high tilt recorded on a subsidence cross line (for full crossline data refer to Figure 11).

4.2 Arcuate cracking

Arcuate cracking (Figure 24) was more readily found during the reconnaissance survey. The mode of formation of these cracks is more by vertical shear so the result is the formation of steps with relatively little dilation.

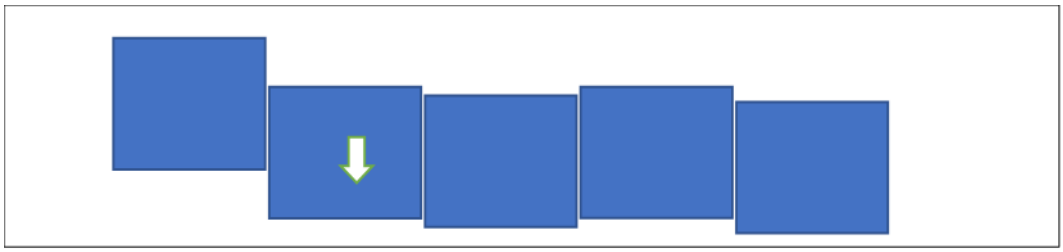
The presence of vertical steps can be interpreted from the centreline survey by calculating the vertical offset between successive pegs which are spaced at 10 m intervals (Figure 25). Most are less than 200 mm but there are some that were up to 400 mm or greater.

5 OVERBURDEN FRACTURING – HYDROGEOLOGICAL CHANGES

Longwall mining results in fracturing of the rock mass above the coal as the overburden sequence collapses/caves into the void left by the extraction of the coal. This is an intrinsic part of the mining system.

Seedsman et al (2023)[7] updated an early hydrogeological model to include estimates of hydraulic conductivity. Hydraulic conductivity within the Enhanced Conductivity Zone (ECZ) and Disrupted zone was estimated using a simple geometric model (Figure 26) for the increase in length along a given horizontal line because of downward movement and assuming a given spacing of fractures (be they joints or mining induced). The model assumes no dilation at the centreline above the Potential Consolidation Zone (PCZ). The dilation is equally distributed between the fractures and conductivity is calculated based on laminar fracture flow with smooth interfaces. The predicted conductivity is isotropic. The parameters for the PCZ were derived from large scale permeameter tests.

[7] Seedsman, R., Fellowes, M. Thoeni, K. and Fityus, S. (2023). Hydrogeological aspects of pumped hydro schemes using abandoned longwall mines. Proceedings of the 14th Australia and New Zealand Conference on Geomechanics, Cairns.



Longwall centreline – blocks move downwards (and to a lesser degree sideways) at discrete intervals

Figure 24 Acuate cracks

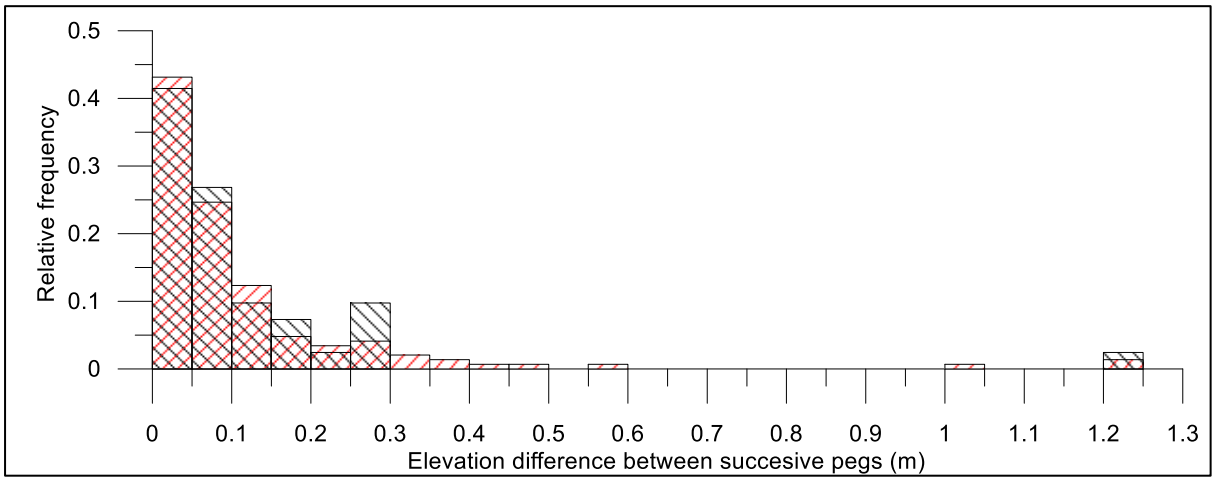


Figure 25 Evidence of vertical steps derived from the LW16 centreline survey.

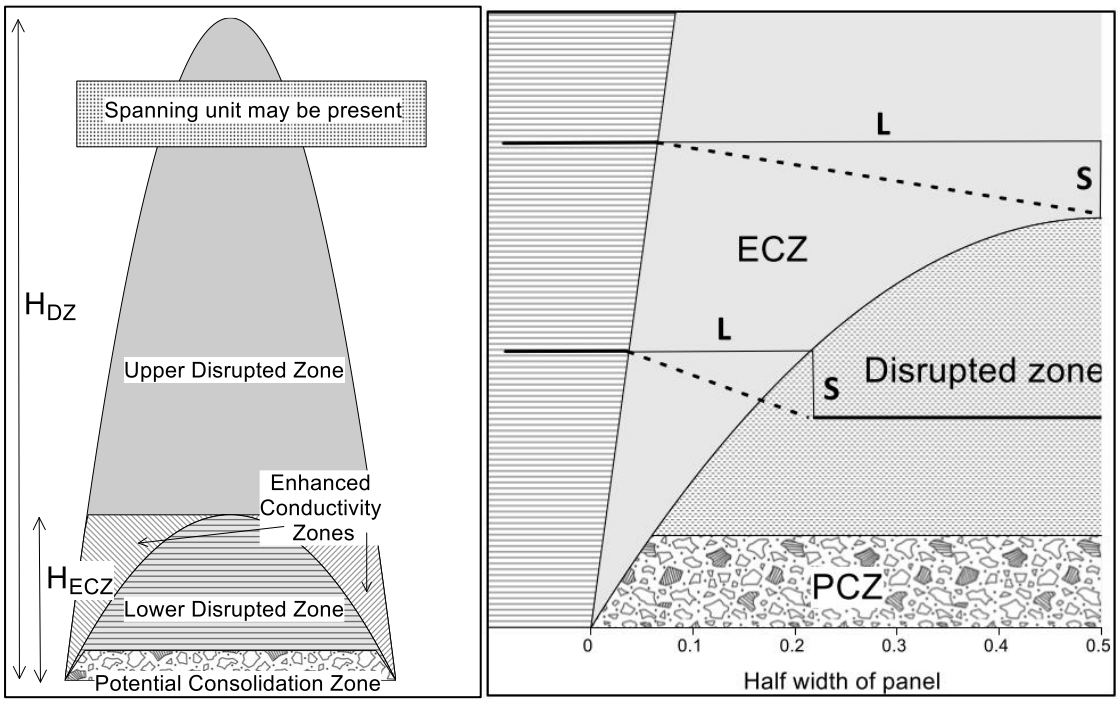


Figure 26 Basis of the geotechnical crack dilation model

The input variables to the geotechnical model are:

• Maximum vertical subsidence, or more precisely the difference in the maximum subsidence at /near the panel centreline relative to the subsidence above the chain pillars.
• The extraction width.
• The spacing of the cracks – these may be mining-induced or the natural geological joints.

Note that the prediction is particularly sensitive to assumptions about the spacing of cracking induced by the longwall extraction. The only rock mass property used in the geotechnical model is the spacing of the joints – the rock mass is assumed to be a dilated fractured volume of rigid blocks. The geotechnical model is applicable to the Permian and Tertiary sequences but does not include the possible role of Quaternary and Recent alluvials at the surface.

Estimates of the resulting hydraulic conductivity are presented in Figure 27. The data for a crack spacing of 2 m is currently recommended for Broadmeadow Mine.

After mine flooding it is possible that conductivities in the lower portions of the Enhanced Conductivity Zones will decrease to values similar to those for the Disrupted Zone. It is anticipated that there will be lesser decreases in the upper disrupted zones

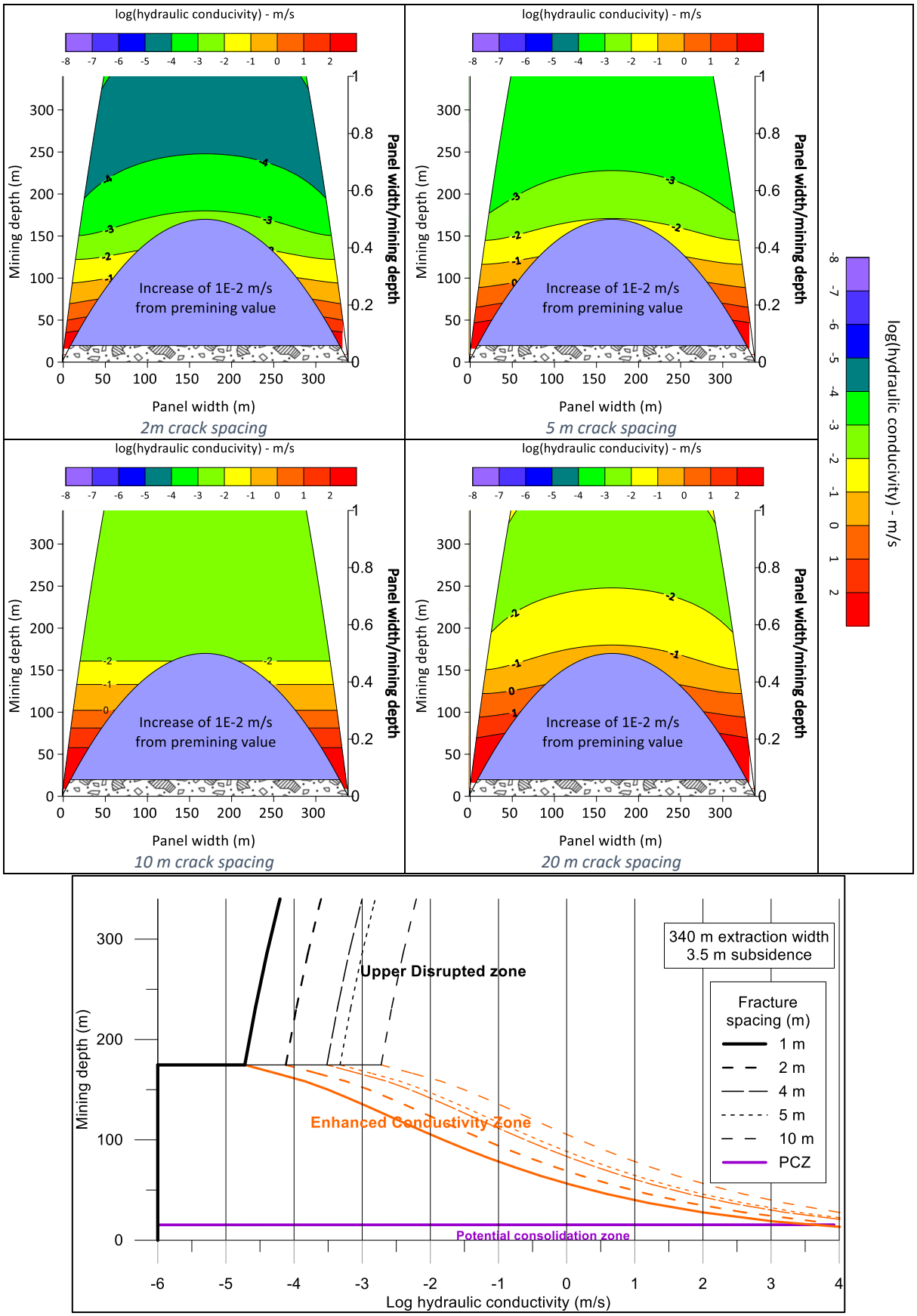


Figure 27 Hydraulic conductivity distribution depends on the spacing of fractures (340 m wide extraction, 3.5 m subsidence.

6 STABILITY ASSESSMENT

An assessment of the current and ongoing stability of the underground workings is critical to understand the subsidence risk at closure. Specifically, the possibility of pillar collapse leading to surface subsidence or roof collapse leading to pot-hole subsidence and the impacts on the post mining land use nominated for the area.

6.1 Standing pillars

6.1.1 Mains

For operational reasons the pillars in the main access roadways (Mains pillars) are typically designed with high levels of stability and a design life in excess of 50 years. Typically, Mains pillars are dimensioned with a factor of safety in excess of 2.0 and there is a conjecture that the probability of failure is better than 1:1 000 000. It is valid to assume that these mains pillars have not and will not collapse at BRM.

Specifically for the GMS seam the minimum main pillar width is 19.5 m at depths between 75 m to 105 m and these have stability factors in excess of 3.0 (Figure 28). The associated subsidence ranges are estimated from 18 mm to 32 mm.

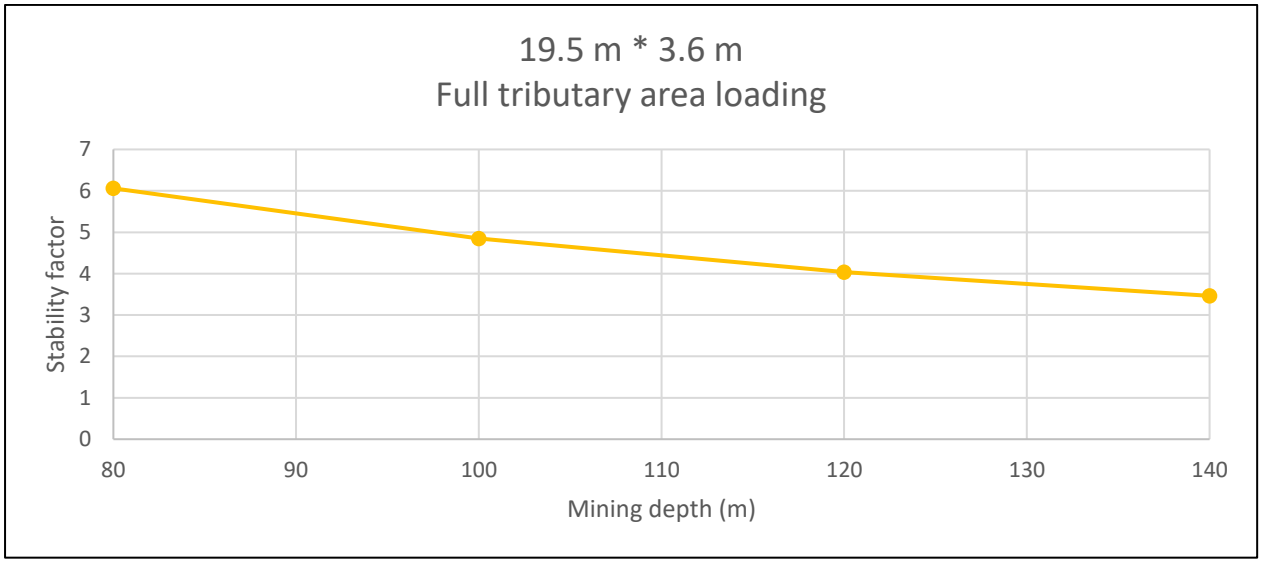


Figure 28 Stability factors for GMS mains pillars.

For the GLS seam, the 29.6 m wide pillars are planned for all depths down to 300m. Mains are aligned with the Isaac River. Figure 29 indicates that these are long-term stable and will have negligible surface subsidence associated with them.

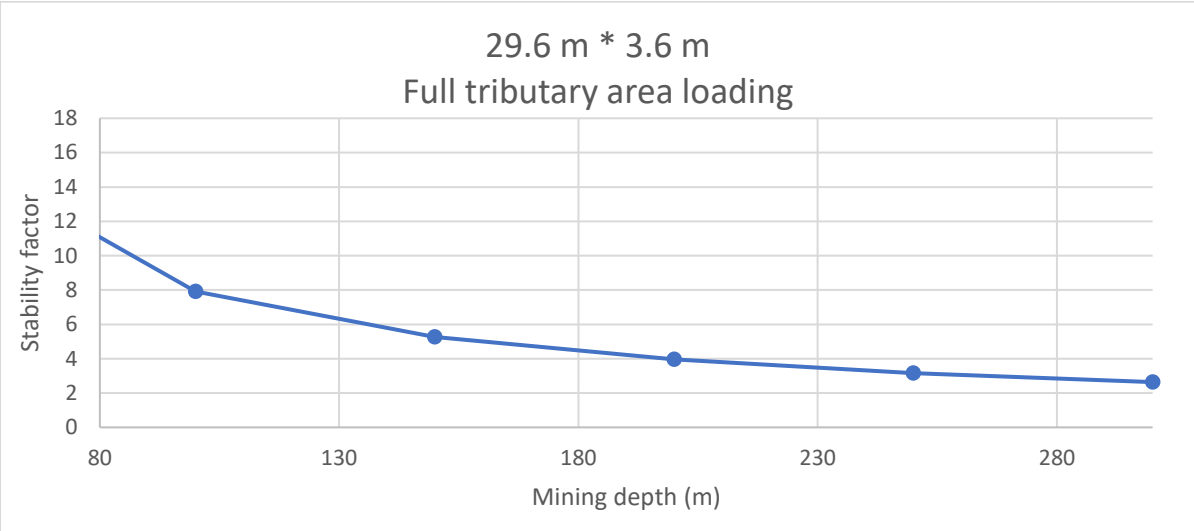


Figure 29 Stability factors for GLS mains pillars

6.1.2 Chain pillars

A number of different chain pillar widths have been used or are planned for the GMS and GLS operations. Figure 30 is a cross plot of pillar width and mining depth showing the relationship to stability and subsidence. Stability factors are in excess of about 1.5 except for one area of the GMS seam which was of limited extent and has already been extracted.

Note that the subsequent collapse of the goaf means that at mine closure the chain pillars will be laterally confined so they will have greater stability than that implied by this analysis.

An elastic (non-failure) analysis suggests surface subsidence between 400 mm and 1.4 m which is considered to be in agreement with what has been recorded to date.

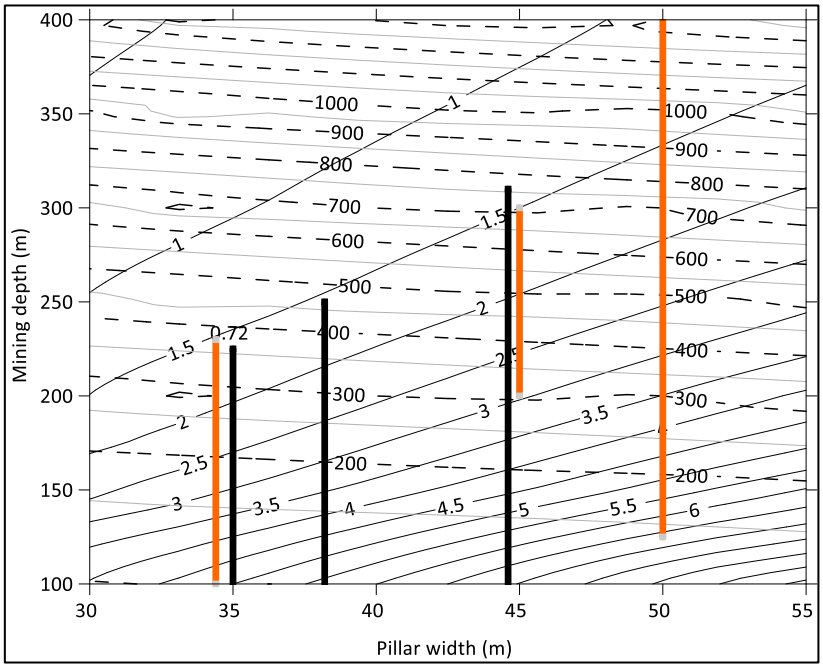


Figure 30 Range of stability factors (solid) and surface subsidence (dashed, in mm) of GMS (black) and GLS (orange) chain pillars.

6.2 Potholes

The depth of mining is such that there is no hazard of pothole subsidence outside of any NUMA associated with the highwall entries of the GMS.

6.3 Stability after mine flooding

Groundwater recovery has a possible impact on stability. Flooding of the workings can occur naturally at closure through the re-establishment of ground water or artificially with water being actively pumped into the workings. This flooding will remove oxygen from the workings and lower the potentially acid forming pollutants and displace any explosive atmosphere located within the mine.

Laboratory testing indicates there is a measurable decrease in uniaxial compressive strength on saturation of coal measure rocks. This strength reduction has the potential to impact pillar stability and it could be appropriate to consider a 10% reduction in long term pillar strength.

There is also a possibility of reduction in the floor strength of the roadways which would result in a reduction in the bearing strength of the pillar floor system (Figure 31). The reduction in roadway floor strength may be relatively small so the impact on pillar stability will be minor unless the impacted layer is very thick and initial floor stability was low. Quantification of this mechanism will require knowledge of the strength of the floor to a nominal 10 m below the mined seam – this information is needed at a 5-10 cm resolution. The material under the pillar will not lose strength as water cannot flow in this direction against the pore pressure gradient induced by the loaded pillars.

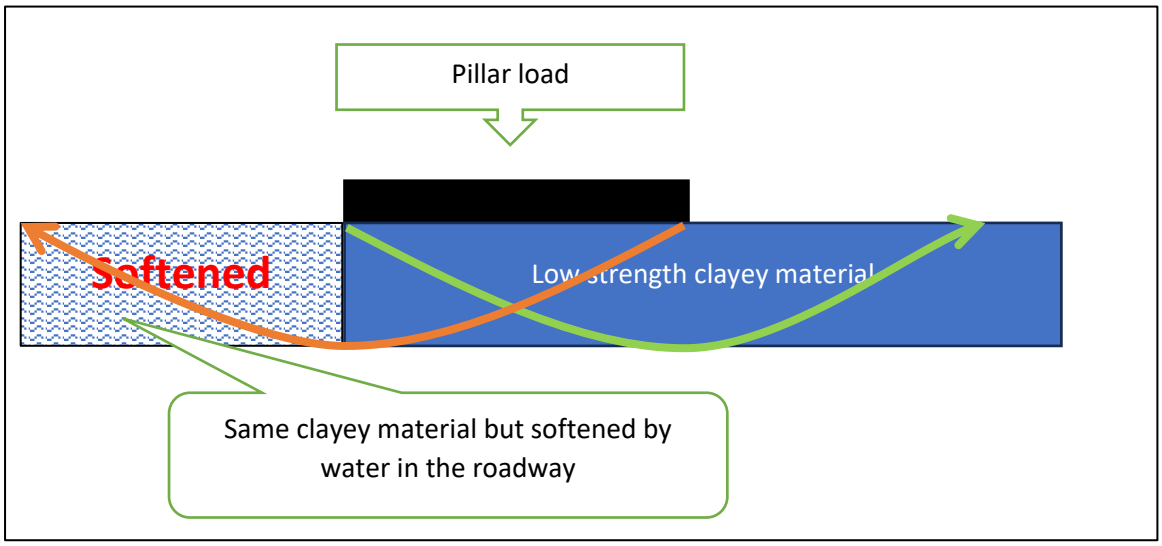


Figure 31 Softening of the floor of a roadway- strength along the green failure trajectory is greater than that along the orange trajectory.

In contrast to these reductions in strength, there will be an overall trend for an increase in stability related to a buoyancy effect as the water level rises above the coal seam. The result is that any decrease in stability will be temporary while the material at or below seam level softens and the water level is such that there is no buoyancy effect. Over time as the water level rises above the coal seam level, buoyancy will dominate and stability will increase beyond that at mine closure. It is valid to include consideration of buoyancy when using the available method to estimate pillar loading.

7 SEALING OF UNDERGROUND WORKINGS

Mine seals are used to manage or limit water and gas flows if required, as well as to control physical access to the underground mine.

Depending on their functional requirements there are three types of seals (US EPA4[8]):

- Dry seals – prevent physical access only.
- Air seals – prevent physical access without retaining water.
- Hydraulic seals – prevent physical access and retain water.

Broadmeadow Mine is downdip mining such that the mine entries are elevated with respect to the mine workings.

Due to the flooding of the underground workings and void lakes establishing in the residual voids used to access the underground workings after mining, dry seals are required at Broadmeadow Mine to prevent physical access. Their location means there will be little or no hydrostatic pressure applied to them. A corollary of this is that they need to be permeable to water.

A suitable dry seal for portals with concrete arches or culverts (as at Broadmeadow Mine) could be constructed by backfilling the concrete section and then covering further to an equal height (Figure 41).

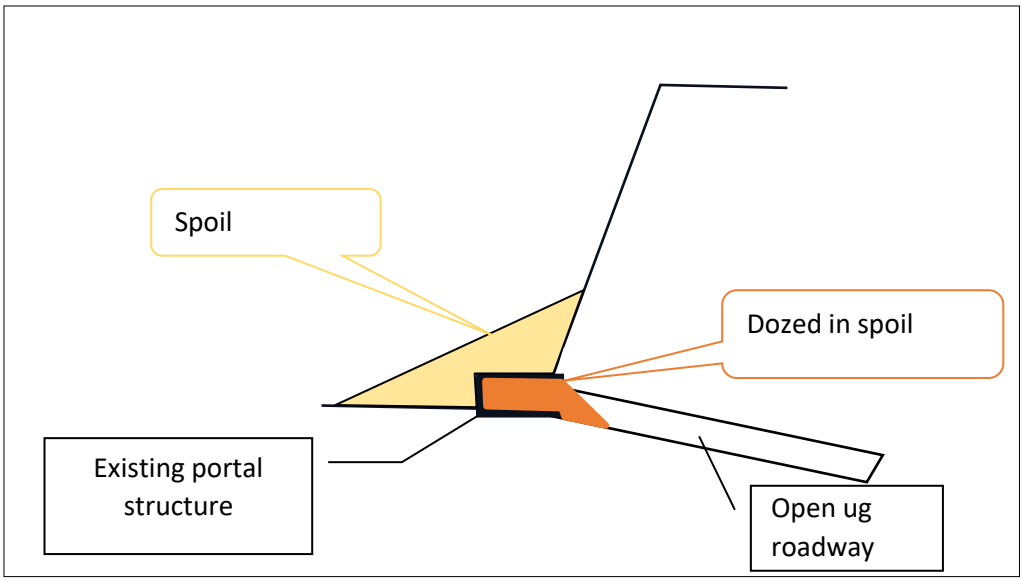


Figure 32 Concept for access (dry) seals at portals with concrete arches or culverts

8 MONITORING AFTER MINE CLOSURE

Subsidence monitoring should be conducted along a limited number of subsidence lines until the groundwater level in the underground is judged to have reached close to long-term equilibrium and then continued for another 2 years to confirm that significant movements have stopped. Broad scale mapping of the surface should be conducted at the 2-year interval to confirm that additional subsidence (if developed) has not resulted in unacceptable cracking. It is anticipated that all movements will have ceased by year 5.

[8] Inactive and abandoned underground mines – water pollution prevention and control. US Environment Protection Agency EPA-440/9-75-007

GOONYELLA RIVERSIDE MINE COMPLEX – MATERIAL CHARACTERISATION STUDY

October 2024

QUALITY SCIENCE | PRACTICAL OUTCOMES

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1 INTRODUCTION

BHP Mitsubishi Alliance (BMA) engaged Landloch to provide a material characterisation study of potential growth media at the Goonyella Riverside Mine Complex (GRM). Specifically, the study is to evaluate the quality of materials for their use as growth media in rehabilitation.

To ensure rehabilitation success, the materials planned to be placed near the surface of the rehabilitated landforms need to be assessed for their suitability to support the vegetation required to meet the post-mining land use (PMLU).

1.1 Project description

GRM is a coal mine operated by BMA located approximately 30 km north of Moranbah in Queensland's Bowen Basin. It forms part of the Goonyella Riverside/Broadmeadow Mine Complex, that includes the Goonyella Riverside mine and the Broadmeadow underground mine (BRM). Both are operated by BMA. Mining activities commenced in 1971 and still operate today, consisting of an open cut mine using dragline and truck and shovel fleets, in conjunction with the underground operations at BRM. BMA also operates the Red Hill Mine, an approved underground mine located directly east of GRM.

1.2 Scope of work

The scope of work involved the following tasks:

1. Review previous soil, waste, and land assessments undertaken at GRM.
2. Review available published soils, geology, and land data within the region.
3. Conduct a data gap analysis to determine information required to:
    a. Develop an inventory of materials available for rehabilitation; and
    b. Assess the suitability of materials as a plant growth media.
4. Sample and analyse the topsoil stockpiles to gain data and fill the identified information gaps.
5. Collate existing and newly acquired soil and waste characterisation data.
6. Interpret data, characterise materials, and prepare a report.

2 DESKTOP REVIEW

2.1 Climate

The mine is situated in Queensland's sub-tropical climate zone, that is characterised by high summer temperatures, warm dry winters and a distinct wet and dry season.

The closest meteorological recording station is located at Moranbah Airport (Site No. 034035). Data from this station indicate mean seasonal temperature ranges from 20.5°C to 35.6°C in summer and 8.6°C to 26.1°C in winter, with a summer dominant rainfall pattern averaging a total of 562 mm annually (Bureau of Meteorology 2023). Rainfall events are often associated with short-duration, intense thunderstorms. These

high intensity rainfall events produce high runoff rates and can produce conditions conducive to erosion. The area is also susceptible to prolonged periods of drought.

2.2 Topography

The topography of the study area is flat to gently sloping landforms with low rolling hills. There are five creeks that exist within or are near GRM: Goonyella Creek, Eureka Creek, Fisher Creek, Platypus Creek, Holding Paddock Creek and 12 Mile Gully. These are all tributaries of the Isaac River which runs east of the current operations within the site boundary, forming part of the Isaac River Catchment.

2.3 Regional geology

Geoscience Australia mapping of the mine identifies four major geological units. Descriptions of each geological unit are provided in Table 1.

Table 1: Geological units and descriptions for GRM (Geoscience Australia 2024).

Geological unit	Description
Czs – Sand plain	Sand or gravel plains; may include some residual alluvium; quartz sand sheets commonly with ferruginous pisoliths or pebbles; local clay, calcrete, laterite, silcrete, silt and colluvium.
Qa - Alluvium	Channel and flood plain alluvium; gravel, sand, silt, clay; may be locally calcreted.
Czc – Suttor Formation	Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt.
Qrc – Colluvium	Residual deposits, sheetwash, talus, scree; boulder, gravel, sand; may include minor alluvial or sand plain deposits, local calcrete and reworked laterite.
Czb – Mafic Volcanic Rock	Volcanic rocks, predominantly mafic; basalt, trachyte, trachybasalt, trachyandesite, leucitite, basanite, nephelinite, limburgite, rhyolite, tuff and high level intrusives; rare volcaniclastic sediments

2.4 Waste materials

The waste materials at GRM consist of overburden/interburden materials (spoil), coal rejects, and tailings.

2.4.1 Spoils

Based on regional geology characteristics and spoil analysis data over the life of the mine, overburden/interburden geology at GRM can be broadly classified into:

- Tertiary/Weathered materials: Cainozoic tertiary colluvium (ferruginous) and Quaternary alluvial sediments consisting of clay, silt, sand, gravel, and soil. These weathered materials are typically sodic, highly erodible, and prone to clay

dispersion. They are also known to have varying levels of salinity, but their main constraint is their high erosion risk.

- Permian materials: Permian sediments from the Back Creek Group consist of quartzose to lithic sandstone, siltstone, carbonaceous shale, minor coal and sandy coquinite. Carbonaceous zones are present close to the coal seams. The physical and chemical properties of these materials are highly variable, but are generally sodic, alkaline and with varying salinity. Some carbonaceous strata are acidic or potentially acid forming. Erosion risk varies based on physical properties and sodicity, and generally the sandstones are more competent and resistant to weathering and erosion than the siltstones or carbonaceous material. The predominantly fresh, medium to coarse grained grey sandstone materials offer greater stability benefits to rehabilitation. However, their potential to weather increases after blasting.

2.4.2 Coal rejects

Coarse coal rejects are emplaced within the spoil materials. They are not currently used as a rehabilitation resource, but further investigation may identify some that are beneficial for rehabilitation use due to their high organic carbon and coarse physical structure. Alternatively, strategies may be developed in the future for mixing them with spoil of high ANC to produce a combined material that is more suitable for use as a growth medium. Characterisation of these materials is not included in this report.

2.4.3 Tailings

Tailings are not characterised in this report as they are not currently considered a rehabilitation resource.

2.5 Soils

2.5.1 Regional soils

Regional soils mapping of the mine identifies four broad soil groups (Department of Resources 2024). Relevant details of these soil groups are provided in Table 2.

Table 2: Summary details of regional soils.

Soil Landscape Code	Description	Associated Australian Soil Classification (ASC)
CC33	Uniform cracking and self-mulching, deep brown clays with >35% clay	Vertosol
My28	Gradational friable earths that are massive or only weakly structured.	Kandosol
Sl12	Strong texture contrast soils with sodic B horizons that are not strongly acidic.	Sodosol

Soil Landscape Code	Description	Associated Australian Soil Classification (ASC)
Va52	Texture-contrast soils with sodic subsoils	Sodosol

2.5.2 Recoverable soils

GSS Environmental (GSSE) undertook a detailed soil and land suitability assessment as part of the Red Hill Environmental Impact Statement, which covered areas of GRM. This report involved the compilation of data from two previous soil surveys undertaken on site (GJR Holding 2007; GSS Environmental 2009) with an additional fieldwork and assessment component undertaken by GSS Environmental in 2011 (GSS Environmental 2011).

The survey was undertaken at a scale of 1:50,000 for the entire project site and 1:25,000 for disturbance areas, in accordance with the *Guidelines for Surveying Soil and Land Resources* (McKenzie *et al.* 2008). Soil samples were analysed for various physical and chemical soil attributes by a NATA accredited laboratory. Within the survey area, 11 soil types were identified and are detailed in Table 3. The table includes scores for land suitability focusing on grazing across each soil type. Land suitability scores were assessed using the land suitability classes defined for use in Queensland (Department of Natural Resources and Mines, 2015). Land suitability decreases progressively from Class 1 to Class 5.

A soil map displaying broad ASC soil types for the GRM and Red Hill area is provided in Figure A-13 (Appendix A). The data used to generate this map is a synthesis of soils data and mapping sourced from:

- existing soil assessments completed by the sources above;
- existing land systems information sourced from the QLD Globe online spatial data system (State of Queensland (Department of Resources), 2024); and
- a regional land resource assessment completed by (Burgess, 2003).

The map is Landloch's interpretation of the available soils information.

A grazing land suitability map for the GRM and Red Hill area is provided in Figure A-14 (Appendix A). The data used to generate this map is a synthesis of land suitability scores from the existing soils assessments that were used for the ASC mapping.

2.5.3 Stockpiled soils

Location and volume information on the current soil stockpiles was provided by BMA. The approximate volume of available stockpiled material is 6,619,361 m^3 (in April 2023). Locations of topsoil stockpiles on GRM are presented in Figure 1.

2.6 Post-mining land uses

BMA's rehabilitation objectives for GRM are to create a safe, stable, non-polluting, and sustainable landscape with PMLUs in accordance with the EA:

- Cattle grazing;
- Woodland habitat;

- Water storage; and
- Watercourse.

The predominant pre-mining land use was cattle grazing.

Table 3: Summary details of the soil types identified in the GSS Environmental (2011) soil survey.

Soil Type	Soil Description	Soil Landscape	Grazing Suitability Class	Area (ha)
Lithic Rudosol	Shallow rocky (skeletal) soils with a clay loam or clayey soil matrix associated with or underlain by shallow bedrock. Structurally stable with low potential for dispersion, and is generally of moderate salinity, strongly acidic.	Occur on the low hills and on lower escarpment slopes of sections throughout the eastern and western portion of the study area.	3	426
Tenosol	Poor structure and loose sandy texture comprising deep (>1 metre) sand or silty sand grading to loamy or light clayey sand subsoils. Generally nondispersive, and has low levels of salinity, with a neutral pH.	Flat lower area of the catchment, within drainage lines or on the immediate floodplain of the Isaac River.	4	269
Red Kandosol	Sandy loam to loamy surface and medium to heavy clay subsoils. The topsoil is non-dispersive to moderately dispersive, mainly non-saline to slightly saline and varies from slightly acidic to mildly alkaline.	Gently to moderately inclined slopes and undulating low rises, as well as some higher alluvial terraces, undulating plains and on mid to lower valley slopes.	2	2,051
Brown Kandosol	Sandy loam to light clayey surface soils grading to light to medium or heavy clay subsoils. Slightly to moderately dispersive, non-saline and mainly neutral to slightly acidic.	Occurs on gently inclined slopes to drainage lines, on flat to depressional plains, in depressional drainage ways and on low rises.	2	386
Brown Kurosol	Loamy surface duplex soil, acidic to strongly acidic dark brown heavy clay subsoil horizon. Moderately dispersive and slightly to moderately saline with a neutral pH.	This soil type occurs on gently to moderately inclined foot slopes in a small area to the northwest of the study area.	5	186
Brown Chromosol	Sandy and loamy surface duplex soils, non-sodic to marginally sodic, non-saline sandy clay or medium to heavy clay subsoils. The topsoil is structurally stable with a low potential for dispersion. Most topsoil is non-saline although can be slightly saline and is slightly acidic to moderately alkaline.	Occur on alluvial terraces and on broadly rounded rises and dissection slope interfluves, common throughout the eastern study area.	2	1,444
Brown Sodosol	Medium to deep hard-set thin loamy surface duplex soils, light medium to heavy clay deep subsoils. The topsoil is non-dispersive to moderately dispersive, is generally moderately saline, and the topsoil was generally neutral, or in some instances moderately acidic. The subsoils are generally highly sodic and dispersive.	Occur on alluvial flats, back-plains, and older alluvial plains, on gently inclined plains, gently undulating rises dissection and on slope interfluves and slopes to drainage.	3	1,757

Soil Type	Soil Description	Soil Landscape	Grazing Suitability Class	Area (ha)
Brown Dermosol	Hard-set or thin weak self-mulching clay loam to medium clay surface horizon. Non-dispersive to moderately dispersive, is non-saline and varied from slightly acidic to moderately alkaline, with occasionally high gravel content. The subsoils are generally moderately to highly dispersive.	Alluvial plains, depressional plains with prominent gilgai development and on older alluvial plains.	3	816
Shallow Vertosol	Cracking clay soils with a thin weak self-mulching surface soil over dark brown or brownish black sodic moderately saline heavy clay subsoils underlain by weathered rock. The topsoil is typically nondispersive, although occasionally has moderate dispersion ratings, is non-saline to slightly saline, and neutral to slightly alkaline.	Undulating plains and gently to moderately inclined slopes, but mainly on crestal areas and lower slopes in strongly undulating lands and on low rocky rises associated with the Tertiary Basalt geological regime.	3	692
Deep Vertosol	Cracking clay soils with a thin weak self-mulching surface soil over dark brown or brown strongly structured mostly sodic heavy clay subsoils. The topsoil is mainly non-dispersive, occasionally moderately dispersive, varying from non-saline to moderately saline and is slightly acidic to slightly alkaline. The subsoils are generally non-dispersive to moderately dispersive.	Occurs extensively mainly in the northern sector of the study area, comprising drainage-ways, drainage flats and alluvial plain, on near level older alluvial plains and gently undulating plain, and on gently inclined slopes, foot-slopes and low rises.	3	589
Deep Salic Vertosols	Cracking clay soils mostly with self-mulching surface soils, mainly non-dispersive, varies from non-saline to high saline and is moderately acidic to moderately alkaline. The subsoil is mainly non-dispersive.	Occurs extensively in the study area and is particularly common in the north-eastern areas, comprising drainage-ways, drainage flats and alluvial plain, on near level older alluvial plains and gently undulating plain, and on gently inclined slopes, foot-slopes and low rises.	3	2,674

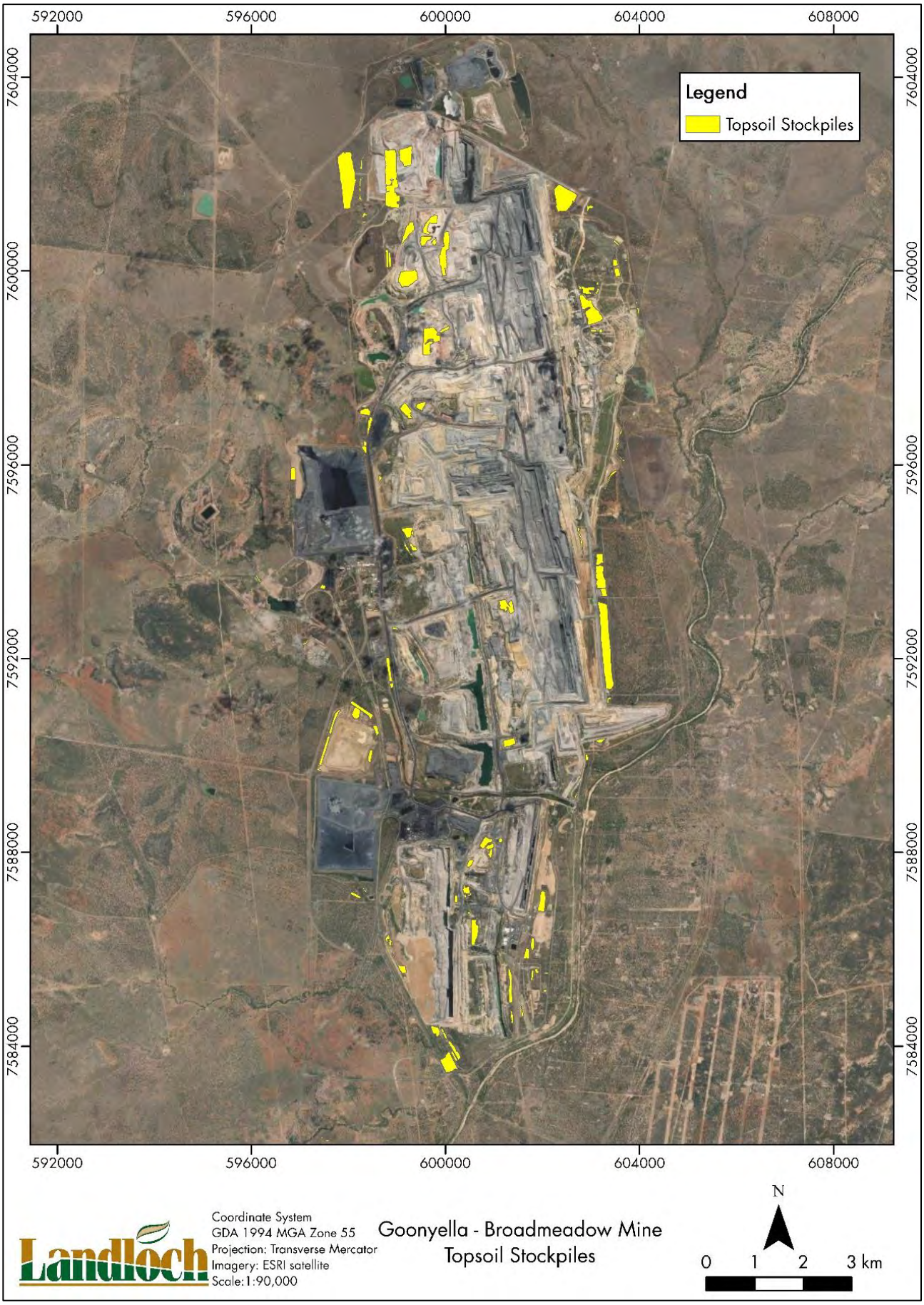

Figure 1: Stockpiled topsoil materials across GRM.

2.7 Revegetation methodology

The aim is to implement a planned progressive rehabilitation program across disturbed areas of GRM. Rehabilitation methods will vary between domains and PMLUs. Broadly, rehabilitation of disturbed areas will include:

- Respreading stockpiled or freshly stripped topsoil, or creating a growth media from spoil;
- Contour ripping;
- Seeding with an appropriate seed mix for the PMLU; and
- Applying appropriate fertiliser and ameliorants for plant establishment if required.

Where available, competent materials will be placed on steeper slopes to aid erosional stability. A suitable seed mix will be used to establish a sustainable vegetation cover.

The material characterisation and landform design studies aim to identify and improve where possible:

- Growth media placement depth and soil profile depths relevant to the PMLU;
- Growth media preparation details; and
- Expected growth media amelioration activities.

More details on revegetation methodology can be found in the relevant section of the PRC Plan.

3 MATERIAL CHARACTERISATION METHODOLOGY

3.1 Materials

Soils and spoils were targeted for consideration as potential growth media. When considering the growth media at GRM, the quality of the stockpiled soil rather than the *in situ* topsoils is more representative of the material available for rehabilitation. Therefore, stockpiled soils were sampled by Landloch in a field program completed as part of this study. Spoil data collected by Landloch, as part of erodibility assessments for the Landform Design section of the PRC Plan and data from previous studies were considered in the assessment of spoils as a potential growth media. All sampled materials were characterised in terms of their basic chemical and physical properties. Any materials with the potential to be used at the surface of a rehabilitated landform as a primary growth media were subjected to additional fertility assessments.

3.2 Stockpiled soils

3.2.1 Field program details

The field program was undertaken between 3 and 14 October 2023. Site conditions were dry across GRM at the time of the field program. For the month preceding the field program, the Bureau of Meteorology's Moranbah Airport weather station (34 km south-east of GRM) recorded less than 2 mm of rainfall.

3.2.2 Sampling plan and intensity

The soil sampling plan completed as part of this assessment is listed in Table 4 and the stockpile sampling locations are shown in Figures A1–A6 (Appendix A).

The sample density adopted is consistent with a 'high (detailed)' intensity 1:25,000 survey (McKenzie *et al.* 2008) and assumes soil will be placed at an average depth of 0.1–0.15 m at rehabilitation. Using these criteria, Table 5 shows the sample density for the stockpiles. Stockpile location details are provided in Table B1 (Appendix B).

Table 4: Soil stockpile sampling plan.

Stockpile ID	Area (ha)	Sampling Sites	Stockpile ID	Area (ha)	Sampling Sites
625	2.9	1	695	1.5	1
634	30.1	6	696	4.9	2
649	1.4	1	704	30.0	15
662	3.5	2	707	1.7	1
664	2.4	2	708	7.8	4
665	1.4	1	709	2.8	1
666	3.4	2	716	13.7	2
667	1.6	1	726	17.4	4
675	2.6	1	729	2.8	1
678	2.7	2	730	5.0	1
680	8.3	4	731	4.8	1
685	1.1	1	735	10.7	3
687	4.3	2	755	27.7	6
694	1.9	1			
				Total	69

Table 5: Sample density for soil stockpiles.

Soil Volume (m^3)	Reinstatement Coverage (ha)	Total Samples	Sampling Density	Sampling Density	Survey Scale
6,619,361	4,413*	276	1 sample/ 23,983 m^3	1 sample/ 16 ha	1:25,000

* Based on a replacement depth of 0.15m

3.2.3 Sample collection

Samples of materials were taken from test pits and the depth of excavation was to the base of the stockpile, or to the limit of excavation (~3–5 m). Samples were collected at depth intervals of 0.5–1.0 m (e.g. 0.5–1.0 m, 1.5–2.0 m, 2.5–3.0 m etc.). Brief details and descriptions of the collected materials were recorded in the field. Sampling included composite and discrete samples, where each composite sample was composed of materials from three discrete samples.

3.2.4 Laboratory analysis

Laboratory analysis was undertaken by East West EnviroAg, a laboratory with National Association of Testing Authorities (NATA) and Australian Soil and Plant Analysis Council (ASPAC) accreditations. Analysis of composite samples used a 'topsoil suite' to characterise the soil nutrients and physico-chemical parameters of the materials. Laboratory analysis of discrete samples used a 'basic suite' of pH and salinity to indicate the heterogeneity (variability) within the stockpile and expose potential extreme values that may be masked in the testing of the composite samples. Laboratory analyses are described in Table 6.

Table 6: Laboratory analytical suites.

Analyses	Analysis Suite	
	Topsoil	Basic
pH_w and Electrical Conductivity ($EC_{1:5}$).	✓	✓
Exchangeable cations (with calculations of effective cation exchange capacity and exchangeable sodium percentage) and chloride	✓	
Total nitrogen and phosphorous; available phosphorous, potassium, and sulphur; trace nutrients (Cu, Zn, Mn, Fe, B), chloride, organic carbon, phosphorus buffer index (PBI), field texture	✓	
Dispersion potential	✓	
Total number of samples	69	207

3.3 Spoil materials

Chemical and physical characterisation data for the spoils were collated from multiple assessments previously conducted for the project and from waste characterisation data collected as part of the PRC Plan preparation. Information sources included:

- *Spoil and Reject Characterisation – Goonyella/Riverside* (AGC Woodward-Clyde 1992);
- *Overburden and Interburden Characteristics of the Northern End of the Goonyella/Riverside Mine Area and Suitability of Specific Layers for Capping* (Land Reclamation Services 1993);
- *Environmental Geochemistry Characterisation of Out-of-pit Spoil at the BHP Goonyella/Riverside Mine* (Environmental Geochemistry International 1995);
- *Mineral Waste Geochemical Assessment – Goonyella-Riverside Expansion Project* (Terrenus Earth Sciences 2009);
- *Goonyella Riverside Mine Contaminants Sources Study, Mineral Waste Analysis for BM Alliance Coal Operations Pty Ltd* (Koskela Group 2013);
- Spoil data collected and analysed to inform Landloch's landform erodibility study as part of the PRC plan development (Landloch 2024); and
- Internal BMA spoil monitoring data.

4 FINDINGS

The two categories of materials available for rehabilitation were characterised as part of this assessment and include topsoil stockpiles and spoils.

This section of the report provides information about these materials. Site location details are provided in Figures A1–A6 (Appendix A) and in Table B1 (Appendix B). Stockpile description records are provided in Table B2–B3 and laboratory results are provided in Tables B4–B5 (Appendix B).

4.1 Topsoil stockpiles

A total of 278 samples were collected from 27 topsoil stockpiles. The 'topsoil suite' analysis was conducted on 69 samples and the 'basic suite' analysis was conducted on the remaining 207 samples. Stockpiled topsoil for use in rehabilitation was categorised into two management groups:

1. Clay topsoil; and
2. Loam topsoil.

A summary of key chemical and physical properties is presented in Table 7. Topsoil within each management group is detailed in the following sections. Land suitability scores have not been provided for stockpile topsoil materials. Land suitability measures are based on established profiles and cannot be until topsoil is reinstated at rehabilitation.

Table 7: Summary of key chemical and physical properties for topsoils at GRM.

Analysis	Clay Topsoil	Loam Topsoil
Chemical Properties		
pH_w (pH Units)	Slight to strongly alkaline (7.7 – 9.0)	Moderate to strongly alkaline (6.5 – 8.3)
$EC_{1:5}$ (dS/m)	Low to high (0.1 – 1.0)	Low (<0.2)
Chloride (mg/kg)	Low to high (42 – 1,317)	Low (<50)
Exchangeable sodium percentage (ESP) (%)	Non-sodic to strongly sodic (5.8 – 21.8)	Non-sodic to sodic (1.5 – 7.1)
Total N (mg/kg)	Low (323 – 775)	Low (171 – 724)
Available P (mg/kg)	Low (6 – 21)	Low (5 – 13)
Available K (mg/kg)	Low (63 – 123)	Low (130 – 191)
Total Organic Carbon (TOC) (%)	Low to moderate (0.4 – 1.3)	Low to moderate (0.4 – 1.0)
Effective Cation Exchange Capacity (ECEC) (meg/100g)	Low to moderate (5.6 – 20.1)	Low (1.9 – 7.9)
Ca/Mg (ratio)	Low to low Ca (0.8 – 2.4)	Low Ca to balanced (1.4 – 4.6)

Analysis	Clay Topsoil	Loam Topsoil
Physical Properties		
Clay content (%)	>35	>35
Rock content (%)	2 – 30	<20
Dispersion (EAT)	Dispersive to stable (1 – 7)	Slightly dispersive to slaking (3a – 5)
Permeability	Low to moderate	Moderate to high
Associated regional soil	CC33 (Vertosol)	Sl12 (Sodosol), Va52 (Sodosol) and My28 (Kandosol)
Associated SLU	Brown Dermosol, Shallow Vertosol, Deep Vertosol, Deep Salic Vertosol	Lithic Rudosol, Red Kandosol, Brown Kandosol, Brown Kurosol, Brown Chromosol, Brown Sodosol

Note: Chemical properties for topsoil are based on average 10th and 90th percentile values for all stockpile samples analysed.

4.1.1 Clay topsoils

Clay topsoils account for approximately 80% of samples assessed across GRM topsoil stockpiles and are concentrated in the northern, eastern, and southern areas of the mine. This ratio is likely to stay consistent through future stripping areas, particularly through the northern and eastern portions of the mine area. Generally, these soils have relatively similar physical properties, but occasional minor inclusions of loams were noted at varying stockpile depths. This is likely a result of topsoils from smaller texture-contrast or kandosol soil units being stripped simultaneously with the more dominant clays.

The soils are generally dark brown, brown, or reddish brown in colour with occasional mottling and have textures ranging from light to medium-heavy clay. Gravel content varies from 2% to 30% with gravel size being less than 60 mm in diameter. The soils often have vertic properties making them susceptible to slaking, thereby increasing the risk of erosion. Figures 2–5 illustrate representative clay topsoils and vegetation cover levels on clay stockpiles at GRM.

Stockpiled clay soils are commonly sodic and often have elevated salts, particularly chloride. Any soils with elevated salts should be prepared in a way that maximises infiltration to aid in the leaching of salts from the desired root zone. If sodic soils are placed on steeper-gradient outer batter slopes, management of erosion risk during the period of vegetation establishment would be critical for rehabilitation success, and establishment of appropriate levels of persistent vegetation groundcover will be essential. Incorporation of the clay soil with durable waste rock could be considered as a means of increasing the erosion resistance of this topsoil.

The main requirements for this soil are to ensure that its chemical limitations and erosion risks are managed. Any sodicity issues will need to be addressed by incorporating gypsum prior to rehabilitation. Fertility will need to be improved to ensure vigorous vegetation growth in the initial stage of rehabilitation and to maintain suitable levels of surface groundcover in the longer term. Incorporation of durable rock into this soil could be considered to improve erosion performance.

Figure 2: Soil material excavated at sampling site 685.

Figure 3: Soil profile at sampling site 685.

Figure 4: Soil material at sampling site 685.

Figure 5: Vegetation cover on sampling site 685.

4.1.2 Loam topsoils

Loam soils account for 20% of samples assessed across GRM topsoil stockpiles and are scattered around the south to south-west portion of the mine. This ratio is likely to stay consistent through future stripping areas, but loams will to be the dominant topsoil source in the southern portion of the mine. These materials have been recovered from a variety of soil types, but have similar physical soil properties once stockpiled, so have been grouped together to aid their management.

The soils are generally dark to pale brown in colour and have textures ranging from sandy loam to clay loam (sandy). Gravel content can be variable but is generally less than 20% with gravel size being less than 60 mm in diameter. The soils are susceptible to slaking, thereby increasing the risk of erosion. Figures 6–9 illustrate representative loam topsoils and stockpile vegetation cover levels at GRM.

The main requirement for this soil is to ensure that its chemical fertility is managed to support vigorous vegetation growth in the initial stage of rehabilitation and maintain suitable levels of surface groundcover in the longer term. A suitable rock armouring can also be applied to reduce the erosion risk while vegetation establishes. The use of loam topsoils as a capping layer on slopes should be assessed by an adequately qualified person to determine the rock and vegetation cover requirements.

Figure 6: Soil material excavated at sampling site 662a.

Figure 7: Soil profile at sampling site 662a.

Figure 8: Soil material at sampling site 664b.

Figure 9: Vegetation cover at sampling site 664b.

4.1.3 Topsoil limitations

Elevated salts were identified throughout stockpiled clay soils, particularly chloride-based salts. The measured salt concentrations are likely to affect seed germination rates, but once established, regional vegetation appears to be tolerant of salinity. If the stockpiled clay soils are required for use as a growth medium, it is recommended that vegetation establishment initially favours species that tolerate saline soil conditions such as Rhodes grass (*Chloris gayana*) until adequate leaching of the profile has occurred.

4.2 Spoils

From the previous assessments detailed in Section 3.3, spoil characteristics were found to be heterogeneous within each spoil type and across sampling areas. For this reason, spoils are categorised into three management groups that have broad similarities:

- Mudstone/Siltstone (dominant) spoils;
- Sandstone (dominant) spoils; and
- Tertiary materials.

A summary of key chemical and physical properties is presented in Table 8. Each spoil management group is described in further detail in the following sections.

Table 8: Summary of key chemical and physical properties for spoils at GRM.

Analysis	Mudstone/Siltstone Spoil	Sandstone Spoil	Tertiary
Chemical Properties			
pH_w	Moderately alkaline to strongly alkaline (8.2 – 9.7, can be neutral)	Moderately alkaline to strongly alkaline (8.3 – 9.9, can be acidic)	Strongly acidic to moderately alkaline (4.5 – 8.1)
$EC_{1:5}$ (dS/m)	Low to high (0.17 – 1.46)	Low to moderate (0.28 – 0.80)	Low to high (0.09 – 0.97)
Acid Neutralising Capacity (ANC) (H_2SO_4/t)	Low to high (5.7 – 203)	Low to high (24 – 365)	Low (7.1)
Potential for acid formation	Low	Low	Low
ECEC (meq/100g)	Low to adequate (12 – 27)	Low to adequate (8 – 24)	Low (8 – 12)
ESP (%)	Strongly sodic (25 – 41)	Sodic to strongly sodic (6 – 36)	Non-sodic to strongly sodic (5 – 35)
Ca/Mg (ratio)	Very low (0.4 – 0.8)	Very low to low Ca (0.4 – 1.2)	Very low (0.3 – 0.5)
Physical Properties			
Clay content (%)	20 – 50	10 – 35	>30
Rock content (%)	20 – 50%	Often >50%	10 – 20
Permeability	Low – Moderate	Moderate	Low
Dispersion potential	Moderate to high	Moderate to high	Moderate to high
Dispersion risk	High	Moderate to high	High

4.2.1 Mudstone/siltstone spoil

Mudstone and siltstone dominated spoils present at GRM are weathered Permian materials and tend to vary depending on the degree of weathered inclusions. Generally, materials have appreciable amounts of friable rock, consisting primarily of mudstone and siltstone with some sandstone inclusions. The clay content in the fine fraction ranges from 20–50%, and the coarse rock fraction similarly ranges from 20–50%. Water holding capacity and permeability are variable and depend on the clay content along with the volume and composition of rock present. It is generally grey or pale brown in colour but may vary to orange-brown after some weathering. The material ranges from moderately to highly dispersive but this can occasionally be masked by the presence of saline lenses. The material is considered to have reasonable ANC potential. Figure 10 is representative of mudstone and siltstone dominated spoil at GRM.

Weathered Permian is considered suitable as a secondary growth media but should be capped with a quality topsoil material to prevent its exposure at the final rehabilitated surface. If exposed, this material will be susceptible to erosion due to the tendency to rapidly weather and disperse. For material with elevated salinity, it is preferable to mix it with more permeable materials to promote infiltration and leaching of salts. If more permeable material isn't available, placement should be limited to slopes less than 10% gradient. Due to the heterogeneity, discrete characterisation testing should be conducted prior to rehabilitation that uses this material.

Figure 10: Mudstone/siltstone material present at the mine. A large portion of stockpiled material is weathered.

4.2.2 Sandstone spoil

Sandstone dominated spoils at GRM account for a large proportion of the unweathered Permian materials and tend to be reasonably consistent in their characteristics given the range of strata locations and proximity to carbonaceous layers. Generally, these materials have a high content of competent rock consisting of fine or coarse-grained sandstone with minor inclusions of other rock types. The clay content in the fine fraction ranges from 10–35% and the coarse rock fraction often exceeds 50% of the mass of the material. Similar to the mudstone/siltstone spoils, its water holding capacity and permeability are variable and depend on the clay content along with the volume and composition of rock present. It is generally grey in colour. The material ranges from slightly to highly dispersive. Salts are generally low. It is considered to have reasonable ANC potential. Figure 11 is representative of sandstone dominated spoil at GRM.

Of the spoil management groups, sandstone spoils are considered most suitable for placement close to the final rehabilitated surface for use as a secondary growth media. Due to the heterogeneity, discrete testing should be conducted prior to rehabilitation. Competent (durable), fresh Permian sandstone has potential to be used as a rock armour to greatly increase batter slope resistance to erosion and to stabilise steeper areas.

4.2.3 Tertiary materials

Tertiary materials are highly weathered and contain small portions of fragile (low durability) rock. Generally, it has a clay content above 35%, resulting in moderate to high water holding capacity. It is typically pale orange to pale brown in colour. The material tends to be strongly sodic and occasionally high in salinity. Compared to the sandstone spoil, the Tertiary material is more susceptible to slaking and dispersion but has similar dispersion characteristics of the weathered Permian spoil. Figure 12 is representative of Tertiary spoil at GRM.

Placement of this material close to the final rehabilitated surface is not recommended due to its susceptibility to erosion. However, testing did identify Tertiary materials that are slightly acidic to alkaline, non-sodic, and low in salts. If these materials can be identified and segregated consistently, they could form a valuable secondary growth medium for high productivity grazing areas for where required (i.e. possible alternative growth media).

Figure 11: Fresh Permian sandstone material present at the mine. Large-sized competent rock is present throughout the stockpile.

Figure 12: Tertiary material stockpiled at the mine.

5 GROWTH MEDIA SUITABILITY AND AMELIORATION

The materials encountered have been classified according to their ability to support plant growth, as either *primary* or *secondary* growth media.

5.1 Primary growth media

Primary growth media infers the ability of materials to be used as a topsoil or topsoil surrogate. It is the upper-most layer placed over the rehabilitated area. It can be applied at various thicknesses depending on the PMLU and consists of surface soil (topsoil) materials recovered prior to mining and applied over the area, or a growth medium developed from subsoils or spoil materials, ameliorated to a standard suitable to support sustainable plant growth. It is typically higher in organic matter and macro- and micro-nutrients and has low to negligible limitations to plant growth. Its primary purpose is to provide nutrients and a stable surface for vegetation establishment.

If sufficient suitable primary growth media is not available, an alternative growth media may be derived by amelioration of suitable subsoils or spoil materials. Amelioration products and application rates for the primary growth media should be assessed by an appropriately qualified person prior to rehabilitation, and to also ensure the desired PMLU and vegetation is considered. Amelioration must address both the physical and chemical suitability of the material.

5.2 Secondary growth media

Secondary growth media infers the ability of materials to be used as a subsoil or subsoil surrogate. Typically, secondary growth media layers are capped with primary growth media. In the absence of subsoil, it may be a spoil material, or an intermediate layer of ameliorated spoil situated above un-ameliorated spoil material.

The main purpose of the secondary growth medium is to increase the soil water storage capacity in the root zone, and/or meet the soil depth criterion for certain vegetative PMLUs and target vegetation communities.

In some circumstances, secondary growth media may be able to be sufficiently improved by the addition of ameliorants (e.g. gypsum, lime, organic matter) to convert them to a primary growth medium.

5.3 Suitability classification

A four-class suitability system is applied in the evaluation of materials as growth media. These classes are defined as follows:

Class A – Good Quality

- Negligible limitations to plant growth.
- Good quality material for intended purpose.
- Nil to low levels of ameliorants will be required.

Class B – Fair Quality

- Minor limitations to plant growth.
- Reasonable quality material for intended purpose.
- Low to moderate levels of ameliorants may will be required.

Class C – Marginal Quality

- Moderate limitations to plant growth.
- Moderate to high levels of ameliorants may be required to improve material quality to support plant growth.

Class D – Not Suitable

- Severe limitations to plant growth.
- It will generally be uneconomic or unviable to amend these materials to the degree needed to support plant growth.

The suitability of materials as primary or secondary growth media is presented with recommendations in Table 9.

5.4 Fertiliser and ameliorants

Fertiliser and amelioration rates for spoils are dependent on the intended PMLU for each rehabilitated area. For example, cattle grazing requires the generation of biomass and as such, nitrogen and phosphorus-based amendments would be recommended for these areas. As a guide to amelioration application for grazing, PMLU should aim to provide:

- Available phosphorus (Colwell) content of the growth media to within a target concentration of 25–40 mg/kg;
- An appreciable source of starter nitrogen;
- Adequate macro- and micronutrients; and
- Gypsum to reduce sodicity and potential for dispersion.

Amelioration recommendation for woodland areas should be assessed on a case-by-case basis and represent the specific requirements of the target vegetation community.

Table 9: Recommended fertiliser and ameliorant treatments for materials and growth media suitability classification.

Material	Limitations	Amendments	Suitability Class	
			Primary (1)	Secondary (2)
Clay topsoil	• Often strongly alkaline • Sometimes high salinity • Often sodic and sometimes dispersive • Susceptible to slaking • Often low ability to retain nutrients • Low N, P and K • Often low TOC and Ca	• Gypsum: due to heterogeneity between stockpiles, rates should be calculated for individual stockpile prior to use. • Fertiliser and/or compost rates are to be determined by an appropriately qualified person prior to individual stockpiles being used in rehabilitation. • Any soil with elevated salinity should be initially seeded with salt tolerant species. • Incorporation with rock to increase erosion resistance.	1B/C	2A
Loam topsoil	• Sometimes strongly alkaline • Occasionally sodic • Susceptible to slaking • Low ability to retain nutrients • Low N, P, K and Ca • Often low TOC	• Fertiliser and/or compost rates are to be determined by an appropriately qualified person prior to individual stockpiles being used in rehabilitation. • Incorporation with rock to increase erosion resistance.	1B	2A
Mudstone/siltstone spoil	• Strongly alkaline • Sometimes high salinity • Strongly sodic and dispersive • Often low ability to retain nutrients	• Gypsum: due to heterogeneity between spoil samples, rates should be calculated for broad spoil areas after placement. • Mix all saline material with a more benign and permeable material or bury to a depth greater than 2 m below the surface.	1D	2B/C
Sandstone spoil	• Strongly alkaline • Often strongly sodic and dispersive • Often low fertility and ability to retain nutrients • High variability in physical and chemical characteristics	• Gypsum: due to heterogeneity between spoil samples, rates should be calculated for broad spoil areas after placement. • If to be used as a primary growth media further assessment by an appropriately qualified person is required to determine amelioration required.	1B/C	2B
Tertiary spoil	• Often strongly acidic or strongly alkaline • Sometimes high salinity • Sodic or strongly sodic and dispersive • Low permeability • Low fertility	• Gypsum: due to heterogeneity between spoil samples, rates should be calculated for broad spoil areas after placement. • Mix all saline material with a more benign and permeable material or bury to a depth greater than 2 m below the surface. • Segregate the neutral pH, non-sodic and non-saline material for use as a secondary growth media where possible.	1C/D	2B/C

Note: Class A – Good Quality: Negligible limitations to plant growth; Class B – Fair Quality: Minor limitations to plant growth; Class C – Marginal Quality: Moderate limitations to plant growth; and Class D – Not Suitable: Severe limitations to plant growth.

5.4.1 Fertiliser

A balanced NPK fertiliser such as Crop King 55 (N: ~13.5 %, P: ~15 %, K: 12.5 %) and slow-release nitrogen source such as Coated Urea (N: ~46 %) or organic compost is recommended to provide a balanced source of nutrients to plants during rehabilitation. Any composted material should comply with the Australian Standard for Composting (AS4454-2012).

Accurate application rates and fertiliser types based on the required nutrients should be determined by an appropriately qualified person prior to use in rehabilitation.

Fertiliser and mulch/compost should be applied at seeding. It can be broadcast with a spreader or applied hydraulically or pneumatically. Spreaders are typically suitable for slopes with gradients <35%, and hydraulic or pneumatic applications will be required for steeper slopes.

5.4.2 Gypsum

Gypsum application is recommended for sodic/dispersive materials or where calcium is low. It should be applied in a manner that allows for as thorough mixing as is practicable of the surface materials. Gypsum should be applied during the soil preparation stages prior to seeding and fertilising.

Depth of sodicity amelioration depends on erosion risk/land gradient. Generally, for slopes with gradients less than ~35%, incorporate gypsum into the upper 0.3 m depth of sodic materials.

Considering the annual rainfall at GRM is approximately 560 mm, it is expected that (as a 'rule of thumb') gypsum will dissolve at a rate of 0.5–1.0 t/ha/y. Hence, there is benefit in applying gypsum at the time materials are recovered (i.e. stripped) or as soon as is practical in the rehabilitation program to allow the gypsum to be as effective as possible.

6 SUMMARY AND RECOMMENDATIONS

This material characterisation report describes and characterises the materials identified on-site for use in rehabilitation using the topsoil stockpile assessment, erodibility studies, previous soil and spoil assessments, and other GRM project-related documents.

6.1 Topsoil stockpiles

Generally, the stockpiled topsoil is considered to be of adequate quality for use as a primary growth media if chemical limitations are managed. Due to the high degree of heterogeneity, the summarised laboratory data should be considered representative of the soils as a whole, and not representative of individual stockpiles. The sampling program is considered adequate to describe these materials into broad soil management groups. Therefore, any stockpile not included in this assessment should be sampled and characterised prior to use in rehabilitation.

The main limitations of the stockpiled soils for use in rehabilitation are low fertility and for clay dominated topsoil, sodicity and salinity.

Chemical fertility of the stockpiled soils is often low. A balanced NPK fertiliser or compost should be applied during rehabilitation to provide a starter source of nutrients for initial vegetation growth. Subsequent applications of fertiliser, particularly nitrogen, may be required to maintain adequate fertility levels and ensure vegetation is established in the long-term.

Amelioration of sodicity requires the thorough incorporation of gypsum. Due to the high degree of heterogeneity of measured sodicity within stockpiles, gypsum rates should be calculated for individual stockpiles prior to use in rehabilitation.

Amelioration products and application rates should be assessed by an appropriately qualified person prior to use for rehabilitation and to complement the desired PMLU.

The elevated salinity identified in the clay topsoil, while high, should still allow the establishment of salt tolerant species. Species like Rhodes grass (*Chloris gayana*) should be favoured initially with the aim of establishing an adequate leaching profile to flush the salts from the rootzone before seeding species that are consistent with the desired PMLU.

Incorporation of durable rock into this soil could be considered to improve erosion performance.

6.2 Spoils

Generally, sandstone dominated spoils have the highest potential to be used as secondary growth media through varying degrees of amelioration. However, Tertiary materials with favourable chemistry also offer a possible value alternative as a secondary growth media on low gradient or flat areas, provided they can be identified and segregated consistently. Failure to do so would risk use of a Tertiary material that would not support the PMLU.

Where primary growth media availability is limited, a topsoil/unweathered sandstone spoil mix may be adopted to form a primary growth media with potential to support a

woodland PMLU, provided adequate amelioration is completed to negate any limiting properties of the spoil. If adopted, the chemical and physical properties and the overall viability of the proposed material should be assessed by a suitably qualified person before being applied to the broader rehabilitation.

All spoils with elevated salinity must be managed to adequately leach salts from the rootzone. Maximising infiltration by limiting slope gradient or mixing with a more permeable material are considered the most practical approaches.

Due to the high degree of heterogeneity in the spoils, the summarised laboratory data should only be considered a guide to their suitability. Targeted sampling of spoils planned for use in the upper cover layer profile (i.e. primary or secondary growth media) should be conducted prior to rehabilitation.

Chemical fertility of the spoils was no assessed as part of this study, but vegetation would benefit from an application of a balanced NPK fertiliser or compost to help alleviate some of the fertility issues identified with the stockpile topsoils.

6.3 Growth media for PMLU

Physical and chemical properties of the soil and spoils available on site will meet the requirements to establish the primary PMLUs for rehabilitated areas of cattle grazing and woodland habitat if appropriate amelioration is conducted. It is recommended that the growth media for each rehabilitation campaign be assessed by an appropriately qualified person prior to rehabilitation, to identify the required ameliorants and fertilisers.

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APPENDIX A: MAPS AND FIGURES

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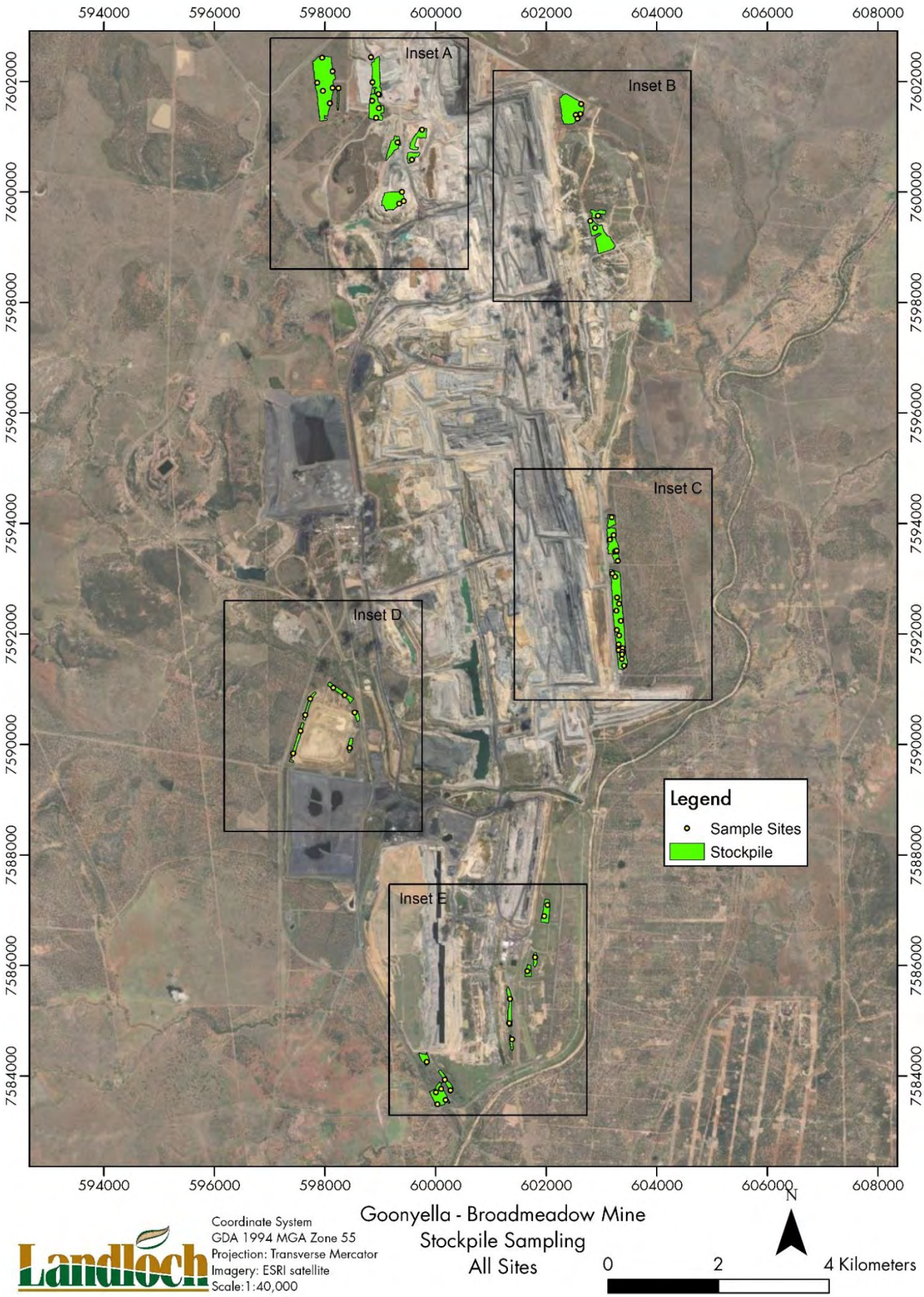


Figure A-1: GRM topsoil stockpile sampling locations.

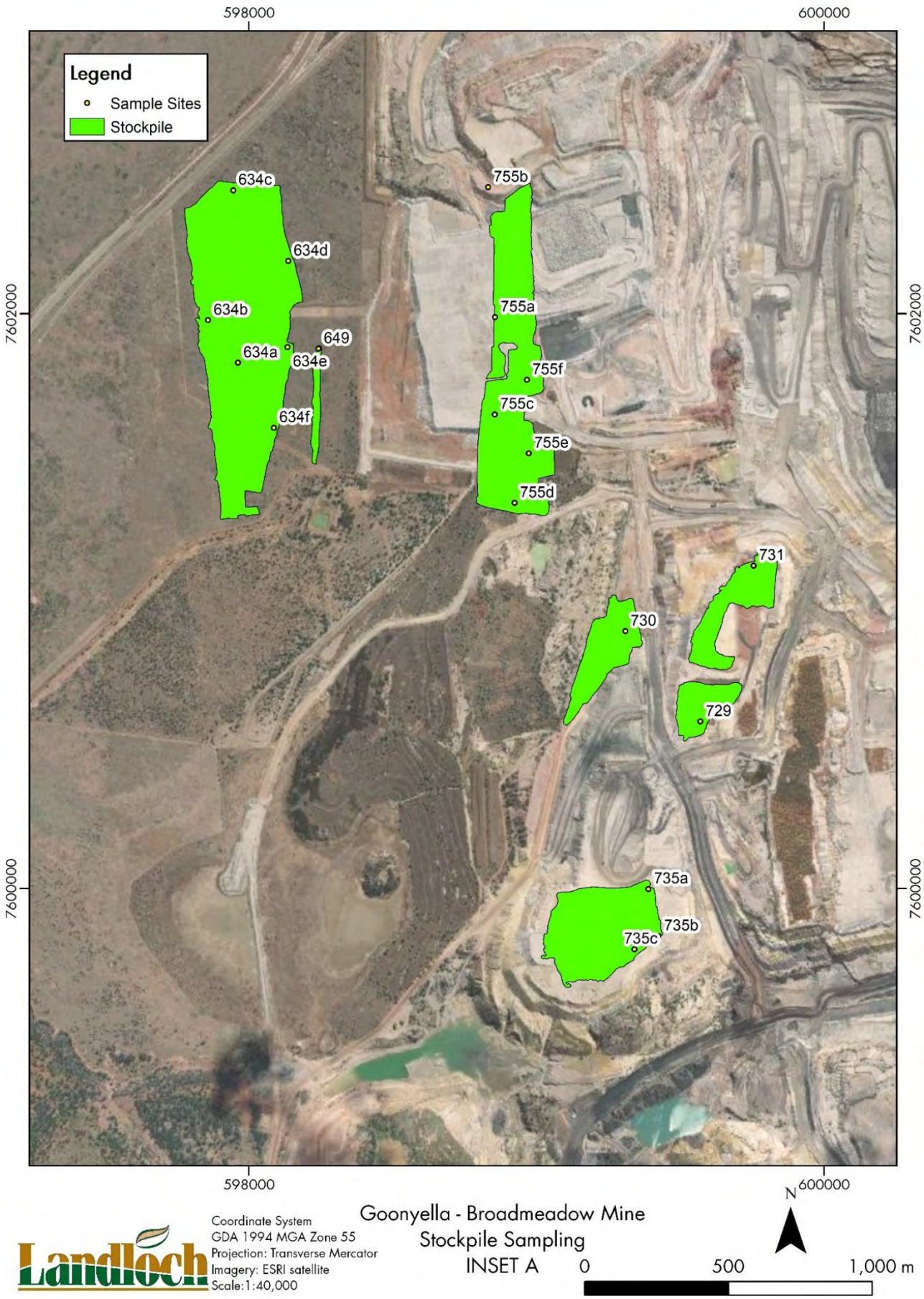


Figure A-2: GRM soil stockpile sampling locations in the mine area (Inset A).

Figure A-3: GRM soil stockpile sampling locations in the mine area (Insert B).

Figure A-4: GRM soil stockpile sampling locations in the mine area (Insert C).

Figure A-5: GRM soil stockpile sampling locations in the mine area (Insert D).

Figure A-6: GRM soil stockpile sampling locations in the mine area (Insert E).

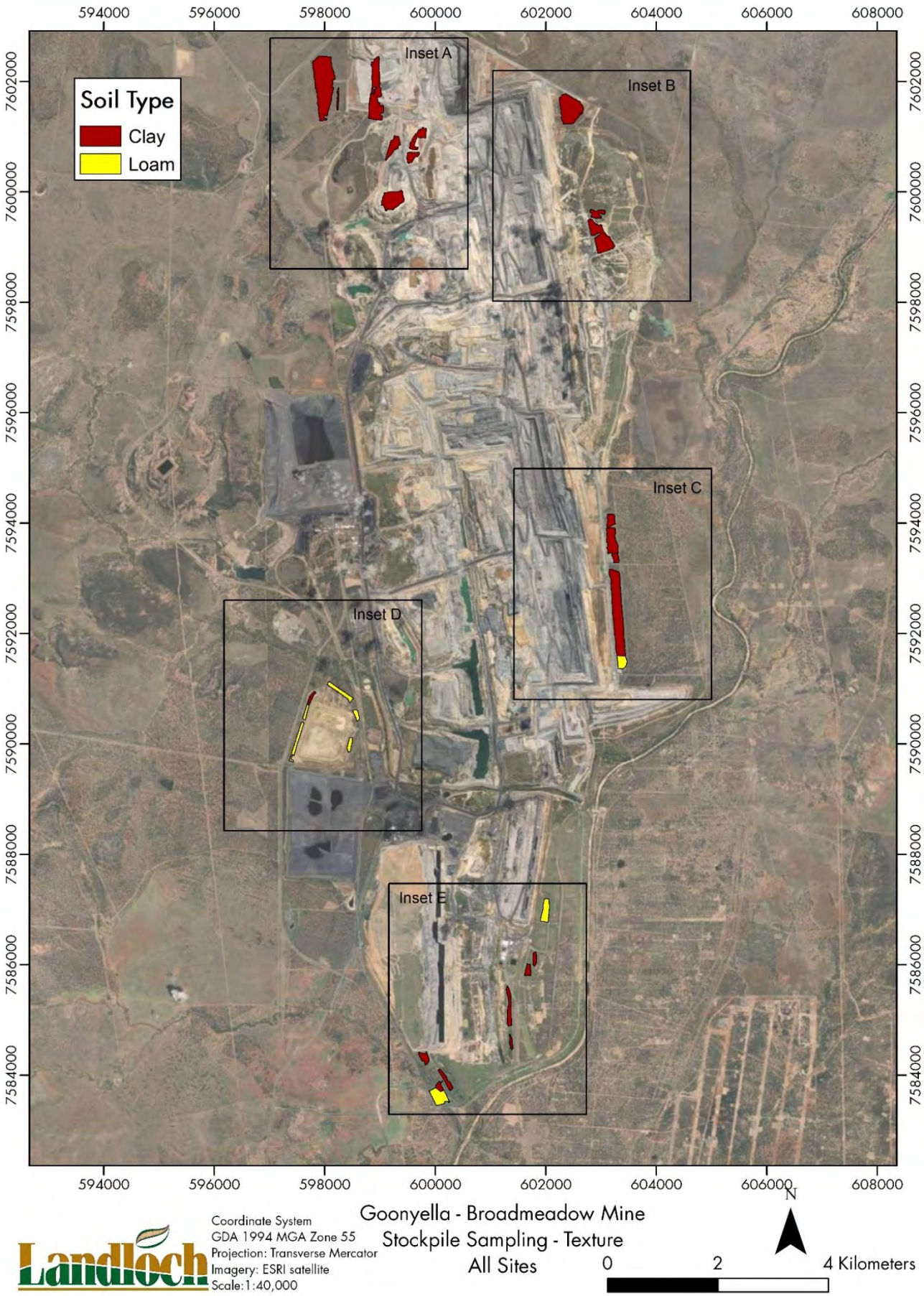


Figure A-7: Distribution of stockpiled topsoil materials at GRM.

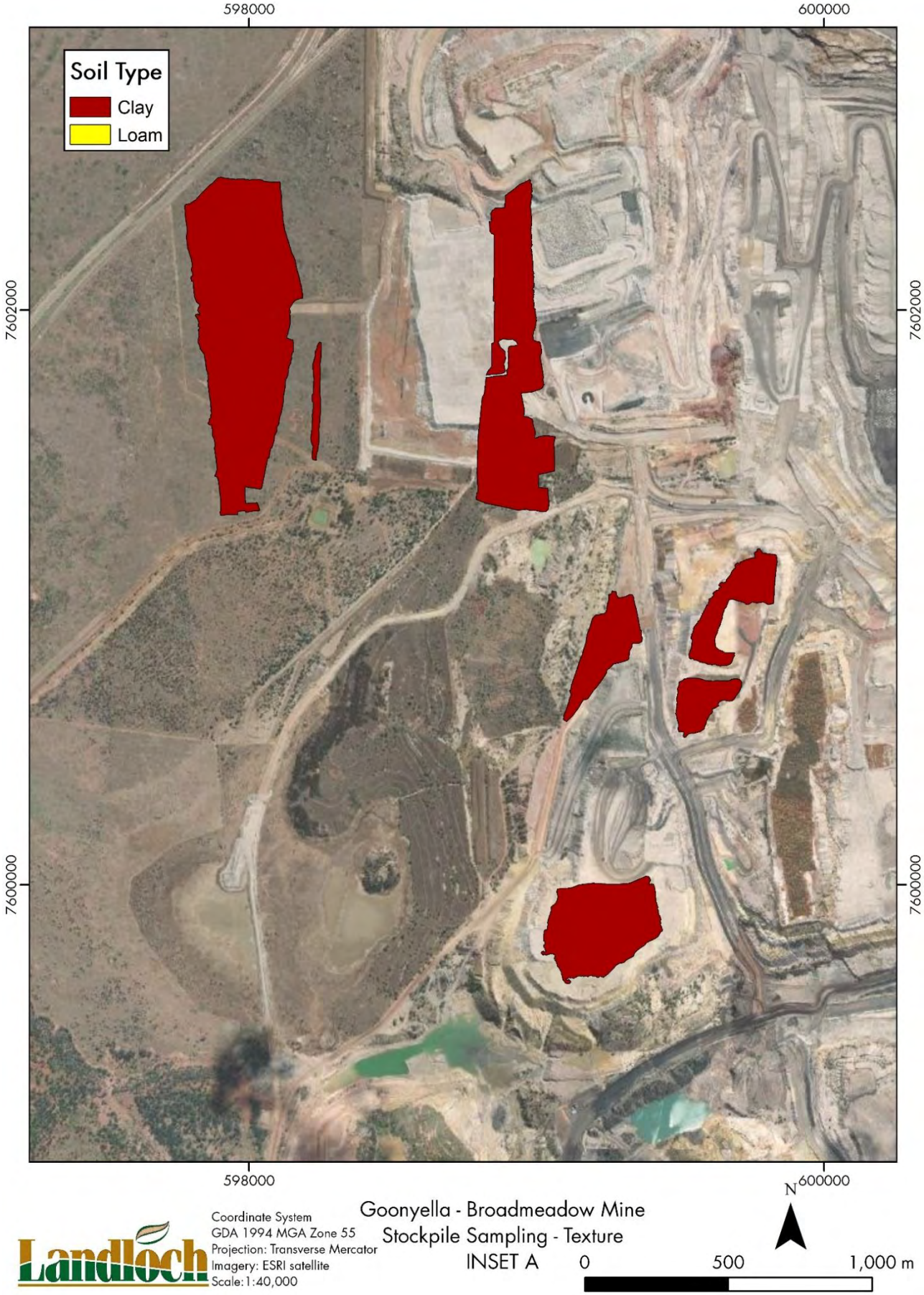


Figure A-8: Distribution of stockpiled soil materials at GRM (Insert A).

Figure A-9: Distribution of stockpiled soil materials at GRM (Insert B).

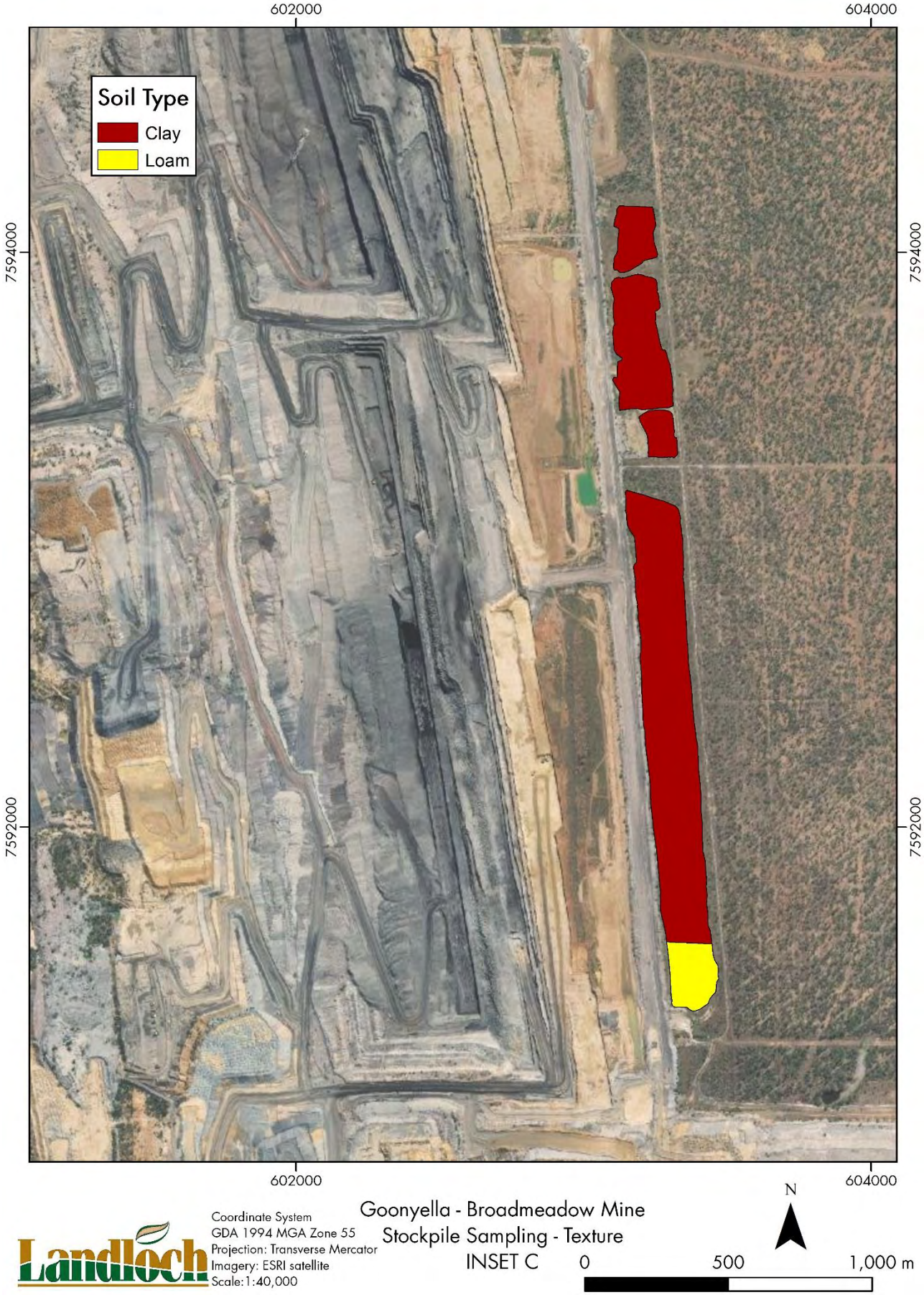


Figure A-10: Distribution of stockpiled soil materials at GRM (Insert C).

Figure A-11: Distribution of stockpiled soil materials at GRM (Insert D).

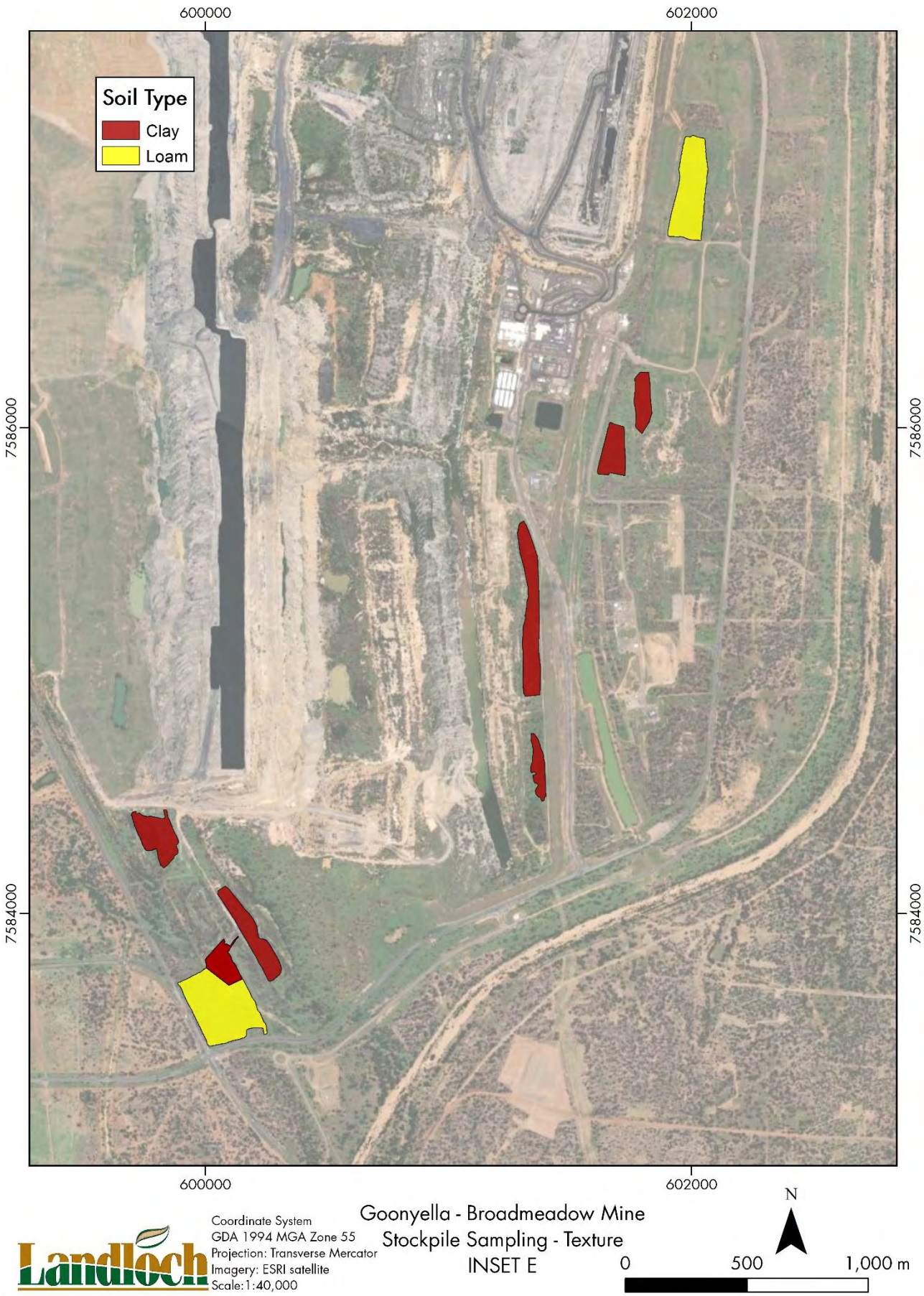
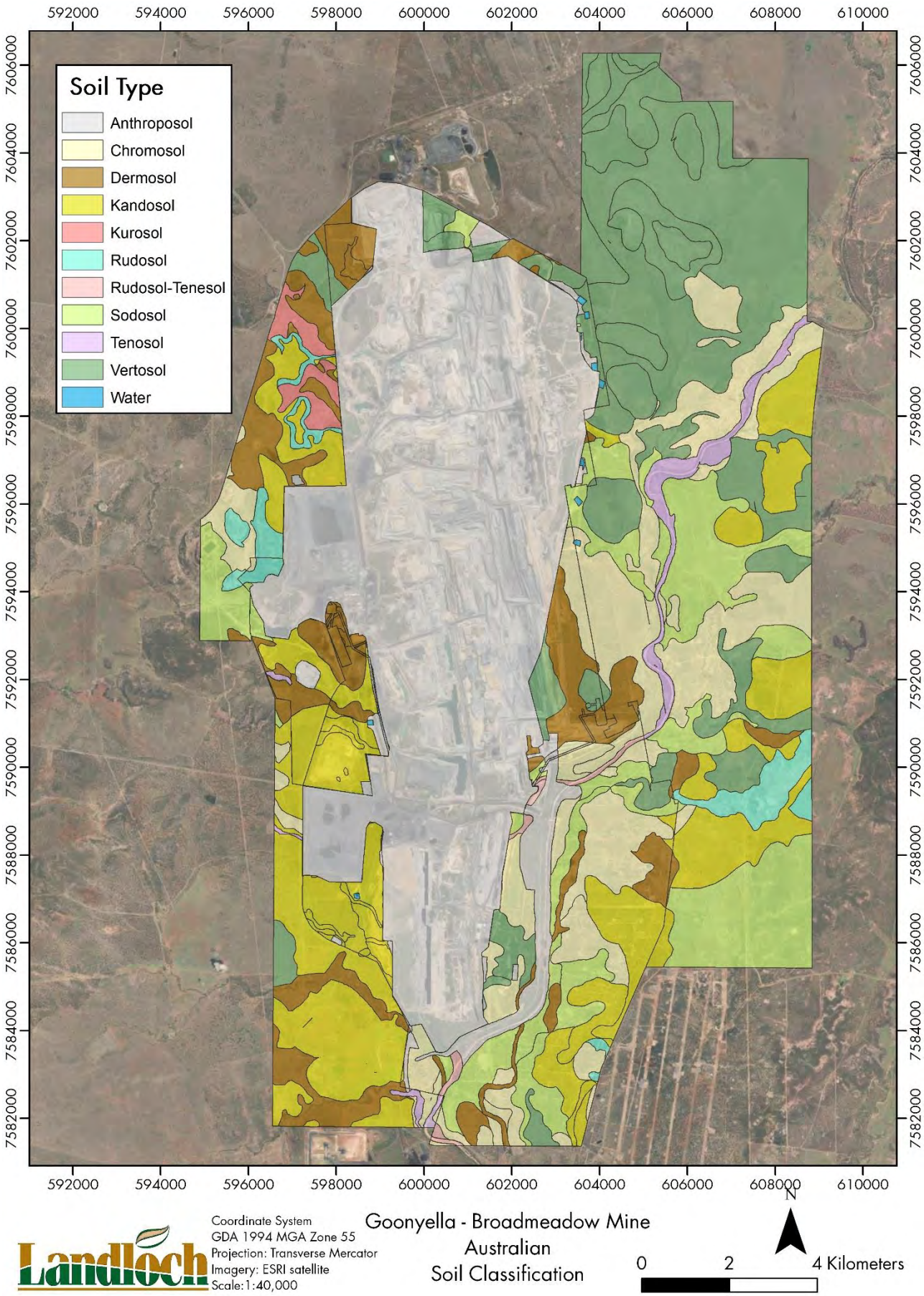


Figure A-12: Distribution of stockpiled soil materials at GRM (Insert E).



Coordinate System
GDA 1994 MGA Zone 55
Projection: Transverse Mercator
Imagery: ESRI satellite
Scale:1:40,000

Goonyella - Broadmeadow Mine
Australian
Soil Classification

Figure A-13: ASC soil mapping synthesised from existing soil assessments.

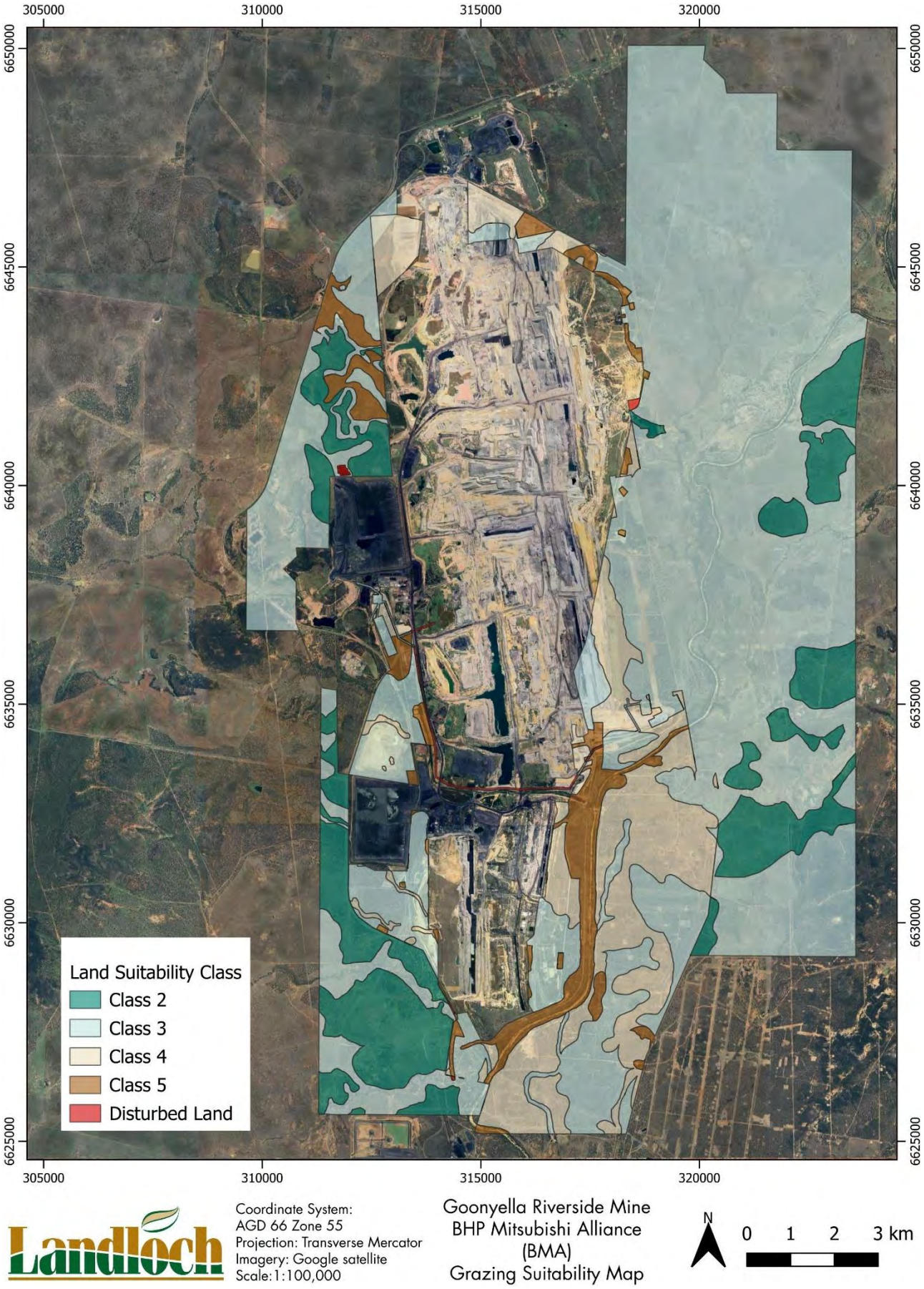


Figure A-14: Grazing land suitability class mapping synthesised from existing assessments.

APPENDIX B: DATA TABLES

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Table B-1: Sampling site locations.

Site ID	LATITUDE	LONGITUDE
625	-21.70432848	147.9951729
649	-21.68359622	147.9493759
665	-21.78577528	147.9531266
667	-21.79158645	147.9523015
675	-21.8428444	147.9661538
707	-21.76072472	147.9990511
709	-21.75359384	147.9978883
729	-21.69536833	147.9625542
730	-21.6925437	147.9600175
731	-21.69046203	147.9643118
634a	-21.68418225	147.9469384
634b	-21.6828513	147.9459266
634c	-21.67876491	147.946744
634d	-21.68097885	147.9486084
634f	-21.68622102	147.9481602
643e	-21.68368377	147.9486024
662a	-21.78176062	147.9493769
662b	-21.78294837	147.9513802
664a	-21.78622577	147.9445207
664b	-21.78360623	147.9453901
666a	-21.79253565	147.9424565
666b	-21.788835	147.9437345
678a	-21.84744675	147.9703407
678b	-21.84570871	147.9693235
680a	-21.84972811	147.9680712
680b	-21.8490352	147.969492
680b	-21.84903509	147.9694921
680c	-21.847223	147.9687005
680d	-21.84779716	147.9678087
704a	-21.77783334	148.0002574
704b	-21.776776	147.9998339

Site ID	LATITUDE	LONGITUDE
704c	-21.77599949	147.9998628
704d	-21.77559318	147.9998983
704e	-21.77531141	147.9992603
704f	-21.77502216	147.9999375
704g	-21.77436489	147.9992485
704h	-21.77293047	147.9993404
704i	-21.77204497	147.9989515
704j	-21.77051992	147.99962
704k	-21.76885661	147.9988301
704L	-21.76774284	147.9992958
704m	-21.76673899	147.9989609
704n	-21.76332133	147.9985948
704o	-21.76281223	147.9981089
708a	-21.7590476	147.9988043
708b	-21.75917464	147.9985599
708c	-21.75725212	147.9976429
708d	-21.75653654	147.9982578
716a	-21.7051901	147.9938422
716b	-21.70632616	147.9946898
726a	-21.68607085	147.9921159
726b	-21.68768247	147.9919724
726c	-21.68784167	147.991164
726c	-21.68846693	147.9914567
735a	-21.70064393	147.9608453
735b	-21.70211863	147.9611981
753c	-21.70253699	147.960388
755a	-21.68270393	147.9555755
755b	-21.67862097	147.955316
755c	-21.68575868	147.9555869
755d	-21.68853547	147.9562671
755e	-21.68697184	147.9567335
755f	-21.68466453	147.9566577

Table B-2: Ground observations and surface descriptions.

Site ID	Morphological Type	Stoniness (size)	Groundcover % (veg)	Veg/Litter	Stoniness (abundance)
625	Flat	<20mm	80-100%	80/20	2-10%
649	Bund	<20mm	80-100%	80/20	2-10%
665	Flat	<20mm	80-100%	80/20	2-10%
667	Flat	<20mm	0-20%	100/0	50-90%
675	Flat	<20mm	80-100%	80/20	2-10%
707	Flat	<20mm	80-100%	80/20	2-10%
709	Flat	<60mm	20-40%	80/20	20-50%
729	Flat	<60mm	80-100%	80/20	10-20%
730	Flat	<200mm	80-100%	80/20	10-20%
731	Flat	<200mm	60-80%	60/40	20-50%
634a	Flat		60-80%	80/20	2-10%
634b	Flat		60-80%	80/20	<2%
634c	Flat	<20mm	20-40%	80/20	10-20%
634d	Flat	<20mm	20-40%	80/20	10-20%
634f	Flat	<20mm	60-80%	80/20	2-10%
643e	Flat	<60mm	60-80%	80/20	2-10%
662a	Flat	<20mm	80-100%	80/20	2-10%
662b	Flat	<20mm	80-100%	80/20	2-10%
664a	Bund	<60mm	80-100%	80/20	10-20%
664b	Bund	<20mm	80-100%	80/20	2-10%
666a	Bund	<60mm	80-100%	80/20	10-20%
666b	Bund	<20mm	80-100%	80/20	2-10%
678a	Flat	<20mm	80-100%	80/20	2-10%
678b	Flat	<20mm	80-100%	80/20	2-10%
680a	Flat	<20mm	80-100%	80/20	2-10%
680b					
680b	Flat	<20mm	80-100%	80/20	2-10%
680c	Flat	<60mm	80-100%	80/20	2-10%
680d	Flat	<20mm	80-100%	80/20	2-10%
704a	Flat	<60mm	80-100%	80/20	2-10%
704b	Flat	<20mm	80-100%	80/20	

Site ID	Morphological Type	Stoniness (size)	Groundcover % (veg)	Veg/Litter	Stoniness (abundance)
704c	Flat	<20mm	80-100%	80/20	2-10%
704d	Flat	<60mm	80-100%	80/20	10-20%
704e	Flat	<200mm	80-100%	80/20	10-20%
704f	Flat	<60mm	80-100%	80/20	2-10%
704g	Flat	<20mm	80-100%	80/20	2-10%
704h	Flat	<20mm	80-100%	80/20	2-10%
704i	Flat	<60mm	80-100%	80/20	2-10%
704j	Flat	<20mm	80-100%	80/20	2-10%
704k	Flat	<20mm	80-100%	80/20	2-10%
704L	Flat	<20mm	80-100%	80/20	2-10%
704m	Flat	<60mm	80-100%	80/20	2-10%
704n	Flat	<20mm	80-100%	80/20	2-10%
704o	Flat	<20mm	80-100%	80/20	2-10%
708a	Flat	<20mm	80-100%	80/20	2-10%
708b	Flat	<200mm	80-100%	80/20	10-20%
708c	Flat	<200mm	80-100%	80/20	20-50%
708d	Flat	<20mm	80-100%	80/20	2-10%
716a	Flat	<20mm	60-80%	80/20	10-20%
716b	Flat	<60mm	80-100%	80/20	10-20%
726a	Flat	<20mm	20-40%	80/20	
726b	Flat	<20mm	20-40%	80/20	10-20%
726c	Flat	<20mm	20-40%	80/20	10-20%
726c	Flat	<20mm	20-40%	80/20	10-20%
735a	Flat	<20mm	60-80%	80/20	10-20%
735b	Flat	<20mm	60-80%	80/20	10-20%
753c	Flat	<20mm	60-80%	80/20	10-20%
755a	Batter Top	<60mm	0-20%		2-10%
755b	Batter Top	<60mm	0-20%		2-10%
755c	Flat	<60mm	0-20%		10-20%
755d	Flat	<60mm	0-20%		10-20%
755e	Flat	<60mm	0-20%		10-20%
755f	Flat	<60mm	0-20%		10-20%

Table B-3: Morphological description of stockpiled soil materials.

Site ID	Date	Total Depth (m)	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)				Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Roots	Origin (i.e topsoil, subsoil, overburden); Parent Materials; and Proportions	Comments	Sample ID / Depth (m)	Sample Type
						Primary	Secondary	Mottles	Streaks		%	Size	Shape	%	Size (mm)	Shape					
649	5-Oct-23	1.5	0.5	CLAY	Light Clay	Dark Brown	Red	0		5-10	5-11	6-20	Sub-rounded				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Clay	Dark Brown	Red	10-20		10-20	5-10	6-20	Sub-rounded	5-10	2-6	Rounded	Common	topsoil	20% groups of coarse sand with small gravells, f	0.5-1	Grab
			1.5	CLAY	Medium Clay	Brown	Red	10-20		10-20	10-20	6-20	Sub-rounded				Few	subsoil	10-20% hard carbonates, MC with fine sand	1-1.5	Grab
																				composite	Composite
634a	5-Oct-23	2	0.5	CLAY	Medium Clay	Brown				5-10	5-10	6-20	Sub-rounded				Common	topsoil	mix of angular and subrounded ironstone and n	0-0.5	Grab
			1	CLAY	Medium Clay	Brown			2-5	10-20	5-10	6-20	Sub-rounded	5-10	6-20	Angular	Few	topsoil	mix of angular and subrounded ironstone and n	0.5-1	Grab
			2	CLAY	Medium Clay	Brown			2-5	10-20	5-10	6-20	Sub-rounded	5-10	6-20	Angular	Few	topsoil	mix of angular and subrounded ironstone and n	1.5-2	Grab
																				composite	Composite
634b	5-Oct-23	3	0.5	CLAY	Medium Clay	Brown				10-20	10-20	6-20	Sub-rounded				Common	topsoil	some soft carbonates, mudstone coarse frags, M	0-0.5	Grab
			1.5	CLAY	Medium Clay	Brown			2-5	10-20	10-20	6-20	Sub-rounded				Few	topsoil	some soft carbonates, mudstone coarse frags M	1-1.5	Grab
			3	CLAY	Medium Clay	Brown			2-5	5-10	5-10	6-20	Sub-rounded				Few	topsoil	MC fine sandy	2.5-3	Grab
																				composite	Composite
634c	5-Oct-23	3	0.5	CLAY	Medium Clay	Brown				20-30	10-20	6-20	Sub-rounded	5-10	20-60	Angular	Few	topsoil	angular weathered rock whitish and moderate	0-0.5	Grab
			1.5	CLAY	Clay Loam Sandy	Brown				10-20	10-20	20-60	Angular				Nil	topsoil	angular weathered rock whitish and moderate	1-1.5	Grab
			3	CLAY	Medium Clay	Brown	Red	10-20	0	10-20	10-20	20-60	Angular				Nil	topsoil	grey medium clay fine sandy , angular weathere	2.5-3	Grab
																				composite	Composite
634d	5-Oct-23	3	0.5	CLAY	Medium Clay	Brown	Red		10-20	5-10	10-20	6-20	Angular	5-10	6-20	Sub-rounde	Few	topsoil	grey and orange streaks. weathered rock mudst	0-0.5	Grab
			1.5	CLAY	Medium Clay	Brown	Red		10-20	10-20	10-20	6-20	Angular				Nil	topsoil	grey and orange streaks. weathered rock mudst	1-1.5	Grab
			3	CLAY	Medium Clay	Brown	Red		5-10	5-10	5-10	20-60	Angular				Nil	topsoil	grey and orange streaks. weathered rock mudst	2.5-3	Grab
																				composite	Composite
634e	5-Oct-23	2	0.5	CLAY	Medium Clay	Brown	Red			5-10	5-10	20-60	Sub-rounded				Common	topsoil	mudstone and quartz fragments, MC fine sandy	0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Red			5-10	5-10	20-60	Sub-rounded				Few	topsoil	mudstone and quartz fragments	0.5-1	Grab
			2	CLAY	Medium Clay	Brown	Red			5-10	5-10	20-60	Sub-rounded				Few	topsoil	mudstone and quartz fragments	1.5-2	Grab
																				composite	Composite
634f	6-Oct-23	3	0.5	CLAY	Medium Clay	Brown	Red			10-20	5-10	20-60	Sub-rounded	5-10	60-200	Sub-rounde	Few	topsoil	10% dark brown MHC material mixed	0-0.5	Grab
			1.5	CLAY	Medium Clay	Brown	Red			10-20	5-10	20-60	Sub-rounded	5-10	60-200		Few	topsoil	10% dark brown MHC material mixed	1-1.5	Grab
			3	CLAY	Light Clay	Red				20-30	20-30	6-20	Sub-angular				Nil	topsoil	clear boundary between material clear, gravell	2.5-3	Grab
																				composite	Composite
755a	6-Oct-23	2	0.5	CLAY	Medium Clay	Brown	Pale Red			10-20	5-10	6-20	Sub-angular	5-10	20-60	Sub-rounde	Nil	topsoil	no clear boundaries	0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Pale Red			10-20	5-10	6-20	Sub-angular				Nil		no clear boundaries	0.5-1	Grab
			2	CLAY	Medium Clay	Brown	Pale Red			10-20	5-10	6-20	Sub-angular				Nil			1.5-2	Grab
			c																	composite	Composite
755b	6-Oct-23	3	0.5	CLAY	Light Medium Clay	Brown	Pale Red			2-5	2-5	6-20	Sub-angular				Nil	topsoil	ironstone coarse fragments present.	0.5-1	Grab
			1.5	CLAY	Light Medium Clay	Brown	Pale Red			2-5	2-5	6-20	Sub-angular				Nil		ironstone coarse fragments	1.5-2	Grab
			2.5	CLAY	Light Medium Clay	Brown	Pale Red			5-10	5-10	6-20	Sub-angular				Nil		ironstone fragments	2.5-3	Grab
			c																	composite	Composite
755c	6-Oct-23	2	0.5	CLAY	Medium Clay	Pale Brown	Brown			2-5	2-5	6-20	Sub-rounded				Nil	topsoil	ironstone fragments	0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Pale Red			2-5	2-5	20-60	Sub-angular				Nil		larger ironstone fragments	1-1.5	Grab
			2.5	CLAY	Medium Clay	Brown	Pale Red			2-5	2-5	6-20	Sub-angular				Nil			2-2.5	Grab
			c																	composite	Composite
755d	7-Oct-23	3	0.5	CLAY	Medium Clay	Pale Brown	Brown			5-10	5-10	20-60	Sub-angular				Common	topsoil	ironstone fragments	0-0.5	Grab
			1.5	CLAY	Medium Clay	Brown	Pale Brown			5-10	5-10	20-60	Sub-angular				Few			1-1.5	Grab
			2.5	CLAY	Medium Clay	Brown	Dark Brown			5-10	5-10	6-20	Sub-angular				Nil			2.5-3	Grab
			c																	composite	Composite
755e	7/10/2023	2	0.5	CLAY	Medium Clay	Brown	Pale Red			5-10	5-10	20-60	Sub-angular				Few	topsoil		0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Pale Red			5-10	5-10	20-60	Sub-angular				Few			0.5-1	Grab
			1.5	CLAY	Medium Clay	Brown	Pale Red			5-10	5-10	20-60	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
755f	7/10/2023	2	0.5	CLAY	Medium Clay	Brown	Pale Brown			5-10	5-10	20-60	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Pale Red			5-10	5-10	20-60	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Medium Clay	Dark Brown	Pale Red			5-10	5-10	20-60	Sub-angular				Common			1.5-2	Grab
			c																	composite	Composite
730	7/10/2023	3	0.5	CLAY	Light Clay	Brown				5-10	5-10	6-20	Sub-angular				Many	topsoil	all the same material . light clay with fine sand	0-0.5	Grab
			1.5	CLAY	Light Clay	Brown				5-10	5-10	6-20	Sub-angular				Many			1-1.5	Grab
			3	CLAY	Light Clay	Brown				5-10	5-10	6-20	Sub-angular				Common			2.5-3	Grab
			c																	composite	Composite
729	7/10/2023	2	0.5	CLAY	Medium Heavy Clay	Brown				5-10	5-10	6-20	Sub-angular				Common	topsoil	carbonates present. some fine sand in textures	0-0.5	Grab
			1	CLAY	Medium Heavy Clay	Brown				5-10	5-10	6-20	Sub-angular				Common		carbonates present. some fine sand in textures	0.5-1	Grab
			2	CLAY	Medium Heavy Clay	Brown				5-10	5-10	6-20	Sub-angular				Few		carbonates present. some fine sand in textures	1.5-2	Grab
			c																	composite	Composite

Site ID	Date	Total Depth (m)	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)				Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Roots	Origin (i.e topsoil, subsoil, overburden); Parent Materials; and Proportions	Comments	Sample ID / Depth (m)	Sample Type
						Primary	Secondary	Mottles	Streaks		%	Size	Shape	%	Size (mm)	Shape					
731	7/10/2023	3	0.5	CLAY	Medium Clay	Brown	Pale Brown			10-20	10-20	20-60	Angular				Common	topsoil	3 separate face cuts made into stockpile edge	0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Pale Brown			5-10	5-10	20-60	Angular				Few			1-1.5	Grab
			3	CLAY	Medium Clay	Brown	Pale Brown			5-10	5-10	20-60	Angular				Few			2.5-3	Grab
			c																	composite	Composite
735a	8/10/2023	3	0.5	CLAY	Medium Heavy Clay	Dark Brown		5-10	5-10	5-10	5-10	6-20	Angular				Few	topsoil	red and orange mottles/streaks,very tough for (	0-0.5	Grab
			1	CLAY	Medium Heavy Clay	Dark Brown		5-10	5-10	5-10	5-10	6-20	Angular				Few			1-1.5	Grab
			3	CLAY	Medium Heavy Clay	Dark Brown		5-10	5-10	5-10	5-10	6-20	Angular				Few			2.5-3	Grab
			c																	composite	Composite
735b	8/10/2023	3	0.5	CLAY	Light Medium Clay	Red	Brown			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Nil	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Red	Brown			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Nil			1-1.5	Grab
			3	CLAY	Light Medium Clay	Red	Brown			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Nil			2.5-3	Grab
			c																	composite	Composite
735c	8/10/2023	3	0.5	CLAY	Medium Clay	Brown		5-10		10-20	10-20	6-20	Angular	2-5	20-60	Sub-angular	Few	topsoil	some orange mottles	0-0.5	Grab
			1	CLAY	Medium Clay	Brown		5-10		10-20	10-20	6-20	Angular	2-5	20-60	Sub-angular	Few		as far as we could get access	1-1.5	Grab
			3	CLAY	Medium Clay	Brown		5-10		10-20	10-20	6-20	Angular	2-5	20-60	Sub-angular	Few		gravelly ironstone throughout	2.5-3	Grab
			c																	composite	Composite
726a	8/10/2023	3	0.5	CLAY	Medium Clay	Brown	Red			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Few	topsoil		0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Red			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Few			1-1.5	Grab
			3	CLAY	Medium Clay	Brown	Red			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Few			2.5-3	Grab
			c																	composite	Composite
726b	8/10/2023	3	0.5	CLAY	Medium Clay	Brown	Red			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Few	topsoil	some weak angular pale brown frags 50mm, gra	0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Red			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Few		gravelly ironstone	1-1.5	Grab
			3	CLAY	Medium Heavy Clay	Brown				5-10	5-10	6-20	Angular				Few		change to brown clay diffues at 2.5	2.5-3	Grab
			c																	composite	Composite
726c	8/10/2023	3	0.5	CLAY	Medium Clay	Brown	Red	10-20		10-20	10-20	6-20	Sub-angular				Few	topsoil	pale brown material 10-20%	0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Red	10-20		10-20	10-20	6-20	Sub-angular				Few		pale brown material 10-20%	1-1.5	Grab
			3	CLAY	Medium Clay	Pale Brown				5-10	5-10	6-20	Angular				Few			2.5-3	Grab
			c																	composite	Composite
726d	8/10/2023	3	0.5	CLAY	Medium Clay	Red	Brown			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Few	topsoil		0-0.5	Grab
			1	CLAY	Medium Clay	Red	Brown			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Few			1-1.5	Grab
			3	CLAY	Medium Clay	Red	Brown			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Few			2.5-3	Grab
			c																	composite	Composite
716a	8/10/2023	3	0.5	CLAY	Light Medium Clay	Red	Brown			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Few	topsoil	gravellg ironstone throughout	0-0.5	Grab
			1	CLAY	Light Medium Clay	Red	Brown			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Nil			1-1.5	Grab
			3	CLAY	Light Medium Clay	Red	Brown			10-20	10-20	6-20	Sub-angular	2-5	20-60	Sub-angular	Nil			2.5-3	Grab
			c																	composite	Composite
625	9/10/2023	3	0.5	CLAY	Medium Clay	Dark Brown	Brown			20-30	20-30	6-20	Sub-angular				Common	topsoil	small coarse fragments throughout	0-0.5	Grab
			1	CLAY	Medium Clay	Brown	Pale Brown			20-30	20-30	6-20	Sub-angular				Common		small coarse fragments throughout	1-1.5	Grab
			3	CLAY	Medium Clay	Brown	Pale Brown			20-30	20-30	20-60	Sub-angular				Few			2.5-3	Grab
			c																	composite	Composite
716b	9/10/2023	2	0.5	CLAY	Light Medium Clay	Pale Red	Pale Brown			5-10	5-10	20-60	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Pale Red				10-20	10-20	20-60	Sub-angular				Few			0.5-1	Grab
			2	CLAY	Light Medium Clay	Pale Red	Pale Brown			10-20	10-20	20-60	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
704a	10/10/2023	2	0.5	LOAM	Clay Loam Sandy	Pale Brown				5-10	5-10	20-60	Sub-angular				Common	topsoil	very compacted	0-0.5	Grab
			1	LOAM	Clay Loam Sandy	Pale Brown				5-10	5-10	20-60	Sub-angular				Few			0.5-1	Grab
			2	LOAM	Clay Loam Sandy	Pale Brown				5-10	5-10	20-60	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
704b	10/10/2023	3	0.5	LOAM	Silty Clay Loam	Pale Brown				2-5	2-5	6-20	Sub-angular				Many	topsoil		0-0.5	Grab
			1	LOAM	Silty Clay Loam	Pale Brown				2-5	2-5	6-20	Sub-angular				Common			1-1.5	Grab
			3	LOAM	Silty Clay Loam	Pale Brown				2-5	2-5	6-20	Sub-angular				Few			2.5-3	Grab
			c																	composite	Composite
704c	10/10/2023	2	0.5	CLAY	Light Clay	Pale Brown				20-30	20-30	6-20	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Clay	Pale Brown				20-30	20-30	6-20	Sub-angular				Few			0.5-1	Grab
			2	CLAY	Light Clay	Pale Brown				20-30	20-30	6-20	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
704d	10/10/2023	2	0.5	CLAY	Light Clay	Pale Brown	Pale Grey			10-20	10-20	6-20	Angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Clay	Pale Brown				5-10	5-10	6-20	Sub-angular				Few			0.5-1	Grab
			2	CLAY	Light Clay	Pale Brown				5-10	5-10	6-20	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite

Site ID	Date	Total Depth (m)	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)				Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Roots	Origin (i.e topsoil, subsoil, overburden); Parent Materials; and Proportions	Comments	Sample ID / Depth (m)	Sample Type
						Primary	Secondary	Mottles	Streaks		%	Size	Shape	%	Size (mm)	Shape					
704e	10/10/2023	2	0.5	CLAY	Light Medium Clay	Pale Brown	Pale Grey			20-30	20-30	20-60	Sub-angular				Common			0-0.5	Grab
			1	CLAY	Light Clay	Pale Brown	Pale Grey			20-30	20-30	20-60	Sub-angular				Few			0.5-1	Grab
			2	CLAY	Light Clay	Pale Brown	Pale Grey			20-30	20-30	20-60	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
704f	10/10/2023	2	0.5	CLAY	Light Medium Clay	Pale Brown	Pale Red			2-5	2-5	2-6	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Pale Brown	Pale Red			2-5	2-5	2-6	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Light Medium Clay	Pale Brown				5-10	5-10	20-60	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
704g	10/10/2023	2	0.5	CLAY	Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Many	topsoil	compacted	0-0.5	Grab
			1	CLAY	Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Many			0.5-1	Grab
			2	CLAY	Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Common			1.5-2	Grab
			c																	composite	Composite
704h	11/10/2023	2	0.5	CLAY	Light Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Many	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Light Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Common			1.5-2	Grab
			c																	composite	Composite
704i	11/10/2023	2	0.5	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Few			0.5-1	Grab
			2	CLAY	Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
704j	11/10/2023	2	0.5	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Angular				Common		red/maroon and grey coarse fragments 20mm	0.5-1	Grab
			2	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Angular				Few		red/maroon and grey coarse fragments 20mm	1.5-2	Grab
			c																	composite	Composite
704k	11/10/2023	2	0.5	CLAY	Medium Clay	Brown	Pale Brown			2-5	2-5	2-6	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
704L	11/10/2023	2	0.5	CLAY	Light Clay	Dark Brown	Pale Red			2-5	2-5	6-20	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Clay	Brown	Pale Brown			2-5	2-5	20-60	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Light Medium Clay	Brown	Pale Brown			2-5	2-5	20-60	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
704m	11/10/2023	2	0.5	CLAY	Light Medium Clay	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Medium Clay	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Few		white material on pit face, possibly carbonates	1.5-2	Grab
			c																	composite	Composite
704n	11/10/2023	2	0.5	CLAY	Light Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Many	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Light Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
704o	11/10/2023	2	0.5	CLAY	Light Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Common	topsoil	very compacted	0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown				2-5	2-5	2-6	Sub-angular				Few			0.5-1	Grab
			2	CLAY	Light Medium Clay	Brown	Pale Red			2-5	2-5	2-6	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
707	11/10/2023	2	0.5	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Few			0.5-1	Grab
			2	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
708a	11/10/2023	2	0.5	CLAY	Medium Clay	Brown				5-10	5-10	6-20	Angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Medium Clay	Brown				5-10	5-10	20-60	Angular				Few		grey rock	0.5-1	Grab
			2	CLAY	Medium Clay	Brown				2-5	2-5	6-20	Angular				Few			1.5-2	Grab
			c																	composite	Composite
708b	12/10/2023	2	0.5	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Few			0.5-1	Grab
			2	CLAY	Light Medium Clay	Brown	Pale Brown			2-5	2-5	20-60	Sub-angular				Nil			1.5-2	Grab
			c																	composite	Composite
708c	12/10/2023	3	0.5	CLAY	Light Medium Clay	Pale Brown				10-20	10-20	20-60	Sub-angular				Few	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Pale Brown				10-20	10-20	20-60	Sub-angular				Few			1-1.5	Grab
			3	CLAY	Light Medium Clay	Pale Brown	Brown			10-20	10-20	20-60	Sub-angular				Nil			2.5-3	Grab
			c																	composite	Composite

Site ID	Date	Total Depth (m)	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)				Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Roots	Origin (i.e topsoil, subsoil, overburden); Parent Materials; and Proportions	Comments	Sample ID / Depth (m)	Sample Type
						Primary	Secondary	Mottles	Streaks		%	Size	Shape	%	Size (mm)	Shape					
708d	12/10/2023	2	0.5	CLAY	Medium Clay	Brown	Dark Brown			2-5	2-5	6-20	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Common			1.5-2	Grab
			c																	composite	Composite
709	12/10/2023	3	0.5	CLAY	Medium Clay	Brown	Dark Brown			5-10	5-10	6-20	Sub-angular				Few	topsoil		0-0.5	Grab
			1	CLAY	Medium Clay	Brown				10-20	10-20	6-20	Sub-angular				Few			1-1.5	Grab
			3	CLAY	Medium Clay	Brown	Dark Brown			20-30	20-30	6-20	Sub-angular				Nil			2.5-3	Grab
			c																	composite	Composite
666a	12/10/2023	3	0.5	LOAM	Sandy Clay Loam	Brown				2-5	2-5	6-20	Sub-angular				Many	topsoil	probably mixed pile	0-0.5	Grab
			1	LOAM	Sandy Clay Loam	Brown	Pale Brown			2-5	2-5	6-20	Sub-angular				Common			1-1.5	Grab
			3	LOAM	Sandy Clay Loam	Brown	Dark Brown			2-5	2-5	6-20	Sub-angular				Common			2.5-3	Grab
			c																	composite	Composite
666b	12/10/2023	3	0.5	LOAM	Light Clay	Brown				5-10	5-10	6-20	Sub-angular				Many	topsoil	mixed pile. timber mixed in	0-0.5	Grab
			1	LOAM	Sandy Clay Loam	Dark Brown	Brown			5-10	5-10	6-20	Sub-angular				Common			1-1.5	Grab
			3	LOAM	Sandy Clay Loam	Dark Brown	Brown			5-10	5-10	6-20	Sub-angular				Few			2.5-3	Grab
			c																	composite	Composite
664a	12/10/2023	3	0.5	LOAM	Clay Loam Sandy	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Common	topsoil		0-0.5	Grab
			1	LOAM	Clay Loam Sandy	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Few			1-1.5	Grab
			3	LOAM	Sandy Clay Loam	Dark Brown	Brown			5-10	5-10	6-20	Sub-angular				Few			2.5-3	Grab
			c																	composite	Composite
664b	12/10/2023	3	0.5	CLAY	Light Medium Clay	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Many	topsoil		0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Common			1-1.5	Grab
			3	CLAY	Silty Clay Loam	Brown	Dark Brown			5-10	5-10	6-20	Sub-angular				Few			2.5-3	Grab
			c																	composite	Composite
662a	12/10/2023	3	0.5	LOAM	Sandy Clay Loam	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Many	topsoil		0-0.5	Grab
			1	LOAM	Sandy Clay Loam	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Few			1-1.5	Grab
			3	LOAM	Sandy Clay Loam	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Few			2.5-3	Grab
			c																	composite	Composite
662b	12/10/2023	3	0.5	LOAM	Sandy Clay Loam	Brown	Pale Brown			2-5	2-5	6-20	Sub-angular				Many	topsoil		0-0.5	Grab
			1	LOAM	Sandy Clay Loam	Brown	Pale Brown			2-5	2-5	6-20	Sub-angular				Common			1-1.5	Grab
			3	LOAM	Sandy Clay Loam	Brown	Pale Brown			2-5	2-5	6-20	Sub-angular				Few			2.5-3	Grab
			c																	composite	Composite
665	12/10/2023	3	0.5	LOAM	Sandy Clay Loam	Grey	Pale Brown			2-5	2-5	6-20	Sub-angular				Many	topsoil		0-0.5	Grab
			1	LOAM	Sandy Clay Loam	Grey	Pale Brown			2-5	2-5	6-20	Sub-angular				Common			1-1.5	Grab
			3	LOAM	Sandy Clay Loam	Pale Brown	Pale Grey			2-5	2-5	6-20	Sub-angular				Few			2.5-3	Grab
			c																	composite	Composite
667	12/10/2023	2	0.5	LOAM	Sandy Clay Loam	Pale Brown				20-30	20-30	6-20	Sub-angular				Few	topsoil	stony surface	0-0.5	Grab
			1	LOAM	Sandy Clay Loam	Pale Brown		2-5		20-30	20-30	6-20	Sub-angular				Few			0.5-1	Grab
			2	LOAM	Sandy Clay Loam	Pale Brown	Pale Red			10-20	10-20	6-20	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
678a	13/10/2023	2	0.5	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Many	topsoil	photo shows incorrect depth of 1-1.5. sample b	0-0.5	Grab
			1	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Common		very compacted	0.5-1	Grab
			2	CLAY	Light Medium Clay	Brown				2-5	2-5	6-20	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
680a	13/10/2023	2	0.5	LOAM	Clay Loam Sandy	Brown	Pale Brown			2-5	2-5	2-6	Sub-angular				Common	topsoil		0-0.5	Grab
			1	LOAM	Clay Loam Sandy	Brown	Pale Brown			2-5	2-5	2-6	Sub-angular				Common			0.5-1	Grab
			2	LOAM	Sandy Clay Loam	Brown				2-5	2-5	2-6	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
680b	13/10/2023	2	0.5	LOAM	Sandy Clay Loam	Brown				2-5	2-5	2-6	Sub-angular				Common	topsoil		0-0.5	Grab
			1	LOAM	Sandy Clay Loam	Brown				2-5	2-5	2-6	Sub-angular				Common			0.5-1	Grab
			2	LOAM	Sandy Clay Loam	Brown				2-5	2-5	2-6	Sub-angular				Few			1.5-2	Grab
			c		Sandy Clay Loam															composite	Composite
680c	13/10/2023	2	0.5	CLAY	Light Clay	Brown				5-10	5-10	6-20	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Clay	Brown				5-10	5-10	6-20	Sub-angular				Few			0.5-1	Grab
			2	CLAY	Light Clay	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite
680d	13/10/2023	2	0.5	LOAM	Sandy Clay Loam	Brown	Pale Brown			2-5	2-5	2-6	Sub-angular				Common	topsoil		0-0.5	Grab
			1	LOAM	Sandy Clay Loam	Brown	Pale Brown			2-5	2-5	2-6	Sub-angular				Common			0.5-1	Grab
			2	LOAM	Sandy Clay Loam	Brown	Pale Brown			2-5	2-5	2-6	Sub-angular				Few			1.5-2	Grab
			c																	composite	Composite

Site ID	Date	Total Depth (m)	Layer Depth (m)	Texture Group 1o	Texture Field	Colour (rapid)				Total Coarse Fragment %	Coarse Fragments 1°			Coarse Fragments 2°			Roots	Origin (i.e topsoil, subsoil, overburden); Parent Materials; and Proportions	Comments	Sample ID / Depth (m)	Sample Type
						Primary	Secondary	Mottles	Streaks		%	Size	Shape	%	Size (mm)	Shape					
678b	13/10/2023	2	0.5	CLAY	Light Clay	Brown				5-10	5-10	2-6	Sub-angular				Common	topsoil		0-0.5	Grab
			1	CLAY	Light Clay	Brown				5-10	5-10	2-6	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Light Clay	Brown				5-10	5-10	6-20	Sub-angular				Common			1.5-2	Grab
			c																	composite	Composite
675	13/10/2023	2	0.5	CLAY	Light Clay	Brown	Pale Brown			5-10	5-10	6-20	Sub-angular				Common	topsoil	compacted	0-0.5	Grab
			1	CLAY	Light Clay	Brown	Pale Brown			10-20	10-20	6-20	Sub-angular				Common			0.5-1	Grab
			2	CLAY	Light Clay	Brown	Dark Brown			5-10	5-10	6-20	Sub-angular				Common			1.5-2	Grab
			c																	composite	Composite
694	6/10/2023	4	1	LOAM	Sandy Clay Loam	Brown				0							Common	Topsoil		0-0.5	grab
			2	LOAM	Light Medium Clay	Brown		10-20	5-10	0							Few	Topsoil	mottles of g r ey MC and streaks of orange	1-1.5	grab
			3	LOAM	Clay Loam Sandy	Brown		10-20	5-10	0							Nil	Topsoil	mottles of g r ey MC and streaks of orange	2.5-3	grab
			4																	Composite	Composite
695	6/10/2023	6	1	CLAY	Light Clay	Brown				5-10	5-10	6-20	Angular				Common	subsoil	grey and orang mottled subsoily material, 20t e	0-0.5	grab
			2	CLAY	Light Clay	Brown				10-20	5-10	6-20	Angular	5-10	20-60	Sub-rounde	Few	subsoil	pale grey clay cgunks with small angular frags	1-1.5	grab
			3	CLAY	Light Clay	Brown				10-20	5-10	6-20	Angular	5-10	20-60	Sub-rounde	Nil	subsoil	dark grey MHC 5% In clumps	2.5-3	grab
			4																	Composite	Composite
696	6/10/2023	4	1	LOAM	Sandy Loam	Brown		5-10		5-10	5-10	6-20	Angular				Common	Topsoil	some slight 10% light brown mottles, some silt	0-0.5	grab
			2	LOAM	Sandy Loam	Brown		5-10		5-10	5-10	6-20	Angular				Few	Topsoil	some slight 10% light brown mottles, some silt	1-1.5	grab
			3	LOAM	Sandy Loam	Brown		5-10		5-10	5-10	6-20	Angular				Nil	Topsoil	some slight 10% light brown mottles,some silt	2.5-3	grab
			4																	Composite	Composite
696b	6/10/2023	3	1	LOAM	Sandy Loam	Brown		0									Common	Topsoil	5-10% of a orange grey mottled clay loamsandy	0-0.5	grab
			2	LOAM	Sandy Clay Loam	Brown		0									Few	Topsoil	10-20% of a orange grey mottled clay loamsand	1-1.5	grab
			3	LOAM	Sandy Clay Loam	Brown		0									Few	Topsoil	10-20% of a orange grey mottled clay loamsand	2.5-3	grab
			4																	Composite	Composite
687a	9/10/2023	4	1	CLAY	Medium Clay	Brown				5-10	5-10	6-20	Angular				Common	Topsoil	moderate strength angular mudstones, MC san	0-0.5	grab
			2	CLAY	Medium Clay	Brown				5-10	5-10	6-20	Angular				Few	Topsoil	moderate strength angular mudstones, MC san	1-1.5	grab
			3	CLAY	Medium Clay	Brown				5-10	5-10	6-20	Angular				Few	Topsoil	moderate strength angular mudstones, MC san	2.5-3	grab
			4																	Composite	Composite
687b	9/10/2023	5	1	CLAY	Clay Loam Sandy	Brown	Pale Brown			0							Common	Topsoil	pale brown sandy loam material intermixed, la	0-0.5	grab
			2	CLAY	Medium Clay	Brown				0							Nil	Topsoil	MC sandy	1-1.5	grab
			3	CLAY	Medium Clay	Dark Brown				0							Nil	Topsoil	very hard to excavate this material, couldnt tex	2.5-3	grab
			4																occasional bare patch sandy and gravelly	Composite	Composite
685	9/10/2023	2.5	1	CLAY	Clay Loam Sandy	Brown	Orange			0							Common	Topsoil	orange brown material, layer extends to approx	0-0.5	grab
			2	CLAY	Medium Clay	Brown	Orange			0							Few	Topsoil	MC sandy	0.5-1	grab
			3	CLAY	Medium Clay	Orange				0							Few	Topsoil	MC sandy with dark brown clay material 10-20%	2-2.5	grab
			4																	Composite	Composite

Table B-4: Laboratory analysis data for loam topsoils. Part 1 of 2.

Laboratory Results Loams														
	Lab No	232027-108	232027-112	232027-192	232027-196	232027-200	232027-208	232027-212	232027-216	232027-220	232027-228	232027-232	232027-240	232027-252
	Sample ID	704a	704b	666a	666b	664a	662a	662b	665	667	680a	680b	680d	694
	Sample Depth	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
	Field Texture	CLS	CL	SCL	SCL	SCL	SCL	SCL	SCL	SCL	SCL	SCL	SCL	CLS
Analyses	Unit	-	-	-	-	-	-	-	-	-	-	-	-	-
pH - Water	pH units	9.13	6.89	7.17	7.35	7.13	6.37	6.76	6.78	7.46	7.02	7.68	6.37	8.21
Electrical Conductivity	dS/m	0.23	0.11	0.06	0.06	0.07	0.05	0.04	0.04	0.1	0.02	0.05	0.03	0.07
Chloride	mg/kg	47.0	27.1	18.6	20.1	42.6	31.2	15.3	24.7	50.7	<5.00	10.3	9.6	29.8
Total Nitrogen - Kjeldahl	mg/kg	435.0	539.0	783.0	635.0	758.0	674.0	487.0	333.0	193.0	227.0	171.0	166.0	293.0
Phosphorus - Colwell extr	mg/kg	6.18	13.1	14.1	6.63	8.78	11.1	5.07	6.43	5.26	6.82	<5.00	<5.00	5.65
Potassium - Colwell ext	mg/kg	98.10	181.00	169.00	190.00	241.00	153.00	174.00	145.00	124.00	153.00	193.00	180.00	150.00
Sulphur - KCl	mg/kg	15.9	20.5	14.6	6.6	7.5	4.1	6.5	6.4	13.2	<3.00	7.3	8.5	7.5
Organic Carbon	%	0.76	0.74	1.51	0.79	1.03	1.03	0.54	0.51	<0.20	0.52	0.49	<0.20	0.39
Copper	mg/kg	0.6	0.92	1.02	1.12	1.28	0.98	0.7	0.56	0.22	0.35	0.2	0.22	0.7
Iron	mg/kg	10.10	12.40	63.20	43.20	32.40	53.20	30.50	19.60	6.62	6.67	6.04	5.96	8.48
Manganese	mg/kg	6.90	15.50	28.80	43.90	91.30	21.20	15.30	12.70	4.06	8.37	3.10	4.36	13.00
Zinc	mg/kg	0.28	0.20	0.40	0.48	0.56	0.54	0.34	0.30	0.28	0.26	0.24	0.24	0.28
Boron	mg/kg	1.42	0.74	0.72	0.70	0.66	0.62	0.48	0.58	1.42	0.78	0.98	0.48	0.56
Cation Extraction Method	Rayment& Lyons	15C1	15A1	15C1	15C1	15A1	15A1	15A1	15A1	15C1	15A1	15C1	15A1	15C1
Cation Exchange Capacity	meq/100g	11.6	9.3	2.7	2.9	5.9	5.3	4.0	4.0	2.2	4.5	1.7	2.8	4.8
Ex Calcium Percent	%	47.08	58.42	76.43	72.29	72.32	74.92	72.86	65.04	53.58	69.42	66.98	46.21	56.35
Ex Magnesium Percent	%	37.97	32.57	12.77	14.88	22.00	20.73	22.63	24.79	29.53	26.63	15.51	40.17	33.78
Ex Potassium Percent	%	1.55	4.87	8.39	9.33	3.91	1.59	1.98	7.24	8.49	2.43	12.74	11.24	4.23
Ex Sodium Percent	%	13.20	3.9	1.60	2.74	1.4	2.3	2.0	2.4	7.39	1.0	3.45	1.6	5.18
Ex Aluminium Percent	%	0.19	0.24	0.82	0.76	0.38	0.42	0.55	0.56	1.01	0.49	1.32	0.81	0.46
Exchangeable Calcium	mg/kg	1089	1082	416	425	849	801	585	516	235	630	226	255	545
Exchangeable Magnesium	mg/kg	527	362	41.7	52.5	155	133	109	118	77.7	145	31.4	133	196
Exchangeable Potassium	mg/kg	70.1	176	89	107	89.6	33.2	31	112	72.6	43	83.8	121	79.8
Exchangeable Sodium	mg/kg	351	83	10	18.5	18.7	28.8	18.3	21.7	37.3	10.8	13.4	10	57.6
Exchangeable Aluminium	mg/kg	2	2.00	2	2	2.00	2.00	2.00	2.00	2	2.00	2	2.00	2
Exchangeable Calcium	meq/100g	5.45	5.41	2.08	2.13	4.25	4.01	2.93	2.58	1.18	3.15	1.13	1.28	2.73
Exchangeable Magnesium	meq/100g	4.39	3.02	0.35	0.44	1.29	1.11	0.91	0.98	0.65	1.21	0.26	1.11	1.63
Exchangeable Potassium	meq/100g	0.18	0.45	0.23	0.27	0.23	0.09	0.08	0.29	0.19	0.11	0.21	0.31	0.20
Exchangeable Sodium	meq/100g	1.53	0.36	0.04	0.08	0.08	0.13	0.08	0.09	0.16	0.05	0.06	0.04	0.25
Exchangeable Aluminium	meq/100g	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Calcium/Magnesium Ratio	-	1.2	1.8	6.0	4.9	3.3	3.6	3.2	2.6	1.8	2.6	4.3	1.2	1.7
Emerson Aggregate	Class	2	3a	7	3b	3b	3b	3b	3b	5	3b	3a	5	3a
Phosphorus Buffer Index	mg/kg	65.7	56.3	41.1	49.2	41.3	50.2	29.8	28.1	58.9	31.4	34.1	45.5	29.9
Gypsum Amelioration	kg/m^3	1.45	0.30	0.00	0.00	0.04	0.05	0.00	0.00	0.00	0.01	0.00	0.00	0.06

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B-4: Laboratory analysis data for loam topsoils. Part 2 of 2.

Laboratory Results Loams													
	Lab No	232027-260	232027-264	Mean	LCL 95%	UCL 95%	Std Dev	Count	CI 95% (+/-)	10%ile	90%ile	Min	Max
	Sample ID	696	696b										
	Sample Depth	Composite	Composite										
	Field Texture	SCL	SCL										
Analyses	Unit	-	-										
pH - Water	pH units	7.41	8.4	7.3	7.0	7.7	0.8	15	0.4	6.5	8.3	6.4	9.1
Electrical Conductivity	dS/m	0.04	0.05	0.1	0.0	0.1	0.1	15	0.0	0.0	0.1	0.0	0.2
Chloride	mg/kg	10.9	9.9	24.8	17.5	32.2	14.0	14	7.3	10.0	45.7	9.6	50.7
Total Nitrogen - Kjeldahl	mg/kg	172.0	206.0	404.8	290.2	519.4	226.5	15	114.6	171.4	724.4	166.0	783.0
Phosphorus - Colwell extr	mg/kg	<5.00	<5.00	8.1	6.2	10.0	3.2	11	1.9	5.3	13.1	5.1	14.1
Potassium - Colwell ext	mg/kg	139.00	143.00	162.2	145.2	179.2	33.7	15	17.0	130.0	191.8	98.1	241.0
Sulphur - KCl	mg/kg	7.1	4.4	9.3	6.8	11.8	4.8	14	2.5	5.0	15.5	4.1	20.5
Organic Carbon	%	<0.20	0.21	0.7	0.5	0.9	0.4	12	0.2	0.4	1.0	0.2	1.5
Copper	mg/kg	0.28	0.32	0.6	0.4	0.8	0.4	15	0.2	0.2	1.1	0.2	1.3
Iron	mg/kg	7.28	5.30	20.7	11.0	30.5	19.2	15	9.7	6.0	49.2	5.3	63.2
Manganese	mg/kg	12.90	6.64	19.2	7.7	30.7	22.7	15	11.5	4.2	37.9	3.1	91.3
Zinc	mg/kg	0.26	0.48	0.3	0.3	0.4	0.1	15	0.1	0.2	0.5	0.2	0.6
Boron	mg/kg	0.34	0.56	0.7	0.6	0.9	0.3	15	0.2	0.5	1.2	0.3	1.4
Cation Extraction Method	Rayment& Lyons	15C1	15C1	*	*	*	*	0	*	*	*	0.0	0.0
Cation Exchange Capacity	meq/100g	1.5	3.6	4.5	3.0	5.9	2.8	15	1.4	1.9	7.9	1.5	11.6
Ex Calcium Percent	%	63.84	58.16	63.6	58.6	68.6	9.9	15	5.0	49.7	74.1	46.2	76.4
Ex Magnesium Percent	%	21.28	29.68	25.7	21.5	29.9	8.3	15	4.2	15.1	36.3	12.8	40.2
Ex Potassium Percent	%	10.44	4.92	6.2	4.3	8.1	3.7	15	1.9	1.7	10.9	1.6	12.7
Ex Sodium Percent	%	2.94	6.63	3.8	2.2	5.5	3.2	15	1.6	1.5	7.1	1.0	13.2
Ex Aluminium Percent	%	1.50	0.62	0.7	0.5	0.9	0.4	15	0.2	0.3	1.2	0.2	1.5
Exchangeable Calcium	mg/kg	189	418	550.7	402.1	699.3	293.7	15	148.6	229.6	988.8	189.0	1089.0
Exchangeable Magnesium	mg/kg	37.8	128	149.8	82.7	216.9	132.6	15	67.1	39.4	295.6	31.4	527.0
Exchangeable Potassium	mg/kg	60.3	68.9	82.5	63.7	101.3	37.2	15	18.8	37.1	117.4	31.0	176.0
Exchangeable Sodium	mg/kg	10	54.8	49.6	6.0	93.2	86.1	15	43.6	10.0	72.8	10.0	351.0
Exchangeable Aluminium	mg/kg	2	2	2.0	2.0	2.0	0.0	15	0.0	2.0	2.0	2.0	2.0
Exchangeable Calcium	meq/100g	0.95	2.09	2.8	2.0	3.5	1.5	15	0.7	1.1	4.9	0.9	5.4
Exchangeable Magnesium	meq/100g	0.32	1.07	1.2	0.7	1.8	1.1	15	0.6	0.3	2.5	0.3	4.4
Exchangeable Potassium	meq/100g	0.15	0.18	0.2	0.2	0.3	0.1	15	0.0	0.1	0.3	0.1	0.5
Exchangeable Sodium	meq/100g	0.04	0.24	0.2	0.0	0.4	0.4	15	0.2	0.0	0.3	0.0	1.5
Exchangeable Aluminium	meq/100g	0.02	0.02	0.02	0.02	0.02	0.00	15.00	0.00	0.02	0.02	0.02	0.02
Calcium/Magnesium Ratio	-	3.0	2.0	2.9	2.2	3.6	1.4	15	0.7	1.4	4.6	1.2	6.0
Emerson Aggregate	Class	5	3b	4.8	3.2	6.4	1.8	5	1.6	3.2	6.2	2.0	7.0
Phosphorus Buffer Index	mg/kg	19.7	31.4	40.8	34.2	47.5	13.2	15	6.7	28.8	57.9	19.7	65.7
Gypsum Amelioration	kg/m^3	0.00	0.00	0.03									

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B-5: Laboratory analysis data for clay topsoils. Part 1 of 5.

Laboratory Results Clays																
	Lab No	232027-4	232027-8	232027-12	232027-16	232027-20	232027-24	232027-28	232027-32	232027-36	232027-40	232027-44	232027-48	232027-52	232027-56	232027-60
	Sample ID	649	634a	634b	634c	634d	634e	634f	755a	755b	755c	755d	755e	755f	730	729
	Sample Depth	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
	Field Texture	LC	LMC	LMC	LMC	LMC	MC	LMC	LMC	LMC	LMC	MC	LMC	LMC	LC	MC
Analyses	Unit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH - Water	pH units	9.16	9.19	9.14	8.84	8.57	8.55	8.68	8.61	9.03	8.52	8.44	8.62	8.59	8.33	9.05
Electrical Conductivity	dS/m	0.36	0.91	1.05	0.45	0.76	0.68	0.63	0.76	0.48	1	1.27	1.02	1.07	0.3	0.91
Chloride	mg/kg	137.0	887.0	1150.0	247.0	885.0	569.0	491.0	881.0	297.0	1320.0	1910.0	1310.0	1520.0	138.0	932.0
Total Nitrogen - Kjeldahl	mg/kg	426.0	414.0	460.0	619.0	518.0	765.0	381.0	510.0	711.0	633.0	496.0	531.0	403.0	1052.0	540.0
Phosphorus - Colwell extr	mg/kg	<5.00	<5.00	11.0	22.2	16.9	5.1	<5.00	7.03	6.37	15.6	6.59	7.91	7.91	10.1	<5.00
Potassium - Colwell ext	mg/kg	62.70	56.20	72.10	213.00	63.70	72.50	60.70	73.60	83.70	98.30	68.50	65.90	49.90	109.00	87.80
Sulphur - KCl	mg/kg	24.3	58.6	78.5	29.6	7.4	36.8	29.5	48.8	40.5	25.7	41.5	51.9	47.8	35.6	59.1
Organic Carbon	%	0.85	0.46	0.69	0.83	1.20	1.17	0.38	0.65	0.74	0.78	0.49	0.61	0.48	1.36	0.61
Copper	mg/kg	0.47	0.62	0.86	0.60	0.64	0.86	0.28	0.54	0.84	0.66	1.3	0.68	0.68	1.2	0.82
Iron	mg/kg	11.00	12.10	11.80	11.30	12.40	16.10	9.66	9.72	12.70	13.30	21.60	12.80	13.70	14.20	21.80
Manganese	mg/kg	15.90	14.60	14.40	12.40	12.60	20.10	12.40	12.10	16.80	13.60	17.80	13.00	14.00	19.60	15.60
Zinc	mg/kg	0.48	0.46	0.52	0.62	0.58	0.54	0.44	0.58	0.58	0.66	0.82	0.54	0.52	0.82	0.54
Boron	mg/kg	1.72	2.50	2.76	1.84	2.04	1.64	2.24	1.84	2.12	2.35	2.18	2.00	1.90	0.84	2.22
Cation Extraction Method	Rayment& Lyons	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1
Cation Exchange Capacity	meq/100g	12.3	18.4	21.2	11.6	9.7	20.3	12.3	11.1	27.7	11.3	21.8	15.8	17.6	10.0	24.0
Ex Calcium Percent	%	40.97	32.95	31.29	38.66	37.80	42.66	43.56	40.58	42.34	33.97	46.11	36.23	36.16	58.17	34.31
Ex Magnesium Percent	%	44.87	42.93	44.21	44.51	43.31	42.07	40.50	44.08	44.34	44.20	35.54	46.28	47.22	34.32	45.61
Ex Potassium Percent	%	1.06	0.61	0.71	3.05	1.37	0.74	1.07	1.44	0.68	1.65	0.64	0.88	0.64	1.97	0.73
Ex Sodium Percent	%	12.92	23.39	23.68	13.58	17.28	14.43	14.70	13.70	12.57	19.98	17.61	16.46	15.86	5.32	19.26
Ex Aluminium Percent	%	0.18	0.12	0.10	0.19	0.23	0.11	0.18	0.20	0.08	0.20	0.10	0.14	0.13	0.22	0.09
Exchangeable Calcium	mg/kg	1009	1215	1326	896	736	1736	1072	899	2346	766	2013	1143	1275	1161	1650
Exchangeable Magnesium	mg/kg	663	950	1124	619	506	1027	598	586	1474	598	931	876	999	411	1316
Exchangeable Potassium	mg/kg	50.9	43.9	59	138	52.1	58.4	51.2	62.4	73	72.7	54.7	54.4	44.2	76.6	68.4
Exchangeable Sodium	mg/kg	366	992	1154	362	387	675	416	349	801	518	884	597	643	122	1065
Exchangeable Aluminium	mg/kg	2.0	2.0	2.0	2.0	2.0	2.0	2	2	2	2	2	2	2	2	2
Exchangeable Calcium	meq/100g	5.05	6.08	6.63	4.48	3.68	8.68	5.36	4.50	11.73	3.83	10.07	5.72	6.38	5.81	8.25
Exchangeable Magnesium	meq/100g	5.53	7.92	9.37	5.16	4.22	8.56	4.98	4.88	12.28	4.98	7.76	7.30	8.33	3.43	10.97
Exchangeable Potassium	meq/100g	0.13	0.11	0.15	0.35	0.13	0.15	0.13	0.16	0.19	0.19	0.14	0.14	0.11	0.20	0.18
Exchangeable Sodium	meq/100g	1.59	4.31	5.02	1.57	1.68	2.93	1.81	1.52	3.48	2.25	3.84	2.60	2.80	0.53	4.63
Exchangeable Aluminium	meq/100g	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Calcium/Magnesium Ratio	-	0.9	0.8	0.7	0.9	0.9	1.0	1.1	0.9	1.0	0.8	1.3	0.8	0.8	1.7	0.8
Emerson Aggregate	Class	7.0	4.0	2.0	4.0	2.0	7.0	4	4	4	5	6	4	4	5	4
Phosphorus Buffer Index	mg/kg	61.1	63.0	67.4	67.2	77.8	70.9	84.8	69	66.6	107	62.2	80.8	64.6	60.7	79.9
Gypsum Amelioration	kg/m^3	1.56	4.91	5.92	1.50	1.44	3.43	1.78	1.41	4.34	2.11	4.57	2.82	3.15	0.46	5.62

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B-5: Laboratory analysis data for clay topsoils. Part 2 of 5.

Laboratory Results Clays																
	Lab No	232027-64	232027-68	232027-72	232027-76	232027-80	232027-84	232027-88	232027-92	232027-96	232027-100	232027-104	232027-116	232027-120	232027-124	232027-128
	Sample ID	731	735a	735b	735c	726a	726b	726c	726d	716a	625	716b	704c	704d	704e	704f
	Sample Depth	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
	Field Texture	LMC	LC	LMC	LC	LMC	LMC	LC	LC	LMC	LMC	LMC	LC	LC	LC	LC
Analyses	Unit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH - Water	pH units	8.51	8.5	8.29	8.87	8.61	8.69	8.38	7.71	7.42	8.58	7.26	8.63	8.65	8.58	8.32
Electrical Conductivity	dS/m	0.81	0.74	2.03	0.33	0.9	0.38	1.57	0.96	0.37	0.88	0.75	0.28	0.49	0.5	0.13
Chloride	mg/kg	984.0	994.0	2900.0	209.0	1060.0	216.0	2310.0	1380.0	262.0	1203.0	930.0	143.0	423.0	535.0	52.5
Total Nitrogen - Kjeldahl	mg/kg	458.0	428.0	575.0	598.0	612.0	778.0	492.0	440.0	851.0	1143.0	771.0	549.0	675.0	303.0	567.0
Phosphorus - Colwell extr	mg/kg	7.03	5.49	66.6	10.3	121	12.3	8.58	<5.00	13.2	42.3	22.5	9.08	11.8	9.66	10.2
Potassium - Colwell ext	mg/kg	82.00	69.80	70.80	57.50	67.80	103.00	68.20	59.70	176.00	155.00	167.00	126.00	126.00	151.00	154.00
Sulphur - KCl	mg/kg	51.2	25.0	114.0	27.4	51.4	29.9	62.3	41.8	34.0	44.4	42.3	33.8	39.5	56.1	19.5
Organic Carbon	%	0.51	0.5	0.6	0.64	1.32	1.65	0.86	0.47	1.04	1.24	1.33	0.74	1.34	0.64	0.61
Copper	mg/kg	0.74	0.7	0.64	0.88	0.82	1.08	0.82	0.48	0.68	2.96	0.68	1.14	0.98	0.56	1.14
Iron	mg/kg	10.40	17.10	11.40	13.50	12.80	17.60	10.50	11.80	10.90	14.20	14.30	11.50	9.17	9.02	12.40
Manganese	mg/kg	14.90	13.00	15.90	14.60	15.00	16.10	14.90	13.10	17.50	11.50	9.80	9.14	7.25	3.82	7.00
Zinc	mg/kg	0.52	0.54	0.52	0.56	0.56	0.60	0.58	0.54	0.60	0.64	0.32	0.22	0.30	0.28	0.24
Boron	mg/kg	2.02	2.28	2.76	1.78	2.65	1.76	2.24	2.40	1.08	2.18	1.32	1.16	1.30	1.62	1.10
Cation Extraction Method	Rayment& Lyons	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15A2	15C1	15C1	15C1	15C1
Cation Exchange Capacity	meq/100g	13.0	7.9	12.0	13.0	14.5	13.2	12.4	8.9	5.6	21.4	12.2	10.5	9.8	9.3	7.5
Ex Calcium Percent	%	49.49	24.81	36.00	41.13	38.80	50.59	39.22	41.32	75.81	37.90	44.69	52.81	48.61	37.45	56.42
Ex Magnesium Percent	%	36.99	45.47	44.98	46.00	44.83	35.16	38.85	42.79	16.09	43.58	45.29	32.13	35.12	37.61	29.39
Ex Potassium Percent	%	1.20	1.58	1.11	1.03	1.01	1.42	1.30	1.46	5.27	1.70	2.37	2.33	2.55	2.04	3.23
Ex Sodium Percent	%	12.15	27.86	17.74	11.67	15.20	12.66	20.45	14.19	2.43	16.72	7.47	12.52	13.50	22.66	10.67
Ex Aluminium Percent	%	0.17	0.28	0.19	0.17	0.15	0.17	0.18	0.25	0.40	0.10	0.18	0.21	0.23	0.24	0.29
Exchangeable Calcium	mg/kg	1289	391	863	1073	1125	1331	969	737	848	1622	1092	1104	955	697	851
Exchangeable Magnesium	mg/kg	578	430	647	720	780	555	576	458	108	1119	664	403	414	420	266
Exchangeable Potassium	mg/kg	60.8	48.5	51.7	52.6	57	73.1	62.6	50.7	115	142	113	95.1	97.8	74	94.9
Exchangeable Sodium	mg/kg	364	505	489	350	507	383	581	291	31.2	823	210	301	305	485	185
Exchangeable Aluminium	mg/kg	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Exchangeable Calcium	meq/100g	6.45	1.96	4.32	5.37	5.63	6.66	4.85	3.69	4.24	8.11	5.46	5.52	4.78	3.49	4.26
Exchangeable Magnesium	meq/100g	4.82	3.58	5.39	6.00	6.50	4.63	4.80	3.82	0.90	9.33	5.53	3.36	3.45	3.50	2.22
Exchangeable Potassium	meq/100g	0.16	0.12	0.13	0.13	0.15	0.19	0.16	0.13	0.29	0.36	0.29	0.24	0.25	0.19	0.24
Exchangeable Sodium	meq/100g	1.58	2.20	2.13	1.52	2.20	1.67	2.53	1.27	0.14	3.58	0.91	1.31	1.33	2.11	0.80
Exchangeable Aluminium	meq/100g	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Calcium/Magnesium Ratio	-	1.3	0.5	0.8	0.9	0.9	1.4	1.0	1.0	4.7	0.9	1.0	1.6	1.4	1.0	1.9
Emerson Aggregate	Class	4	2	6	2	6	3a	4	6	7	7	5	3a	3b	2	3a
Phosphorus Buffer Index	mg/kg	88.4	73.3	97.3	94.3	110	94.7	142	117	86.8	81.1	53.9	64.8	60.3	40.4	67.1
Gypsum Amelioration	kg/m^3	1.60	1.57	2.06	1.54	2.32	1.69	2.49	1.02	0.06	4.23	0.89	1.18	1.14	1.75	0.55

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B-5: Laboratory analysis data for clay topsoils. Part 3 of 5.

Laboratory Results Clays																
	Lab No	232027-132	232027-136	232027-140	232027-144	232027-148	232027-152	232027-156	232027-160	232027-164	232027-168	232027-172	232027-176	232027-180	232027-184	232027-188
	Sample ID	704g	704h	704i	704j	704k	704L	704m	704n	704o	707	708a	708b	708c	708d	709
	Sample Depth	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
	Field Texture	LMC	LMC	LMC	LMC	LMC	LC	LMC	LC	LMC	LC	LC	LC	LMC	MC	MC
Analyses	Unit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH - Water	pH units	8.82	8.94	8.52	8.63	7.84	8.67	8.98	8.33	9.01	7.38	9.15	8.47	8.6	8.45	8.74
Electrical Conductivity	dS/m	0.56	0.42	0.77	0.31	0.13	0.15	0.26	0.15	0.36	0.09	0.31	0.52	0.48	0.42	0.87
Chloride	mg/kg	542.0	328.0	772.0	278.0	81.6	8.7	100.0	39.8	257.0	31.8	78.0	564.0	493.0	265.0	775.0
Total Nitrogen - Kjeldahl	mg/kg	561.0	472.0	695.0	253.0	453.0	480.0	539.0	623.0	438.0	497.0	479.0	579.0	478.0	837.0	577.0
Phosphorus - Colwell extr	mg/kg	5.02	<5.00	9.66	<5.00	15.5	7.92	7.54	7.73	6.38	10.8	8.5	7.54	6.18	16.9	6.96
Potassium - Colwell ext	mg/kg	119.00	122.00	168.00	90.00	87.20	89.50	104.00	240.00	121.00	216.00	109.00	114.00	131.00	117.00	108.00
Sulphur - KCl	mg/kg	63.7	34.3	49.3	33.6	31.5	19.1	21.7	17.5	26.3	21.1	26.2	38.9	39.6	40.9	78.0
Organic Carbon	%	0.77	0.6	1.28	0.27	0.72	0.46	0.82	0.49	0.44	0.82	0.8	0.38	0.71	1.1	0.59
Copper	mg/kg	1	1.08	1.22	0.58	0.86	0.82	0.8	0.54	0.72	0.68	1.12	0.76	0.54	0.98	1.3
Iron	mg/kg	15.10	14.80	16.80	9.26	13.00	11.10	10.10	7.56	8.22	10.20	9.82	7.00	5.44	12.50	10.60
Manganese	mg/kg	6.34	7.34	5.46	4.58	11.40	8.82	6.52	8.32	7.28	9.94	6.50	4.16	5.34	6.18	7.12
Zinc	mg/kg	0.22	0.20	0.32	0.22	0.28	0.32	0.22	0.27	0.22	0.98	0.24	0.20	0.34	0.26	0.22
Boron	mg/kg	3.76	2.86	2.74	1.74	0.84	0.92	1.68	0.66	2.24	0.74	1.82	1.86	1.60	1.76	3.66
Cation Extraction Method	Rayment& Lyons	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1
Cation Exchange Capacity	meq/100g	16.0	13.5	15.3	8.2	9.3	7.1	9.6	5.5	9.6	7.8	9.8	8.7	10.7	15.3	19.6
Ex Calcium Percent	%	43.82	41.76	46.00	57.78	54.06	43.42	44.24	78.41	44.32	70.55	39.47	41.63	37.76	55.04	37.48
Ex Magnesium Percent	%	35.19	39.25	37.98	29.61	33.13	38.48	36.95	11.17	33.89	20.65	35.41	36.36	43.46	35.38	42.67
Ex Potassium Percent	%	1.41	1.35	1.96	1.04	0.98	1.21	1.61	6.84	2.32	5.66	1.58	1.39	1.95	1.50	1.20
Ex Sodium Percent	%	19.45	17.48	13.92	11.30	11.60	16.58	16.98	3.17	19.23	2.85	23.31	20.37	16.62	7.93	18.53
Ex Aluminium Percent	%	0.14	0.16	0.14	0.27	0.24	0.31	0.23	0.41	0.23	0.29	0.23	0.26	0.21	0.15	0.11
Exchangeable Calcium	mg/kg	1399	1128	1411	943	1009	615	852	858	850	1099	773	725	808	1683	1467
Exchangeable Magnesium	mg/kg	674	636	699	290	371	327	427	73.3	390	193	416	380	558	649	1002
Exchangeable Potassium	mg/kg	87.5	70.9	117	33.1	35.6	33.5	60.4	146	86.9	172	60.4	47.1	81.3	89.3	91.7
Exchangeable Sodium	mg/kg	714	543	491	212	249	270	376	39.9	424	51	525	408	409	279	834
Exchangeable Aluminium	mg/kg	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Exchangeable Calcium	meq/100g	7.00	5.64	7.06	4.72	5.05	3.08	4.26	4.29	4.25	5.50	3.87	3.63	4.04	8.42	7.34
Exchangeable Magnesium	meq/100g	5.62	5.30	5.83	2.42	3.09	2.73	3.56	0.61	3.25	1.61	3.47	3.17	4.65	5.41	8.35
Exchangeable Potassium	meq/100g	0.22	0.18	0.30	0.08	0.09	0.09	0.15	0.37	0.22	0.44	0.15	0.12	0.21	0.23	0.24
Exchangeable Sodium	meq/100g	3.10	2.36	2.13	0.92	1.08	1.17	1.63	0.17	1.84	0.22	2.28	1.77	1.78	1.21	3.63
Exchangeable Aluminium	meq/100g	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Calcium/Magnesium Ratio	-	1.2	1.1	1.2	2.0	1.6	1.1	1.2	7.0	1.3	3.4	1.1	1.1	0.9	1.6	0.9
Emerson Aggregate	Class	2	3b	4	3a	2	3a	2	5	2	3b	2	3a	3b	4	4
Phosphorus Buffer Index	mg/kg	81.9	76.5	99.1	51.4	64.9	58.8	69.5	64.6	63.7	50.8	74.6	61.5	44.2	72.6	65.8
Gypsum Amelioration	kg/m^3	3.39	2.42	2.30	0.68	0.90	0.74	1.39	0.07	1.56	0.16	1.96	1.40	1.62	1.30	4.20

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B-5: Laboratory analysis data for clay topsoils. Part 4 of 5.

Laboratory Results Clays										
	Lab No	232027-204	232027-224	232027-236	232027-244	232027-248	232027-256	232027-268	232027-272	232027-276
	Sample ID	664b	678a	680c	678b	675	695	687a	687b	685
	Sample Depth	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite	Composite
	Field Texture	LC	LMC	LC	LMC	LC	LC	LC	LC	LC
Analyses	Unit	-	-	-	-	-	-	-	-	-
pH - Water	pH units	7.49	8.92	8.76	7.64	7.52	8.71	8.67	7.76	8.3
Electrical Conductivity	dS/m	0.11	0.17	0.12	0.05	0.06	0.24	0.29	0.3	0.16
Chloride	mg/kg	57.1	35.6	64.7	10.2	13.8	172.0	164.0	310.0	48.0
Total Nitrogen - Kjeldahl	mg/kg	833.0	263.0	179.0	371.0	281.0	259.0	469.0	450.0	584.0
Phosphorus - Colwell extr	mg/kg	9.16	9.16	5.65	<5.00	<5.00	<5.00	<5.00	7.6	13.5
Potassium - Colwell ext	mg/kg	235.00	122.00	135.00	104.00	97.10	142.00	200.00	157.00	134.00
Sulphur - KCl	mg/kg	14.9	7.4	7.2	10.0	9.3	23.6	22.6	17.9	11.8
Organic Carbon	%	1.03	0.22	<0.20	0.31	0.52	0.51	0.67	0.93	0.75
Copper	mg/kg	1.44	0.36	0.28	0.36	0.42	0.52	0.61	0.86	0.68
Iron	mg/kg	55.70	6.28	5.18	6.80	8.04	6.18	6.84	14.50	9.72
Manganese	mg/kg	60.50	5.12	3.76	7.80	11.80	11.30	5.75	10.30	8.00
Zinc	mg/kg	0.52	0.28	0.28	0.30	0.26	0.36	0.35	0.34	0.40
Boron	mg/kg	1.40	2.76	2.28	1.42	0.94	0.90	1.42	0.72	0.86
Cation Extraction Method	Rayment& Lyons	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1	15C1
Cation Exchange Capacity	meq/100g	4.2	6.6	5.7	4.3	3.9	4.2	7.5	8.1	7.8
Ex Calcium Percent	%	66.45	44.65	35.33	66.39	54.60	48.77	54.81	55.96	64.51
Ex Magnesium Percent	%	20.81	36.89	40.72	25.97	32.53	37.56	33.73	32.74	25.27
Ex Potassium Percent	%	7.01	2.35	1.24	2.89	3.75	4.41	2.71	2.73	2.93
Ex Sodium Percent	%	5.20	15.77	22.32	4.24	8.55	8.72	8.45	8.30	7.01
Ex Aluminium Percent	%	0.52	0.34	0.39	0.52	0.57	0.53	0.30	0.28	0.29
Exchangeable Calcium	mg/kg	564	591	402	571	428	409	818	903	1000
Exchangeable Magnesium	mg/kg	106	293	278	134	153	189	302	317	235
Exchangeable Potassium	mg/kg	116	60.7	27.4	48.4	57.4	72.1	79	86	88.5
Exchangeable Sodium	mg/kg	50.8	240	292	41.9	77.1	84.1	145	154	125
Exchangeable Aluminium	mg/kg	2	2	2	2	2	2	2	2	2
Exchangeable Calcium	meq/100g	2.82	2.96	2.01	2.86	2.14	2.05	4.09	4.52	5.00
Exchangeable Magnesium	meq/100g	0.88	2.44	2.32	1.12	1.28	1.58	2.52	2.64	1.96
Exchangeable Potassium	meq/100g	0.30	0.16	0.07	0.12	0.15	0.18	0.20	0.22	0.23
Exchangeable Sodium	meq/100g	0.22	1.04	1.27	0.18	0.34	0.37	0.63	0.67	0.54
Exchangeable Aluminium	meq/100g	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Calcium/Magnesium Ratio	-	3.2	1.2	0.9	2.6	1.7	1.3	1.6	1.7	2.6
Emerson Aggregate	Class	7	2	1	3a	3a	3b	3b	3b	3b
Phosphorus Buffer Index	mg/kg	68.4	62.4	49.9	62	56.6	30.6	54.4	39.3	39.4
Gypsum Amelioration	kg/m^3	0.02	0.60	0.55	0.02	0.00	0.02	0.43	0.49	0.38

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Table B-5: Laboratory analysis data for clay topsoils. Part 5 of 5.

Laboratory Results Clays											
		Mean	LCL 95%	UCL 95%	Std Dev	Count	CI 95% (+/-)	10%ile	90%ile	Min	Max
Analyses	Unit										
pH - Water	pH units	8.5	8.4	8.6	0.5	54	0.1	7.7	9.0	7.3	9.2
Electrical Conductivity	dS/m	0.6	0.4	0.7	0.4	54	0.1	0.1	1.0	0.1	2.0
Chloride	mg/kg	588.2	423.3	753.2	618.5	54	165.0	42.3	1317.0	8.7	2900.0
Total Nitrogen - Kjeldahl	mg/kg	543.5	493.7	593.3	186.8	54	49.8	323.4	775.9	179.0	1143.0
Phosphorus - Colwell extr	mg/kg	14.6	8.7	20.5	19.7	43	5.9	6.2	21.1	5.0	121.0
Potassium - Colwell ext	mg/kg	113.6	100.8	126.3	47.8	54	12.8	63.0	173.6	49.9	240.0
Sulphur - KCl	mg/kg	36.2	30.8	41.6	20.2	54	5.4	12.7	59.0	7.2	114.0
Organic Carbon	%	0.8	0.7	0.8	0.3	53	0.1	0.4	1.3	0.2	1.7
Copper	mg/kg	0.8	0.7	0.9	0.4	54	0.1	0.5	1.2	0.3	3.0
Iron	mg/kg	12.4	10.6	14.3	7.0	54	1.9	6.9	16.6	5.2	55.7
Manganese	mg/kg	11.8	9.7	14.0	8.0	54	2.1	5.4	16.6	3.8	60.5
Zinc	mg/kg	0.4	0.4	0.5	0.2	54	0.0	0.2	0.6	0.2	1.0
Boron	mg/kg	1.8	1.7	2.0	0.7	54	0.2	0.9	2.8	0.7	3.8
Cation Extraction Method	Rayment& Lyons	*	*	*	*	0	*	*	*	0.0	0.0
Cation Exchange Capacity	meq/100g	11.8	10.3	13.2	5.4	54	1.4	5.6	20.1	3.9	27.7
Ex Calcium Percent	%	46.3	43.2	49.3	11.4	54	3.0	35.5	62.6	24.8	78.4
Ex Magnesium Percent	%	37.3	35.2	39.4	8.0	54	2.1	27.0	45.2	11.2	47.2
Ex Potassium Percent	%	2.0	1.6	2.4	1.5	54	0.4	0.7	3.6	0.6	7.0
Ex Sodium Percent	%	14.2	12.6	15.8	5.9	54	1.6	5.8	21.8	2.4	27.9
Ex Aluminium Percent	%	0.2	0.2	0.3	0.1	54	0.0	0.1	0.4	0.1	0.6
Exchangeable Calcium	mg/kg	1027.7	921.3	1134.2	399.1	54	106.4	577.0	1575.5	391.0	2346.0
Exchangeable Magnesium	mg/kg	553.9	469.5	638.2	316.3	54	84.4	190.2	1001.1	73.3	1474.0
Exchangeable Potassium	mg/kg	74.0	65.8	82.2	30.6	54	8.2	45.1	115.7	27.4	172.0
Exchangeable Sodium	mg/kg	410.7	338.4	482.9	270.9	54	72.3	79.2	816.4	31.2	1154.0
Exchangeable Aluminium	mg/kg	2.0	#NUM!	#NUM!	0.0	54	#NUM!	2.0	2.0	2.0	2.0
Exchangeable Calcium	meq/100g	5.1	4.6	5.7	2.0	54	0.5	2.9	7.9	2.0	11.7
Exchangeable Magnesium	meq/100g	4.6	3.9	5.3	2.6	54	0.7	1.6	8.3	0.6	12.3
Exchangeable Potassium	meq/100g	0.2	0.2	0.2	0.1	54	0.0	0.1	0.3	0.1	0.4
Exchangeable Sodium	meq/100g	1.8	1.5	2.1	1.2	54	0.3	0.3	3.5	0.1	5.0
Exchangeable Aluminium	meq/100g	0.02	0.02	0.02	0.00	54.00	0.00	0.02	0.02	0.02	0.02
Calcium/Magnesium Ratio	-	1.4	1.2	1.7	1.1	54	0.3	0.8	2.4	0.5	7.0
Emerson Aggregate	Class	4.1	3.5	4.6	1.8	38	0.6	2.0	7.0	1.0	7.0
Phosphorus Buffer Index	mg/kg	70.7	65.2	76.2	20.5	54	5.5	50.2	96.5	30.6	142.0
Gypsum Amelioration	kg/m^3	1.60									

	Highly acidic		Extremely alkaline		High salinity		Sodic		Strongly sodic

Goonyella Riverside and Broadmeadow Mine (GRM and BRM) Progressive Rehabilitation and Closure Plan (PRCP) - Community Consultation Register

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRCP DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Group	**Stakeholder Title**	**Organisation/ Property**	**Previous engagement**	**Consultation type**	**Consultation date**	**Information provided**	**Issues raised/discussed**	**How issues were considered**	**Decisions/outcomes of engagement**	**Commitments**
Traditional Owners	Chair	Barada Barna Aboriginal Corporation (BBAC)	BMA has regular engagement with Barada Barna People on a range of issues including cultural heritage and community and economic development. BMA holds a Native Title Project Agreement with BBAC on behalf of Barada Barna peoples. The Agreement was signed on 31 July 2024. Engagement includes meetings and correspondence through the BBAC-BMA Relationship Committee and regular Barada Barna and BMA Closure Planning Working Group meetings. Businesses owned by BBAC and/ or their members are currently involved in rehabilitation works at BMA sites.	Letter, via email to BBAC Chair Meeting and correspondence Monthly meeting Several meetings and emailed correspondence	4/07/2024 Frequent FY 24 monthly September and October 2024	Queensland Government requirements for mine rehabilitation and closure planning PRCP inclusions Asset location Environmental Authority held for RHM PRCP submission date Mining leases within the EA area and approved activities Life of asset BMA's commitment to progressive rehabilitation Rehabilitation objective and methods EP Act requirements for rehabilitation PRCP requirements Progressive rehabilitation timeframes (in general terms) Approved post-mining land use (PMLU) options Commitment to future engagement on PRCPs Invitation to seek information or discussion about PRCP Contacts for further information Seeding requriments and recommendations (Barada Barna only) Spatial data in relation to Area 4 (Barada Barna only)	No issues raised in response to the letter, but issues discussed in other engagements between BMA and BBAC include opportunities to be involved in rehabilitation execution via Barada Barna-owned businesses, cultural heritage management and access to land that is no longer required for mining.	Ongoing opportunities for the involvement of Barada Barna People and businesses in rehabilitation works and land management are planned across BMA assets, as rehabilitation is a core contracting commitment in the BMA and BBAC Native Title Project Agreement.	Traditional Owners will have access to land within the EA area in accordance within the terms of the registered Indigenous Land Use Agreement. Ongoing opportunities for the involvement of Barada Barna People and businesses in rehabilitation works and land management are planned across BMA, as rehabilitation is a core contracting commitment in the Native Title Project Agreement. Barada Barna People's interest in environmental management and mine rehabilitation will be progressed as part of ongoing engagement with them. Exclusion zone boundaries in relation to Area 4 and specific locations where rehabiliation activities should be carried out in relation to historical disturbance.	BMA will continue to consult with the Barada Barna People, and seek their inputs on rehabilitation and PMLUs. BMA will engage with Traditional Owners and Indigenous businesses to understand business capabilities and the pipeline of opportunities that relate to rehabilitation work and land management, and to involve Traditional Owners' businesses in supplying progressive rehabilitation works. Treatment of Area 4 in relation to exclusion zone and rehabiliatoin activies as described in the PRCP
	Secretary	Widi People of the Nebo Estate #2	BMA has a constructive relationship with Widi People, meeting as needed.	Letter, via email to Secretary	4/11/2024	As detailed in the first row.	No feedback received and no issues raised.	No feedback received and no issues raised.	Opportunities for the involvement of Widi People and businesses in rehabilitation works and land management are anticipated.	BMA will continue to consult with Widi People, and seek their inputs on rehabilitation and PMLUs. BMA will engage with Traditional Owners and Indigenous businesses to understand business capabilities and the pipeline of opportunities that relate to rehabilitation work and land management, and to involve Traditional Owners' businesses in supplying progressive rehabilitation works.
Local Government	Mayor, Councillors and CEO	Isaac Regional Council (IRC)	BMA has regular bi-annual meetings with IRC, and meets with Councillors and officers as needed on specific issues. BMA provides regular briefings and updates to Council on BMA's PRCPs. IRC owns land within the EA area for a road reserve (Red Hill Road). BMA and IRC engage in commercial discussions regarding use of IRC land within the EA area, as required.	Bi-annual meetings with Council Additional meetings with Council with a focus on roads on 19/1/24 and 16/4/24 and 30/5/24	06/11/2023 30/05/2024 19/01/24 16/04/24 30/05/2024	As detailed in the first row.	Council receives regular updates and opportunities for discussion on PRCPs for BMA assets via IRC-BMA meetings. The future use, management and maintenance of roads within the EA area is of significant interest to Council.	Council's interest in PRC planning and PRCP outcomes is addressed in the PRCP consultation plan. Engagement processes for PRCPs will include a strategic approach to consultation with Council, to minimise demands on Council's time in responding to PRCP consultation for BMA's assets.	The CEO of the IRC sent an acknowledgement email of the letter that was sent to IRC in relation to the GRM and BRM PRCP. No issues were raised with respect to the GRM and BRM PRCP in general. BMA will continue to engage with IRC regarding PRCPs for GRM and BRM. PRCP updates will be provided at each meeting between BMA and IRC or as agreed with IRC. BMA will also consult IRC on management plans if rehabilitation and/or closure activities would impact on IRC assets including road management and recycling facilities. Future engagement with Council will include discussion of rehabilitation methods and milestones.	BMA will engage with IRC to understand Council's strategic analysis and planning for the Isaac LGA and the GRM and BRM project area as relevant. BMA will work with Council and other stakeholders in future PRCP consultations to identify and implement social value opportunities. BMA will engage with IRC regarding any impacts on Council roads or road reserves as part of the progressive rehabilitation and closure process, and will update IRC on PRCPs regularly. The PRCP landform proposes a realignment of Red Hill Road. To effect realignment, BMA acknowledge it would need to apply for and obtain, a Works On Road Corridor Permit from IRC. Engineering studies will need to be completed before the permit is applied for. Concerns raised by IRC in relation to any realignment proposal for Red Hill Road will be considered during the permitting process. If changes are made to the proposed realignment as a result of future planning or permitting processes that impact the PRCP schedule, a PRCP amendment will be required.
	Executive Manager of Advocacy and External Affairs and Manager Galilee and Bowen Basin Operations	IRC	BMA meets with Council officers from time to time on issues of shared interest.	Letter to stakeholders and community members provided to Council managers, via email	21/06/2024	As detailed in the first row.	No feedback received and no issues raised.	As above.	As above.	As above.
Underlying landowners	Owner	Private agricultural business	BHP has a long and constructive working relationship with the landowner, including with respect to underlying land and a license agreement for use of BMA-owned land within the EA area. The landowner also owns land which is adjacent to the EA area. BMA engages with the landowner regarding matters relating to land use management and commercial arrangements from time to time.	Letter, via email and post	14/06/2024	As detailed in the first row.	No feedback or enquiries were received. BMA's regular engagements with the landowner indicate that they are interested in long-term grazing options.	BMA's regular engagements with the landowner indicate that their issues of interest include environmental management, land access under current land access and lease agreements, and access to BMA land for grazing use whilst is not required for mining. Landowners' interest in use of the land for grazing was considered in framing PMLUs.	Land within the MLs will continue to be available for grazing under existing agreements with landholders. Landholders and cattle will be excluded from affected areas while land disturbance is occurring. As disturbed land becomes available, it will be rehabilitated to a state suitable for the approved PML) e.g. grazing, woodland, water courses, or managed as a NUMA.	BMA will continue to consult with the landholder and seek their inputs on the GRM and BRM rehabilitation schedule and approved PMLUs. BMA will continue to consult with licensees and lessees regarding licence and lease agreements as and when affected by rehabilitation and/or closure.

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRCP DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Group	**Stakeholder Title**	**Organisation/ Property**	**Previous engagement**	**Consultation type**	**Consultation date**	**Information provided**	**Issues raised/discussed**	**How issues were considered**	**Decisions/outcomes of engagement**	**Commitments**
	Executor	Private estate/agricultural business	BHP had a long and constructive working relationship with the landowner, including with respect to underlying land and a license agreement for use of BMA-owned land within the EA area. The Estate also owns land which is adjacent to the EA area. BMA engages with the Estate executor regarding matters relating to land use management and commercial arrangements from time to time.	Letter, via post	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	BMA's regular engagements with the landowner indicated that their issues of interest include environmental management, land access under current land access and lease agreements, and access to BMA land for grazing use whilst is not required for mining. Landowners' interest in use of the land for grazing was considered in framing PMLUs.	Land within the MLs will continue to be available for grazing under existing agreements with landholders. Landholders and cattle will be excluded from affected areas while land disturbance is occurring. As disturbed land becomes available, it will be rehabilitated to a state suitable for the approved PMLU e.g. grazing, woodland, water courses, or managed as a NUMA.	BMA will continue to consult with the Estate executor or the new landowner as relevant, and seek their inputs on the GRM and BRM rehabilitation schedule and approved PMLUs. BMA will continue to consult with licensees and lessees regarding licence and lease agreements as and when affected by rehabilitation and/or closure.
	CEO	IRC	IRC owns land within the EA area including road reserves and land adjacent to the Goonyella Branch Railway. BMA and IRC have engaged in discussions regarding use of IRC land within the EA area during 2023 and 2024.	Three meetings during 2023-2024 to date discussing roads with the EA area	19/1/2024, 16/4/2024 and 30/5/2024	Information specific to BMA and IRC's interests in roads and road reserves within the EA area	The future use, management and maintenance of roads within the EA area is of significant interest to Council.	IRC interests in planning for roads i.e. Red Hill Road (to be established), and Goonyella Road (a private BMA road used by the public) are addressed in the PRCP.	IRC road reserves are located within the EA area, which has been considered in the PRCP. Prior information and consultation will be required with IRC regarding the future use of roads and road reserves within the EA area.	Consultation with IRC on future PRCP amendments will include consideration of the future use of roads and road reserves within the EA area.
	Site and Third Party Interface Manager	Moranbah North Coal Pty Ltd & Others (Anglo American Australia)	Anglo American Australia owns land which overlaps the EA area. BMA and Anglo American Australia engage in commercial discussions regarding use of land within the EA area, as required.	Letter, via post	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No issues were raised.	BMA will engage with Anglo American Australia regarding any effects of rehabilitation or closure works on land within the MLs that is owned by Anglo American Australia.	BMA will maintain engagement with Anglo American Australia regarding its progressive rehabilitation activities land within the MLs that is owned by Anglo American Australia.
	Manager Tenements Portfolio Australia	Centurion Coal Mining Pty Ltd (previously Peabody (Bowen) Pty. Ltd.)	Centurion Coal Mining Pty Ltd (previously Peabody (Bowen) Pty. Ltd.) owns a parcel of land in the top north of the EA area, adjacent to the North Goonyella Industrial Area. BMA and Peabody (Bowen) Pty. Ltd. (Centurion Coal Mining Pty Ltd going forward) engage in commercial discussions regarding use of land within the EA area, as required.	Letter, via email	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will engage with Centurion Coal Mining Pty Ltd regarding any effects of rehabilitation or closure works on land within the MLs that is owned by Centurion Coal Mining Pty Ltd	BMA will maintain engagement with Centurion Coal Mining Pty Ltd regarding its progressive rehabilitation activities land within the MLs that is owned by Centurion Coal Mining Pty Ltd
	Senior Business Analyst, Network Asset Management	Aurizon Network	Aurizon Network Pty. Ltd owns land within the EA area. DTMR owns the land on which the Goonyella Railway is located (refer to Row 39).	Letter, via email	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	Prior information and consultation will be required with Aurizon Network regarding the decommissioning of rail infrastructure within the EA area. BMA will advise Aurizon Network of any substantive changes to closure planning or the rehabilitation schedule as part of future PRCP processes for GRM and BRM.	BMA will maintain engagement with Aurizon Network regarding its progressive rehabilitation activities as they affect rail assets, and undertake engagement regarding the decommissioning of load out facility/rail infrastructure prior to its closure, in accordance with agreements between BMA and QR/Aurizon at the time.
	A/Deputy Director-General	Lands Division, Department of Resources	Unallocated state land is located within the EA area.	Letter, via email	20/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will keep Lands Division, Department of Resources informed of any planning or implementation of closure or rehabilitation activities that affect unallocated state land within the EA area.	BMA will keep Lands Division, Department of Resources informed of any planning or implementation of closure or rehabilitation activities that affect unallocated state land within the EA area.
Utility owners	Customer Account Manager	Aurizon Network	Goonyella Hay Point Railway, North Goonyella Railway, Goonyella Mine Loop and Riverside Mine Loop are owned by Aurizon Network on land owned by Department of Transport and Main Roads (DTMR) (see also Row 39). Engagement with Aurizon Network is via routine correspondence on commercial and statutory issues, with meetings held as required on specific issues.	Letter, via email	19/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will advise Aurizon Network of any substantive changes to closure planning or the rehabilitation schedule as part of future PRCP processes for GRM and BRM.	BMA will maintain engagement with Aurizon Network regarding its progressive rehabilitation activities as they affect rail assets, and undertake engagement regarding the decommissioning of load out facility/rail infrastructure prior to its closure, in accordance with agreements between BMA and QR/Aurizon at the time.
	Commercial Customers Manager	Eungella Water Pipeline Pty Ltd (Sunwater Pty. Ltd.) and the Burdekin Water Pipeline (Sunwater)	Eungella Pipeline and Burdekin Pipeline (and various Sunwater easements) are located within the EA area. Engagement with Sunwater is via routine correspondence on commercial and statutory issues, with meetings held as required on specific issues.	Letter, via email	19/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will maintain correspondence with Sunwater regarding progressive rehabilitation activities as they affect Sunwater assets, and undertake consultation regarding crossing/interface agreements, if required. Prior information and consultation will be required with Sunwater regarding how closure and rehabilitation activities may impact on the Eungella Water Pipeline.	BMA will advise and consult Sunwater regarding any impacts of closure/rehabilitation activity that may affect Sunwater's asset.
	Tenement Manager	Whitehaven Coal	Whitehaven Coal owns the Braeside West Water Pipeline which is located in close proximity to GRM and BRM. Engagement with Whitehaven Coal is via routine correspondence on commercial and statutory issues, with meetings held as required on specific issues.	Letter, via email	20/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will maintain correspondence with Whitehaven regarding progressive rehabilitation activities as and if they affect Whitehaven Coal assets.	BMA will advise and consult Whitehaven Coal regarding any impacts of closure/rehabilitation activity that may affect Whitehaven Coal's asset.
	Property Services and Management Team Leader	Powerlink	Powerlines and powerline easements are owned/held by Powerlink / QEC Pty Ltd). Engagement with Powerlink is via routine correspondence on commercial and statutory issues, with meetings held as required on specific issues.	Letter, via email	19/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will maintain correspondence with Powerlink regarding progressive rehabilitation activities as and if they affect Powerlink assets.	BMA will advise and consult Powerlink regarding any impacts of closure/rehabilitation activity that may affect Powerlink's assets.

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRCP DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Group	**Stakeholder Title**	**Organisation/ Property**	**Previous engagement**	**Consultation type**	**Consultation date**	**Information provided**	**Issues raised/discussed**	**How issues were considered**	**Decisions/outcomes of engagement**	**Commitments**
	Sales Operations Manager	Telstra	Telstra holds easements within the EA area. Engagement with Telstra is via routine correspondence on commercial and statutory issues.	Letter, via email	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	Prior information and consultation will be required with Telstra regarding the decommissioning/future use of telecommunications infrastructure within the EA area. BMA will maintain correspondence with Telstra regarding progressive rehabilitation activities as they affect Telstra assets, and undertake consultation about telecommunications infrastructure agreements, if required.	BMA will advise and consult Telstra Amplitel regarding any impacts of the closure/rehabilitation activity that may affect their assets.
BMA personnel and suppliers	Personnel	BMA workforce and contractors	BMA communicates with its personnel on a continual basis through toolbox talks, emails, and safety meetings, and through Community Connect and Coal Connect, which are regular newsletters.	Information provided for distribution through Coal Connect	19/06/2024	Progressive rehabilitation as a key focus for BMA PRCP requirements and purpose Timing for PRCP development Commitment to ongoing engagement Contact details for further information or queries.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will keep the workforce updated as the PRCP is implemented and revised.	BMA will keep the workforce updated if there are changes to the PRCP. BMA will provide a communication channel for personnel to ask questions or contribute to discussions about PRCPs and rehabilitation.
	Local and regional business owners	GRM and BRM Suppliers	BMA's procurement team have relationships with an extensive network of small business suppliers. BMA communicates with its suppliers on a continual basis through the C-Res portal, emails, and Community Connect, a regular newsletter.	Information provided through Community Connect	10/06/24 - 16/06/24	Progressive rehabilitation as a key focus for BMA PRCP requirements and purpose Timing for PRCP development Commitment to ongoing engagement Contact details for further information or queries	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will keep suppliers updated as the PRCP is implemented and revised.	BMA will keep suppliers updated if there are changes to the PRCP. BMA will provide a communication channel for suppliers to ask questions or contribute to discussions about PRCPs and rehabilitation.
Moranbah Community	Community Members	Moranbah residents, businesses and community groups	BMA communicates with Moranbah residents, businesses and community groups through stakeholder meetings, community events and forums, media and social media, and Community Connect, a regular newsletter.	Letter box drop to Moranbah postcode (POA 4744) Information provided through Community Connect	15/07/2024 - 19/07/24 10/6/24 - 16/6/24	Information provided via the letterbox drop as per Row 4. Information provided in Community Connect included: Progressive rehabilitation as a key focus for BMA PRCP requirements and purpose Timing for PRCP development Commitment to ongoing engagement Contact details for further information or queries.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will keep community members updated as the PRCP is implemented and revised.	BMA will continue to provide information about PRCPs to Moranbah community members, and consider their feedback in future PRCP development.
	STAC Members	Moranbah STAC	The Smart Transformation Project including the Moranbah and Dysart Smart Transformation Advisory Councils (STACs) was established by BMA in 2019. Moranbah STAC members meet every two months to consider a range of issues and priorities related to the future and sustainability of Moranbah's community and economy.	Letter, via email	12/07/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will keep STAC members updated as the PRCP is implemented and revised.	BMA will continue to provide information about PRCPs to Moranbah STAC members, and consider their feedback in future PRCP development. BMA will participate in initiatives led by the Council, industry or local communities which aim to harness social value from mine closure and rehabilitation planning, and/or work towards economic transformation.
	Chair	Isaac Business Chamber	The Isaac Business Chamber has recently formed to represent businesses within the Isaac LGA. BMA has financially supported the Isaac Business Chamber and attended its launch event.	Letter, via email	15/07/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will keep the Isaac Business Chamber updated as the PRCP is implemented and revised.	BMA will continue to provide information about PRCPs to the Isaac Business Chamber, and consider their feedback in future PRCP development.
Adjacent and nearby mining interests	Manager Tenements Portfolio Australia	Centurion Coal Mining Pty Ltd (previously Peabody (Bowen) Pty. Ltd.)	Centurion Coal Mining Pty Ltd (previously Peabody (Bowen) Pty. Ltd.) owns an open-cut mine known as Eaglefield and an underground mine previously known as North Goonyella and now called Centurion Coal Mine, adjacent to GRM and BRM's north. Centurion Coal Mining Pty Ltd, a Peabody-owned company, has a petroleum lease adjacent to the EA area. Engagement to date, with Peabody (Bowen) Pty. Ltd., is via routine correspondence on commercial and statutory issues.	Letter via email	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will engage with Centurion Coal Mining Pty Ltd regarding any effects of rehabilitation or closure works on adjacent mining operations.	BMA will keep Centurion Coal Mining Pty Ltd updated if there are substantive future changes to the PRCP.
	Tenure and Compliance Manager, and Site and Third Party Interface Manager	Anglo American Australia	Anglo American Australia owns the Moranbah North Coal Mine to the south, including land within the GRM and BRM EA area. Anglo also holds nearby PPLs for gas pipelines. Engagement with Anglo American is via routine correspondence on commercial and statutory issues.	Letter via email	14/06/2024	As detailed in the first row.	Acknowledgement received	No feedback received and no issues raised.	BMA will engage with Anglo American Australia regarding any effects of rehabilitation or closure works on adjacent mining operations.	BMA will keep Anglo American Australia updated if there are substantive future changes to the PRCP.
	Authorised Holder Representative	Wealth Mining Pty Ltd	Wealth Mining hold adjacent MDL and EPC tenements. BMA and Wealth Energy have not previously engaged.	Letter via email	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will keep Wealth Mining Pty Ltd updated as the PRCP is implemented and revised.	BMA will keep Wealth Mining Pty Ltd updated if there are substantive future changes to the PRCP.
	Authorised Holder Representative	Mayfair Energy Pty Ltd	Mayfair Energy hold nearby EPC (but not adjacent). BMA and Mayfair Energy have not previously engaged.	Letter via email	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will keep Mayfair Energy Pty Ltd updated as the PRCP is implemented and revised.	BMA will keep Mayfair Energy updated if there are substantive future changes to the PRCP.
	Manager Tenure & Senior Geologist	Stanmore SMC Pty Ltd	Stanmore SMC Pty Ltd owns the Wards Well underground development project, which is located immediately north of the Peabody's Centurion (North Goonyella) Mine. BMA and Stanmore have previously engaged with respect to the transfer of ownership of the Wards Well project from BMA to Stanmore.	Letter via email	19/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will keep Stanmore SMC Pty Ltd updated as the PRCP is implemented and revised.	BMA will keep Stanmore SMC Pty Ltd updated if there are substantive future changes to the PRCP.

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRCP DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
Group	**Stakeholder Title**	**Organisation/ Property**	**Previous engagement**	**Consultation type**	**Consultation date**	**Information provided**	**Issues raised/discussed**	**How issues were considered**	**Decisions/outcomes of engagement**	**Commitments**
Petroleum tenement holders	Principal Commercial Adviser	CH4 Pty Ltd (Arrow Energy Pty. Ltd.)	CH4 Pty Ltd (Arrow Energy Pty. Ltd.) holds an Authority to Prospect within the EA area and also an Authority to Prospect (ATP1103) which overlaps ML70421. There is a Co-Development Agreement in place between Arrow Energy and BMA, which governs and coordinates activities on Red Hill ML 70421 and Arrow Energy's overlapping PL 486. BMA communicates with Authorised Resource Holders regarding tenure issues on an as-needed basis.	Letter via email	19/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will advise CH4 Pty Ltd (Arrow Energy Pty. Ltd.) of any substantive changes to the closure or rehabilitation schedule as part of future PRCP processes for GRM and BRM.	BMA will advise CH4 Pty Ltd (Arrow Energy Pty. Ltd.) of any substantive changes to closure or rehabilitation schedule as part of future PRCP processes for GRM and BRM.
	Principal Commercial Adviser	Arrow CSG (Apt 364) Pty Ltd (Arrow Energy Pty. Ltd.)	Arrow CSG (Apt 364) Pty Ltd has a petroleum licence adjacent to the EA area, with a Co-Development Agreement in place. BMA communicates with Authorised Resource Holders regarding tenure issues on an as-needed basis.	Letter via email	19/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will advise Arrow CSG (ATP 364) Pty Ltd of any substantive changes to the closure or rehabilitation schedule as part of future PRCP processes for GRM and BRM.	BMA will advise Arrow CSG (ATP 364) Pty Ltd of any substantive changes to closure or rehabilitation schedule as part of future PRCP processes for GRM and BRM.
	General Manager Power and Pipelines	North Queensland Pipeline No 1 Pty Ltd	PPL 89 for the Moranbah to Townsville (North Qld Gas Pipeline) is in close proximity to GRM and BRM. The pipeline is owned by North Queensland Pipeline No 1 Pty Ltd and is located within easements held by Enertrade Pty Ltd.	Letter via email	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will advise North Queensland Pipeline No 1 Pty Ltd of any substantive changes to the closure or rehabilitation schedule as part of future PRCP processes for GRM and BRM.	BMA will advise North Queensland Pipeline No 1 Pty Ltd of any substantive changes to closure or rehabilitation schedule as part of future PRCP processes for GRM and BRM.
	Authorised Holder Representative	Enertrade Pty. Ltd.	Enertrade holds the easements under the North Qld Gas Pipeline which is near the EA area.	Letter via email	14/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will advise Enertrade Pty Ltd of any substantive changes to the closure or rehabilitation schedule as part of future PRCP processes for GRM and BRM.	BMA will advise Enertrade Pty Ltd of any substantive changes to closure or rehabilitation schedule as part of future PRCP processes for GRM and BRM.
State Government	PRCP Team	Department of Environment Science and Innovation (DESI)	BMA and DESI have engaged through meetings and correspondence regarding the preparation and delivery of the PRCP.	Pre-notification meeting	29/11/2021	PRCP Notification memo	Provision of draft PRCP and discussion of requirements	DESI feedback was considered in the development of the PRCP.	The PRCP will be completed in accordance with BMA's agreements with DESI.	BMA will comply with the legislative and regulatory requirements for PRCPs.
				Pre-submission meeting	4/11/2024	Draft PRCP main points	Site specific issues	DESI feedback was considered in the development of the PRCP.	The PRCP will be completed in accordance with BMA's agreements with DESI.	BMA will comply with the legislative and regulatory requirements for PRCPs.
	Deputy Director-General Georesources	Department of Resources	BMA provides briefings to the Deputy Director-General Georesources on an as needed basis, and meets and corresponds with Department of Resources regarding resource development commitments.	Letter via email	20/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will update the Deputy Director-General Georesources on any future changes to the PRCP.	BMA will provide updates on PRCPs to the Deputy Director General Georesources as requested
	Acting Director Native Title Services and Coal Hub, Rockhampton	Department of Resources	BMA provides briefings to the Acting Director Native Title Services and Coal Hub on an as needed basis, and meets and corresponds with Department of Resources regarding resource development commitments.	Letter via email	20/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will update the Director Native Title Services and Coal Hub, Rockhampton on any substantive future changes to the PRCP.	BMA will provide updates on PRCPs to the Director Native Title Services and Coal Hub, Rockhampton as requested.
	A/Deputy Director-General Lands Division	Department of Resources	Unallocated state land is located within the EA area. Recent consultation with the Lands Division has not been required.	Letter via email	20/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will update the DDG Lands Division, Department of Resources on any substantive future changes to the PRCP.	BMA will provide updates on PRCPs to the DDG Lands Division, Department of Resources, as requested.
	A/Regional Planning Manager (Central Queensland) and Principal Town Planner	DTMR	DTMR owns land within the EA area on which rail infrastructure is located.	Letter via email	20/06/2024	As detailed in the first row.	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will update the A/Regional Planning Manager (Central Queensland) and Principal Town Planner on any substantive future changes to the PRCP.	BMA will provide updates on PRCPs to the Regional Planning Manager (Central Queensland) and Principal Town Planner as requested.
	Chief of Staff/Secretary	Office of the Minister for Resources and Critical Minerals	BMA provides briefings to the Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Minister's office as requested.	BMA will update the Office of the Minister on any substantive future changes to the PRCP.
	Chief of Staff/Secretary	Office of the Minister for Agriculture Industry Development and Fisheries and Minister Rural Communities	BMA provides briefings to the Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Minister's office as requested.	BMA will update the Office of the Minister on any substantive future changes to the PRCP.
	Chief of Staff/Secretary	Office of the Minister Energy, and Clean Economy Jobs	BMA provides briefings to the Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Minister's office as requested.	BMA will update the Office of the Minister on any substantive future changes to the PRCP.
	Chief of Staff/Secretary	Office of the Minister for Environment, Science and Innovation and Minister for the Great Barrier Reef	BMA provides briefings to the Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Minister's office as requested.	BMA will update the Office of the Minister on any substantive future changes to the PRCP.
	Chief of Staff/Secretary	Office of the Minister for Regional Development and Manufacturing and Minister for Water	BMA provides briefings to the Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Minister's office as requested.	BMA will update the Office of the Minister on any substantive future changes to the PRCP.
	Chief of Staff/Secretary	Queensland Parliament - Member for Burdekin	BMA provides briefings to the Member for Burdekin's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Member's office as requested.	BMA will update the Member's office on any substantive future changes to the PRCP.

COMMUNITY MEMBERS AND PREVIOUS ENGAGEMENT				PRCP DEVELOPMENT ENGAGEMENT			ENGAGEMENT OUTCOMES			
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	Chief of Staff/Secretary	Queensland Parliament - Shadow Minister for Natural Resources and Mines	BMA provides briefings to the Shadow Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Shadow Minister's office as requested.	BMA will update the Shadow Minister's office on any substantive future changes to the PRCP.
	Chief of Staff/Secretary	Shadow Minister for Environment and the Great Barrier Reef and Shadow Minister for Science and Innovation	BMA provides briefings to the Shadow Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Shadow Minister's office as requested.	BMA will update the Shadow Minister's office on any substantive future changes to the PRCP.
	Chief of Staff/Secretary	Shadow Minister for Energy and Cost of Living	BMA provides briefings to the Shadow Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Shadow Minister's office as requested.	BMA will update the Shadow Minister's office on any substantive future changes to the PRCP.
	Chief of Staff/Secretary	Shadow Minister for Water and the Construction of Dams	BMA provides briefings to the Shadow Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Shadow Minister's office as requested.	BMA will update the Shadow Minister's office on any substantive future changes to the PRCP.
	Chief of Staff/Secretary	Shadow Minister for Regional Development and Manufacturing	BMA provides briefings to the Shadow Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Shadow Minister's office as requested.	BMA will update the Shadow Minister's office on any substantive future changes to the PRCP.
Federal Government	Chief of Staff/Secretary	Office of the Minister and Dep. Sec. Environment Protection, Department of Climate Change, Energy, the Environment and Water	BMA provides briefings to the Minister's office on an as-needed basis.	Correspondence and meetings on request	Per agreed briefing schedule	Per PRCP discussion points, referencing information as detailed in the first row	No feedback or enquiries were received.	No feedback received and no issues raised.	BMA will provide updates on PRCPs to the Minister's office as requested.	BMA will update the Office of the Minister on any substantive future changes to the PRCP.

Goonyella Riverside Mine Progressive Rehabilitation and Closure Plan

Voids in Floodplain Report

BHP Mitsubishi Alliance

409 Adelaide St,
Brisbane City
QLD
4000

Prepared by:

SLR Consulting Australia Pty Ltd

Level 16, 175 Eagle Street, Brisbane, QLD, Australia,
4000

SLR Project No.: 620.31051.00000

20 November 2024

Revision: R01-v3.0

Making Sustainability Happen

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
R01-v2.0	20 November 2024	HM	MD	HM
R01-v2.0	27 September 2024	HM	MD	HM
R01-v1.0	27 March 2024	HM	MD	MD

Basis of Report

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with BHP Mitsubishi Alliance (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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Appendices

Appendix A – TUFLOW Model Results

Acronyms and Abbreviations

1D	One dimensional
2D	Two dimensional
AEP	Annual Exceedances Probability
ARF	Aerial Reduction Factor
ARR	Australian Rainfall and Runoff
BMA	BHP Mitsubishi Alliance
BoM	Bureau of Meteorology
DR	Department of Resources
DEM	Digital Elevation Model
EA	Environmental Authority
EP	Environmental Protection
GRM	Goonyella Riverside Mine
GSDM	Generalised Short Duration Method
GTSMR	Revised Generalised Tropical Storm Method
IFD	Intensity-Frequency-Duration
NUMA	Non-use Management Areas
PRCP	Progressive Rehabilitation and Closure Plan
PMLU	Post Mining Land Use
QRT	Quantile Regression Technique
RFFE	Regional Flood Frequency Estimate
SA	Source Area
WBNM	Watershed Bounded Network Model

1.0 Introduction

SLR was engaged by BHP to undertake floodplain modelling at Goonyella Riverside Mine (GRM). The modelling was undertaken to inform the Transitional Progressive Rehabilitation and Closure Plan (PRCP) for GRM.

GRM is located in Central Queensland, approximately 170 kilometres west of Rockhampton and 20 kilometres north of Moranbah. **Figure 1** illustrates the location of GRM and key surrounding features including the Isaac River which drains through the Mine. The GRM complex includes the Mining Leases shown in Table 1

Table 1 Goonyella Complex Mining Leases

Goonyella Mine Complex Mining Leases	
• ML1763 – Goonyella	• ML70288 – Goonyella Industrial
• ML1764 – Riverside	• ML70289 – West Airstrip Pit
• MLML1802 – Riverside Extended	• ML70421 – Red Hill
• ML1900 – Riverside West	• ML70468 – Riverside West Extension 1
• ML700003 – Mabbin	• ML70469 – Riverside West Extension 2
• ML70121 – Riverside Tailings Extension	• ML70478 – Goonyella West 1
• ML70193 – Riverside West Extension North	• ML70478 – Goonyella West 2
• ML70194 – Riverside West Extension South	• ML70493 – Riverside North West
• ML70287 – Goonyella Tailings	• ML70494 – Riverside North

The assessment detailed in this document was undertaken specifically to address the voids in floodplain modelling as part of the PRCP requirements for GRM.

1.1 Aims and Objectives

To meet the requirements of the Environmental Protection Act 1994 (EP Act) and Environmental Protection Regulation 2019 (EP Regulation), floodplain modelling is required for all relevant watercourses in the vicinity of voids, to assess the flood immunity and extents for the final landform conditions.

The scope of this project is to undertake floodplain modelling of the relevant watercourses as defined by the EP Regulation in relation to the proposed voids, including the following key tasks:

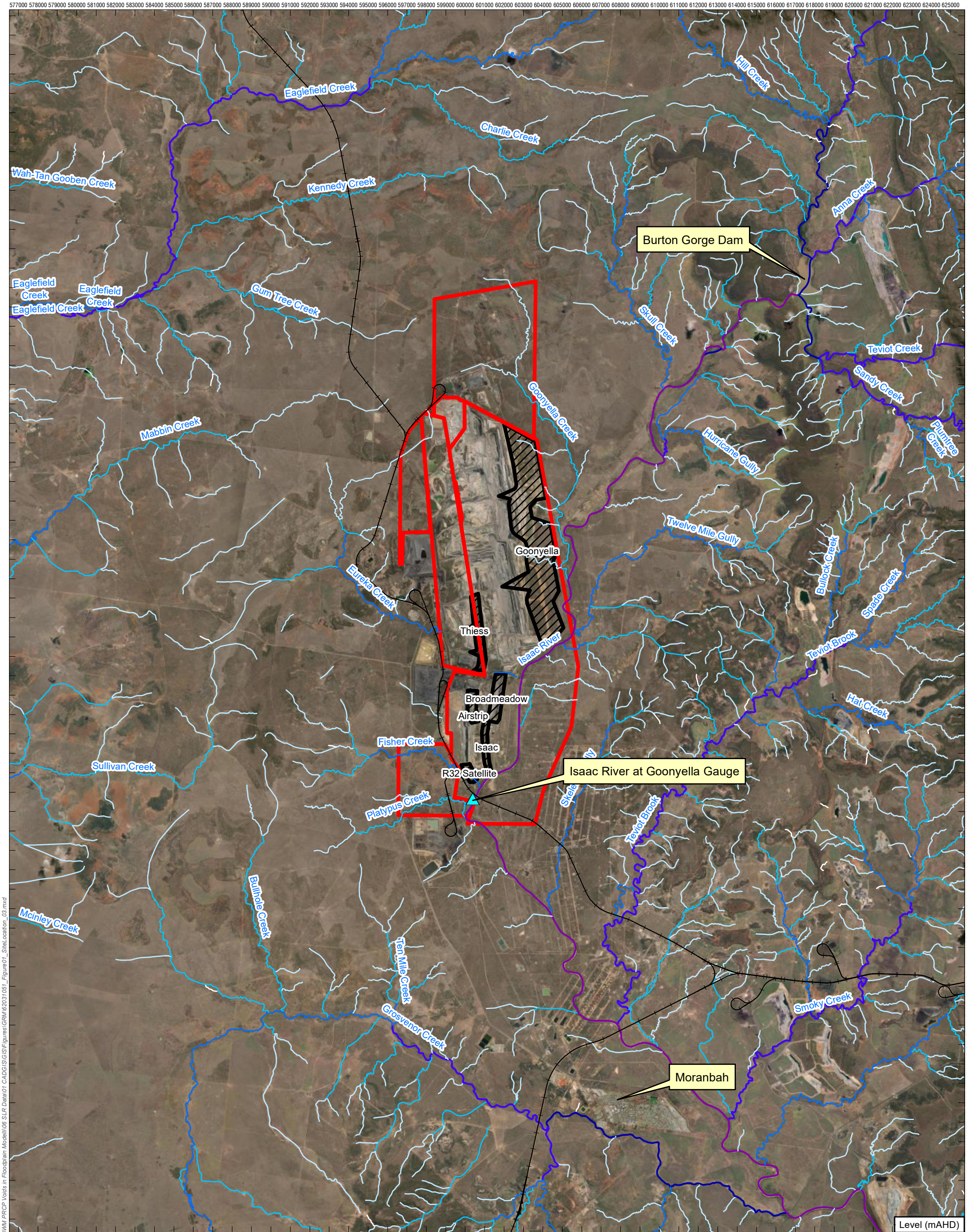
- Undertake a catchment study for each proposed void in the floodplain, including determining the pre-mining landform and developing or updating hydrologic modelling to be consistent with the requirements of Australian Rainfall and Runoff (AR&R 2019).
- Update and/or develop hydraulic models for the purpose of identifying flood risks posed to the proposed voids. The purpose of this is to define the baseline flood risks caused by the major creeks, which will be used to assess the inundation risk in the 0.1% Annual Exceedance Probability (AEP) flood event for each void, informed by the re-constructed pre-mining topography.
- Produce a Voids in Floodplain Model Report detailing the methodology and findings of the above assessments, including all relevant mapping of flood extents, levels and depths. GIS data and models will also be provided as an output of this assessment.

The assessments detailed in this report were undertaken and reviewed by appropriately qualified persons.

1.2 Input Data

Data for the assessment, including locations and extents of final voids, was provided by BHP.

Further data was obtained for use in the assessment from public sources, including topographic data, rainfall data, catchment specific hydrologic data, watercourse data and hydraulic structure data. Further detail on the data utilised in the assessment is provided in **Section 3.0**.



0 1.25 2.5 5 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:175,000 at A3
Project Number:	620.31051
Date:	27-Sep-2024
Drawn by:	GN/HM

LEGEND

- Mining Leases
- Residual Voids
- Stream Gauge
- Rail Network

Watercourses **Stream Order**

- 0
- 1
- 2
- 3
- 4
- 5
- 6

GOONYELLA MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

Site Location

SLR

Service Layer Credits: Source: Esri, Maxar, Earthstar

Figure 1

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADG\SIG\SIFigures\GRM\620310 51_Figure01_SiteLocation_03.mxd

2.0 Legislation and Guidelines

This assessment has been undertaken in accordance with the following legislation and guidelines:

- *Environmental Protection Act 1994;*
- *Environmental Protection Regulation 2019;*
- *'Information Sheet – Environmental Protection Act 1994 – Voids in Flood Plains'*, Department of Environment and Science, March 2020; and
- *'Guideline – Progressive Rehabilitation and Closure Plans'*, Department of Environment and Science, March 2021 (PRCP Guideline).

The Environmental Protection Act 1994 states:

'In accordance with section 126D(3) of the EP Act, if land the subject of the proposed PRCP schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.'

The Environmental Protection Regulation 2019 section 41C(3) also states:

"The administering authority must treat the land as a flood plain to the extent the results of the flood plain modelling show that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the ARR."

Further guidance is provided in the PRCP Guideline and the Voids in Flood Plains Information Sheet.

Sections 3.4 and 3.6.1 of the PRCP Guideline both require a floodplain assessment to be carried out. Specifically, Section 3.4 requires a Void in Floodplain assessment for all unapproved NUMA voids (i.e. floodplain assessment of the pre-mining landform), whilst Section 3.6.1 requires a post-mining landform assessment irrespective whether a post-mining land use (PMLU) or NUMA is proposed.

2.1 Applicability to the Project

Based on the review of the EP Act, EP Regulation, PRCP Guideline and the Voids in Floodplains information sheets, it is considered that the legislative requirements set out in **Table 2** are applicable to the project.

Table 2 Applicable Legislative Requirements

Requirement	Application to the Project	Source
For transitional sites, a floodplain assessment is required where: A void has been identified as a NUMA in a land outcome document but the location has not been specified; or Where there are no land outcomes in the land outcome document.	The PRCP for GRM includes six final voids which are proposed to be developed as NUMAs. Therefore, floodplain assessment is required.	PRCP Guideline Section 3.4
Floodplains associated with a stream order 4 or greater are required to be modelled.	Using the Strahler classification system, the Isaac River is a stream order 5 watercourse that may affect the proposed voids. Therefore, floodplain modelling of the Isaac River was undertaken. No other watercourses in the vicinity of GRM are of a stream order 4 or greater.	Voids in Flood Plains Information Sheet Section 5.
The modelling must not include any artificial features on the site. However, the modelling must include all existing and approved artificial features that, at the	A Digital Elevation Model (DEM) of the area was created to be used as the model landform for the assessment.	Voids in Flood Plains Information

Requirement	Application to the Project	Source
time of modelling, are located outside of the mining tenure boundary.	The model landform DEM was developed to represent the pre-mining topography within the Mining Lease (ML), and existing and future topography outside of the ML, including on adjacent MLs where applicable. The topography outside of the ML included existing and future artificial features, including Burton Gorge Dam, based on available data.	Sheet Section 4.
The requirement for a flood assessment under section 3.6.1 of the Guideline applies to the post mining landform across the whole site irrespective of whether a PMLU or a NUMA are proposed. Furthermore, section 3.6.1 is not only required to indicate flood risk but also to demonstrate the final landform (including waste rock dumps and diversions) will remain in a stable condition in a range of flood flow conditions.	Not included in the scope of this assessment.	PRCP Guideline Section 3.6.1.

2.2 Definitions and Terminology

Table 3 provides the definitions and terminology that are utilised in this assessment, in accordance with the PRCP Guideline and the Voids in Flood Plains Information Sheet.

Table 3 Definitions and Terminology

Term	Definition	Source
Voids	An area of land to be excavated in carrying out a mining activity. Therefore, all voids (PMLU or NUMA) are subject to the requirements of the EP Act.	Section 126D of the EP Act.
Flood plain	A void is considered to be located in a flood plain if the flood plain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level in a 0.1% AEP for a relevant watercourse under the guideline Australian Rainfall and Runoff (2019) (ARR).	Section 41C of the EP Regulation; and PRCP Guideline Section 3.4.
Stable condition	The land is safe and structurally stable; There is no environmental harm being caused by anything on or in the land; and The land can sustain a PMLU.	Section 126D(3) of the EP Act; and PRCP Guideline Section 3.6.3.
Relevant watercourse	a) A watercourse classified as stream order 4 or higher under the Strahler stream order classification system; or b) If a watercourse mentioned in paragraph (a) is permanently diverted under – (i) A condition, or proposed condition, of an environmental authority mentioned in the Water Act 2000, section 98; or (ii) A water license or proposed water license under the Water Act 2000; the watercourse as permanently diverted.	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 5.
Flood plain modelling	For land the subject of a PRCP schedule, means modelling of the landform of the land –	PRCP Guideline Section 8; and

Term	Definition	Source
	a) Carried out under the ARR; (and) b) Excluding any artificial features for the land	Voids in Flood Plains information Sheet Section 4.
Artificial feature	For land the subject of a PRCP schedule, means – a) A structure or feature that is temporary and, under the PRCP schedule or otherwise, is to be removed from the land; or b) A structure or feature that, under the PRCP schedule, will require a level of maintenance after the land is surrendered that is greater than the level of maintenance that would be required for the land if the relevant activities the subject of the PRCP schedule had not been carried out; or c) A feature forming part of the landform of the land, other than the natural landform, if the feature interferes with or affects – i) A relevant watercourse; or ii) The natural flow of water on the land.	PRCP Guideline Section 8; and Voids in Flood Plains information Sheet Section 6.

3.0 Data

3.1 Available Data

A data package was provided to SLR by BHP for use in the assessment. The package included:

- PRCP Residual Void Locations and Extents;
- Pre-mining topographic data (dated 1968) within the GRM Mine Lease extents as a DEM with 2m grid cell spacing;
- LiDAR topographic data (dated 2023) within Goonyella Mine extents as a DEM with 1m grid cell spacing.
- LiDAR topographic data (dated 2023) within Red Hill Mine extents as a DEM with 1m grid cell spacing.

Additional data was obtained from publicly available sources including:

- Fitzroy River catchment 25m DEM (Department of Resources (DR), 2023);
- Watercourse Lines – Queensland GIS dataset (DR, 2023);
- Lake Elphinstone 1m DEM (Department of Natural Resources and Mines, 2023);
- 1 second SRTM 30 metre DEM terrain data (Geoscience Australia);
- Historic gauged stream flow data for the Goonyella (130414A) and Deverill (130410A) Stream Gauges (DNRM); and
- Burton Gorge Dam Emergency Action Plan, 2018, (Peabody).

The provided data was analysed for suitability for the purposes of this assessment. The outcomes of the review are detailed below.

3.2 Watercourses

A review of the existing watercourses in the vicinity of GRM was undertaken using hydrologic streamline data sourced from DR.

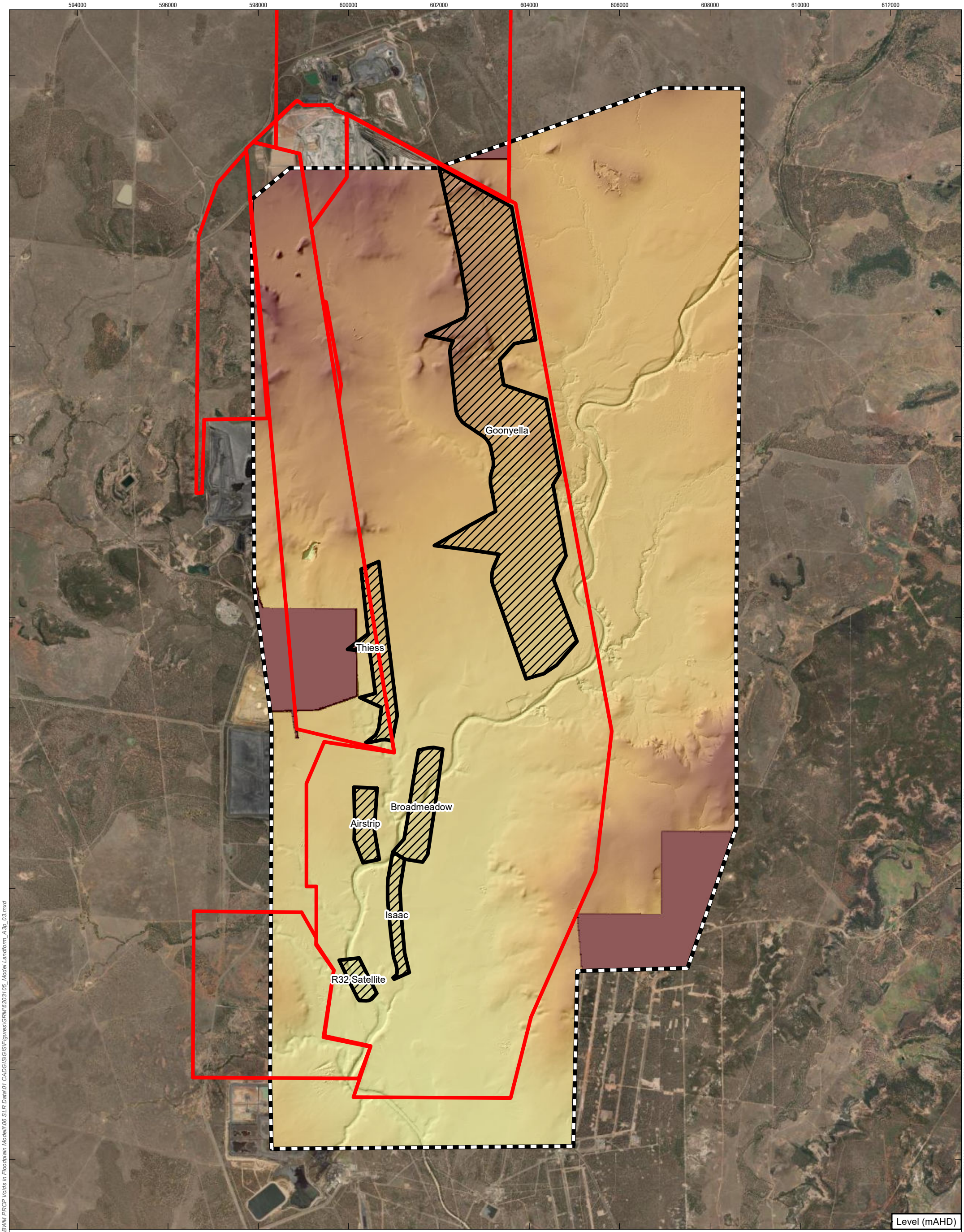
The dataset contained Strahler Stream Order classifications for each watercourse, which ranged from order 1 to order 9 within the extent of the data. The dataset was reviewed and interrogated to identify watercourses of Strahler stream order 4 or greater and may affect the proposed final voids.

As outlined in **Table 2** and illustrated in **Figure 1**, the Isaac River was the only watercourse of stream order 4 or greater in the vicinity of GRM. Therefore, flood modelling of the Isaac River in the vicinity of GRM was undertaken.

3.3 Topography and Landforms

A Model Landform was developed for use in the floodplain modelling of the Isaac River. The landform consisted of a combination of the 2023 Red Hill LiDAR DEM, which was applied outside of the GRM extents and the 1968 GRM Pre-mining topography DEM which was applied within the GRM extents.

The model landform is illustrated in **Figure 2**.



0 0.5 1 2 km

LEGEND

- Mining Leases
- Residual Voids
- Model Extent

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:75,000 at A3
Project Number:	620.31051
Date:	27-Sep-2024
Drawn by:	GN/HM

GOONYELLA MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

Model Landform

SLR

Service Layer Credits: Source: Esri, Maxar, Earthstar

Figure 2

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADGIS\GIS\Figures\GRM\62031051_Model Landform_A3p_03.mxd

3.4 Artificial Features

A review of the existing landscape in the vicinity of GRM was undertaken. The following noteworthy artificial features were identified:

- Burton Mine
- Burton Gorge Dam
- Moranbah North Mine
- Goonyella System Rail Line

Of the identified artificial features, the Burton Gorge Dam has the potential to influence flooding conditions within GRM, and was therefore included in the hydrologic model, as detailed in the following sections.

4.0 Hydrologic Modelling

4.1 Model Setup

4.1.1 Software

Hydrologic modelling was undertaken to estimate runoff hydrographs at various locations throughout the catchments of the relevant watercourses. The model was developed using the Watershed Bounded Network Model Version 2019 (WBNM). WBNM is an industry standard rainfall-runoff routing software package.

4.1.2 Catchment Characterisation

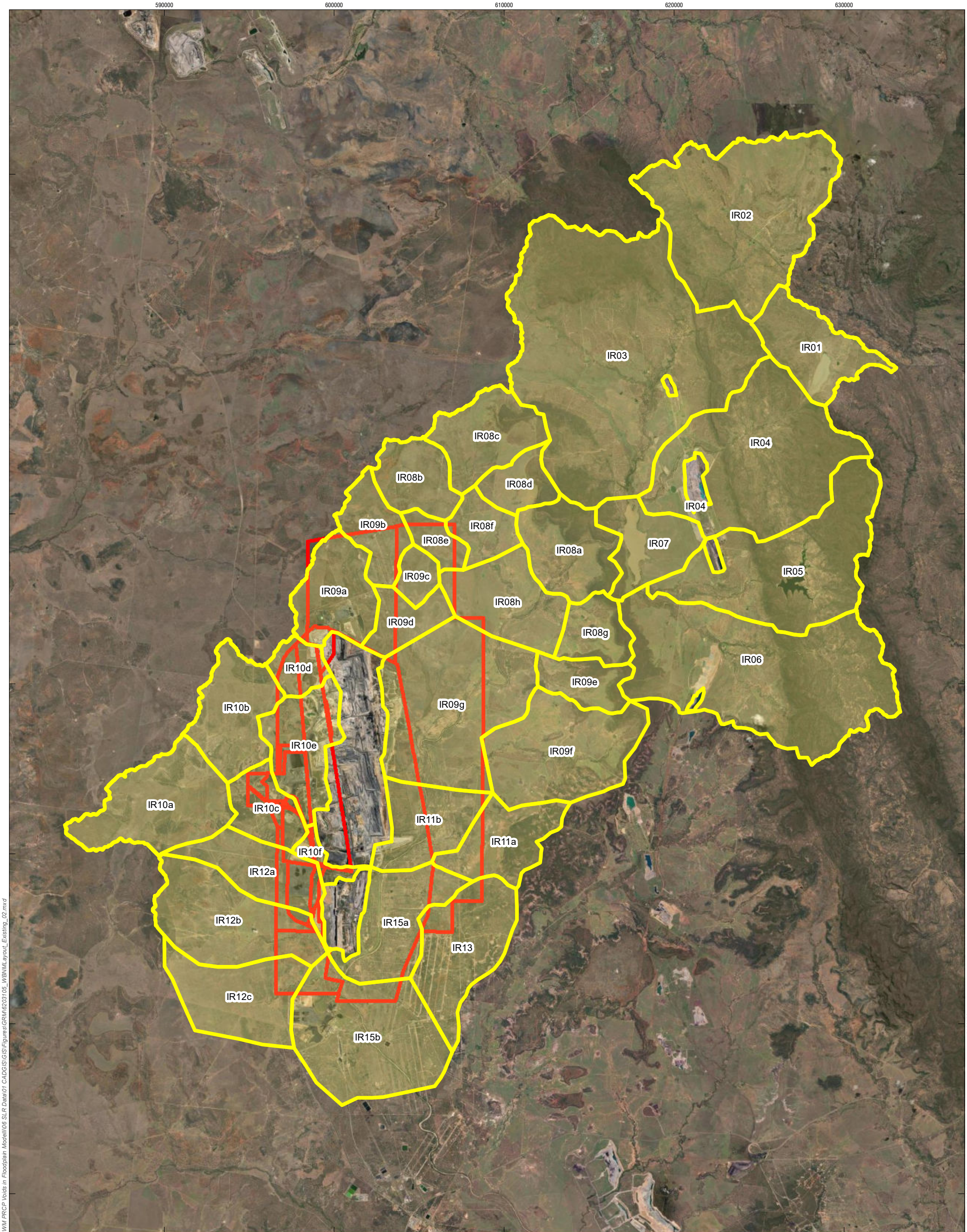
The Isaac River model covers a catchment area of approximately 1,250 km^2, spanning from the catchment headwaters upstream of Burton Gorge Dam to approximately 6km downstream of GRM. The model extent covers the Goonyella gauge, which is located within the GRM ML1763 at the Isaac River crossing of the Goonyella System Rail Line.

Two model scenarios were developed:

- **Existing Catchment Scenario**. Representing the current catchment conditions. The model sub-catchments were delineated based on available topographic data that best represented the existing conditions including the 2023 LiDAR DEM datasets for Goonyella and Red Hill Mines and the SRTM DEM. As part of the sub-catchment delineation, areas within the model extent that drained to existing mining pits, which act as sinks, were excluded from the model area. The model was utilised to verify the model results in comparison to the Flood Frequency Analysis undertaken for the Isaac River stream gauge at Goonyella. The model layout is illustrated in **Figure 3**.
- **Model Landform Scenario**. Representing the model landform catchment conditions. That is, pre-mining topography within the GRM extents excluding all artificial features. Model sub-catchments were delineated based on the model landform, otherwise this scenario adopted all model parameters as per the Existing Catchment Scenario. The model layout is illustrated in **Figure 4**.

4.1.3 Storm Events

The 0.1% AEP event was the primary design storm event for this assessment. In accordance with ARR, Probably Maximum Flood (PMF) temporal patterns were adopted for the 0.1% AEP event. ARR recommends the Generalised Short Duration Method (GSDM) for events with a duration up to 6 hours, and the Revised Generalised Tropical Storm Method (GTSMR) for durations of 24 hours or more. There is no set guidance for which method to adopt for storms with durations between 6 and 12 hours, therefore the GSDM temporal pattern was adopted for all durations up to and including the 12 hour duration, and the GTSMR temporal patterns for durations of between 12 hours and 72 hours.



0 1.5 3 6 km

Coordinate System: GDA 1994 MGA Zone 55

Scale:	1:200,000 at A3
Project Number:	620.31051
Date:	25-Mar-2024
Drawn by:	GN

LEGEND

- Mining Leases
- WBNM Catchment Boundaries

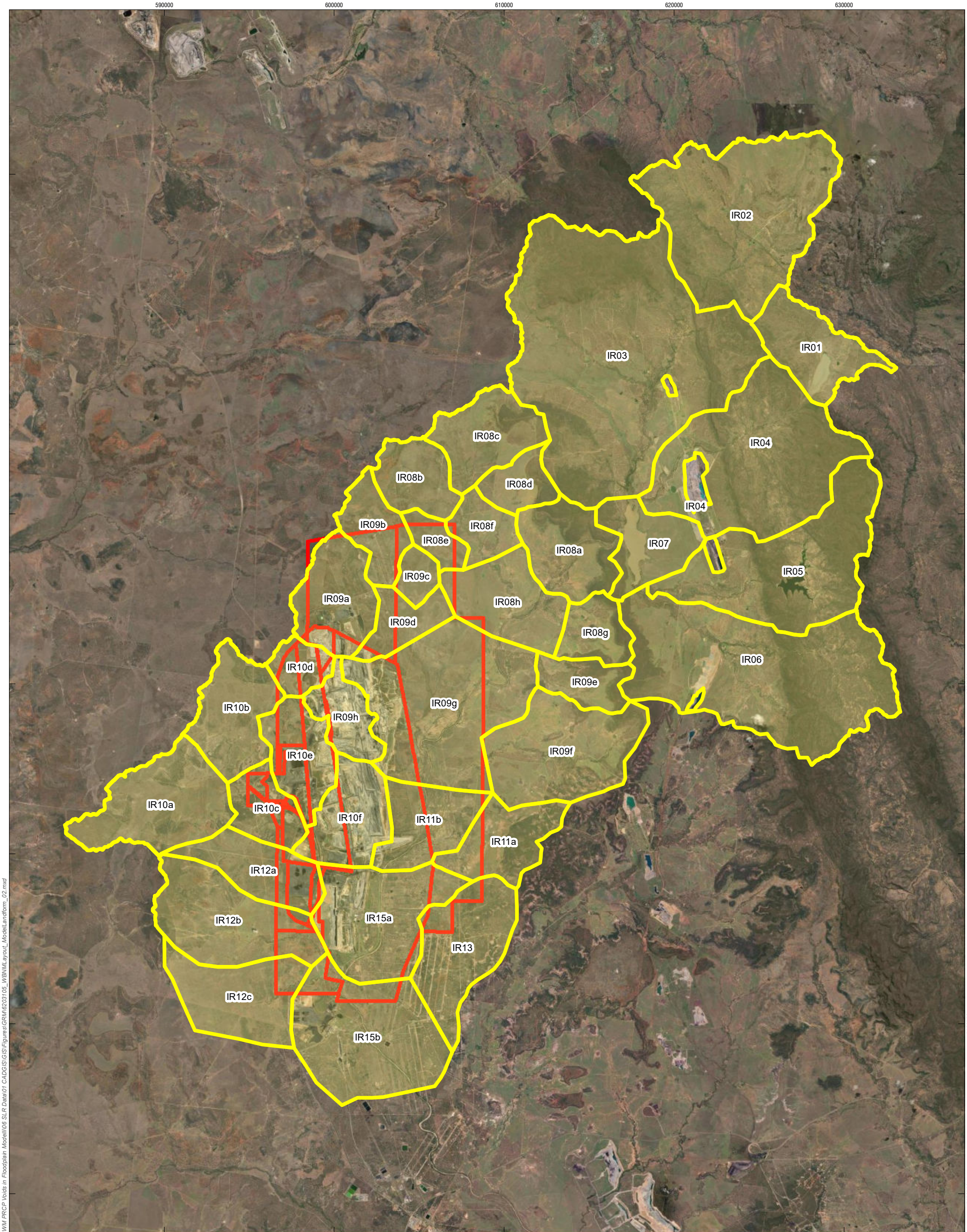
GOONYELLA MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

WBNM Model Layout
Existing Catchment Scenario

SLR

Figure 3

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADG\GIS\GIS\Figures\GRM\620310 5_WBNMLayout_Existing_02.mxd



0 1.5 3 6 km

Coordinate System: GDA 1994 MGA Zone 55

Scale:	1:200,000 at A3
Project Number:	620.31051
Date:	25-Mar-2024
Drawn by:	GN

LEGEND

- Mining Leases
- WBNM Catchment Boundaries

GOONYELLA MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

WBNM Model Layout
PRCP Model Landform Catchment Scenario

SLR

Service Layer Credits: Source: Esri, Maxar, Earthstar

Figure 4

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADG\GIS\GIS\Figures\GRM\6203105_WBNMLayout_ModelLandform_02.mxd

4.1.4 Intensity-Frequency-Duration Rainfall Data

Rainfall Intensity-Frequency-Duration (IFD) data for the catchment was sourced from the Bureau of Meteorology (BoM) online IFD data portal for a range of Annual Exceedance Probabilities (AEP). The adopted design rainfall intensity for the 0.1% AEP event is provided below.

Table 4 Design Rainfall Intensity Frequency Duration Data – 0.1% AEP

Storm Duration (h)	Design AEP Event Rainfall Depth (mm)
1	132
1.5	151
2	165
3	188
4.5	216
6	239
9	277
12	309
18	362
24	404
30	438
36	466
48	512

4.1.5 Losses

An initial loss of 0 mm was applied given the expected antecedent catchment conditions in the 0.1% AEP event. A continual loss value of 2.70 mm/h was applied based on the data provided by the ARR Data Hub for the area.

4.1.6 Lag Parameter

A catchment lag parameter of 1.60 was adopted in the WBNM model. The WBNM documentation recommends a lag parameter value between 1.40 and 1.80 where possible, therefore the adopted lag parameter was within the recommended range.

4.1.7 Aerial Reduction Factor

An Aerial Reduction Factor (ARF) was applied in the model. The ARF was based on a catchment area of 1,100 km^2, which is the area to the point at which the Isaac River discharges from the GRM site.

4.1.8 Storages

The Burton Gorge Dam is located on the Isaac River some 23 km upstream of GRM. The catchment area draining to the Dam is 540 km^2, approximately 50% of the catchment area of the Isaac River that drains through GRM. The Dam was incorporated into the hydrologic model as a reservoir storage node. Outflows from the Dam were modelled using a stage-storage-discharge relationship based on the storage and discharge curves provided in the Burton Gorge Dam Emergency Action Plan.

An initial water level of 298 mAHD (Full Supply Level + 500mm) was adopted in the model.

Table 5 WBNM Model – Burton Gorge Dam Stage-Storage-Discharge Relationship

Stage (m AHD)	Storage Volume (ML)	Discharge (m^3/s)
297	12,750	0
297.5	14,830	34
298	16,910	95
298.5	18,990	267
299	21,070	489
299.5	23,150	753
300	25,230	1,054
300.5	27,310	1,386
301	29,390	1,748
301.5	31,470	2,136
302	33,550	2,700
302.5	35,630	3,250
303	37,710	3,850

4.2 Validation

4.2.1 Stream Gauge

Flood frequency analysis was undertaken for Isaac River. Stream gauge data upstream of the site was obtained from the Qld Government Water Monitoring Information Portal.

There are two stream gauges upstream of the site; Isaac River at Goonyella (13414A) and Isaac River at Burton Gorge (130402A). Although there is 38 years of data available, due to the construction of the Burton Gorge Dam, the Isaac River at Goonyella gauge is considered to be lacking in homogeneity, and hence it is not suitable for flood frequency analysis.

Flood frequency analysis was therefore undertaken for the gauge at Isaac River at Burton Gorge (130402A). Data for this gauge is available between 1964 and 1988 (24 years). Burton Gorge Dam was constructed in 1992, so the dataset is not influenced by the dam.

4.2.2 Flood Frequency Analysis

RMC-BestFit v1.0, a Bayseian estimation and fitting software developed by the US Army Corps of Engineers (USACE) Risk Management Center (RMC), was used for flood frequency analysis.

A Log-Pearson Type III distribution was fitted to the data. The peak flow prediction beyond 1% AEP goes outside the 90% credible intervals, and therefore should not be used for comparison with hydrological model results. Note that the peak flow of $0m^3/s$ from 1969 was treated as low outlier data and not included in the analysis.

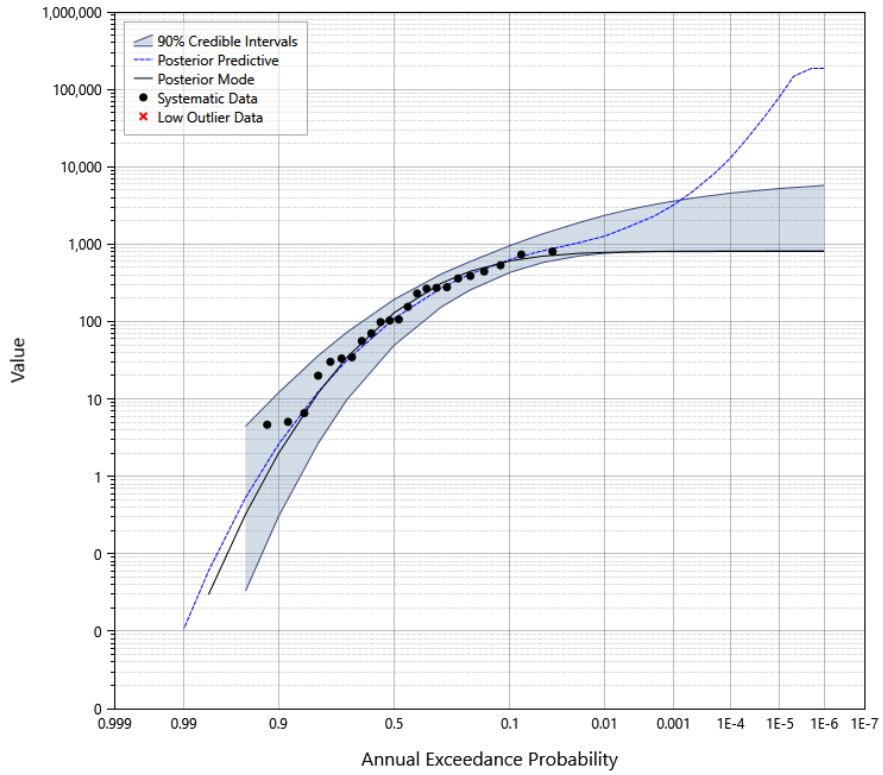
The results of the FFA are shown in **Table 6** and **Figure 5** below.

Table 6 FFA Results for Issac River at Burton Gorge gauge

AEP	Peak Flow (m^3/s)	Lower 90% confidence limit (m^3/s)	Upper 90% confidence limit (m^3/s)
39%	165	83	273

AEP	Peak Flow (m^3/s)	Lower 90% confidence limit (m^3/s)	Upper 90% confidence limit (m^3/s)
20%	412	257	597
10%	635	433	961
5%	824	581	1,362
2%	1,052	710	1,914
1%	1,269	763	2,354

Figure 5 FFA Results for Issac River at Burton Gorge gauge



4.2.3 Comparison to 2019 FFA

A flood frequency analysis was undertaken for the Goonyella and Broadmeadow mines in the Goonyella and Broadmeadow Hydraulic Assessment (WRM 2019).

Analysis was undertaken for the Isaac River at Goonyella gauge. An "all-data" scenario using all 35 years of data and a "post-dam" scenario which uses only the data after Burton Gorge Dam construction (27 years). Although the Isaac River at Goonyella gauge was deemed not suitable for an FFA (refer to **Section 4.4.1**), the peak flows from the WRM FFA and subsequent XP-RAFTS model results are of similar magnitude to the WBNM model output. Comparison to these results are shown in **Table 8**.

4.3 Results

The peak flows from the WBNM model at Burton Gorge gauge were compared to the peak flow from the FFA in **Table 7**.

The WBNM peak flows were generally consistent with the 2% and 1% AEP FFA results. The WBNM model peak flow was lower than the FFA results in the 39% AEP. However, the 39% AEP results were utilised to assess the peak flood bed shear stress, stream power and velocity and subsequently the associated scour and erosion risk, and these parameters are not significantly affected by relatively small changes in peak flow.

Table 7 Peak flow at Burton Gorge gauge

AEP (%)	WBNM Peak Flow (m^3/s)	FFA Peak Flow (m^3/s)	% difference from FFA	RFFE Discharge (m^3/s)	RFFE Lower confidence Limit 5% (m^3/s)	RFFE Upper confidence Limit 95% (m^3/s)
39	112	165.6	-32%	-	-	-
10	463	635	-27%	707	334	1,560
5	682	825	-17%	874	397	2,010
2	1,025	1,052	-2%	1,110	476	2,700
1	1,307	1,270	3%	1,300	532	3,310
0.1	2,502	-	-	-	-	-

The peak flows from the WBNM model at Isaac River at Goonyella gauge were compared to the peak flow from the FFA from WRM as shown in **Table 8**.

Table 8 Peak flow at Isaac River at Goonyella

AEP (%)	WBNM Peak Flow (m^3/s)	WRM (2019) Peak Flow (m^3/s)	% difference from WRM
10	718	830	-13%
5	1,080	1,167	-7%
2	1,689	1,707	-1%
1	2,187	2,079	5%
0.1	4,365	3,808	15%

The flows produced by the WBNM model are comparable to the peak flows from the FFA and the RFFE at Burton Gorge. The results are also comparable to the flows from the WRM (2019) FFA at Goonyella. Although the outcome suggests that the 0.1% AEP results may be conservative on the high side, there is insufficient gauge information to confirm this.

Therefore the WBNM model was deemed suitable for use for this assessment.

Flow hydrographs generated by the WBNM model for the 0.1% AEP event were extracted from the WBNM model at the outlet of each sub-catchment. The hydrographs were utilised as inflow boundaries for the TUFLOW hydraulic model, details of which are provided in the following section.

5.0 Hydraulic Modelling

5.1 Software

Hydraulic modelling was undertaken for the Isaac River in the vicinity of GRM, including the proposed final voids.

The industry standard hydrodynamic modelling software TUFLOW (build 2023-03-AD) was utilised for the hydraulic modelling.

Details of the modelling approach, setup and results are provided below.

5.2 Topography

The following topographic data were utilised in the TUFLOW model:

- Red Hill Mine 2023 LiDAR 1m DEM.
- GRM pre-mining (1968) 1m DEM.

The GRM pre-mining DEM was applied within the GRM mine lease extents and downstream of GRM, and the Red Hill Mine LiDAR DEM was applied within the Red Hill Mine extent upstream of GRM.

The model extent was dictated by the extent of the available topographic data, as illustrated in **Figure 6**.

5.3 Model Grid Cell Size

A grid cell size of 20m was adopted. The native sub-grid sampling functionality was applied in the model, with a sampling distance of 2m.

This approach provided adequate resolution of the Isaac River watercourse cross-section, which is generally 20-50m in width within the model extent.

5.4 Hydraulic Roughness

The hydraulic roughness for the model was determined based on available aerial imagery. The Manning's n values adopted in the model are detailed in **Table 9**.

Table 9 TUFLOW Model Manning's n Values

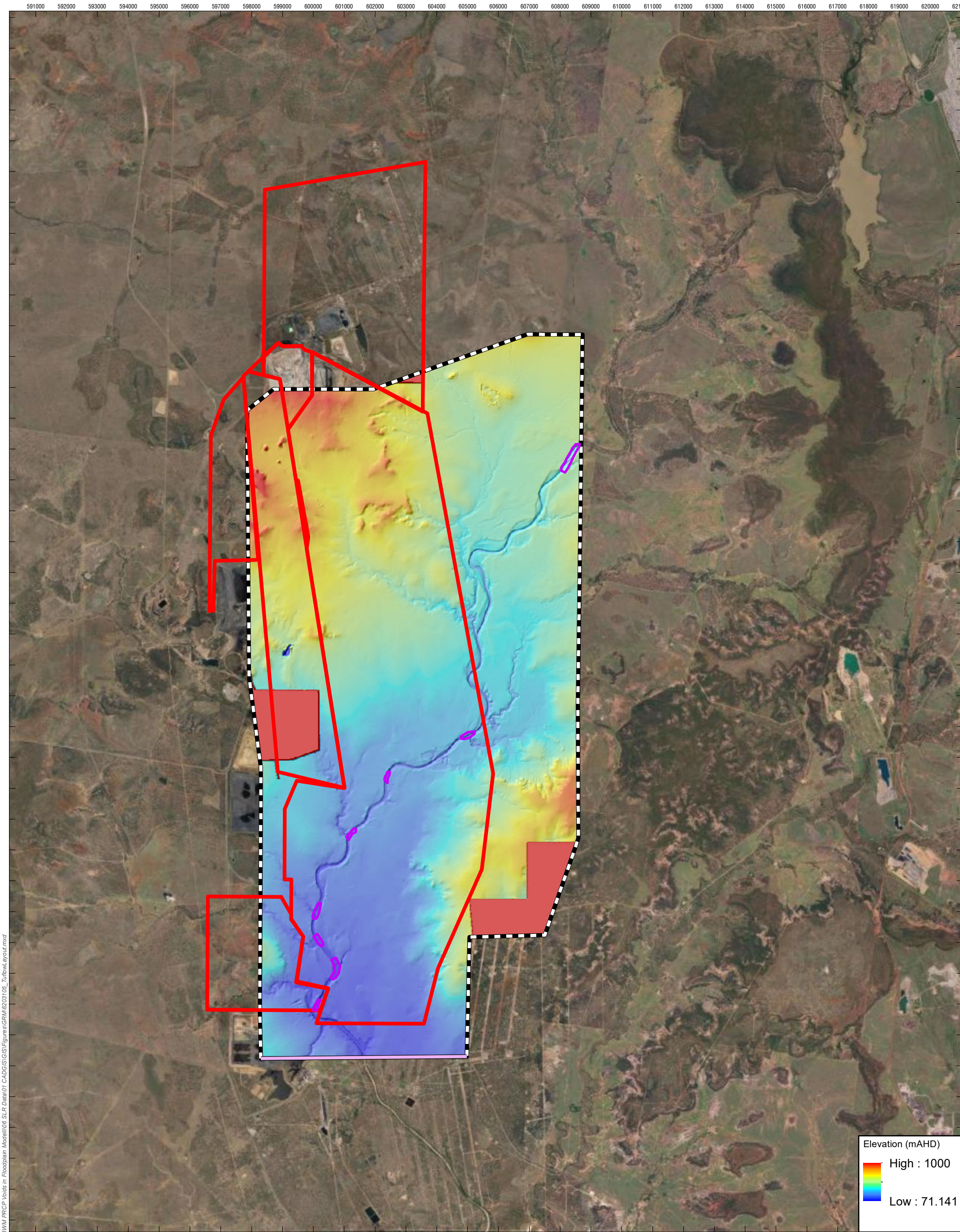
Land use	Manning's n
Light Vegetation	0.06
Overbanks	0.08
Channel bed	0.04

5.5 Boundaries

Flow hydrographs extracted from the WBNM model were applied as inflows to the TUFLOW models. They were applied as local or total hydrographs where appropriate.

Stage-discharge relationships were applied as the downstream boundary conditions in each model. The relationships were derived based on the flood surface gradient at each boundary location using the built-in functionality provided in TUFLOW.

In the Isaac River model, the downstream boundary is located approximately 2.8km downstream of the nearest final void, and the peak flood levels at the boundary were approximately 6 metres lower than in the vicinity of the nearest final void. Therefore, the model boundary did not influence peak flood levels in in the vicinity of the final void extents.



0 0.75 1.5 3 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:110,008 at A3
Project Number:	620.31051
Date:	25-Mar-2024
Drawn by:	GN

LEGEND

- Model Extent
- Mining Leases
- SA Inflows
- Downstream Boundary

GOONYELLA MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

TUFLOW Model Layout

SLR

Figure 6

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADG\S\G\S\Figures\GRM\6203105_TuflowLayout.mxd

5.6 Results

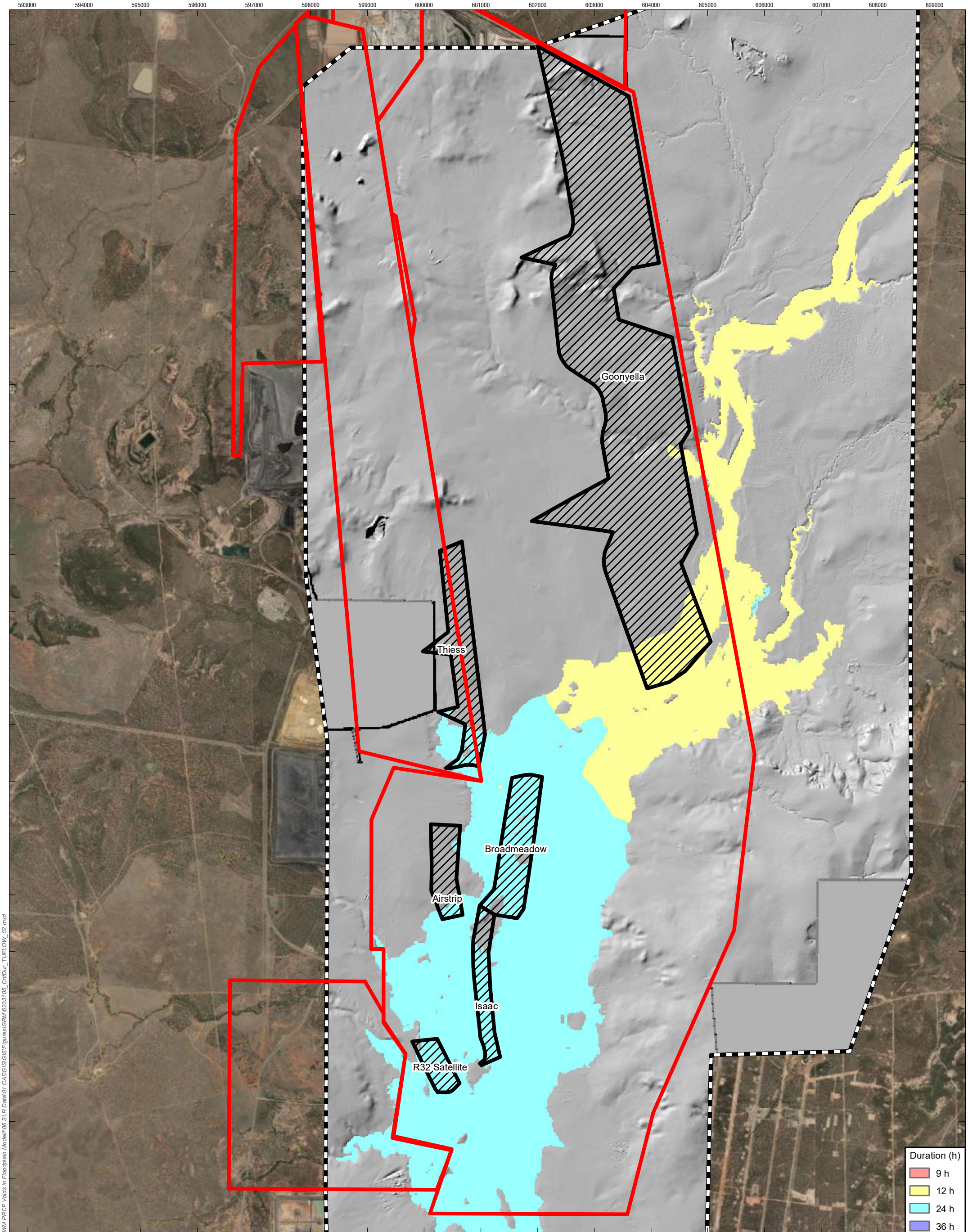
The TUFLOW models were simulated for the 0.1% AEP event for a range of storm durations, including as detailed in **Section 4.1.3.** The critical storm durations across the model extent were extracted from the model results, as illustrated in **Figure 7**.

Peak flood levels, depths and velocities were extracted from the model results and are presented in **Appendix A.**

The peak 0.1% AEP flood inundation extent generated by the TUFLOW model is illustrated in **Figure 8**. The model results show that each of the proposed final voids are located within the 0.1% AEP floodplain extent.

For the Thiess and Goonyella final voids, the floodplain extends in limited areas in the south of the void extents and a small area along the eastern extremities of the Goonyella void.

For the Broadmeadow, R32 Satellite and Isaac voids, the majority of the void extents are located within the 0.1% AEP floodplain extent. The Airstrip void is only partially within the 0.1% AEP Floodplain extent. It is noted that the existing Isaac River Diversion is situated approximately 1 km west of the Broadmeadow final void. The TUFLOW model topography was based on the 1968 DEM which represents the pre-mining topography prior to the development of the Isaac River Diversion.



0 0.5 1 2 km

LEGEND

- Mining Leases
- Residual Voids
- Model Extent

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	27-Sep-2024
Drawn by:	GN/HM

GOONYELLA MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

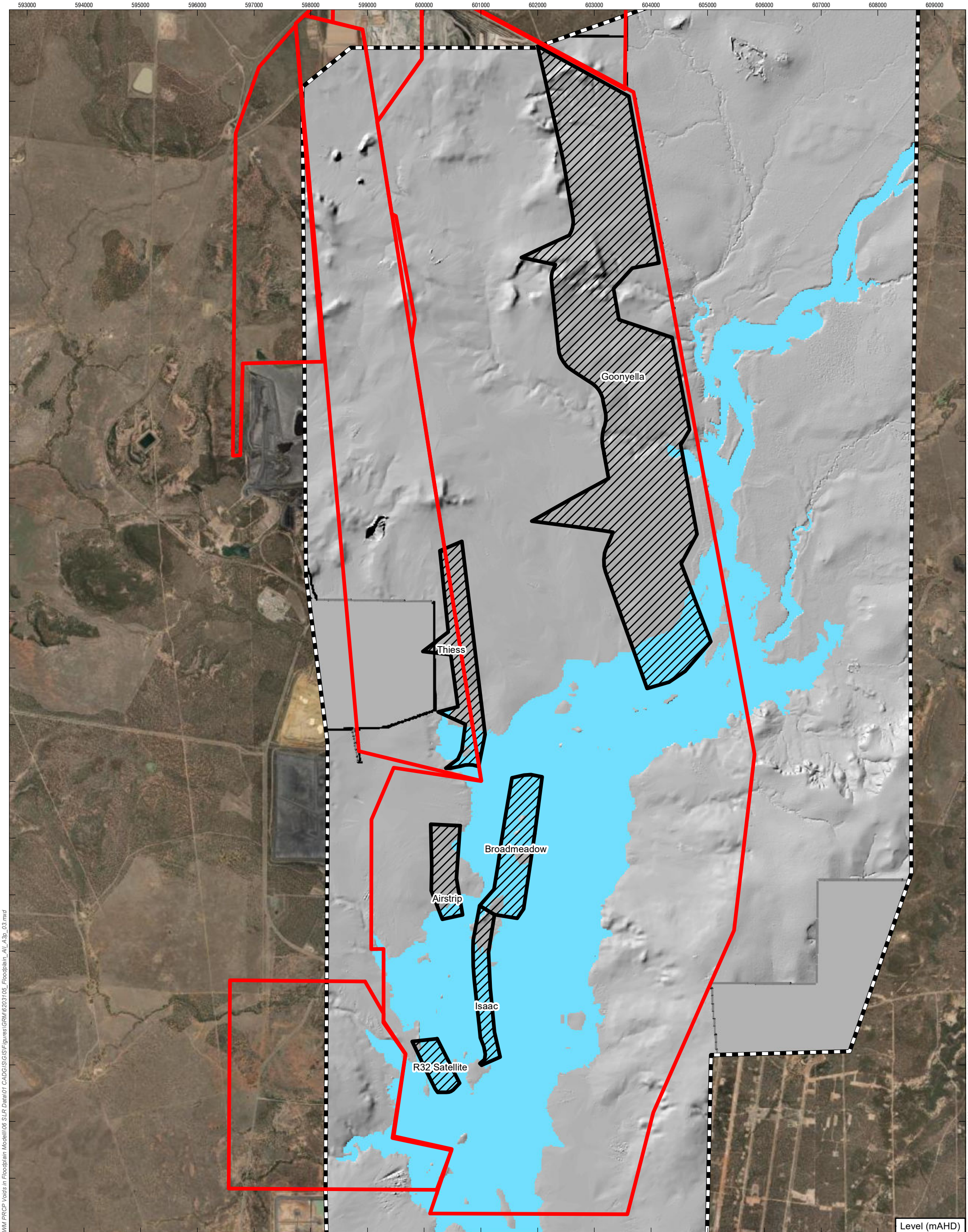
TUFLOW Model Results
Critical Storm Durations
0.1% AEP Event

SLR

Service Layer Credits: Source: Esri, Maxar, Earthstar

Figure 6

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADD\GIS\GIS\Figures\GRM\620310 5_CritDur_TUFLOW_02.mxd



0 0.5 1 2 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	27-Sep-2024
Drawn by:	GN/HM

LEGEND

- Mining Leases
- Residual Voids
- Model Extent
- 0.1% AEP Inundation Event

GOONYELLA MINE PRCP
VOIDS IN FLOODPLAIN MODELLING

TUFLOW Model Results
Modelled Flood Inundation Extent
0.1% AEP Event

SLR

Service Layer Credits: Source: Esri, Maxar, Earthstar

Figure 7

H:\Projects-SLR\620-BNE\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CAD\GIS\GIS\Figures\GRM\620310105_Floodplain_All_A3p_03.mxd

6.0 Groundwater Impact on Floodplain Extents

Consideration was made to the potential effects of groundwater on the floodplain extents. The floodplain extents were based on the peak 0.1% AEP event flood levels. During a flood event of this magnitude, any groundwater interaction with surface water would have a negligible impact on the resulting floodplain extents.

7.0 Conclusion

As part of the PRCP for Goonyella Mine, it is proposed to incorporate six final voids as NUMAs. Therefore, in accordance with the EP Act and EP Regulation and specifically Section 3.4 of the PRCP Guideline, floodplain modelling has been undertaken for all relevant watercourses that may affect the voids.

Data for the assessment was provided by BHP, and sourced from various public providers. The data was reviewed and modified for use where appropriate. Model landforms were developed to account for relevant artificial features outside of the GRM mine extents, and pre-mining topography within the mine extents based on the information available at the time of the study.

A hydrologic model was developed for the catchment of the Isaac River in the vicinity of GRM. The model results were verified against peak flows generated by flood frequency estimates and the results of an at-site Flood Frequency Analysis based on gauged stream flow data.

A hydraulic model of the Isaac River floodplain was developed using available topographic data. The model landform was developed to represent the pre-mining topography within the GRM mine lease extents in accordance with the PRCP Voids in Floodplain Modelling Guidelines. Hydrographs from extracted from the hydrologic model at relevant locations were applied as inflows to the hydraulic model.

The results of the hydraulic model provided the predicted 0.1% AEP flood event inundation extent based on the model landform. Predicted peak flood levels and depths were also produced by the hydraulic model. The model results showed that the proposed final voids were situated within the modelled pre-mining 0.1% AEP flood inundation extents.

8.0 Limitations

This report, including the hydrologic and hydraulic modelling, is not necessarily suitable for application for purposes other than as detailed above.

This Voids in Floodplain Assessment has relied upon, and assumed accurate, information which was received from BHP and other sources. Except where noted, no verification of accuracy of the information has been carried out. In the event that some of the information which was relied upon for this assessment is found to be inaccurate, then some or all of the findings may change.

Although the analyses undertaken as detailed in this report were done so with the appropriate care and professionalism, this report shall only be used for the purposes intended. The analyses detailed in the sections above were undertaken solely for the purpose of addressing the requirements for voids in floodplain modelling for Goonyella Riverside Mine in accordance with:

- *Environmental Protection Act 1994;*
- *Environmental Protection Regulation 2019;*
- *'Information Sheet – Environmental Protection Act 1994 – Voids in Flood Plains'*, Department of Environment and Science, March 2020; and
- *'Guideline – Progressive Rehabilitation and Closure Plans'*, Department of Environment and Science, March 2021 (PRCP Guideline).

This report should be read in full and no excerpts are to be taken as representative of the findings. This report has been prepared on behalf of BHP Metcoal Holdings Pty Ltd and SLR accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Appendix A TUFLOW Model Results

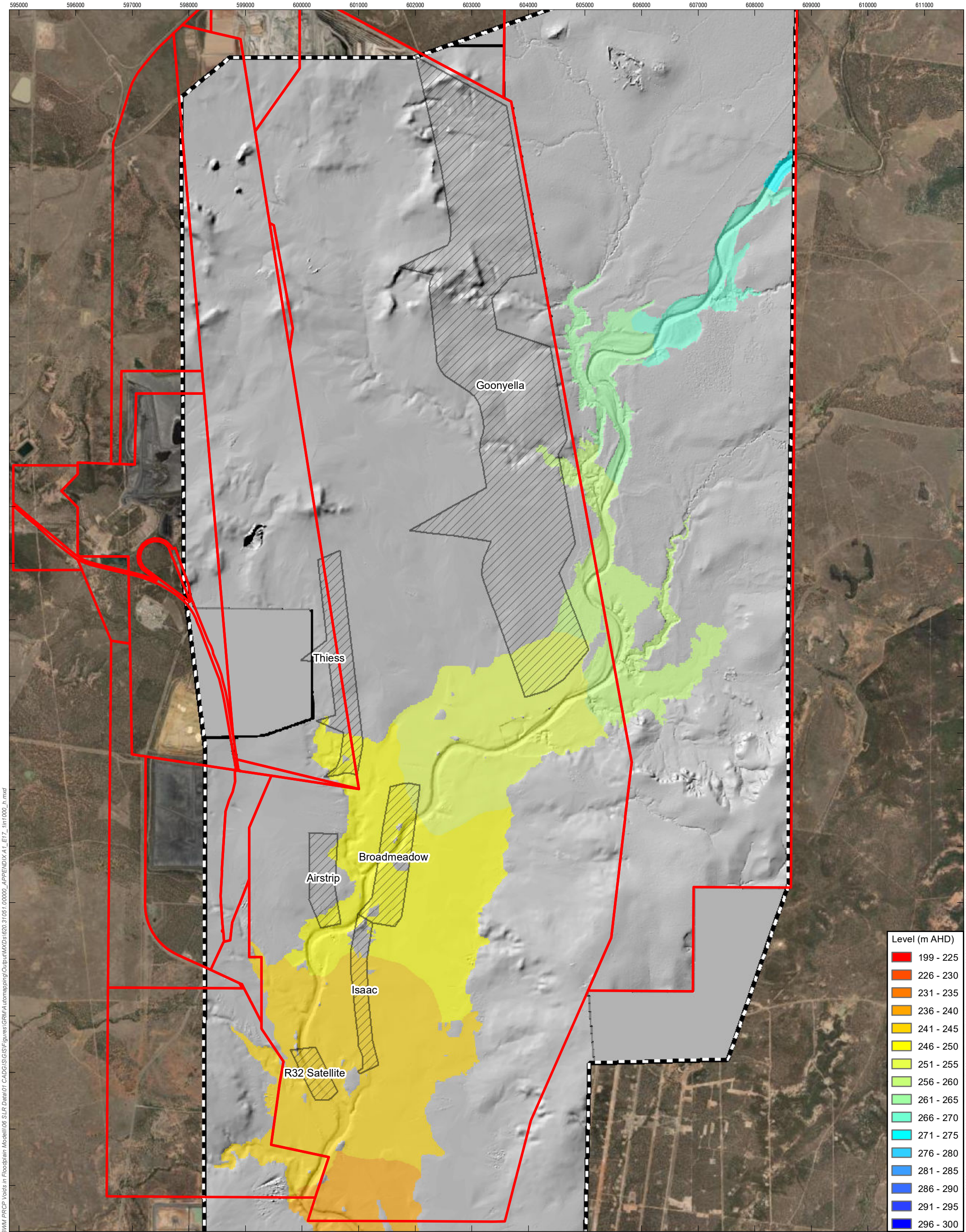
Goonyella Riverside Mine Progressive Rehabilitation and Closure Plan

Voids in Floodplain Report

BHP Mitsubishi Alliance

SLR Project No.: 620.31051.00000

20 November 2024



0 0.5 1 2 km

LEGEND

- TUFLOW Model Extent
- Mining Leases
- Final Void Extents

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	27-Sep-2024
Drawn by:	HM

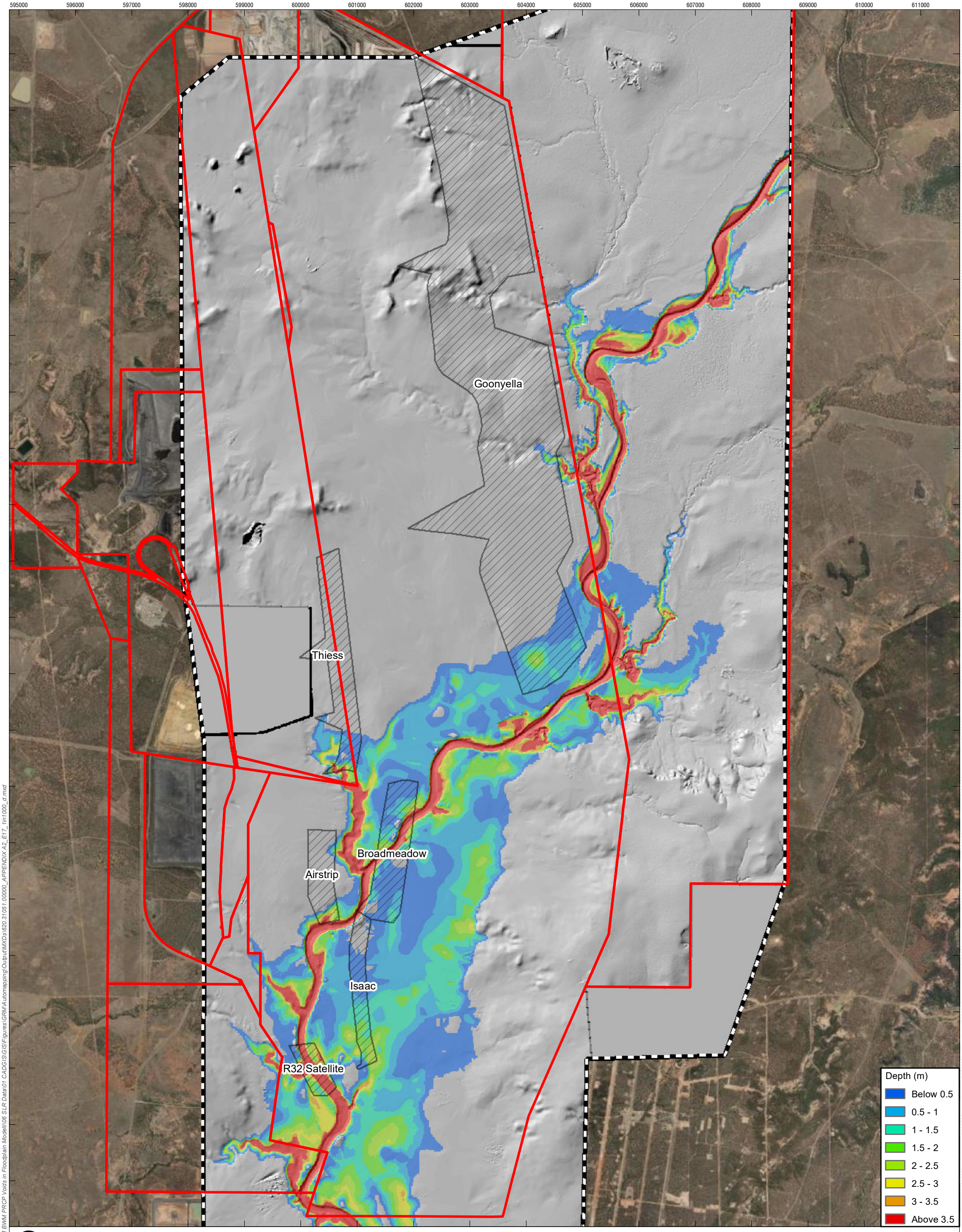
SLR

GOONYELLA RIVERSIDE MINE PRCP VOIDS IN FLOODPLAIN MODELLING

Isaac River
Peak Flood Levels - 0.1% AEP

APPENDIX A1

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADG\SIG\SIFigures\GRMIAutomapping\Output\MXDs\620.31051.00000_APPENDIX A1_E17_1in1000_h.mxd



0 0.5 1 2 km

LEGEND

- TUFLOW Model Extent
- Mining Leases
- Final Void Extents

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	27-Sep-2024
Drawn by:	HM

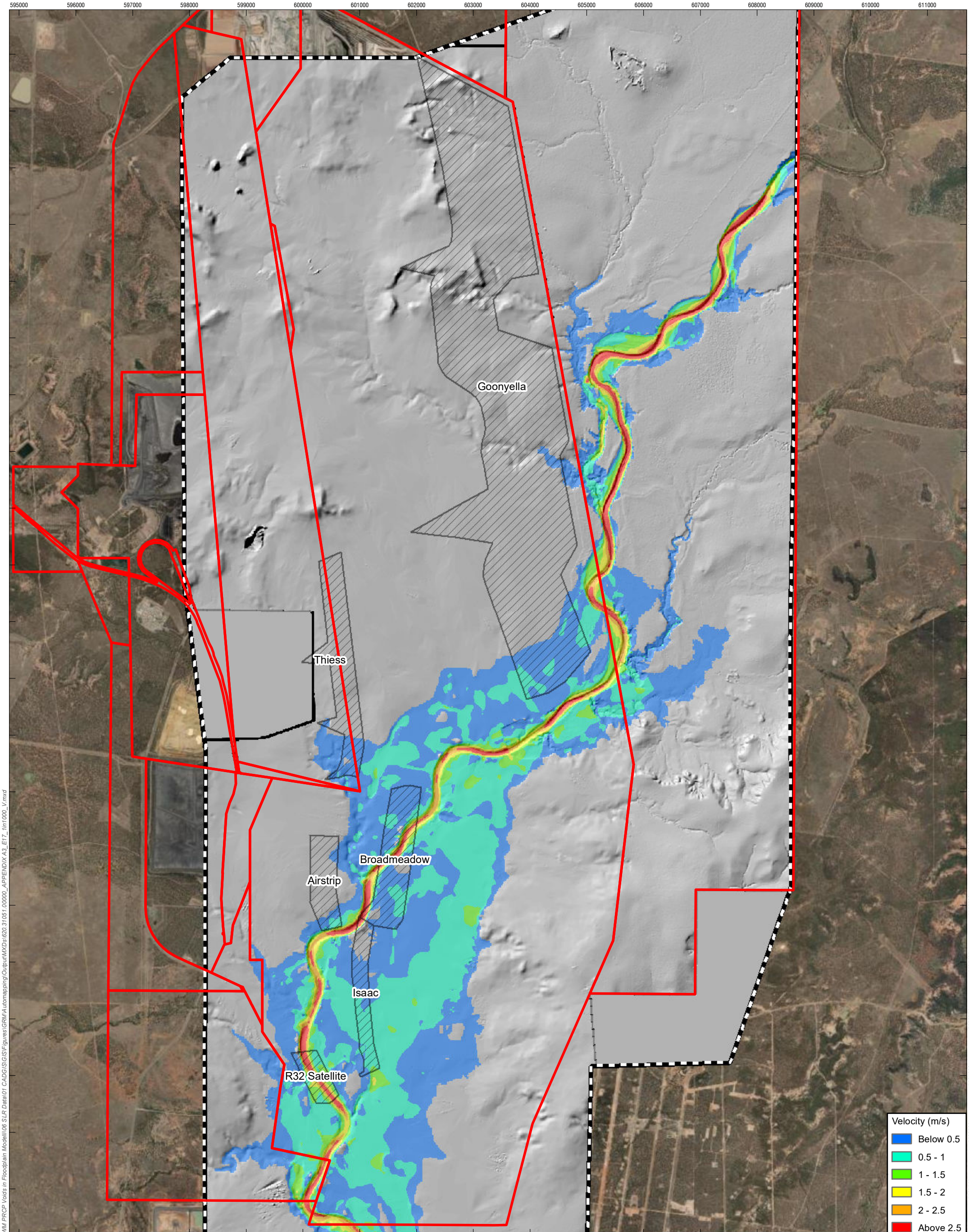
SLR

GOONYELLA RIVERSIDE MINE PRCP VOIDS IN FLOODPLAIN MODELLING

Isaac River
Peak Flood Depths - 0.1% AEP

APPENDIX A2

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADGIS\GIS\Figures\GRM\Automapping\Output\MXDs\620.31051.00000_APPENDIX A2_E17_1in1000_d.mxd



0 0.5 1 2 km

Coordinate System:	GDA 1994 MGA Zone 55
Scale:	1:60,000 at A3
Project Number:	620.31051
Date:	27-Sep-2024
Drawn by:	HM

LEGEND

- TUFLOW Model Extent
- Mining Leases
- Final Void Extents

GOONYELLA RIVERSIDE MINE PRCP VOIDS IN FLOODPLAIN MODELLING

Isaac River
Peak Flood Velocities - 0.1% AEP

SLR

APPENDIX A3

H:\Projects-SLR\620-BNE\620.31051.00000 GRM BWM PRCP Voids in Floodplain Modelling\06 SLR Data\01 CADGIS\GIS\Figures\GRM\Automapping\Output\MXDs\620.31051.00000_APPENDIX A3_E17_1in1000_V.mxd

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