SARAJI EAST MINING LEASE PROJECT

Environmental Impact Statement

Chapter 10
Geochemistry and Mineral Waste

BHP

Contents

Saraji East Mining Lease Project

10 Geochemistry and Mineral Waste

10.1 Introduction

This chapter describes the geochemical characteristics of waste rock, potential coal reject and coal materials likely to be produced from the Project and assesses the potential environmental issues that may be associated with the mining, handling and storing of these materials.

Mineral wastes arising from the Project include waste rock from portal and ventilation shaft construction, reject materials from the coal handling and preparation plant (CHPP), including dense medium coarse rejects, reflux classifier and dewatered floatation tailings. The anticipated waste rock and rejects from the Project will be deposited at the existing Saraji Mine within the existing in-pit spoil dumps with mineral waste from existing open cut operations in accordance with authorised Saraji Mine mineral waste management practices.

10.2 Legislation and policy

To protect environmental values, the primary legislative requirements for the management of acid and metalliferous drainage (AMD) and contaminated land are contained within the *Environmental Protection Act 1994* (EP Act). The EP Act is administered by the Department of Environment and Science (DES). Additional guideline documents relevant to this assessment include:

- Department of Minerals and Energy (1995a), Assessment and Management of Acid Drainage
- Department of Minerals and Energy (1995c), Guidelines for the Assessment and Management of Saline/Sodic Waste
- AMIRA (2002), Acid Rock Drainage Test Handbook, Project P387A Prediction and Control of Acid Metalliferous Drainage
- Department of Industry, Innovation and Science Australia (2016), Managing Acid and Metalliferous Drainage, Leading Practice Sustainable Development Program for the Mining Industry
- ANZECC/ARMCANZ (2000) Australian and New Zealand guidelines for fresh and marine water quality. Volume 1, The guidelines / Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand
- National Environmental Protection Council. National Environment Protection (Assessment of Site Contamination) Measure 1999 (Assessment of Site Contamination NEPM), Guideline on investigation levels for soil and groundwater, published 16 May 2013, including amendments up to National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1).

10.3 Methodology

The geochemistry assessment for the Project used historic geochemical data from BMA's exploration drilling and coal quality testing program conducted between 2010 and 2011, and additional samples collected by RGS-Terrenus in 2012 (refer **Appendix G-1 Geochemistry Technical Report**). The geochemical dataset comprised:

- waste rock samples from BMA drill-cores and highwall grab samples at the proposed access portal area (RGS-Terrenus, 2012)
- potential reject selected from drill core samples (by RGS-Terrenus from BMA exploration cores)
- coal samples from the BMA exploration cores
- coarse reject grab samples collected by RGS-Terrenus from the coarse reject stockpile at the Saraji Mine in 2012.

The sampling regime provided reliable geochemical data from locations within and relevant to the Project Site. **Figure 10-1** indicates the locations of the geochemistry samples for the investigation.

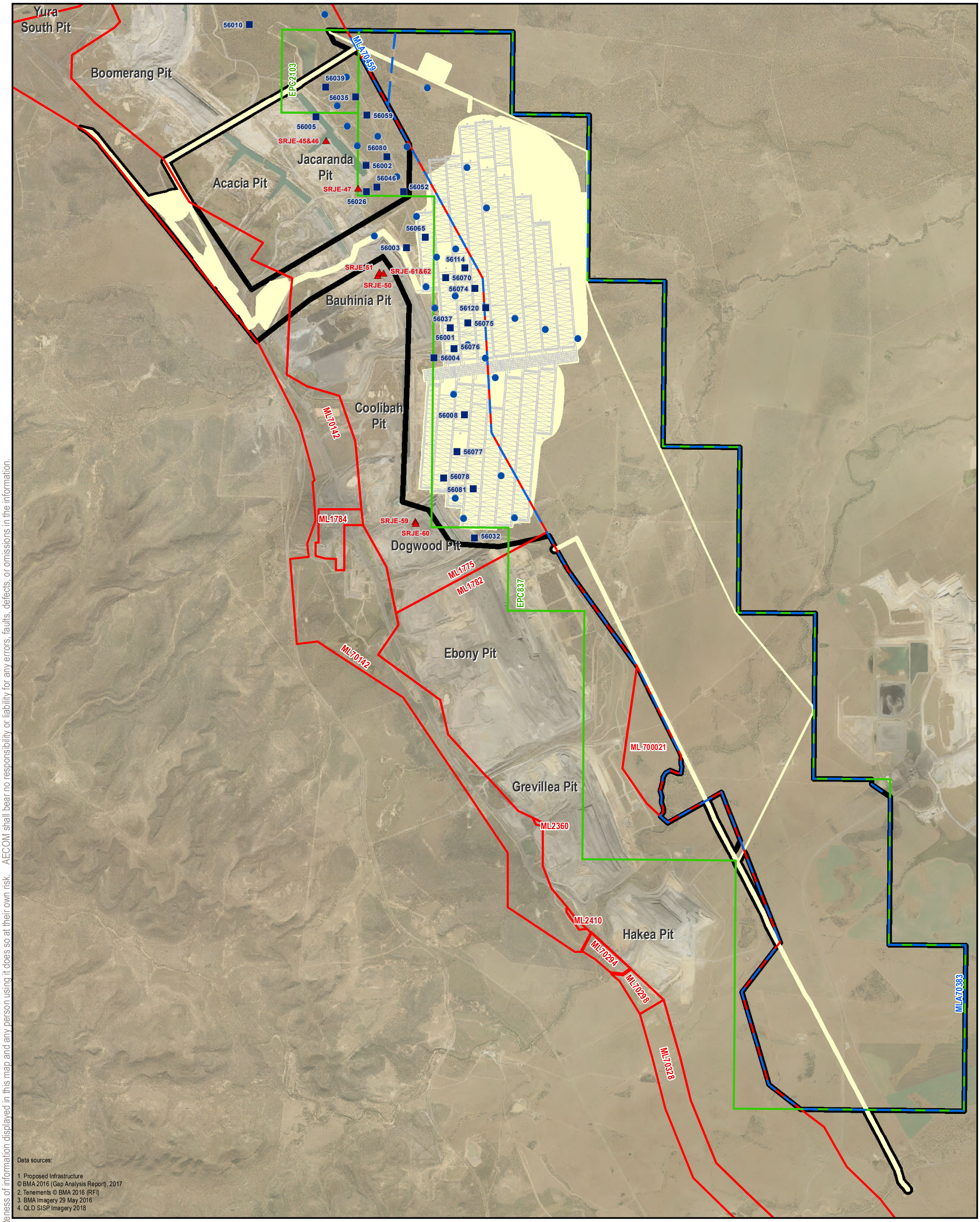
The assessment included a comparison of Project-specific waste and coal geochemistry against information from geochemical studies on the existing Saraji Mine coal and waste material (EGI, 1993; Emmerton, 2009; Emmerton, 2010, RGS, 2017). Findings from the existing Saraji Mine sampling programs (Emmerton 2009; 2010) were used by RGS-Terrenus (2012) to aid selection of 60 samples for detailed geochemical testing from the cores of 26 of the 55 BMA exploration drill-holes and grab samples close to the proposed portal location.

Where the geology and nature of the resource is well understood, a risk-based approach was generally used to aid selection of samples for environmental geochemical investigations. Supplementary drilling and sampling completed for the Project considered existing information from geological and exploration drilling. Drill core samples that were provided represent the various mineral waste materials likely to be generated during the project.

A summary of total samples collected and analysed is outlined in Table 10.1

Table 10.1 Summary of mineral waste samples assessed for the Project

Mineral waste type	Waste description	Number of samples	
		RGS-Terrenus (2012)	BMA (2010-2011)
Drill cores (total)		**26**	**55**
Waste rock	Waste sedimentary rock from construction of mine portal	14	-
Coal samples	Sampled directly from the coal seam	6	-
Coal (potential) reject samples	Selected from drill core samples	37	195
Coarse reject samples	Roof and floor waste material sampled from the CHPP	3	-
Samples (total)		**60**	**195**



LEGEND

- Project Site
- Project Footprint
- Exploration Permit Coal (EPC)
- Mining Lease (ML)
- Mining Lease Application (MLA)
- Underground layout (optimised)
- Drill Hole - Detailed
- Drill Hole - Total Sulfur Only
- Highwall Grab Sample

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Figure 10-1
Drill-core locations for Geochemical and Mine Waste Investigation

Environmental Impact Statement
Saraji East Mining Lease Project

0 0.5 1 2
Kilometres

Scale: 1:110,000 (when printed at A4)

Projection: Map Grid of Australia - Zone 55 (GDA94)

BHP

DATE: 4/08/2020 VERSION: 2

10.3.1 Acid rock drainage

Deposition of the organic precursors of coal promotes low oxygen conditions that can encourage sulfide formation in the coal, rock and sediment layers that become associated with a coal seam. Left buried and undisturbed, sulfide remains unreactive; however, mining the seam can expose the sulfide to air. If iron pyrite (FeS_2) is among the sulfides exposed, it reacts with oxygen in the air and water to form sulfuric acid (H_2SO_4).

Waste rock left exposed to air and rainfall have the potential to result in the generation of acidity. Acidic water can leach metals from mineral wastes resulting in elevated metal and sulfate concentrations that have the potential to impact groundwater as well as surface water. Near-neutral (non-acidic) but metalliferous and/or saline drainage from mineral waste to groundwater and surface water can also occur when acid consuming minerals are present within the matrix

Geochemical analysis undertaken as part of the RGS-Terrenus (2012) assessment evaluated the potential for mineral waste to generate acidic (acid rock drainage), non-acidic and metalliferous (NMD) and saline drainage (SD). The assessment included an analysis of the sulfide content of mineral wastes and determined the potential for generation of acidity and metal mobilisation under laboratory conditions.

10.3.2 Static geochemical analysis

Static geochemical testing on the samples selected by RGS-Terrenus (2012) for testwork included:

- pH (1:5)
- electrical conductivity (EC) (1:5)
- acid neutralising capacity (ANC)
- total sulphur and sulfide-sulfur (S_{CR})
- net acid generation (NAG)
- exchangeable sodium percentage (ESP).

Based on results of the static geochemical testing, individual samples were selected to undergo additional acid-buffering characteristic curve (ABCC) testing to assess the amount of neutralising capacity likely available under field condition.

The BMA 2010-11 exploration drilling allowed for the identification of 195 potential reject samples; for all these samples, total sulfur was determined as part of the coal quality assessment. Assessment of the total sulfur distribution by RGS-Terrenus showed that only 42 samples (22 percent of the total number of samples) had a total sulfur content greater than 0.2%; of these the 37 samples with the highest sulfur content, and therefore the highest potential for acid generation, underwent static geochemical testing (RGS-Terrenus, 2012).

Samples from similar stratigraphies and geochemical characteristics were composited and submitted for multi-element testing on solids and leach testwork. The solids and associated leachates were analysed for pH, EC, total metals and metalloids, soluble metals and metalloids, and soluble cations and anions.

10.3.3 Multi-element scans

Multi-element scans were carried out to identify elements potentially enriched in the samples that may represent a potential hazard with respect to revegetation and / or surface water quality if mobilised.

Elements identified as enriched compared to un-mineralised crust are not necessarily a concern for revegetation, human or animal health, or drainage water quality; however, were still evaluated.

Similarly, although an element is not enriched it may become a concern in the future; for example, certain conditions (e.g. low pH) may promote the mobilisation of common, environmentally important elements such as aluminium (Al), copper (Cu), cadmium (Cd) and zinc (Zn).

Total concentrations of each element reported in the mineral waste samples were compared to the Assessment of Site Contamination NEPM (1999) health-based investigation levels (HIL) category 'E' for open spaces, as set out in the 2012 RGS-Terrenus study (**Appendix G-1 Geochemistry Technical Report**). The NEPM guideline for open spaces was applied as it aligns with the current land use around the mine, and its potential post mining land use following closure and rehabilitation (i.e. grazing).

An update to the NEPM published in 2013 included revised HILs; HILs for public open space increased, except lead (Pb) that remained unchanged. RGS-Terrenus reassessed the multi-element scan data against amended HIL for public open space (HIL-C) to evaluate potential future risks to human health from intermittent exposure to mineral wastes post site closure and rehabilitation.

Water extract tests were completed to assess the potential mobility of readily leachable metals and metalloids. Direct comparison of water quality data from leach testwork against water quality guidelines was not appropriate. Leach testwork can provide an indication of what metals and metalloids are readily mobile under laboratory conditions but cannot provide exact concentrations that would be measured in the field. This is because under field conditions, reactions can occur that would generally mitigate mobilisation including retardation and sequestration due to surface adsorption or precipitation due to buffering reactions. As a high-level qualitative exercise, soluble concentrations of each element extracted from coal and mineral waste materials were compared to livestock drinking water guidelines (ANZECC, 2000); this comparison is indicative only, considered conservative and worst case.

The Assessment of Site Contamination NEPM establishes groundwater investigation levels (GILs) based on the ANZECC guidelines.

10.3.4 Kinetic geochemical analysis

Kinetic geochemical testing provided data on the geochemical characteristics of sample materials over time, if the samples were subjected to a series of drying and wetting cycles. Kinetic leach column (KLC) testing was completed on selected mineral waste samples based on static testwork results. Additional details of the specific test methods are found in **Appendix G-1 Geochemistry Technical Report**.

Six composite samples of coal, potential coal rejects and coarse rejects were selected for KLC testing, with seven leaching events simulated over a period of 12 weeks. All composite samples are composites of drill-core samples only or grab samples only (i.e. no mixed drill-core and grab composites). Samples were analysed for total sulfur by BMA as part of the coal-quality assessment program. All other testing was initiated by RGS-Terrenus as part of their assessment.

The intent of the KLC test program was to characterise ongoing water quality in leachate from potential coal reject samples subjected to routine wetting and drying cycles that simulate environmental exposure, not necessarily linked to any climatic region. The KLC test method was based upon the AMIRA (2002) guideline method, with some modifications made and justified by RGS-Terrenus (2012), to better suit the types of materials being assessed.

Leachate generated from the columns were tested for pH, EC, alkalinity, acidity, soluble metals and metalloids (25 elements), soluble hexavalent chromium, soluble major cations, soluble sulfate, soluble chloride and fluoride. A summary of the geochemical testing that was completed for the Project is presented in Table 10.2.

Table 10.2 Summary of geochemical testing that was completed for the Project (RGS-Terrenus, 2012)

Analytical test	Waste rock	Coal seam immediate roof	Coal seam immediate floor	Coal	Saraji Mine coarse rejects
Static Testing					
Total sulfur	14	95 (drill-core)	100 (drill-core)	-	-
Static Acid-base (pH, EC, total sulfur, SCr, ANC)	5 (drill-core) 9 (grab)	16 (drill-core)	21 (drill-core)	6 (drill-core)	3 (grab)
Total elements and sulfate in solids	2 (individual drill-core) 2 (individual grab)	4 (composite)	4 (composite)	3 (composite)	1 (composite)
Soluble elements and major ions, pH and EC in 1:5 water extracts	2 (individual drill-core) 2 (individual grab)	4 (composite)	4 (composite)	3 (composite)	1 (composite)
Kinetic leach column testing					
Soluble elements and major ions, pH and EC	-	1 (composite)	3 (composite)	1 (composite)	1 (composite)

10.4 Description of environmental values

10.4.1 Existing environment

Existing environment of the Project Site (shown in Figure 10-1), described in Chapter 4 (**Land use and Tenure**), is consistent with land used for livestock grazing with some areas of cropping activity to the southeast. In addition to grazing and grain production, there are 25 operating coal mines in the region, including BMA's Saraji Mine immediately west of the Project site that has been operating as an open cut coal mine since 1974.

Operating since 1974, the existing Saraji Mine has approval for open cut mining to the eastern extent of the Mining Lease (ML) 1775. The proposed longwall underground mine will start at the highwall within ML 1775 and extend underground into Mining Lease Application (MLA) 70383 (Figure 10-1).

10.4.2 Existing mineral waste management practices

Operation of the existing Saraji Mine generates waste rock (overburden) and coal rejects from the CHPP. Rejects (dense medium coarse rejects, fine rejects and tailings) from the CHPP rejects bin are transferred by truck within the mining lease and deposited with waste rock within the existing Saraji Mine in-pit spoil dumps, away from final landform surfaces as per current approved practice.

Mineral waste management at the existing open cut operation is in accordance with existing approved Environmental Authority (EA) reference: EPML00862313 for Saraji Mine as documented within the Waste Management and Minimisation Plan.

Historically, geochemical assessment of the Saraji Mine has classified and mapped the distribution of potential for AMD rock types in the areas where mineral wastes are deposited (BMA, 2020). Past geochemical assessment of waste rock suggests that this material domain is overwhelmingly non-acid forming (NAF) with excess neutralising capacity (i.e. presenting a very low risk for acid generation from in-pit spoil dumps).

A greater hazard for AMD generation is associated with locations where carbonaceous overburden, coal reject and/or waste coal, have been disposed. BMA estimate that, historically, the dominant proportion of coarse reject materials produced on site at Saraji Mine has been disposed within existing in-pit spoil dumps. Monitoring has recorded no evidence of AMD on site from coarse reject materials since mining commenced in 1974 at Saraji Mine (or any of BMA's coal mines in the region) (BMA, 2020). Coarse reject is considered possible but low risk for acid generation.

Conservative assessment of the geochemical likelihood of AMD generation at the existing Saraji Mine is described in **Table 10.3**

Table 10.3 Likelihood of AMD generation

Landform domain	Likelihood of AMD generation
Waste rock	Very low/Unlikely
Coarse reject	Low/Possible

These ratings apply to waste rock and coarse reject storage across the existing Saraji Mine. This geochemistry indicates BMA's existing approved management practices adequately avoids and minimises AMD potential. Measures to reduce the risk of AMD generation as a result of mineral wastes arising from the Project are described in Section 10.7.

10.4.3 Mineral waste quantities

Based on the proposed longwall mining technique described in **Chapter 3 Project Description**, an estimated 150 million tonnes (Mt) run-of-mine (ROM) coal is proposed to be extracted over the 20 year production schedule, with an estimated 110 Mt of product coal and 40 Mt of mineral waste generated.

Most mineral wastes generated will be coal rejects, consisting of coarse rejects, fine reflux classifier rejects and dewatered flotation tailings from extracted coal, coal seam roof, coal seam floor and coal seam parting materials. Some waste rock will be generated during development of the portal, estimated to be approximately 0.005 Mt. The waste volumes are based on the 'optimised underground layout' as illustrated in Figure 3-2 in **Chapter 3 Project Description**. Estimated mineral waste types and volumes generated by the Project are summarised in Table 10.4

Table 10.4 Estimated total mineral waste quantities generated by the Project

Mineral waste type	Estimated lifetime volume	Mineral waste source
Waste rock	0.005 Mt during construction	• highwall - during stabilisation for development of access portal • portal - during drilling of access tunnels through rock to target seam • ventilation shafts - during drilling of ventilation shafts

Mineral waste type	Estimated lifetime volume	Mineral waste source
Coal rejects / dewatered tailings (Mixed Plant Reject – MPR)	40 Mt over life of mine (LOM)	• CHPP - during operation of the mine consisting of: – dense medium coarse reject material – reflux classifier reject material

Handling and processing of waste rock and coal rejects is described in Section 10.4.4 and 10.4.5 respectively.

10.4.4 Waste rock

Where geotechnical conditions permit, the access portal will commence directly into coal through the existing open cut highwall, resulting in negligible waste rock being generated. Where this option is not feasible, the underground access portal may need to commence slightly above the coal, where the roof strength is greater. The resulting portal waste rock (estimated to be 0.005 Mt) is expected to consist of mudstone, siltstone and fine-grained sandstone.

Waste rock with suitable geotechnical properties will be used for engineering and construction purposes such as bulk fill, road sub-base and construction material for laydown areas, resulting in waste minimisation. Waste rock that is unsuitable for engineering purposes, or in excess of construction requirements, will be trucked minimal distances for disposal within-pit spoil dumps for disposal in the mineral waste management system according to the EA and approved overburden management practices (described in Section 10.7.1).

10.4.5 Coal rejects

Coal may be processed within the existing Saraji Mine CHPP or within a new Project CHPP with similar function, to be constructed on ML 70142. Coal rejects generated from the Project CHPP will consist of coarse rejects (from the dense medium cyclones), fine rejects (from the reflux classifiers) and dewatered tailings (from the floatation cells).

The CHPP will be constructed using equipment with capacity in line with current industry practices. It is expected this design strategy will lead to greater efficiencies when compared to traditional CHPP with multiple small capacity parallel streams. The options selected for processing the coal are based on proven technology for each size range. This combination of circuits has been adopted by many of BMA's CHPPs in the region and may include:

- dense medium cyclones for coarse coal
- reflux classifiers for fine coal
- microcell column flotation for ultra-fine coal.

The Project will use belt press filters to dewater the coal tailings.

Coal rejects from either CHPP will be transferred by truck using internal roads to existing Saraji Mine in-pit spoil dumps, away from final landform surfaces as per current approved practices (described in Section 10.7).

10.5 Geochemical characterisation

Data and interpretations provided in this section are reported in the context of mine waste materials likely to result from access portal waste rock or in the context of potential coal rejects and coarse rejects. The classification criteria group mineral wastes based on their potential to generate acidifying, metalliferous or saline conditions.

10.5.1 Geochemical analysis

Samples for the Project were classified with respect to acid generation that may lead to potential impacts on environmental values, using total sulfur and S_{CR}, net acid producing potential (NAPP) and ratio of acid neutralising capacity to the maximum potential acidity (ANC/MPA) into three broad categories:

- non-Acid Forming (NAF)
- uncertain
- potential Acid Forming (PAF).

Classifications of mineral wastes are presented in Table 10.5.

Table 10.5 AMD hazard classification system (RGS-Terrenus, 2012)

Mineral waste classification	Total Sulfur	Sulfide Sulfur (S_{CR})	NAPP (kg H_2SO_4/t)	ANC/MPA ratio
Barren - NAF	≤ 0.1%	-	-	-
NAF	-	≤0.1%	-	>2
	-	-	< -10	>3
Uncertain	-	>0.1%	-10 - 0	<2
PAF – Low Capacity (PAF-LC)	-	>0.1%	0 - 10	-
PAF	-	-	>10	<2

Classification of samples for the potential generation of saline conditions was based on the EC sample, as outlined in Table 10.6.

Table 10.6 Salinity classification system (DME, 1995)

	Very Low	Low	Medium	High	Very High
EC1:5 (sample: water) µS/cm	<150	150 – 450	450 – 900	900 – 2000	>2000

10.5.2 Static geochemical testwork results

The following sections summarise the geochemical testing of mineral waste samples collected from the sources outlined in Table 10.7. Detailed descriptions and a summary of all the geochemical testing completed for the Project are presented in **Appendix G-1 Geochemistry Technical Report**.

Total sulfur in potential mineral waste

The results from all samples analysed for total sulfur are summarised in Table 10.7.

Table 10.7 Summary of mineral waste total sulfur analysis. Source: RGS-Terrenus (2012)

Total Sulfur	Coal seam roof and floor samples (potential rejects)	Portal waste rock samples	Coal reject samples	Coarse reject samples	Coal samples
Number samples analysed	195	14	37	3	6
Minimum	<0.01	0.03	0.03	0.48	0.45
Median (50th percentile)	0.09	0.045	0.41	1.14	0.595
90th percentile	0.29	0.13	1.496	NC	NC
Maximum	3.44	0.19	3.74	1.16	1.24
Number >0.1% sulfur	112	1	14	3	6
Percent >0.1% sulfur	57%	7%	38%	100%	100%

Potential mineral waste $pH_{1:5}$ and $EC_{1:5}$

For the mine waste samples analysed, values of pH1:5 fall within a neutral to alkaline classification, as indicated in Table 10.8. Portal waste rock samples are basic (alkaline), coal reject samples are neutral to basic, coarse reject samples are basic, and coal samples are basic. The neutral to relatively high pH values reported in the 1:5 leachates indicate either:

- low acidity is derived from the readily leachable solutes of each sample
- the readily leachable solutes include adequate buffering capacity.

Table 10.8 Summary of mineral waste $pH_{1:5}$. Source: RGS-Terrenus (2012)

pH	Portal waste rock samples	Coal reject samples	Coarse reject samples	Coal samples
Number samples analysed	14	37	3	6
Minimum	9.20	6.80	8.90	8.30
Median (50 percentile)	9.50	9.40	9.20	8.65
Maximum	9.80	10.00	9.40	9.70
Number of basic (pH >8.0)	14	30	3	6
Number of neutral (pH 6.5 – 8.0)	0	7	0	0
Number of acidic (pH <6.5)	0	0	0	0

Values of EC1:5 ranged from 52 micro siemens percentimeter (µS/cm) (coal sample) to 1630 µS/cm (coal reject sample), with a median $EC_{1:5}$ of 401 µS/cm falling within the ‘Low’ salinity field. Considering that mixing is likely to occur during the development of the mine portal and during coal processing in the CHPP, the median $EC_{1:5}$ is representative of the respective mineral waste streams during mine development and operation.

With the mixing taken into consideration during construction and operation, a review of specific mineral waste streams indicates that portal waste rock $EC_{1:5}$ is predominantly low with a median of 339 µS/cm. Coal rejects $EC_{1:5}$ is predominantly low with a median of 401 µS/cm. Coarse rejects $EC_{1:5}$ is low with a median of 357 µS/cm. Finally, coal sample $EC_{1:5}$ is low with a median of 104 µS/cm.

The $EC_{1:5}$ data indicates relatively low dissolved ion contents in the leachates. This suggests that the readily leachable salinity (major ions) component of the samples is predicted to be minor.

Table 10.9 Summary of mineral waste EC1:5. Source: RGS-Terrenus (2012)

EC (µS/cm)	Portal waste rock samples	Coal reject samples	Coarse reject samples	Coal samples
Number samples analysed (n)	14	37	3	6
Minimum	186	64	331	52
Median (50 percentile)	339	401	357	104
Maximum	544	1,630	519	144
Number of Very Low (<150)	0	5	0	6
Number of Low (150-450)	12	19	2	0
Number of Medium (450-900)	2	10	1	0
Number of High (900-2,000)	0	3	0	0
Number of Very High (>2,000)	0	0	0	0

Potential mineral waste acid base accounting

Acid-Base Accounting (ABA) is an assessment of the potential for a sample to generate acidity and the capacity of the sample to neutralise the acidity generated. Acidity may be expressed as the maximum potential acidity (MPA), whereas neutralisation is expressed as the acid neutralisation capacity (ANC); both are commonly expressed in units of kilograms of sulfuric acid per tonne of sample (kg H_2SO_4/t). MPA is estimated from total S or Sulfide-sulfur values while ANC is measured directly in the laboratory via titration.

ABA testwork results were used to assign an AMD hazard classification to the samples tested based on the classification system summarised in Table 10.9 (RGS-Terrenus, 2012), with a summary of the AMD classification assigned to the samples tested presented Table 10.10. Geochemical testing indicates that approximately 63 percent of analysed mineral waste samples were NAF, 18 percent were uncertain, 10 percent were PAF – low capacity (LC), and 8 percent were PAF.

None of the portal waste rock was classified as PAF-LC or PAF. Of coal reject samples classified, 22 percent are PAF-LC and PAF, 33 percent of coarse reject samples were classified as PAF and 34 percent of coal samples were classified as PAF-LC and PAF. The percentage of uncertain samples are highest for coarse rejects with 67%, while for coal rejects and coal the percentage of samples with uncertain geochemical characteristics is about 20%.

These findings are consistent with the findings of the existing Saraji Mine coarse rejects reports by Emmerton (2009; 2010).

Table 10.10 Summary of geochemical acid-base accounting classification of mineral wastes

Mineral waste classification	Samples in class							
	No. Waste rock	% Portal waste rock	No. Coal reject	% Coal reject	No. Coarse reject	% Coarse reject	No. Coal	% Coal
Number of samples analysed	14		37		3		6	
Barren - NAF (Non-Acid Forming)	13	93%	2	5%	0	0%	0	0%
NAF (Non-Acid Forming)	1	7%	19	51%	0	0%	3	50%

Mineral waste classification	Samples in class							
	No. Waste rock	% Portal waste rock	No. Coal reject	% Coal reject	No. Coarse reject	% Coarse reject	No. Coal	% Coal
Uncertain	0	0%	8	22%	2	67%	1	17%
PAF – Low Capacity (PAF-LC)	0	0%	5	14%	0	0%	1	17%
PAF	0	0%	3	8%	1	33%	1	17%

It is estimated that the majority of the 40 Mt LOM mineral waste (over 99 percent of the total mineral waste mass) for the Project will be coal reject samples and coarse reject samples. The data in Table 10.10 indicates just over 50 percent of these are likely to be PAF-LC and/or PAF.

When considered as a bulk material following processing through the CHPP, coal reject material is expected to be NAF. However, in consideration that 22 percent of coal rejects and 67 percent of coarse rejects are classed as 'uncertain', together with the limited availability of neutralising capacity for the roof and floor samples, the potential for acidity generation from these materials cannot be excluded in spite of the relatively low sulfide concentrations.

Acid buffering characteristic curves

ABCCs provide an indication of the available neutralisation capacity of a sample under field conditions. By titrating a known concentration of acid onto a sample and recording the change in pH following the incremental acid addition, a characteristic curve can be established, which provides information on the likely availability and nature of the neutralisation capacity.

Appendix G-1 Geochemistry Technical Report shows the results of the ABCC tests conducted on the potential coal reject and coarse reject samples. For most samples tested, the available ANC is ≤50 percent of the ANC of the samples measured via single stage titration, as assessed by ABA. This indicates that the waste material is likely to have less buffering capacity, supporting conservative approach taken when classifying samples as PAF or NAF.

10.5.3 Multi-element scans

Details of multi-element bulk chemistry test results for portal waste rock, coal rejects, coarse rejects, coal and six composite samples subjected to KLC testing are presented in **Appendix G-1 Geochemistry Technical Report**. Water quality data for leachate extract for portal waste rock, coal rejects, coarse rejects and coal samples are detailed in **Appendix G-1 Geochemistry Technical Report**.

In brief, the bulk chemistry data show that total metal and metalloid concentrations in portal waste rock, potential mine waste, coarse rejects, and coal samples tested were below NEPM (2013) HIL-C; on this basis, the mineral waste will pose no unacceptable risk to human health if it is exposed following mine closure and rehabilitation.

- for waste rock, leachate testwork results indicate that mercury (all four portal waste rock samples) and selenium (one of the four portal waste rock samples) may be somewhat mobilised during leaching under laboratory conditions. leachate produced under laboratory condition exceeded the anzecc (2000) livestock drinking water quality trigger values (low risk)
- for coal rejects, leachate testwork results indicate that mercury (in one of eight samples), molybdenum (in seven of eight samples), and selenium (in six of eight samples) may be mobilised

during leaching under laboratory conditions. leachate produced under laboratory condition exceeded the anzecc (2000) livestock drinking water quality trigger values (low risk)

- for one coarse rejects molybdenum was mobilised during the testwork at values exceeding the anzecc (2000) livestock drinking water quality trigger values (low risk) and nepm gils
- for coal samples, one of three coal samples analysed mobilised molybdenum in the leachate under testwork condition at values above the ANZECC (2000) livestock drinking water quality trigger values (low risk) and NEPM GIL.

The analytical limits of reporting (LOR) for cadmium, copper, lead, nickel and zinc were greater than the respective NEPM GIL and no assessment of relative risk could be made in the four mineral waste streams assessed.

Selenium is a naturally occurring metal, with the level of toxicity dependant on the form the selenium occurs in (valency state), with selenium-IV being more toxic than selenium-VI. Selenium uptake in organisms via food is a greater concern than direct uptake via water for aquatic organisms, where lower toxicity selenium-VI can be readily bioaccumulated through the food chain if released to surface waters. However, the uptake of selenium by aquatic organisms is affected by pH, hardness, sulfur and phosphate content of natural waters (after ANZECC, 2000), while the form of selenium (IV vs VI) is dependent on the oxygenation level of the water.

10.5.4 Kinetic geochemical analysis

To provide an indication of leaching potential under laboratory conditions, modified KLC tests (described in **Appendix G-1 Geochemistry Technical Report**) were completed on six composite samples:

- SRJE-C17 potential coal rejects - H16 roof siltstone and carbonaceous siltstone
- SRJE-C18 potential coal rejects - H16 floor siltstone with some very fine sandstone
- SRJE-C19 potential coal rejects - D14 floor carbonaceous mudstone and siltstone
- SRJE-C20 potential coal rejects - D24 floor siltstone, mudstone and claystone (some carbonaceous)
- SRJE-C21 potential coarse reject - carbonaceous siltstone from the Saraji Mine Ramp 4 rejects stockpile
- SRJE-C22 potential coal composite - from H16, D14 and D24 seams (contains minor (trace) claystone and mudstone).

KLC test results for potential coal reject samples

Based on the overall ABA results summarised in Table 10.10, the H16 roof KLC sample (SRJE-C17) was expected to be NAF, whereas the H16 floor (SRJE-C18), D14 floor (SRJE-C19) and D24 floor (SRJE-C20) samples were assigned ‘uncertain’ classifications, as the individual samples used to prepare these composites have all three classifications, namely, NAF, uncertain and PAF.

After seven leaching events over a 12 -week period, KLC test results indicated that the coal reject composite samples generated low acidity. Leachate from these samples generally reported neutral to slightly alkaline pH, low to moderate salinity, low sulfate release rates and low concentrations of soluble metals.

KLC tests indicated that the coal reject samples were likely to be NAF. The likelihood of acid generation from composite coal reject samples is considered very low, even if one or more of these samples were to generate increased acidity, the acid concentrations in leachate would likely be very low and would not pose management problems.

Details of KLC testing and results are provided in **Appendix G-1 Geochemistry Technical Report**.

KLC test results for the composite coarse reject sample

Average ABA results for the individual samples that were used to generate the composite sample for KLC testing indicated that Saraji Mine coarse rejects could be PAF. After seven leaching events over approximately 12 weeks, leachate reported neutral to slightly alkaline pH values (7.53-8.47), very low acidity, and low to moderate salinity. The composite sample generated leachate with an initial EC of 1,410 µS/cm, which decreased throughout the leaching program to a final value of 430 µS/cm.

The sulfate release rate was initially elevated at 300 milligram per kilogram per flush (mg/kg/flush), but decreased throughout the leaching program to a final value of 109 mg/kg/flush. Metal and metalloid concentrations in coarse rejects leachate were low, generally at or close to the laboratory LOR.

The initial elevated sulfate release rate reported in the KLC test suggests that sulfide oxidation may have commenced early in the test. Alternatively, this may be due to leaching of sulfate present in the sample prior to testing (e.g. on an oxidised surface). Leachate from this sample has however consistently reported neutral to slightly alkaline pH values, indicating that acidity potentially generated through sulfate release has been buffered by sample ANC. Sulfide oxidation may have stabilised, and may have decreased over the course of the test, as indicated by the concurrent decrease in leachate sulfate and EC.

On this basis the composite coarse rejects are considered NAF and the likelihood of acid generation is considered low. It is possible that this sample may begin to generate weak acidity in the long-term, although the capacity for this sample to generate significantly acidic leachate is low.

KLC test results for the composite coal sample

Average ABA values for the individual samples that were used to prepare the composite sample, show that the coal sample has an ‘uncertain’ ABA classification. After seven leaching events over approximately 12 weeks, leachate was pH-neutral and fluctuated between pH 6.75 and 7.39, with a final pH of 6.81. Very low salinity and an EC of less than 100 µS/cm was reported.

The sulfate release rate was very low (less than 13 milligrams per kilogram per flush (mg/kg/flush)), with an average value of 4.4 mg/kg/flush. Metal and metalloid concentrations in leachate were very low, generally less than the laboratory LOR.

The results show that leachate is similar in composition to the de-ionised water used as the leaching fluid, with very low concentrations of major ions, salts and metals being released. Coal samples are considered unlikely to generate significant acidity that may lead to acidic runoff/leachate from coal stockpiles during rain events.

KLC multi-element test results

Review of multi-element (soluble) results from the seven KLC leaching events per sample indicated minimal leaching of metals and metalloids. Results of KLC multi-element tests of composited coal rejects from the Dysart Lower (D24 and D14) seam determined leachable quantities of metals or metalloids were mostly below LOR. Where leachable quantities were encountered, the ANZECC (2000) livestock drinking water quality trigger values (low risk) and NEPM (2013) GIL were not exceeded. However, leachable selenium from composited coal rejects did exceed the NEPM GIL for freshwater.

Similar to composited coal rejects, results of KLC multi-element tests of the composited existing Saraji Mine coarse reject sample did not result in leachable quantities of metals or metalloids above LOR or, where leachable quantities were encountered, the ANZECC (2000) livestock drinking water quality trigger values (low risk) and NEPM (2013) GIL. Like the coal rejects sample, selenium exceeded the respective NEPM (2013) GIL for freshwater. One aluminium leach result exceeded the respective NEPM (2013) GIL, though all remaining results were either at or below the LOR, suggesting the single result is unlikely to represent the long-term leachable condition of the material.

However, it must be recognised that it is inaccurate to directly compare leachate results from bench-scale columns to water quality guidelines, as leachate from in-pit spoil dumps will be subject to greater dilution than the leachate generated from these columns, and a range of secondary reactions over longer time scales. Furthermore, materials within in-pit spoil dumps are subject to scale-up factors and a range of oxidising conditions.

Whilst the initial KLC tests indicated relatively low concentrations of selenium in coal rejects, the overall impact of selenium has been considered in the development of mitigation measures for the Project (see Section 10.7).

10.6 Potential impacts

10.6.1 Waste rock

Waste rock generated by the Project is anticipated to be less than one percent (0.005 Mt) of mineral waste generated through the Project lifetime. Based on geochemical analysis, waste rock is likely to have a high factor of safety and very low probability of acid generation, and is expected to generate alkaline, low-salinity runoff/seepage following surface exposure when placed into the existing Saraji Mine in-pit spoil dumps.

Waste rock generated from the Project is expected to have the same or very similar characteristics as pre-existing waste rock generated from the Saraji Mine. Waste rock generated from construction of the mine portal is expected to be NAF and unlikely to create conditions for AMD.

The risk of site runoff and seepage from the waste rock material generated by the Project impacting on the surrounding environment is assessed as very low. Waste rock material can generate leachate containing elevated concentrations of soluble elements compared to guidelines under laboratory conditions. However, the likelihood of environmental harm is low given actual field conditions and limited quantity of waste rock material likely to be generated by the Project. Waste rock material will be managed and monitored in accordance with the measures set out in Section 10.7.

10.6.2 Coal rejects

Potential coal rejects are expected to generate pH-neutral to mildly alkaline, relatively low-salinity runoff/seepage following surface exposure. Total sulfur concentrations of coarse reject samples were low. Some samples were classified as PAF; however, the magnitude of any acidity generation is expected to be low. PAF rejects are expected to comprise less than 10% of all reject material, and therefore the risk of environmental harm as a result of leaching is low.

Coarse reject samples from the existing Saraji Mine and from a previous assessment (Emmerton, 2010) demonstrate that the potential for acidity generation is low. No AMD has been identified since commencement of mining operations at Saraji Mine. Surface water monitoring data also demonstrate that the coarse rejects at Saraji Mine are currently managed appropriately and do not pose a significant environmental risk.

There is a risk of leachate from coal rejects containing elevated soluble metal concentrations under laboratory conditions. However, coal rejects will be mixed and therefore potentially elevated concentrations of soluble metals from isolated coal reject sources will be diluted with bulk reject material. Therefore, considering the homogenisation of coarse rejects through the CHPP, environmental risks are considered low. Further measures to reduce the risk of environmental harm resulting from the handling of rejects are set out in Section 10.7.2.

10.7 Mitigation measures

Mineral wastes generated by the Project will be managed in accordance with the mitigation measures proposed below, the existing management practices at the adjacent Saraji Mine and the conditions of EA EPML00862313.

Existing in-pit spoil dumps will be used or developed in line with the approved Saraji Mine plan. The transition from open cut mining to underground longwall mining significantly reduces waste rock generation and coarse rejects volumes due to a more refined and targeted mining method. Consequently, the existing in-pit spoil dumps at Saraji Mine provide ample capacity to accommodate the additional volume of mineral waste generated by the Project.

Management of Project waste rock and rejects within Saraji Mine's existing in-pit spoil dumps is not considered to generate a significant net change in existing conditions. The existing Saraji Mine approval authorises open cut mining to the eastern extent of the Mining Lease (ML) 1775. The proposed longwall underground mine will start at the highwall within ML 1775 and extend into Mining Lease Application (MLA) 70383. Sufficient capacity exists in the existing Saraji Mine mineral waste management system to accommodate the anticipated mineral waste from the Project. No selective handling or additional mitigation is required outside of existing waste rock management practices.

10.7.1 Waste rock

In accordance with the waste management hierarchy, waste rock that has properties suitable for engineering purposes can be re-used as bulk fill, road sub-base, construction material for laydown areas and/or foundations and levees provided suitable surface covering material is applied.

Waste rock with properties unsuitable for engineering and construction purposes will be deposited within in-pit spoil dumps established as part of the existing mineral waste management system at the Saraji Mine in accordance with existing approved management practices.

10.7.2 Coal rejects

Coal rejects from the Project, including coarse rejects, fine rejects and dewatered flotation tailings, will be disposed within existing in-pit spoil dumps at the existing Saraji Mine in accordance with existing Saraji Mine practices. Existing in-pit spoil dumps will be augmented in line with the Saraji Mine plan providing ample capacity to accommodate the anticipated mineral wastes generated by the Project.

10.7.3 Mineral waste management strategy

The mineral waste management strategy for the Project will focus on:

- evaluating the geochemical characteristics of actual reject materials collected from the Project CHPP and in-fill drilling core samples ahead of mining to confirm the NAF nature or delineate PAF materials prior to mining
- strategic placement of mineral waste materials within in-pit spoil dumps to minimise runoff
- co-dispose of PAF material with benign waste rock and rejects
- directing drainage to retention dams for reuse in mine activities.

The existing Saraji Mine mineral waste management strategy will be refined to accommodate the Project and will adopt the following general practices:

- mixing and compaction will occur as appropriate to the properties of the materials to achieve a sustainable final landform
- reject materials will be mixed via alternating disposal of the reject and waste rock material into in-pit spoil dumps at the existing saraji mine

- as a contingency, if marked amounts of paf rejects are identified, consider the option of controlled blending of high anc waste rock and/or limestone with paf waste. lime dosing of compacted coarse reject layers (one to two metres) may be used as a precautionary measure to extend the lag period in the unlikely event of acid generation
- pre-strip weathered waste rock materials will be used to cap the reject disposal and dewatered tailings areas. a minimum thickness of two metres of inert cover material will be used, with final thickness to be determined based on the material characteristics
- coarse reject placement will be sequenced such that capping of the rejects will be completed progressively as the working face progresses down the dip. suitable growth media will be placed onto the re-profiled slopes
- no reject material will be placed below the pre-mining groundwater table and in-pit spoil dumps will be free draining to minimise the potential for geotechnical instability
- over time, in-pit rejects will be covered by waste rock, topsoil and rehabilitated. these areas may be re-shaped and will be covered with a suitable growth media and revegetated with a species mix appropriate to the post-mining land use, or a combination of native grasses supplemented with introduced pasture species in areas where continuous pasture cover is necessary for erosion control.

10.7.4 Rehabilitation

A Rehabilitation Management Plan (RMP) has been developed for the Project (**Appendix K-1 Rehabilitation Management Plan**). The RMP provides the framework within which progressive and final rehabilitation can be planned and executed for the Project. The rehabilitation strategy for the Project is described in **Chapter 5 Land Resources**.

Rehabilitation of the in-pit spoil dumps at the existing Saraji Mine will be undertaken in accordance with the Saraji Mine EA. The scope of the Project will not change the rehabilitation objectives for Saraji Mine.

10.7.5 Monitoring

The Project will adopt the following broad mineral waste performance outcomes:

- compliance with Saraji Mine EA conditions
- ongoing geochemical characterisation of mineral waste material to identify any potential risk of AMD
- where required, management of acid producing rock to ensure that production and release of AMD is prevented or minimised.

Performance against these outcomes will be monitored on the Project as set out below.

Ongoing operational geochemical characterisation

BMA will undertake ongoing operational geochemical characterisation of mineral waste materials in planned deposition areas at the existing Saraji Mine ahead of mining to confirm the geochemical characteristics of these materials.

Characterisation of reject materials (coarse rejects and dewatered tailings) from the Project will also be undertaken to verify their expected geochemical nature. This data will be used to re-evaluate and update the management and disposal strategies for reject materials.

BMA will conduct an ongoing geochemical assessment program that is commensurate with the current AMD risk of the mineral wastes, testwork will include:

- pH (1:5) and EC (1:5)
- Static geochemical work
- Bulk chemistry
- Leach testwork
- CEC, sodium absorption ratio (SAR) and ESP.

Monitoring of potential drainage/seepage water quality from in-pit spoil dumps, with parameters to include for pH, EC, acidity, major cations and ions, and dissolved to include at a minimum Al, As, Cd, Cu, Cr, Co, Fe, Pb, Ni, Mo, Hg, Se and Zn. The monitoring protocol will be reviewed and where appropriate improved overtime based on results of on-going monitoring.

Water quality monitoring

Groundwater and surface water monitoring programs currently implemented at Saraji Mine will continue to identify and manage potential risk of metal mobilisation, with particular attention to mobilisation of mercury or selenium.

Runoff (and seepage water) quality resulting from the contact between meteoric water and mineral waste materials (waste rock and rejects) is not expected to be problematic with respect to acidity, salinity and metals concentrations based on geochemical analysis and historic site observations. However, leachate and site water derived from such materials will be monitored to ensure nearby drainages are not receiving acid, salt and metal loads that could impact upon the existing ecosystem.

Water quality monitoring is undertaken by Saraji Mine in accordance with requirements of its EA. In general, water will be managed by retaining or reusing surface seepage and runoff water on site in accordance with existing site water management system practices. These include capturing mine-affected waters and delivering these to existing storages to enable secure containment and reuse in supporting mine operations such as coal processing and dust suppression.

Monitoring and audit reviews will identify non-conformances and opportunities for improvement that can be addressed by corrective and adaptive management processes set out in the waste minimisation and monitoring plan.

10.8 Residual impacts

Mineral waste management within the existing Saraji Mine is carried out in accordance with the Saraji Mine EA EPML00862313. No significant residual impacts have currently been identified that require additional mitigation.

10.9 Summary and conclusions

The Project will generate mineral waste including an estimated 0.005 Mt of waste rock and 40 Mt of coal and coarse rejects over life of mine that will be safely managed within the in-pit spoil dumps at the approved Saraji Mine.

The existing Saraji Mine has capacity to accommodate the additional waste volumes due to the nature of underground mining producing significantly less volumes of waste rock.

Potential coal rejects are expected to generate pH-neutral to mildly alkaline, relatively low-salinity runoff/seepage following surface exposure. Ongoing operational geochemical characterisation will confirm the suitability of management and disposal strategies for reject materials. Considering the homogenisation of coal rejects through the CHPP, environmental risks are considered low and able to be managed in line with existing practices at Saraji Mine.

No significant residual impacts associated with the Project have been identified.