Peabody ENERGY

APPENDIX K

GEOCHEMISTRY ASSESSMENT

WILPINJONG EXTENSION PROJECT

ENVIRONMENTAL GEOCHEMISTRY ASSESSMENT OF OVERBURDEN, INTERBURDEN AND COAL REJECTS

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Prepared For:

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1.0 Introduction

The Wilpinjong Coal Mine is an existing open cut coal mining operation situated in the Western Coalfield approximately 40 kilometres (km) north-east of Mudgee near the Village of Wollar, within the Mid-Western Regional Local Government Area, in central New South Wales (NSW) (Figures 1 and 2).

Wilpinjong Coal Pty Limited (WCPL), a wholly owned subsidiary of Peabody Energy Australia Pty Limited (Peabody Energy), is the owner and operator of the Wilpinjong Coal Mine.

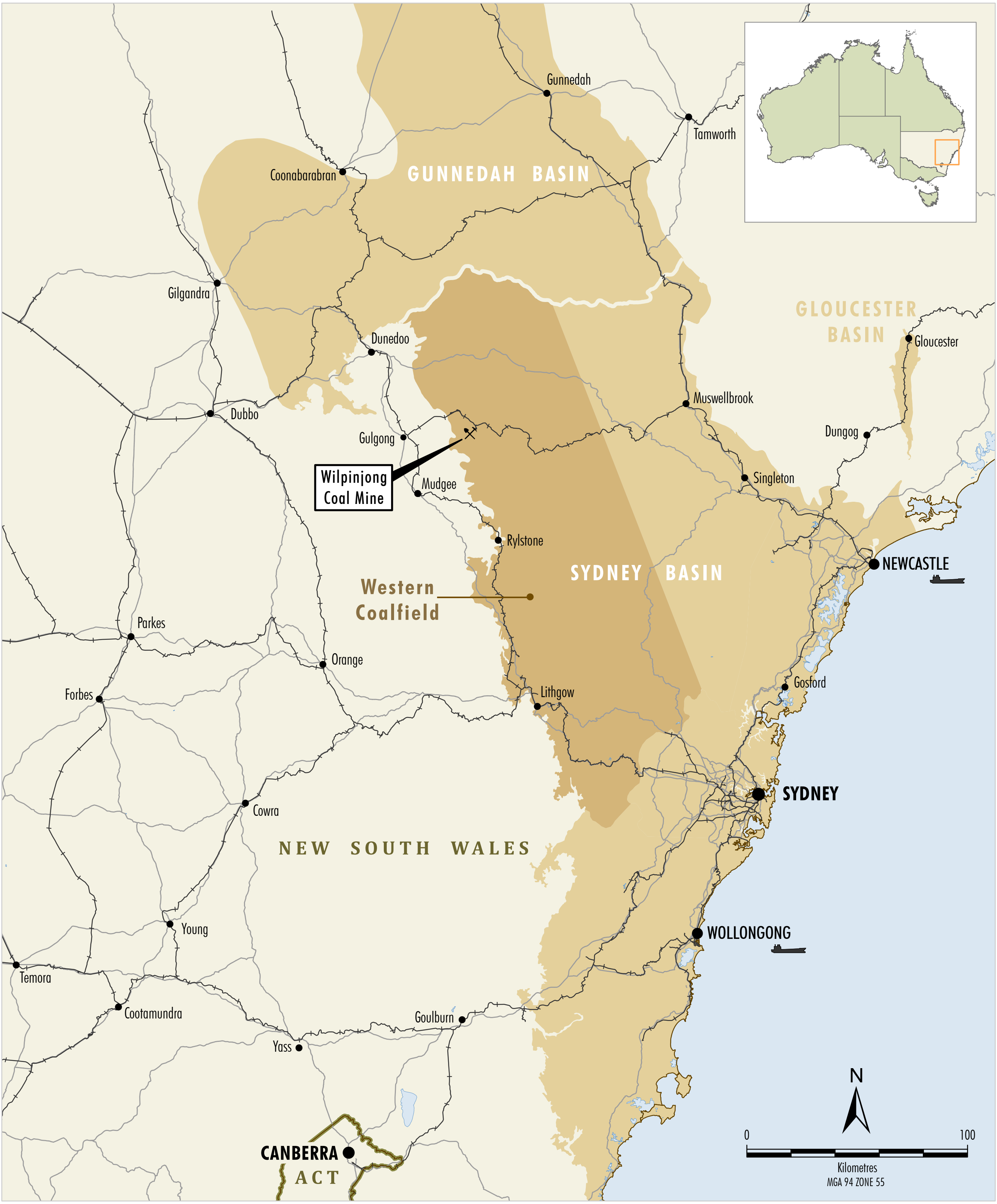
WCPL is seeking development consent to extend the Wilpinjong Coal Mine, including both physical extensions to the mine footprint to gain access to additional run-of-mine (ROM) coal reserves, and an extension to the approved life of the mine. The proposal is herein referred to as the Wilpinjong Extension Project (the Project).

Geo-Environmental Management Pty Ltd (GEM) was commissioned by Peabody Energy to carry out an environmental geochemistry assessment for the Project. This report presents the results and findings of the geochemical assessment program along with the potential geochemical implications identified for the Project, and based on this provides recommendations for waste rock and coal reject management and ongoing monitoring/testing requirements.

1.1 Project Description

The proposed Project is an extension of open cut mining operations at the Wilpinjong Coal Mine for an additional operational life of approximately seven years which would include the following activities:

- open cut mining of ROM coal from the Ulan Coal Seam and Moolarben Coal Member in Mining Lease (ML) 1573 and in new Mining Lease Application areas in Exploration Licence (EL) 6169 and EL 7091;
- approximately 800 hectares (ha) of open cut extensions including:
  - approximately 500 ha of incremental extensions to the existing open cut pits in areas of ML 1573 and EL 6169;
  - development of a new open cut pit of approximately 300 ha in EL 7091 (Pit 8);
- continued production of up to 16 million tonnes per annum (Mtpa) of ROM coal;



LEGEND
Highway
Major Railway
Coalfield

Source: Geoscience Australia (2011)

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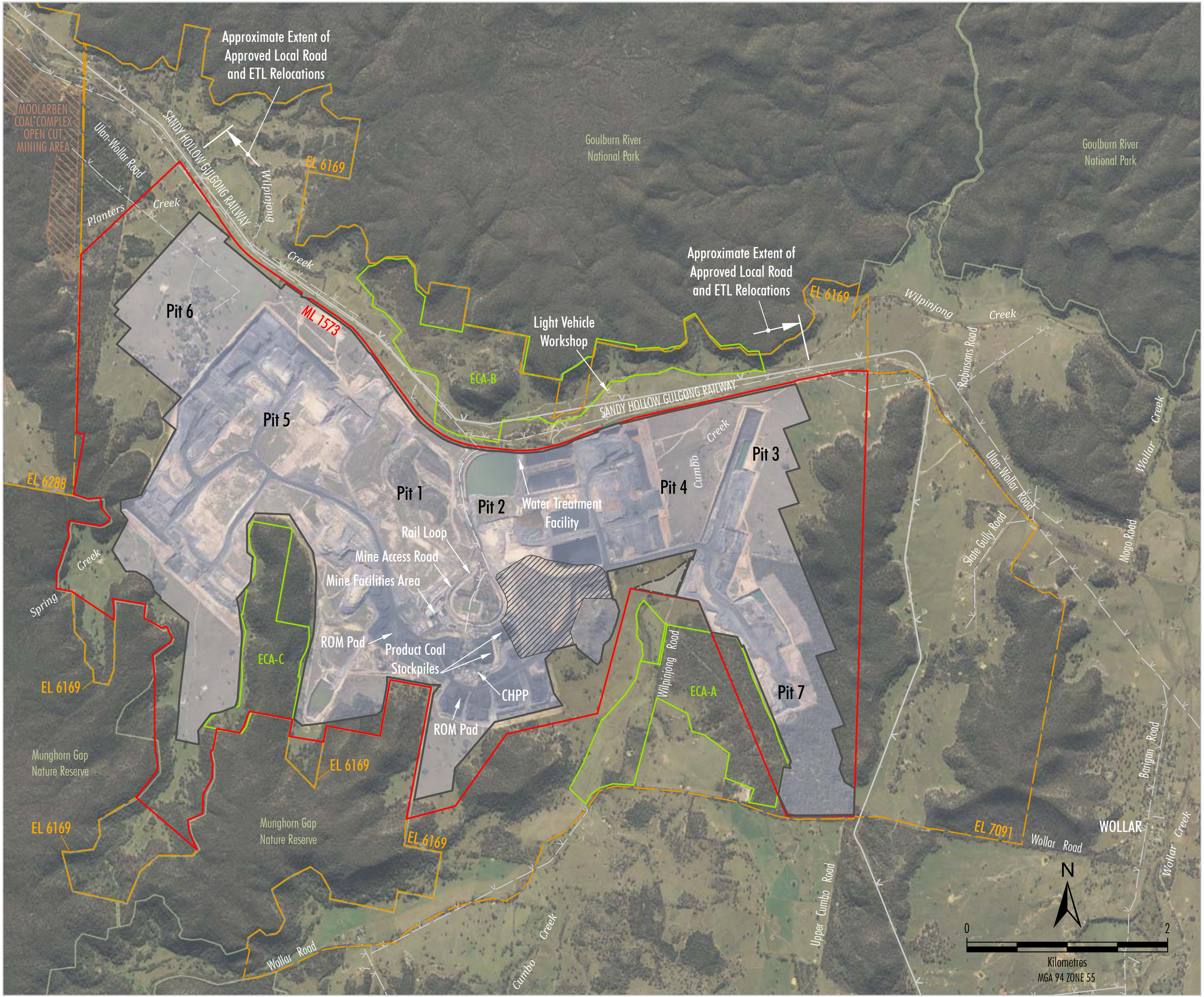
WILPINJONG EXTENSION PROJECT

Regional Location

Figure 1



LEGEND
- Mining Lease Boundary
- Exploration Licence Boundary
- Approved/Existing Open Cut and Contained Infrastructure Area
- Approved Block Bank and Cumbo Creek Relocation Disturbance Area
- Approved Elevated In-Pit Waste Rock Emplacement Area
- Existing Local ETL
- Existing TransGrid 330 kV ETL
- Enhancement and Conservation Area

Source: WCPL (2015); NSW Dept of Industry (2015)
Orthophoto: WCPL (Jun 2015; Jun 2014)

WILPINJONG EXTENSION PROJECT

Aerial Photograph of the Wilpinjong Coal Mine and Surrounds

Figure 2

WIL-12-12_WEP_EIS_Geochem_204C

- continued use of the Wilpinjong Coal Mine Coal Handling and Preparation Plant (CHPP) and general coal handling and rail loading facilities and other existing and approved supporting mine infrastructure;
- rail transport of approximately 13 Mtpa of thermal product coal to domestic and export customers (within existing maximum and annual average daily rail limits);
- relocation of a section of the TransGrid Wollar to Wellington 330 kilovolt electricity transmission line to facilitate mining in Pit 8;
- various local infrastructure relocations to facilitate the mining extensions (e.g. realignment of Ulan-Wollar Road and associated rail level crossing, relocation of local electricity transmission lines and services);
- construction and operation of additional mine access roads to service new mining facilities located in Pits 5 and 8;
- construction and operation of new ancillary infrastructure in support of mining including: mine infrastructure areas, ROM pads, haul roads, electricity supply, communications installations, light vehicle roads, access tracks, remote crib huts, up-catchment diversions, dams, pipelines and other water management structures;
- extension of the approved mine life by approximately seven years (i.e. from approximately 2026 to 2033);
- a peak operational workforce of approximately 625 people;
- ongoing exploration activities; and
- other associated minor infrastructure, plant and activities.

An indicative Project general arrangement, showing the open cut extension areas and key infrastructure relocations is provided on Figure 3.

A detailed description of the Project is provided in Section 2 of the Environmental Impact Statement (EIS).

1.2 Study Objectives

This study was conducted in two stages. Stage 1 involved a review of the Project along with the relevant site data and previous geochemical investigations, and the selection of samples for the geochemical assessment program. Stage 2 involved geochemical characterisation testing, and evaluation and reporting of the results. The specific objectives of the study include the following:

Stage 1

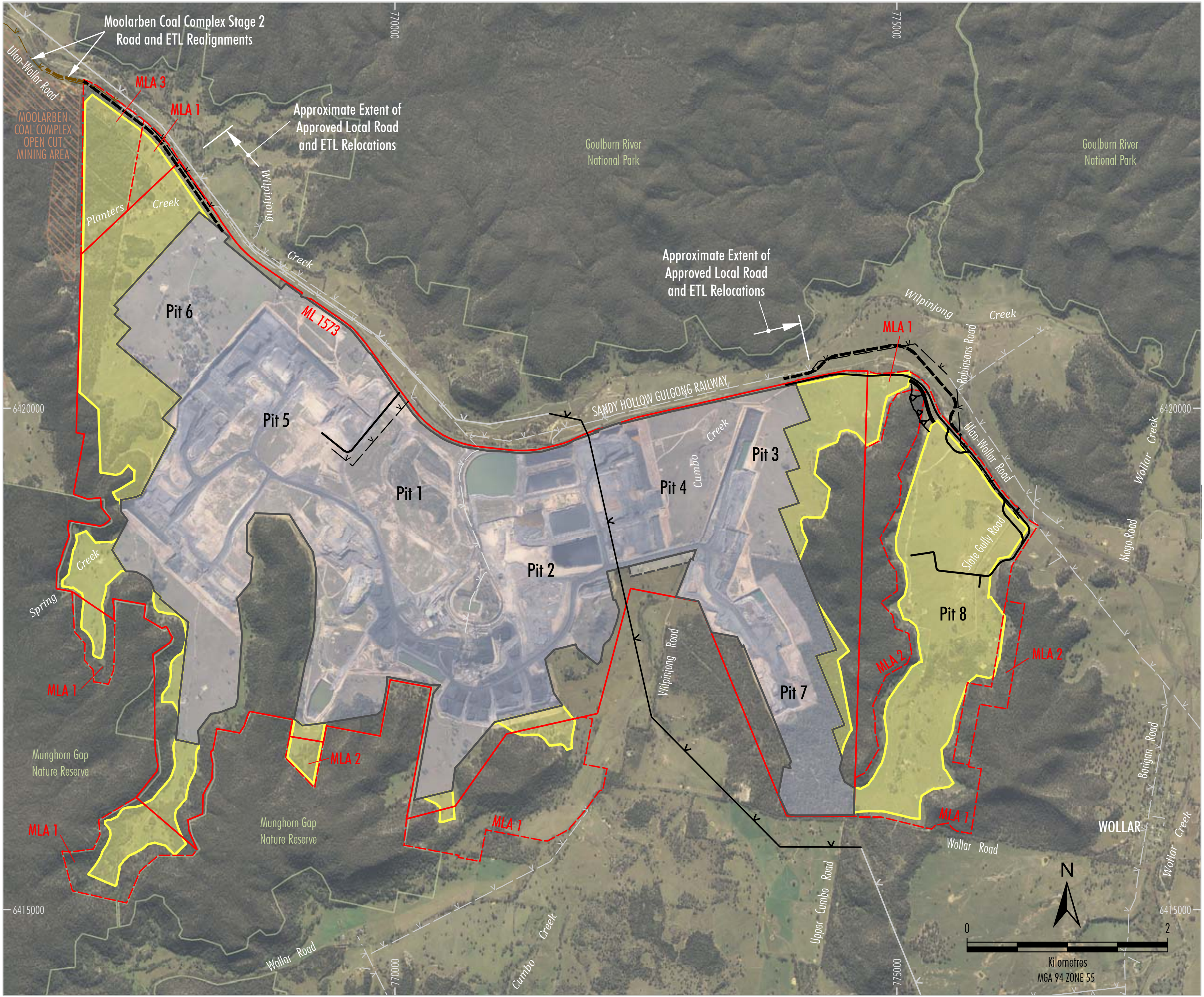
1. Review the test work and findings of the geochemical investigations conducted by Environmental Geochemistry International Pty Ltd (EGi) (2005) for the *Wilpinjong Coal Project Environmental Impact Statement* (WCPL, 2005) and EGi (2006; 2008) for the nearby Moolarben Coal Complex.

2. Review the surface water quality monitoring data presented in Gilbert & Associates (2013) prepared for the *Wilpinjong Coal Mine Modification 5 Environmental Assessment* (WCPL, 2013).
3. Review the groundwater quality monitoring data presented in HydroSimulations (2015) prepared for the *Wilpinjong Extension Project Environmental Impact Statement* (WCPL, 2015a).
4. Review the relevant rehabilitation monitoring data reported in the *Wilpinjong Coal Mine 2013 Annual Review and Environmental Management Report* (WCPL, 2014a).
5. Review the available geological mapping and drill logs for the Project mining areas and liaise with relevant site personnel, as required.
6. Selection of representative samples of the overburden and interburden, including the coal seam partings, that would be encountered during the Project, to be obtained from the available drill core (2013 and 2014 programs) for inclusion in the geochemical testing program.
7. Selection of representative samples of coal rejects (coarse reject and tailings) that have undergone laboratory controlled washing for inclusion in the geochemical testing program.
8. Selection of test work parameters and suitable analytical laboratories to be utilised to assess the acid forming potential and salinity, sodicity and element enrichment and/or solubility of the samples selected in Items 4 and 5, above.

Stage 2

1. Coordination of the sample preparation and testing programs identified in Item 6 of Stage 1.
2. Prepare a geochemistry assessment report which summarises the results of the previous test work, and describes in detail the sampling and testing program for the current study (Items 1 to 6 of Stage 1). The report evaluates the acid forming potential, salinity, sodicity and metal enrichment and/or solubility of the materials that would be encountered, identifies any implications for environmental management of the Project and provides recommendations for waste rock and coal rejects management and ongoing monitoring/testing requirements.

Spontaneous combustion management at the Wilpinjong Coal Mine is conducted in accordance with a specific Spontaneous Combustion Management Plan and is discussed in Section 4 of the EIS (i.e. is not addressed in this report).



LEGEND

- Mining Lease Boundary
- Mining Lease Application Boundary
- Approved/Existing Open Cut and Contained Infrastructure Area
- Relocated Block Bank and Cumbo Creek Disturbance Area
- Proposed Open Cut Extension Area
- Proposed Public Road Realignment
- Proposed Pit 3/8 Haul Road
- Proposed Service Road
- Proposed Local ETL Realignment/Relocation
- Proposed Relocated TransGrid 330 kV ETL
- Existing Local ETL
- Existing TransGrid 330 kV ETL

Source: WCPL (2015); NSW Dept of Industry (2015)
Orthophoto: WCPL (Jun 2015; Jun 2014)

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WILPINJONG EXTENSION PROJECT

Project General Arrangement

Figure 3

WIL-12-12_WEP_EIS_Geochem_202E

2.0 Regional and Local Geology

The Project site is located within the Western Coalfield along the north western edge of the Sydney Basin. The basement rocks in this area comprise Early Permian Rylstone Volcanics of the Lachlan Foldbelt. The basin deposits include conglomerates, sandstones and siltstones of the Late Permian Shoalhaven Group which are overlain by sandstones, claystones and coal deposits of the Illawarra Coal Measures. The Illawarra Coal Measures contains all of the prospective coal seams, and this formation is overlain by conglomerates and sandstones of the Triassic Narrabeen Group. The rocks of the Narrabeen Group have since been eroded to form the present day landscape, dominated by cliffs and extensive plateaus to the north and south of the mine area (Palaris, 2014).

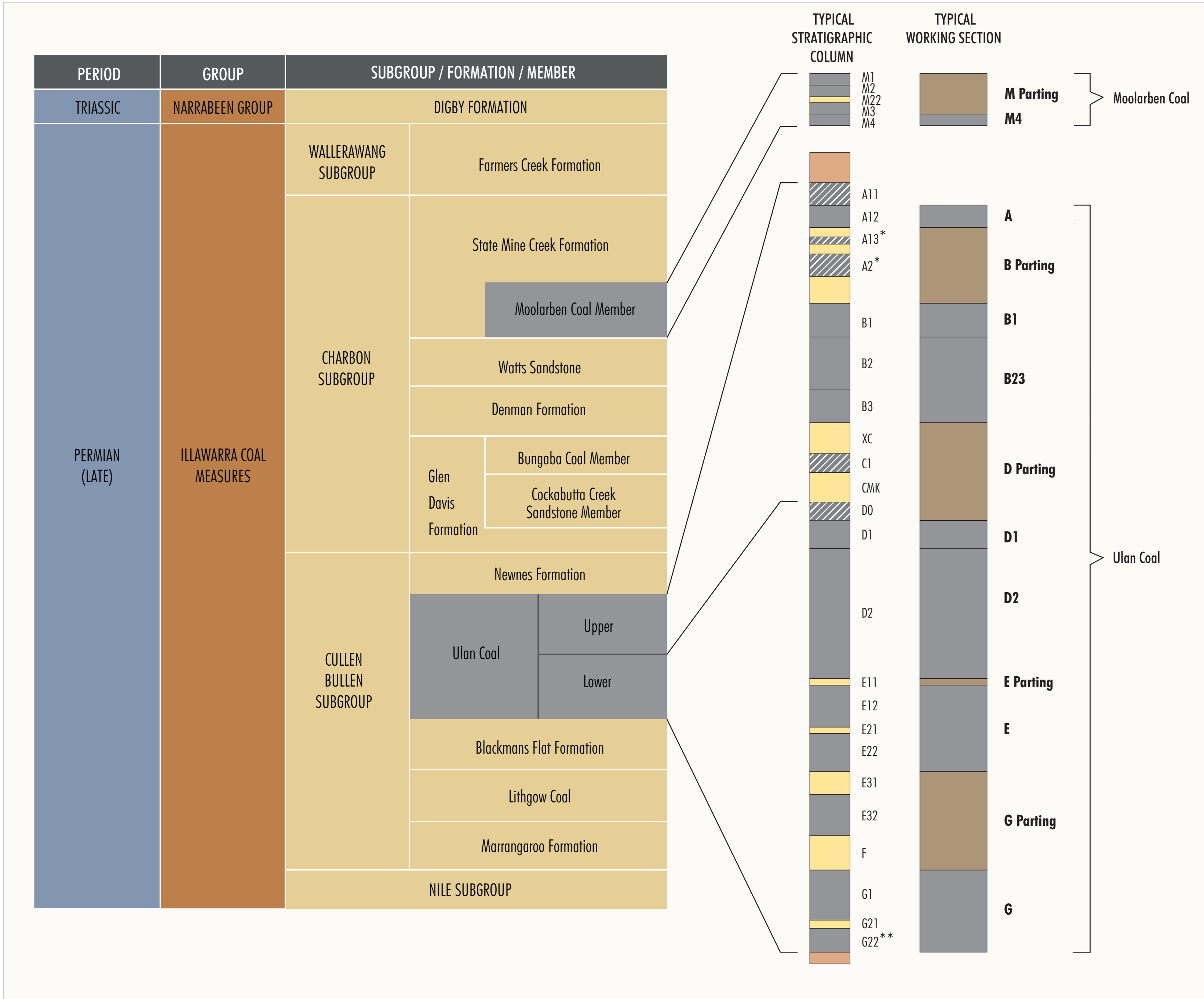
Quaternary alluvial deposits occur throughout the region and in some parts of the Project area palaeochannels occur within the coal measures that have been in-filled with alluvial deposits, consisting predominantly of sand and clay. The weathering depth in this region is relatively shallow, typically being less than 8 metres (m) deep for most of the Project site. However, for scheduling the weathered material quantities, the base of weathering is assigned to the base of the alluvial deposits (i.e. the alluvial deposits are included as weathered material) ranging up to 35 m thick.

The coal measures within the Project area are typically around 115 m thick and dip gently to the north. The dominant lithologies are mudstone, siltstone, sandstone, coal, carbonaceous mudstone and tuffaceous claystone. The coal seams present in the Project area in descending order are:

- Goulburn Seam.
- Turill Seam.
- Moolarben Member.
- Ulan Seam.

Figure 4 is a conceptual stratigraphic section of the Illawarra Coal Measures for the Project area and shows the seams and plies of the stratigraphic section and the target seams and partings (waste rock) of the typical working section. The Ulan Seam has been the primary seam targeted by mining operations at the existing Wilpinjong Coal Mine, and along with this seam, the Project pit extensions would also target the basal ply of the Moolarben Member (i.e. M4 Ply) in some of the pits.

The Goulburn and Turill Seams are both currently considered to be uneconomic to mine due to their relatively high ash content (Palaris, 2014) and would therefore be disposed with waste rock where it occurs in the Project pit extensions.



LEGEND

Stratigraphic Column
- Overburden/Floor Rock (Typically Sandstone)
- Parting (Typically Claystone)
- Stoney Coal
- Coal

Working Section
- Coal
- Waste

* Occurs in some areas of the Project.
** Occurs in eastern areas of the Project (e.g. Pit 8).

Source: WCPL (2015)

WILPINJONG EXTENSION PROJECT

Typical Working Sections

Figure 4

WIL-12-12_WEP_EIS_Geochem_001E

The Goulburn Seam is the upper seam of the Illawarra Coal Measures and is located in the Farmers Creek Formation of the Wallerawang Subgroup. This seam has an average thickness of 3.0 m, and is characterised by coal interbanded with carbonaceous claystone. The coal plies within this seam have a relatively high ash content. The Turill Seam occurs approximately 15 m below the Goulburn Seam and is located in the State Mine Creek Formation of the Charon Subgroup. The Turill Seam comprises two thin plies, approximately 0.3 m thick, with a siltstone parting ranging from 0.1 to 2.3 m thick.

The Moolarben Member is found from 5 to 9 m below the Turill Seam in the Project area. Although this seam comprise 4 plies and a tuff layer (M22), the upper plies have a relatively high ash content and are not considered to be economic, while the basal ply (M4) has a lower ash content and is considered to be a mineable resource for the Project. The thickness of this ply ranges from 0.2 to 0.7 m, with an average thickness of 0.5 m. The partings present include carbonaceous claystone and tuff (Palaris, 2014).

The Ulan Seam occurs approximately 22 m below the Moolarben Member in the Project area. This seam comprises a number of economic and non-economic plies as shown on Figure 4. The stratigraphy of the Ulan Seam is considered to be relatively consistent throughout the Project area and typically ranges in thickness from 14 to 16 m, thickening to over 20 m in the south of the Project area (Palaris, 2014).

Table 1 provides a list of the seams and plies that are considered to be economic and proposed for mining under the Project. Some of these plies have a low ash content and do not require washing (e.g. D1 and D2). These plies would bypass the CHPP and therefore would not produce any rejects.

Table 1: Average thickness and proposed processing of target seams and plies for the Project.

Working Section	Ply	Average Thickness (m)	Proposed Processing
M4	M4	0.50	Wash @ *F160
A	A12	0.49	Wash to 16% Target Ash
B	B1	0.61	Wash to 16% Target Ash
	B2	1.03	
	B3	0.71	
D	D1	0.39	Bypass
	D2	1.77	
E	E12,E21,E22	1.70	Bypass or Wash @ *F160
G	G1,G21,G22	1.17	Bypass or Wash @ *F160

* F160 denotes Floats at a Relative Density of 1.6

3.0 Related Investigations

Previous investigations of relevance to the current geochemistry assessment include a geochemical assessment of the existing Wilpinjong Coal Mine; water quality and rehabilitation performance investigations at the Wilpinjong Coal Mine; and geochemical assessments of the nearby Moolarben Coal Complex.

3.1 Geochemical Investigations

The previous geochemical investigations include a detailed geochemical assessment of overburden, coal and coal washery waste (reject) for the *Wilpinjong Coal Project Environmental Impact Statement* (WCPL, 2005), conducted by EGi (EGi, 2005), and geochemical assessments of overburden, floor rock, coal and coal reject for the nearby Moolarben Coal Complex Stage 1 and Stage 2, also conducted by EGi (EGi, 2006; EGi, 2008).

3.1.1 Wilpinjong Coal Project Geochemical Assessment

The testing program included pH and electrical conductivity (EC) determination, acid-base analysis and net acid generation (NAG) testing, and was designed to assess the salinity and acid forming risks associated with the overburden, stockpiled ROM and product coal, and the coal rejects (coarse rejects and tailings). A total of 50 drill-hole samples representing the overburden and 14 laboratory derived samples representing the product coal (1 sample), raw coal (3 samples), coarse rejects (5 samples) and tailings (5 samples), were utilised for this assessment (EGi, 2005).

The reported results indicated that the overburden is expected to have a circum-neutral pH and to be non-saline with results having an average of 119 microSiemens per centimetre (µS/cm). The majority of the samples (74%) had a low total sulfur (S) content of   0.1%S and acid neutralising capacity (ANC) of   10 kilograms of sulfuric acid per tonne of material (kg H_2SO_4/t) and are considered to be non-acid forming (NAF) and barren in terms of acid generation and neutralisation. However, some of the samples (14%) had a sulfur content > 0.1 %S with an increased risk of being potentially acid forming (PAF). Two samples collected from immediately below the G Seam were found to be PAF, but with only a low capacity to generate acid (i.e.   5 kg H_2SO_4/t) (EGi, 2005).

The coal and coal reject samples typically had a moderate sulfur content, ranging from 0.17 to 0.99 %S with an average of 0.39 %S, and a low ANC ranging from 0 to 16 kg H_2SO_4/t with an average of only 3 kg H_2SO_4/t. Table 2 provides the salinity ranking and geochemical classification of the tailings, coarse reject, raw coal and product coal, based on the samples tested by EGi (2005). These results indicate that two of the tailings samples were classified as PAF and the remaining three samples were classified as PAF/LC.

One of the coarse reject samples was classified as NAF, one was classified as PAF and three of these samples were classified as PAF/LC. All of the raw and product coal samples were classified as PAF/LC.

The coarse reject, raw coal and product coal samples were all non-saline and the tailings samples ranged from slightly to highly saline.

Table 2: Geochemical classification and salinity ranking for the coal and coal reject samples from the Wilpinjong Coal Project geochemical assessment conducted by EGi (2005).

<table>
<tr><th>PLIES</th><th>TAILINGS</th><th>COARSE REJECTS</th><th>RAW COAL</th><th>PRODUCT COAL</th></tr>
<tr><td>A12+B1+B2+B3</td><td>PAF
Highly saline</td><td>PAF/LC
Non-saline</td><td>PAF/LC
Non-saline</td><td rowspan="5">PAF/LC
Non-saline</td></tr>
<tr><td>D0+D1+D2</td><td>PAF/LC
Slightly saline</td><td>PAF/LC
Non-saline</td><td>PAF/LC
Non-saline</td></tr>
<tr><td>E12+E21+E22</td><td>PAF/LC
Saline</td><td>NAF
Non-saline</td><td rowspan="2">PAF/LC
Non-saline</td></tr>
<tr><td>E32</td><td>PAF
Slightly saline</td><td>PAF
Non-saline</td></tr>
<tr><td>G1</td><td>PAF/LC
Saline</td><td>PAF/LC
Non-saline</td><td></td></tr>
</table>

The recommendations provided included (EGi, 2005):

- The overburden and interburden/parting materials were expected to be non-saline and, although a small quantity of PAF/LC material was identified, the bulk of this material was expected to be NAF, and with operational blending would produce an overall NAF material. The overburden and interburden/parting materials were to be disposed as waste rock into the mined out pit voids, and based on these characteristics no special handling requirements were considered to be necessary for the disposal of this material.
- The coarse rejects were expected to be typically non-saline and PAF/LC. The recommended management strategy for this material was to co-dispose it with the waste rock (overburden and interburden) provided the materials could be well mixed at a blend ratio of at least 2:1 (overburden:coarse rejects) in order to ensure that an overall NAF material was produced.
- The outer 5 m of the final waste rock emplacement surfaces were to be restricted to NAF waste rock in order to ensure that PAF or PAF/LC materials were not exposed to oxidation. This cover design was to be modified if the coarse reject co-disposal was not adequately mixed and zones of PAF or PAF/LC material were exposed within the waste rock emplacement.

- The tailings were expected to be saline and either PAF or PAF/LC and therefore the management strategy developed was based on isolating this material from oxidation. The tailings were to be pumped as a slurry into prepared cells within the in-pit waste rock emplacements and covered with at least 2 m of NAF waste rock when the cells are filled. In order to ensure that the tailings are not allowed to oxidise during disposal, the deposited tailings should either be saturated or continually covered with fresh tailings.

3.1.2 Moolarben Coal Complex Geochemical Assessments

The Moolarben Coal Complex shares its eastern mining tenement boundary with the western boundary of the Wilpinjong Coal Mine Exploration Licence (Figure 2). As expected, the stratigraphy of the Moolarben Coal Complex deposit is similar to that of the Wilpinjong Coal Mine deposit, comprising Late Permian sandstone, siltstone, mudstone, tuff and coal deposits of the Illawarra Coal Measures, overlain by Quaternary alluvial deposits. These mines share the primary targeted coal seams (i.e. Ulan Seam). Based on this, it is expected that the overburden, interburden and coal deposits, and hence coal rejects, from both deposits will be geochemically similar. Therefore, the findings from the geochemical assessments for the Moolarben Coal Complex can be used to provide an indication of the geochemical characteristics of the deposits associated with the Project.

Geochemical assessments of the overburden, coal and coal reject was carried out for the Moolarben Coal Complex Stage 1 and Stage 2 (EGi, 2006, 2008). The Stage 1 assessment involved determination of the salinity, sodicity, acid forming characteristics, and metal release and solubility for the proposed underground and open pit mining operations based on a total of 122 overburden and interburden samples (including 8 floor rock samples), 6 coal samples and 2 coal reject samples (EGi, 2006).

The results from this assessment indicated that the majority of the overburden and interburden at the Moolarben Coal Complex Stage 1 was expected to be NAF. Although, a small number of PAF/LC samples were identified, these materials were restricted to the coal seam roof and floor strata. Based on these results, the coal seams were expected to be PAF/LC and rejects from these seams were expected to be PAF (EGi, 2006).

These results also indicated that while the overburden and interburden, and the coal rejects were expected to be non-saline, the coal seams were found to be saline. Additionally, it was identified that the alluvial deposits and weathered materials have a risk of being sodic which may present a concern for sediment dispersion and increased erosion potential. No environmentally significant metals were found to be enriched in any of the overburden, coal seam or coal reject samples (EGi, 2006).

The Stage 2 geochemical assessment involved determination of the salinity and acid forming characteristics of an additional 78 overburden and interburden samples and 29 coal seam samples. Additional to this, the metal enrichment and leaching behavior of two composited samples representing the PAF/LC overburden, and blended NAF and PAF/LC overburden at a ratio of 2:1 was assessed. The results from this assessment were generally consistent with those from the Stage 1 assessment. However, the Stage 2 geochemical assessment identified that, due to the increased sulfur content in the carbonaceous materials, including the coal and carbonaceous shale, these materials had an increased risk of being PAF (EGi, 2008).

Based on the findings of the Stage 1 and Stage 2 geochemical assessments the following recommendations were provided (EGi, 2006; EGi, 2008):

- Due to the expected proportions of NAF and PAF/LC strata, it was expected that operational blending of the overburden and interburden during disposal would be sufficient to ensure that the waste rock emplacements remained overall NAF and therefore no selective handling of this material would be required.
- The coal rejects were expected to contain a significant proportion of PAF material and therefore all coal rejects should be managed as PAF material.
- The management strategy for the PAF materials included in-pit disposal of this material below the watertable and/or construction of a cover to prevent infiltration of water and flushing of the PAF material. If required, the PAF materials could be treated with alkali material (e.g. limestone) to either extend the geochemical lag period, as may be required prior to covering, or convert it to a NAF material.
- If any identified sodic materials are exposed on the final waste rock emplacement surfaces or used in engineered structures treatment, involving the application of soluble calcium salts such as calcium sulfate (gypsum), calcium chloride or calcium carbonate (limestone), may be required to reduce the risk of increased sediment dispersion and/or erosion.

3.2 Water Quality Investigations

3.2.1 Surface Water Quality Investigations

An assessment of the quality of potentially impacted surface waters from the mining operations and related activities was conducted by Gilbert & Associates Pty Ltd (2013) for the *Wilpinjong Coal Mine Modification 5 Environmental Assessment* (WCPL, 2013). This assessment utilised data from the routine surface water quality monitoring program initiated in 2004.

This assessment compared the general water quality parameters (pH, EC, turbidity and sulfate) from the natural drainages upstream and downstream of the mine and various mine-site water storages to the Australian and New Zealand Environment and Conservation Council (ANZECC) protection of aquatic ecosystems and livestock drinking water quality (ANZECC, 2000).

The on-site surface water monitoring sites include various sediment dams, predominantly in the vicinity of the CHPP, and a number of water storages, including the clean water dam[1] (CWD), recycled water dam, Pit 2 West and Ed's Lake; and mine pit water from Pit 1 North. The assessment found that the pH values were typically quasi-neutral with average values ranging from 6.8 to 7.7. However, low pH values ranging from 3.8 to 4.5, were recorded from January to March in 2008 at the sediment control dam (SCD) 3 site and similarly, low values ranging from 3.8 to 4.4, were recorded from April to September in 2010 at the CWD site. Additional to these events, a single sample collected from Ed's Lake in 2010 had a pH of 4.1. The low pH events that have occurred in the on-site water storages indicate the presence of acid drainage emanating from a source/s of exposed PAF material (Gilbert & Associates, 2013).

The natural drainages typically have a slightly alkaline pH with average values ranging from 7 to 8. There is no discernible difference in pH between the upstream and downstream sites and no evident increasing or decreasing trend over time. The EC values are typically relatively high at all sites with the average values ranging from 1,566 to 4,803 µS/cm. The EC values for the Wilpinjong Creek sites downstream of the mine are significantly higher than those upstream and this is attributed to a combination of increased solute load due to confluence with other high EC drainages and increased solute load associated with the coal deposits. However, the lack of an increasing EC trend in the downstream sites at the commencement and during Wilpinjong Coal Mine operations indicates that the mining activities to date have not impacted the EC of the receiving environment (Gilbert & Associates, 2013).

The sulfate concentrations are also typically relatively high at all sites, with average values ranging from 75 to 1,626 milligrams per litre (mg/L). As expected, the sulfate concentrations are consistent with the EC values and show no increasing trend over time from pre-mining to the present (Gilbert & Associates, 2013).
The presented surface water quality monitoring data indicate that the management strategies adopted for the waste rock and coal rejects (coarse reject and tailings) have been successful in negating any potential off-site water quality impacts.

Potential surface water impacts associated with the Project are assessed in the Surface Water Assessment (WRM Water and Environment, 2015).

[1] The CWD holds mine water (i.e. does not contain 'clean' runoff from undisturbed catchments).

3.2.2 Groundwater Quality Investigations

A review of the groundwater quality monitoring results from the existing Wilpinjong Coal Mine operations is provided in the *Wilpinjong Extension Project Groundwater Assessment* (HydroSimulations, 2015). This review includes an assessment of the monitoring results for groundwaters within the vicinity of tailings disposal areas 1 to 4 (i.e. TD1 to TD4). These results indicated that, with the exception of four slightly lowered pH values (i.e. pH approximating 5.5) recorded intermittently at TD3 and TD4, the pH remained quasi-neutral (i.e. ranging from 6.5 to 8.0) throughout the monitoring period at all sites. The EC values recorded at these sites were typically <2,000 µS/cm and significantly lower than those recorded at the established baseline alluvial groundwater quality monitoring sites with EC values ranging from 4,000 to 8,000 µS/cm. A short-term increase in the EC values from <2,000 µS/cm to between 6,000 and 8,000 µS/cm was recorded in groundwaters from TD3 and TD4 during active disposal, however these values remained within the typical EC range recorded for the baseline alluvial groundwater quality monitoring sites. The EC values for these areas subsequently decreased back to typical values (i.e. <2,000 µS/cm) following decommissioning of these sites (HydroSimulations, 2015).

This assessment indicates that no long-term groundwater quality impacts are expected to affect the beneficial use of the groundwater in the vicinity of these tailings disposal areas (HydroSimulations, 2015). Additionally, the findings presented confirm that the tailings management strategy adopted at the site has been successful in negating any potential off-site groundwater quality impacts.

The potential groundwater impacts associated with the Project are assessed in detail and reported in the Groundwater Assessment (HydroSimulations, 2015).

3.3 Rehabilitation Performance Review

Approximately 221 ha of completed landforms at the Wilpinjong Coal Mine have been progressively rehabilitated since 2008 (WCPL, 2015b). An additional 79 ha is scheduled to be rehabilitated in 2015 (WCPL, 2015b).

Landline Consulting (2013) undertook monitoring at 13 permanent transects located within the rehabilitated areas in October 2013. This monitoring indicated that there was an adequate establishment of vegetation, in particular trees and shrubs. However, groundcover and yield were below optimum due to the low amount of fertiliser used and the below average rainfall encountered during the monitoring period. Some areas of significant erosion were identified within the rehabilitated areas, and these were typically associated with failed contour banks. Soil testing indicated that relatively high acidity and sodicity in some of the soils were responsible for the restricted plant growth in some areas.

Landline Consulting (2013) recommended measures to improve rehabilitation outcomes including application of fertiliser and lime to rehabilitated areas.

The rehabilitation monitoring program to date has identified a number of issues with rehabilitation success attributed to a combination of low rainfall, insufficient fertiliser and the inherent soil characteristics (i.e. relatively high acidity and sodicity). However, this program confirms that the respective adopted management strategies have ensured that the waste rock and coal rejects (coarse reject and tailings) have not impacted the soils or the rehabilitation outcomes to date.

4.0 Existing Environmental Management and Monitoring Practices

The existing management strategies for the waste rock and coal rejects (coarse rejects and tailings) at the Wilpinjong Coal Mine function to minimise oxygen diffusion through to emplaced PAF waste rock, coarse rejects or tailings in order to reduce the risk of developing acid conditions within the waste rock emplacements. A summary of the management strategies developed for these materials and the relevant site water management and monitoring programs are provided below.

4.1 Waste Rock

The excavated overburden and interburden is backfilled into the mined-out voids or placed within the Pit 2 elevated waste rock emplacement. A small quantity of identified PAF/LC material is blended with the bulk NAF waste rock material during placement producing an overall NAF material. The outer 2 m of the backfilled waste rock and outer 5 m of the elevated waste rock emplacement is generally restricted to NAF waste rock in order to minimise the potential for any PAF or PAF/LC materials to be exposed to oxidation.

4.2 Coal Rejects

Coal reject management at the Wilpinjong Coal Mine is conducted in accordance with the *Wilpinjong Coal Mine Mining Operations Plan* (WCPL, 2014b), *Wilpinjong Coal Mine Life of Mine Tailings Management Strategy* (Golder Associates, 2014) and the *Wilpinjong Coal Mine Waste Management Plan* (WCPL, 2015c). The coal rejects comprise a coarse reject and a tailings, which are generated during processing of ROM coal in the CHPP. The coarse reject ranges in size from 0.5 to 75 millimetres (mm) and the tailings are typically finer than 0.5 mm.

The coarse rejects are deposited in the mined-out pit voids, and may also be deposited in the elevated waste rock emplacement in Pit 2. Prior to final profiling and rehabilitation of the waste rock emplacements, the coarse rejects deposited in the mined-out voids are covered with NAF waste rock to a minimum depth of 2 m and in the elevated waste rock emplacement, to a minimum depth of 5 m.

The tailings have historically been pumped as a slurry into cells constructed within the backfilled waste rock located in the mined-out pit voids. The potential for the tailings to oxidize prior to being covered with NAF waste rock was minimised due to the saturated state of the tailings. Once the cells are filled they are covered with a minimum 2 m of NAF waste rock to form an oxygen diffusion barrier.

Due to the identified risk of spontaneous combustion, carbonaceous materials and coal seam partings are handled separately and encapsulated within the mined-out voids along with the coarse rejects.

WCPL has installed a tailings filter press in the CHPP to dewater the tailings so the dewatered tailings can be co-disposed as a solid with the coarse rejects. The combined coarse rejects and tailings are deposited with NAF waste rock in the mined-out voids and covered with NAF waste rock to a minimum depth of 2 m prior to final profiling and rehabilitation. The blend ratio of NAF waste rock to combined coarse rejects and tailings is 4:1 to target an overall negative NAPP (Golder Associates, 2014).

A temporary tailings holding cell may be constructed in the vicinity of the CHPP for the short term storage of the tailings in the event that the tailings filter press is not operational (e.g. breakdown, scheduled maintenance). In this event, the tailings will be transferred from the tailings filter press to the temporary tailings holding cell where they will be dewatered and dried, as required, prior to being co-disposed with the coarse rejects within the mined-out voids as described above. In the absence of a constructed tailings holding cell, when the tailings filter press is not operational, the tailings will continue to be transferred to cells in the mine void.

4.3 Site Water

Water management and monitoring at the Wilpinjong Coal Mine is conducted in accordance with the *Wilpinjong Coal Mine Site Water Management Plan* (WCPL, 2014c) which includes a Site Water Balance, Surface Water Management and Monitoring Plan and a Groundwater Monitoring Program.

The mine water management system is based on the collection, storage and use of water collected from areas used for the mining and handling of coal and mine overburden. These areas include:

- open cut pits;
- non-rehabilitated or partially rehabilitated portions of the overburden emplacements;
- tailings disposal areas;
- coal handling areas (i.e. ROM pad, CHPP, haul roads); and
- runoff from undisturbed areas which is not diverted around disturbed areas using upslope diversions.

Monitoring conducted in accordance with the Surface Water Management and Monitoring Plan and a Groundwater Monitoring Program assists identify any potential environmental geochemistry impacts.

5.0 Geochemical Assessment Program

5.1 Testing Methodology and Program

The laboratory program for the assessment included the following tests and procedures:

- pH and EC determination;
- total sulfur (S) assay;
- maximum potential acidity (MPA) calculation;
- ANC determination;
- net acid producing potential (NAPP) calculation;
- exchangeable cation analysis;
- chromium reducible sulfur (CRS) analysis;
- single addition NAG test;
- acid buffering characteristic curve (ABCC) determination;
- kinetic NAG test; and
- multi-element scans on solids and water extracts.

The sample preparation, exchangeable cation analysis, acid-base analysis (total S assays and ANC determinations), NAG testing and ABCC determinations were performed by Australian Laboratory Services Pty Ltd (ALS) in Brisbane. The pH and EC determinations, and water extract preparation were conducted by GEM, and the multi-element scans were performed by Genalysis Laboratories in Perth.

An overview of the testing program used for this assessment is presented below.

5.1.1 pH, Salinity and Sodicity Determination

pH and Electrical Conductivity Determination

The pH and EC of a material is determined by equilibrating the sample in deionised water for a minimum of 2 hours at a solid to water ratio of 1:2 (w/w). This test provides an indication of the inherent acidity and salinity of the material when it is initially exposed. Table 3 provides the salinity rankings based on $EC_{1:2}$ values.

Table 3: Salinity ranking based on the EC value.

$EC_{1:2}$ (dS/m)	Salinity
< 0.5	Non-Saline
0.5 to 1.5	Slightly Saline
1.5 to 2.5	Moderately Saline
> 2.5	Highly Saline

(Rhoades *et al.*, 1999) dS/m = deci-siemens per metre

Exchangeable Cation Analysis

Exchangeable cation analyses are carried out to determine the sodicity of a sample. Sodicity occurs in materials that have high concentrations of exchangeable sodium (Na) relative to the other major cations, calcium (Ca) and magnesium (Mg), causing the material to be highly dispersive. The exchangeable sodium percent (ESP) is used to determine the sodicity of a sample by comparing the amount of exchangeable Na to that of Ca and Mg concentrations. Table 4 provides the sodicity ranking and dispersion characteristics based on the ESP.

Table 4: Sodicity ranking and dispersion characteristics based on the exchangeable sodium percent (ESP).

ESP	Sodicity	Dispersion
< 6	Non-Sodic	Not Dispersive
6 to 15	Slightly Sodic	Slightly Dispersive
15 to 30	Moderately Sodic	Moderately Dispersive
> 30	Highly Sodic	Highly Dispersive

(Northcote & Skene, 1972)

5.1.2 Acid Forming Characteristic Evaluation

A number of test procedures are used to assess the acid forming characteristics of mine waste materials. The most widely used assessment methods are the acid-base account (ABA) and the NAG test. These methods are referred to as static procedures because they involve a single measurement in time.

Acid-Base Account

The ABA involves laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulfide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates). The values arising from the ABA are referred to as the MPA and the ANC, respectively. The difference between the MPA and ANC value is referred to as the NAPP.

The MPA is calculated using the total S content of the sample. This calculation assumes that all of the S measured in the sample occurs as pyrite (FeS_2) and that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)^3 + 2\ H_2SO_4$$

According to this reaction, the MPA of a sample containing 1 %S as pyrite would be 30.6 kg H_2SO_4/t. Hence the MPA of a sample is calculated from the total S content using the following formula:

$$\text{MPA (kg } H_2SO_4\text{/t)} = \text{(Total \%S)} \times 30.6$$

The use of the total S assay to estimate the MPA is a conservative approach because some S may occur in forms other than pyrite. Sulfate-sulfur and native sulfur, for example, are non-acid generating S forms. Also, some S may occur as other metal sulfides (e.g. covellite, chalcocite, sphalerite, galena) that yield less acidity than pyrite when oxidised. The CRS analysis method is used to determine the sulfide-S content and this information is used to assess the proportion of the total S within a sample that occurs as reactive sulfide.

The acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid neutralisation is quantified in terms of the ANC and is determined using the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated giving the ANC expressed in the units of kg H_2SO_4/t.

Determination of the ANC using the Modified Sobek method (Sobek *et al.*, 1978) provides an indication of the total neutralisation capacity of a material. However, in some materials not all mineral phases will be readily available to neutralise sulfide generated acidity. For these material types ABCC can be used to determine the amount of ANC that is available to neutralise any sulfide generated acidity under more natural weathering conditions. The ABCC's are obtained by slow titration of a sample with acid while continuously monitoring pH and plotting the amount of acid added against pH. The plot provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.

The NAPP is a theoretical calculation commonly used to indicate if a material has the potential to produce acid. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H_2SO_4/t and is calculated as follows:

$$\text{NAPP} = \text{MPA} - \text{ANC}$$

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

The ANC/MPA ratio is used as a means of assessing the risk of acid generation from mine waste materials. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. Generally, an ANC/MPA ratio of 3 or more signifies that there is a high probability that the material is not acid generating.

Figure 5 is an ABA plot which is commonly used to provide a graphical representation of the distribution of S and ANC in a sample set. This figure shows a plotted line where the NAPP=0 (i.e. ANC = MPA or ANC/MPA=1). Samples that plot to the lower-right of this line have a positive NAPP and samples that plot to the upper-left of it have a negative NAPP. Figure 5 also shows the plotted lines corresponding to ANC/MPA ratios of 2 and 3.

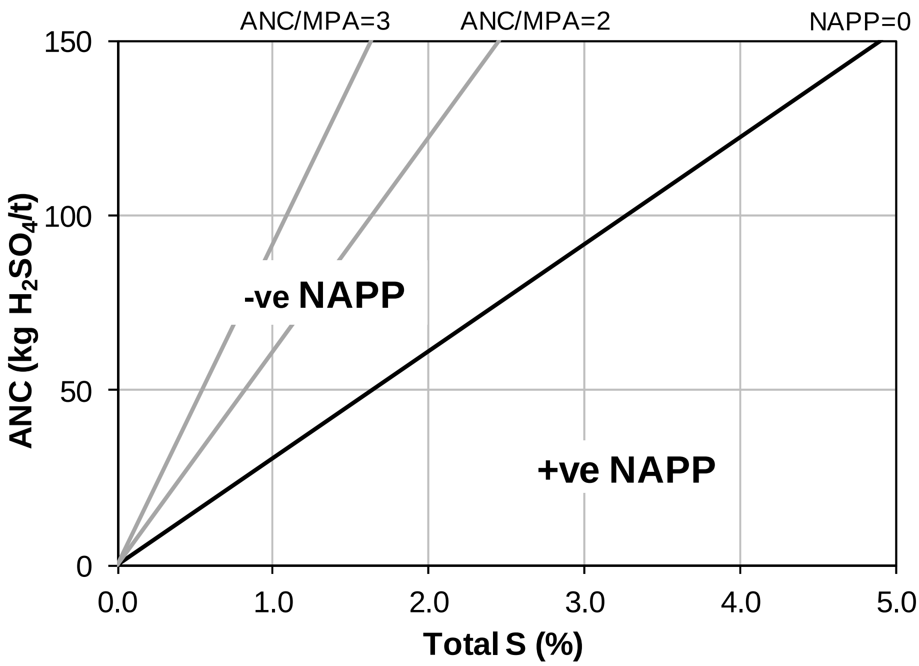


Figure 5: Typical acid-base account plot.

Net Acid Generation Test

The single addition NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The standard (single addition) NAG test involves reaction of a sample with hydrogen peroxide to oxidise any sulfide minerals contained within a sample. During the NAG test, acid generation and neutralisation reactions occur simultaneously and the end result represents a direct measurement of the net amount of acid generated by the oxidised sample. The pH of the NAG solution on completion of the oxidation reaction is referred to as the NAGpH. A NAGpH < 4.5 indicates that acid conditions remain after all acid generating and acid neutralising reactions have taken place and a NAGpH > 4.5 indicates that any generated acidity has been neutralised. An indication of the capacity of the sample to generate acid is provided by titrating the NAG solution to the pH end-points of 4.5 and 7.0. This value is commonly referred to as the NAG capacity and is expressed in the same units as the NAPP (i.e. kg H_2SO_4/t). The titration value at pH 4.5 includes the acidity produced due to free acid (*i.e.* H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides.

The kinetic NAG test uses the same procedure as the single addition NAG test except that the temperature and pH of the solution are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulfide oxidation and acid generation during the test. This, in turn, can provide an insight into the behaviour of the material under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulfidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulfide surfaces and/or oxidation products.

5.1.3 Multi-Element Analysis

Multi-element scans are carried out on the solid samples to identify any elements that are present at concentrations that may be of environmental concern with respect to water quality, revegetation and public health. The assay results from the solid samples are compared to the average crustal abundance for each element to provide a measure of the extent of element enrichment. The extent of enrichment is reported as the Geochemical Abundance Index (GAI). However, identified element enrichment does not necessarily mean that an element will be a concern for water quality, revegetation or public health and this technique is used to identify any significant element enrichments that warrant further examination.

Multi-element scans also are performed on liquor samples to determine the chemical composition of the solution and identify any elemental concerns for water quality. Multi-element scans are performed on water extracts, typically extracted from a 1 part sample to 2 parts deionised water suspension, in order to identify any elements that are likely to be readily soluble under the existing pH conditions. These analyses are designed to identify any elements that may be a concern for water quality and warrant further investigation.

5.2 Geochemical Classification

The acid forming potential of a sample is classified on the basis of the ABA and NAG test results into one of the following categories:

- Barren.
- Non-Acid Forming (NAF).
- Potentially Acid Forming (PAF).
- Potentially Acid Forming Low Capacity (PAF/LC).
- Acid Consuming (AC).
- Uncertain (UC).

Barren

A sample classified as barren essentially has no acid generating capacity and no acid buffering capacity. This category is most likely to apply to highly weathered materials. In essence, it represents an 'inert' material with respect to acid generation. The criteria used to classify a sample as barren may vary between sites, but it generally applies to materials with a total sulfur content 0.1 %S and an ANC 10 kg H_2SO_4/t.

Non-Acid Forming

A sample classified as NAF may or may not have a significant sulfur content, but the availability of the ANC within the sample is adequate to neutralise all of the acid that could theoretically be produced by the contained sulfide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and a final NAGpH 4.5.

Potentially Acid Forming

A sample classified as PAF always has a significant sulfur content, the acid generating potential of which exceeds the inherent ANC of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is classified as PAF if it has a positive NAPP and a final NAGpH < 4.5. Typically, if a PAF sample has a NAPP 5 kg H_2SO_4/t it is considered to only have a low capacity to generate acid and is classified as PAF/LC.

Acid Consuming

A sample is classified as AC if it has the same characteristics as NAF material, but has sufficient ANC to result in a NAPP of minus 100 kg H_2SO_4/t.

Uncertain

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH 4.5).

Figure 6 shows a typical geochemical classification plot for mine waste materials where the NAPP values are plotted against the NAGpH values. Samples that plot in the upper left quadrate, with negative NAPP values and NAGpH values > 4.5, are classified as NAF. Those that plot on the lower right quadrate, with positive NAPP values and NAGpH values 4.5, are classified as PAF. Those that plot in this quadrate with a NAPP 5 kg H_2SO_4/t are classified as PAF/LC. Samples that plot in the upper right or lower left quadrates of this plot have an uncertain geochemical classification (UC) due to a contradiction in the acid-base and NAG test results, and further testing is required to determine the geochemical classification of these material types.

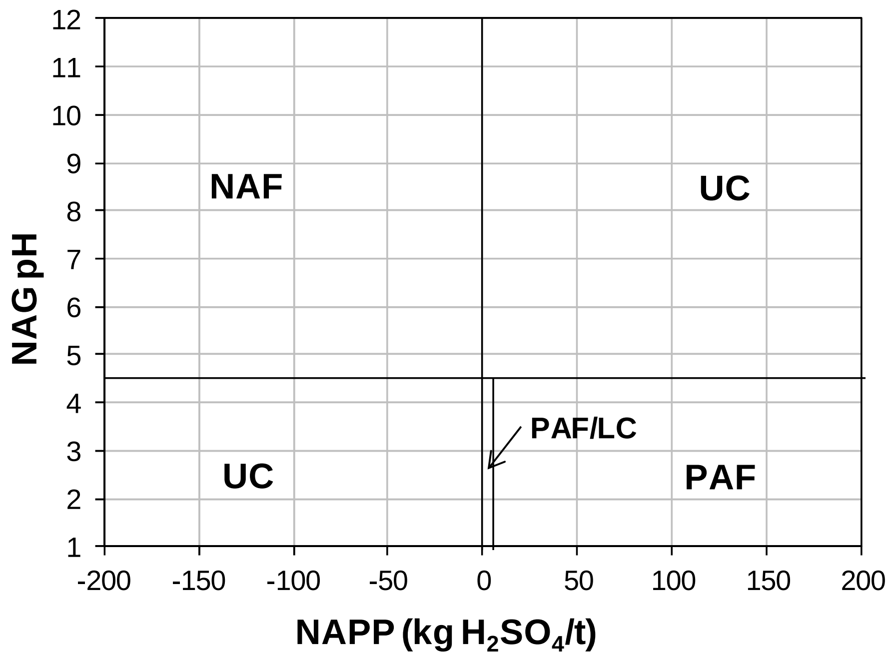


Figure 6: Typical geochemical classification plot.

5.3 Sample Selection and Preparation

The materials sampled for this assessment include the overburden and interburden, including the coal seam partings, and coal rejects. The overburden and interburden samples were collected from selected drill-core by Groundwater Exploration Services Pty Ltd under instruction from GEM, and the coal reject samples were prepared by ALS Coal Division from selected Project coal seam samples used for coal quality and washability testing, also under instruction from GEM. The sample details are provided in Attachment A and include drill-hole, depth interval, and lithology for the overburden and interburden samples (Tables A-1 and A-2), and drill-hole, interval ID, and seam/ply for the coal reject samples (Table A-3). The sampled drill-hole locations are also provided in Attachment A (Figure A-1).

All of the samples were sent to ALS in Brisbane for preparation prior to analysis where they were crushed to minus 4 mm, if required, and a 200 gram (g) split was pulverised to minus 75 micrometres.

5.3.1 Overburden and Interburden Samples

A total of 92 overburden and interburden samples were collected from 10 drill-holes distributed throughout the Project extension areas for Pits 1, 2, 3, 5 and 6, and the new pit (Pit 8) proposed for the Slate Gully area (Figure A-1). The sampling program was designed to provide representative samples of the major lithological units that would be excavated as waste rock from these areas.

To achieve this, continuous drill-core was collected from selected intervals comprising discrete lithology, or mixed lithology (e.g. sandstone/siltstone) where the strata were logged as such. In order to ensure practical sample sizes were maintained, for the larger interval samples (i.e. typically > 1 to 2 m), discs of the core were collected at regular spacings through the selected interval. Typically the discs were 10 mm thick and were spaced from 100 to 200 mm apart.

The drill-holes are typically open-hole drilled through the upper zone due to the friable nature of the weathered material, producing rock-chips that are usually bagged in 1 m intervals. However, the rock-chips from the upper open-holed section of the selected drill-holes were not available for sampling. In order to ensure adequate representation of the weathered overburden materials a number of additional recent drill-holes were selected specifically for sampling the weathered rock-chip materials. For these materials composite samples according to lithology and degree of weathering were prepared for inclusion in the testing program. The individual samples used to produce the composite samples are provided in Attachment A (Table A-2).

Table 5 provides the number, proportion and total interval sampled for the different lithologies and mixed lithologies sampled. The mixed lithology samples are grouped according to the dominant lithology within the sample.

Table 5: Number, proportion and total interval sampled for the different overburden and interburden lithological materials of the Project.

Lithology	Sample Count	Sampled Interval	
		(m)	(%)
Alluvium	3	12.00	11%
Clay (Weathered)	2	10.00	9%
Gravel (Weathered)	1	2.00	2%
Sand (Weathered)	1	3.00	3%
Sandstone (Weathered)	4	3.57	3%
Siltstone (Weathered)	2	0.37	0.3%
Claystone (Weathered)	1	1.50	1%
Carbonaceous Mudstone (Weathered)	2	0.33	0.3%
Sandstone,Siltstone (Weathered)	3	0.67	1%
Conglomerate	6	7.87	7%
Sandstone	12	24.00	22%
Siltstone	5	3.05	3%
Carbonaceous Siltstone	4	2.37	2%
Carbonaceous Claystone	1	0.53	0.5%
Carbonaceous Mudstone	5	1.04	1%
Tuff	10	2.73	3%
Sandstone,Siltstone	10	19.33	18%
Sandstone,Mudstone	2	1.17	1%
Sandstone,Carbonaceous Mudstone	1	0.25	0.2%
Sandstone,Siltstone,Mudstone	8	8.59	8%
Siltstone,Mudstone	6	2.14	2%
Siltstone,Claystone	1	0.20	0.2%
Carbonaceous Siltstone,Carbonaceous Mudstone	2	1.74	2%

5.3.2 Coal Reject Samples

Coal seam samples from the Project that had previously been prepared by ALS Coal Division for coal quality testing were utilised for the geochemical assessment program. The materials produced during flotation (float/sink) testing conducted by ALS were utilised to obtain representative samples of the coal rejects. This was achieved by compositing the samples from the Sinks 1.8 fraction (i.e. density > 1.8) for the seams scheduled for washing and therefore expected to produce a reject material. In order to produce representative samples of these materials from the Project composite samples were made-up from selected drill-holes throughout the Project extension areas. The drill-holes and sample ID's used to make-up the composite samples (Table A-3), and the drill-hole locations (Figure A-1) are provided in Attachment A.

Table 6 lists the coal seams and plies prepared for geochemical characterisation testing. A total of 10 composite coal reject samples were prepared, including the target Ulan Seam plies and the Moolarben Member, M4 ply. Although not scheduled for mining, composite samples of the coal rejects from the Goulburn and Turill Seams were also prepared for inclusion in the testing program.

Table 6 provides a breakdown of the quantity of the different sample types prepared from the different seams.

Table 6: Coal reject samples prepared for the different target seams and plies from the Project.

Seam		Ply	Sample ID
Goulburn Seam*		GLB1:GLB12 GLB2:GLB22 GLB3:GLB4	WIL/GLB
Turill Seam*		TUR1:TUR2	WIL/TUR
Moolarben Member		M4	WIL/M4
Ulan Seam	A	A12	WIL/A12
	B	B1	WIL/B1
		B2	WIL/B2
		B3	WIL/B3
	E	E12:E22	WIL/E
	G	G1	WIL/G1
		G1:G22	WIL/G

* These seams would not be mined as part of the Project.

6.0 Overburden and Interburden Geochemistry

The geochemical test results for the overburden and interburden samples, including the $pH_{(1:2)}$ and $EC_{(1:2)}$, acid forming characteristics, sodicity assessment and element enrichment and solubility, are provided in Attachment B, ABCC plots for selected samples are provided in Attachment C, and those for the kinetic NAG tests are provided in Attachment D. A summary of the $pH_{(1:2)}$ and $EC_{(1:2)}$, and acid forming characteristics for the different overburden and interburden material types within the Project areas are provided on Table 7.

6.1 pH, Salinity and Sodicity

The $pH_{1:2}$ and $EC_{1:2}$ results for these samples are provided in Attachment B (Table B-1). The $pH_{1:2}$ values for the overburden and interburden samples are typically neutral to slightly alkaline with values ranging from 5.1 to 9.0, and an average (median) of 7.7. A number of samples (4) have $pH_{1:2}$ values < 6.0 and these include one sample of the siltstone, two samples of the tuff and one sample of the highly weathered claystone.

The $EC_{1:2}$ values range widely from 0.072 to 1.723 dS/m, but with an average of only 0.373 dS/m. The majority of the samples (75%) have an $EC_{1:2}$ value < 0.5 dS/m and are classified non-saline. One sample, the low pH highly weathered claystone, has an $EC_{1:2}$ value > 1.5 dS/m and is classified moderately saline. The remaining samples, comprising predominantly the weathered materials, have $EC_{1:2}$ values between 0.5 and 1.5 dS/m and are classified as slightly saline.

Thirty of the overburden and interburden samples representing the range of material types based on lithology, weathering and geochemical characteristics, were selected for exchangeable cation analysis and determination of the ESP in order to assess the sodicity risk presented by these materials. The results from these analyses are provided in Attachment B (Table B-2) and indicate that these materials are likely to range from non-sodic to moderately sodic. Figure 7 is a plot of the ESP values compared to the $EC_{1:2}$ values for the different material types. These results indicate that 43% of the samples have ESP values < 6 and are classified non-sodic, 30% have ESP values between 6 and 15, and are classified slightly sodic, and the remaining 27% have ESP values between 15 and 30, and are classified moderately sodic. The samples classified as non-sodic are predominantly restricted to the fresh samples and those classified as slightly to moderately sodic are predominantly restricted to the weathered and alluvial samples.

Table 7: Summary of the pH, EC and acid forming characteristics of the different Project overburden and interburden material types.

Material Type		*$pH_{1:2}$	$EC_{1:2}$ (dS/m)	Total S (%S)	MPA	ANC	NAPP	*NAGpH
					(kg H_2SO_4/t)			
All Samples	*min.*	5.1	0.072	0.02	1	0	-247	3.8
	max.	9.0	1.723	0.33	10	249	6	10.8
(92 samples)	*aver.*	7.7	0.373	0.06	2	16	-14	7.4
Alluvium	*min.*	7.4	0.658	0.03	1	1	-2	6.9
	max.	8.2	1.104	0.03	1	3	0	7.1
(3 samples)	*aver.*	7.6	0.873	0.03	1	2	-1	7.0
Weathered Material	*min.*	5.1	0.072	0.02	1	0	-64	3.8
	max.	8.7	1.723	0.11	3	65	2	9.8
(16 samples)	*aver.*	7.5	0.704	0.04	1	7	-6	7.1
Conglomerate	*min.*	7.6	0.120	0.02	1	1	-63	5.6
	max.	8.8	0.379	0.12	4	64	1	8.9
(6 samples)	*aver.*	8.5	0.244	0.05	2	24	-23	8.0
Sandstone	*min.*	6.6	0.139	0.02	1	1	-98	7.2
	max.	9.0	0.548	0.04	1	99	0	9.8
(12 samples)	*aver.*	8.2	0.253	0.03	1	30	-30	8.3
Siltstone	*min.*	5.9	0.094	0.04	1	0	-10	6.4
	max.	8.1	0.922	0.10	3	13	2	8.4
(5 samples)	*aver.*	7.5	0.455	0.07	2	5	-3	7.2
Carb. Siltstone	*min.*	6.4	0.154	0.05	2	1	-6	4.4
	max.	7.9	0.197	0.24	7	11	6	7.9
(4 samples)	*aver.*	7.7	0.177	0.15	5	4	0	6.0
Carb. Mudstone	*min.*	6.2	0.143	0.11	3	3	-11	4.3
	max.	7.6	0.889	0.20	6	15	2	6.9
(5 samples)	*aver.*	6.5	0.537	0.15	5	6	-2	6.3
Tuff	*min.*	5.4	0.087	0.05	2	4	-26	7.3
	max.	8.3	0.529	0.33	10	31	-1	8.6
(10 samples)	*aver.*	7.2	0.239	0.13	4	12	-8	7.9
Sandstone, Siltstone	*min.*	6.6	0.078	0.02	1	1	-46	6.6
	max.	8.9	0.339	0.06	2	47	0	9.5
(10 samples)	*aver.*	8.0	0.198	0.03	1	13	-12	7.4
Sandstone, Mudstone	*min.*	7.7	0.087	0.06	2	1	-29	4.2
	max.	8.2	0.254	0.15	5	31	4	8.6
(2 samples)	*aver.*	8.0	0.171	0.11	3	16	-13	6.4
Sandstone, Siltstone,Mudstone	*min.*	6.5	0.085	0.03	1	0	-51	6.9
	max.	8.5	0.310	0.06	2	53	1	8.8
(8 samples)	*aver.*	7.8	0.186	0.04	1	17	-16	8.3
Siltstone, Mudstone	*min.*	7.0	0.139	0.03	1	4	-20	6.7
	max.	8.5	0.776	0.11	3	22	-3	8.5
(6 samples)	*aver.*	7.4	0.358	0.06	2	9	-7	7.3
Carb. Siltstone, Carb. Mudstone	*min.*	8.2	0.226	0.05	2	4	-47	7.0
	max.	8.6	0.332	0.14	4	52	-2	8.7
(2 samples)	*aver.*	8.4	0.279	0.10	3	28	-25	7.9
Carb. Claystone		6.9	0.596	0.11	3	7	-3	6.5
Sandstone,Carb. Mudstone		6.9	0.335	0.04	1	2	-1	7.3
Siltstone,Claystone		7.9	0.403	0.05	2	249	-247	10.8

* The median value is used for the average pH rather than the mean due to the pH being a log-scale.

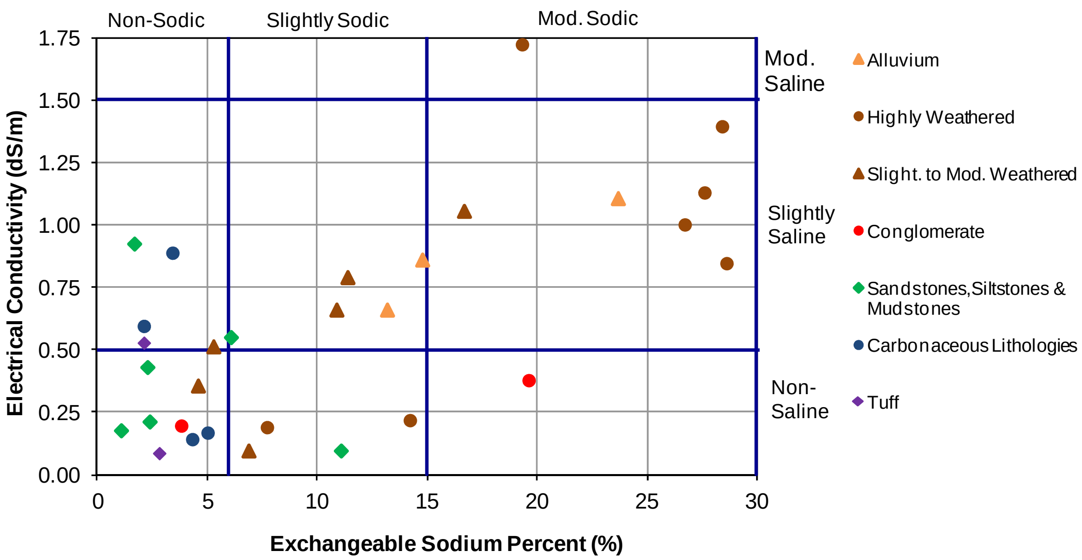


Figure 7: Salinity and sodicity ranking for the different overburden and interburden material types.

6.2 Acid Forming Characteristics

The acid forming characteristic test results for these samples are provided in Attachment B (Table B-1). The total S content of the overburden and interburden samples is typically relatively low ranging from 0.02 to 0.33 %S with an average of 0.06 %S. The majority of the samples (79%) have a total S content 0.1 %S. Nineteen samples were selected for sulfide S analysis. The sulfide S contents range from <0.005 to 0.107 %S and indicate that in all but one sample, the proportion of the total S that is present as reactive sulfide is relatively low, ranging from only 5 to 30%. One mixed lithology sample (sandstone, mudstone) has a total S content of 0.15 %S and, with a sulfide S content of 0.107 %S, 71% of the S occurs as reactive sulfide. These results indicate that the contained sulfur in the overburden and interburden is expected to occur predominantly in a non-reactive form such as sulfate or organic S.

The ANC of these materials is variable, generally ranging from 0 to 99 kg H_2SO_4/t with one mixed lithology sample (siltstone, claystone) having an anomalously high value of 249 kg H_2SO_4/t. The majority of the samples (65%) have a low ANC of 10 kg H_2SO_4/t. Figure 8 is an ABA plot for these samples where the total S content is plotted against the ANC. This plot shows that the majority of the samples (85%) are NAPP negative or zero.

The NAPP positive samples have relatively low values ranging from 1 to 6 kg H_2SO_4/t and when the NAPP is calculated using the sulfide S content the NAPP values are decreased to a range of minus 5 to 2 kg H_2SO_4/t with only one NAPP positive sample (GEM 27/16) identified.

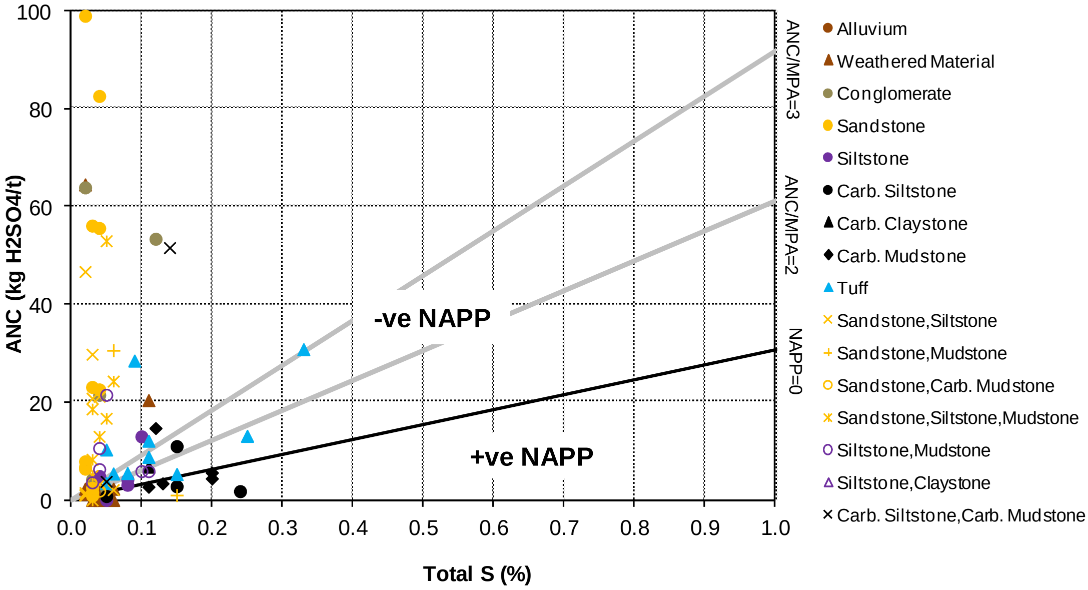


Figure 8: Acid-base account plot for the different overburden types.

Eight of the overburden and parting samples representing the range of material types and ANC values were selected for ABCC testing in order to evaluate the proportion of the ANC that is expected to be readily available to neutralise sulfide generated acidity. The plots for these curves are provided in Attachment C (Figure C-1 to C-8) and indicate that, for all of the selected samples, virtually all of the ANC is readily available. The mixed lithology sample GEM30/8 (siltstone, claystone) has a low total S content (0.05 %S) and a high ANC (249 kg H_2SO_4/t), all of which is expected to be readily available to neutralise any sulfide generated acidity. With a resulting NAPP of minus 247 kg H_2SO_4/t, this sample is classified as acid consuming (AC).

The NAGpH values from the single addition NAG tests range from 3.8 to 10.8 (Table 7). Four of the samples have a NAGpH < 4.5 and these are predominantly carbonaceous materials, including carbonaceous mudstone (GEM30/2 and GEM30/18), carbonaceous siltstone (GEM33/2) and the mixed lithology sandstone/mudstone (GEM27/16).

Figure 9 is a geochemical classification plot where the NAPP values are plotted against the NAGpH values for the different overburden types. The majority of the samples plot in the upper left quadrate with negative NAPP values and NAGpH values > 4.5, confirming that these samples are classified as NAF. The majority of the NAF samples have a low S content (< 0.1 %S) and low ANC (< 10 kg H_2SO_4/t), and are considered barren in terms of acid generation and neutralisation. However a number of samples plot in the upper right quadrate, being NAPP positive with NAGpH values > 4.5 and the classification of the samples is uncertain.

The four samples with NAGpH values < 4.5 are slightly NAPP positive indicating that these samples are PAF. However, when plotted using NAPP values calculated using the sulfide S content, as shown on Figure 10, the uncertain samples are confirmed to be NAF. Three of the PAF samples containing carbonaceous material become NAPP negative, and have an uncertain classification, while one mixed lithology sample sandstone/mudstone (GEM27/16) is confirmed PAF with a low capacity to generate acid (PAF/LC).

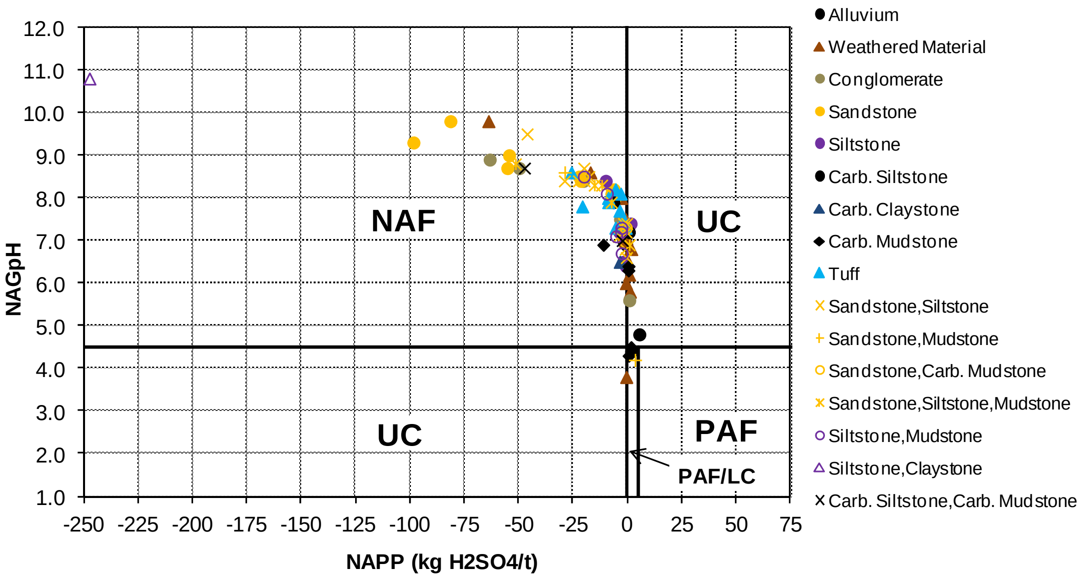


Figure 9: Geochemical classification plot for the different overburden types.

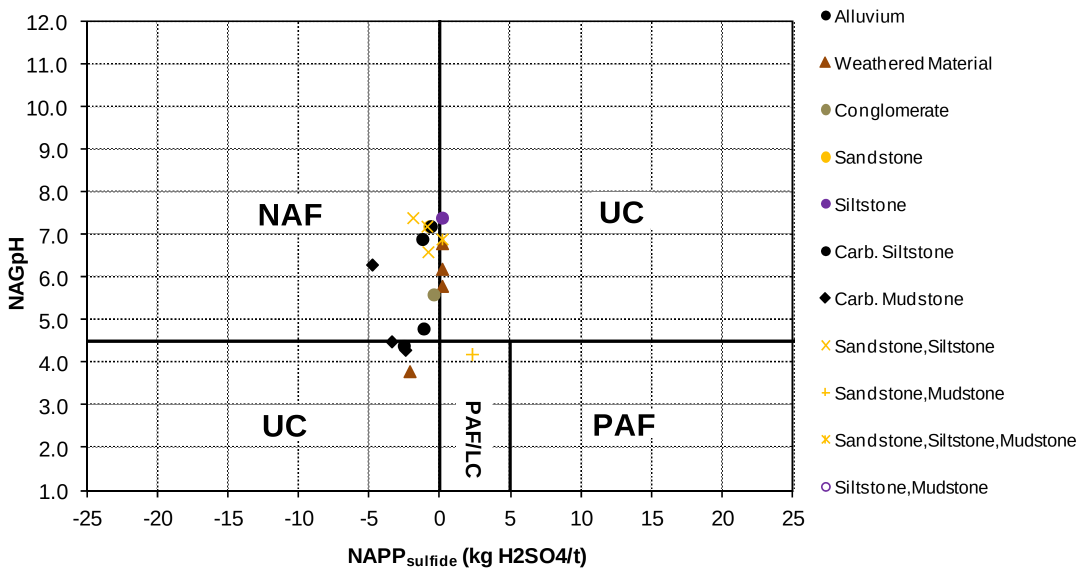


Figure 10: Geochemical classification plot for the different overburden types with the NAPP calculated using the sulfide-S content.

The samples with an uncertain geochemical classification contain carbonaceous material which has the potential to interfere with the NAG test reaction causing the premature breakdown of the hydrogen peroxide and resulting in an incomplete NAG reaction and a misleading low NAGpH result. Based on this it is expected that the low NAGpH values for these samples are attributed to the presence of carbonaceous material rather than acid generation through sulfide oxidation and therefore it is expected that these samples are NAF.

These results indicate that the overburden and interburden from the proposed pit extension areas is typically expected to be NAF and a significant proportion of this material is expected to be relatively barren with low sulfur (<0.1 %S) and ANC (< 10 kg H_2SO_4/t). One mixed lithology sample of siltstone/claystone (GEM30/8) was found to be acid consuming (AC) with a NAPP of minus 247 kg H_2SO_4/t and one mixed lithology sample of sandstone/mudstone (GEM27/16) was found to be PAF/LC. This sample is located at the floor of the G Seam (G1 Ply), consistent with the findings from the Wilpinjong Coal Project Geochemistry Assessment (EGi, 2005).

A kinetic NAG test was performed on the identified PAF/LC sample and the pH and temperature profile plot is provided in Attachment D (Figure D-1). This plot shows the pH and temperature of the sample during the NAG reaction. The time taken for the pH to decrease below 4.0 is used to indicate the geochemical lag period, the time taken for acid conditions to develop following exposure to oxidation, and the occurrence of a temperature peak is used to determine the expected time to peak reaction. These results indicate that the PAF/LC material is likely to only have low reactivity with an expected lag period of 6 to 12 months.

6.3 Metal Enrichment and Solubility

Eighteen of the overburden and interburden samples representing the range of fresh and weathered material types were selected for multi-element analyses. The results from these analyses and the geochemical abundances indices are provided in Attachment B (Tables B-4, B-5 and B-7). These results indicate that arsenic (As) and selenium (Se) are significantly enriched (i.e. GAI of 3) in some of the fresh samples, including in particular the carbonaceous materials and the mixed lithology samples, and that As is slightly to significantly enriched (GAI of 2 to 3) in all of the weathered samples.

Multi-element scans were performed on the water extracts from the fresh and weathered samples submitted for solids multi-element analyses in order to provide an indication of relative element solubility under the existing pH conditions of these materials.

The results from these scans are presented in Attachment B (Table B-6 and B-8). The pH values range from 6.0 to 8.8. For the fresh samples the EC values range from 0.108 to 0.922 dS/m and sulfate is the dominant anion with concentrations ranging from 22.3 to 458.4 mg/L, whereas for the weathered overburden samples the EC values range from 0.511 to 1.395 dS/m and the sulfate concentrations range from 183.3 to 436.1 mg/L. These results indicate that most of the contained metals are relatively insoluble under the prevailing quasi-neutral to slightly alkaline pH conditions. However, molybdenum (Mo) and Se were found to be readily soluble in all of the different fresh overburden and interburden material types, apart from the conglomerate and tuff samples. Lead (Pb) was also found to be highly soluble in one of the weathered gravel samples (GEM/W9). This is unexpected under the slightly alkaline pH of this sample (pH 8.1) and may be due to contamination from an external source.

The concentration ranges of Mo and Se are compared to ANZECC livestock drinking water quality guidelines (ANZECC, 2000) in Table 8 in order to provide an indication of the relative solubility of these elements. These results indicate that the dissolved Mo concentrations are below the guideline value for all but one of the samples and that the dissolved Se concentrations typically exceed the guideline value.

Table 8: Dissolved Mo and Se concentration ranges in the fresh overburden and interburden samples compared to the ANZECC (2000) livestock drinking water guideline values.

Element	**Concentration (µg/L)**		**Livestock Drinking Water Guideline**
	Minimum	**Maximum**	**(ANZECC, 2000)**
Mo	2.65	184.79	150 (µg/L)
Se	<0.5	159.5	20 (µg/L)

7.0 Coal Reject Geochemistry

The geochemical test results for the coal reject samples, including the $pH_{(1:2)}$ and $EC_{(1:2)}$, acid forming characteristics, and element enrichment and solubility, are provided in Attachment B and summaries of the $pH_{(1:2)}$ and $EC_{(1:2)}$, and acid forming characteristics of the coal reject samples from the different seams are provided on Table 9.

Table 9: Summary of the pH, EC, acid-base account and NAGpH test results for the coal reject samples from the Project.

Seam		*$pH_{1:2}$	$EC_{1:2}$	Total S	Sulfide S	ANC	NAPP	*NAGpH
			(dS/m)	(%S)		(kg H2SO4/t)		
Goulburn Seam^		6.7	0.286	0.97	0.824	6	24	2.8
Turill Seam^		7.1	0.143	0.44	0.336	13	0	4.0
Moolarben Member		7.1	0.214	0.17	0.14	9	-4	6.9
Ulan Seam	*min.*	3.3	0.292	0.22	0.098	0	-1	2.3
	max.	6.0	1.072	1.33	1.040	11	41	4.7
(7 samples)	*aver.*	5.2	0.510	0.53	0.389	6	10	3.8

* The median value is used for the average pH rather than the mean due to the pH being a log-scale.
^ These seams would not be mined as part of the Project (refer to Section 5.3.2).

7.1 pH and Salinity

The $pH_{1:2}$ and $EC_{1:2}$ results for the coal reject samples are provided in Attachment B (Table B-3). The $pH_{1:2}$ of the coal reject samples from the Goulburn, Turill and Moolarben seams range from 6.7 to 7.1 and the $EC_{1:2}$ values range from 0.143 to 0.286 dS/m indicating that these samples are all non-saline. However, the $pH_{1:2}$ of the Ulan Seam coal reject samples range from 3.3 to 6.0 and the $EC_{1:2}$ values range from 0.292 to 1.072 dS/m indicating that these samples range from non-saline to slightly saline.

7.2 Acid Forming Characteristics

The acid forming characteristics of the coal reject samples are provided in Attachment B (Table B-3). The total S contents vary widely, ranging from 0.17 to 1.33 %S. However, those for the Ulan Seam coal reject samples are generally moderate ranging from 0.22 to 0.61 %S with the exception of the G1 ply sample (WIL/G1) having a relatively high total S content of 1.33 %S. The Goulburn Seam (WIL/GLB) coal reject sample also has a relatively high total S content of 0.97 %S, while that for the M4 ply (WIL/M4) coal reject sample has a relatively low total S content of 0.17 %S.

The sulfide S analyses indicate that generally a high proportion of the contained S (74 to 85%) occurs as reactive sulfide. However, for the A12 ply (WIL/A12) and B1 ply (WIL/B1) coal reject samples only 48 and 45% of the contained S, respectively, occurs as reactive sulfide.

The ANC of these samples is generally low, ranging from zero to 13 kg H_2SO_4/t. Two coal reject samples representing the B1 and B3 plies (WIL/B1 and WIL/B3) were selected for ABCC testing in order to evaluate the proportion of the ANC that is expected to be readily available to neutralise sulfide generated acidity. The plots from these tests are provided in Attachment C (Figure C-9 and C-10) and indicate that, for the materials represented by these samples, less than 50% of the ANC is likely to be readily available to neutralise any sulfide generated acidity.

Figure 11 is the ABA plot for the coal reject samples from the different seams. This plot shows that all of the samples have an ANC/MPA ratio < 3 and that the majority of the samples are NAPP positive. The NAPP values for the Ulan Seam coal reject samples range from minus 1 to 41 kg H_2SO_4/t and, although the NAPP value for the Turill and Moolarben Member coal rejects is only zero and minus 4 kg H_2SO_4/t, it is significantly higher at 24 kg H_2SO_4/t for the Goulburn Seam coal reject sample.

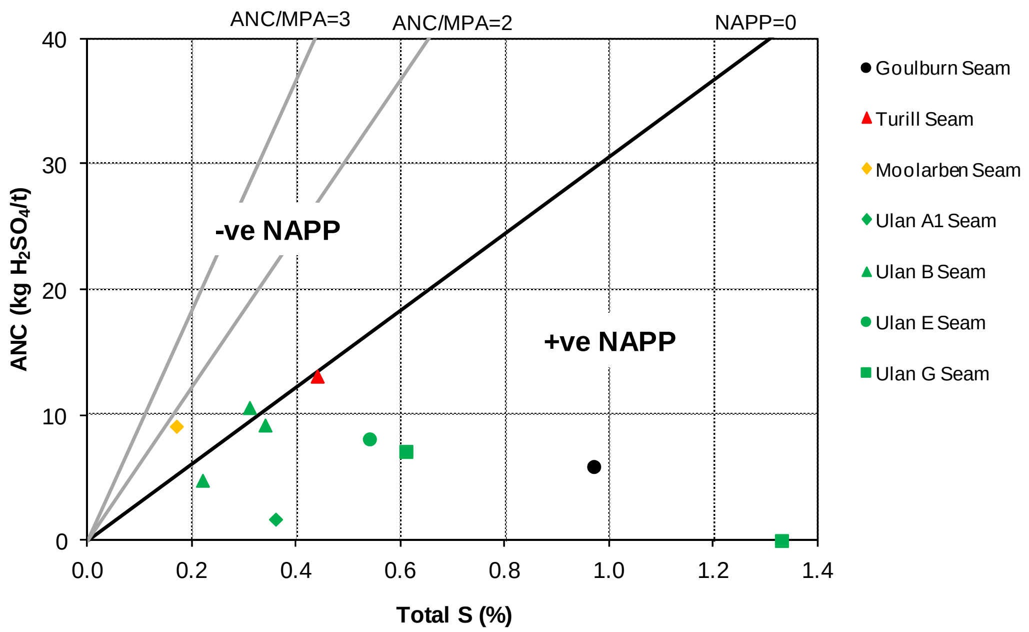


Figure 11: Acid-base account plot for coal rejects from the different seams.

The single addition NAG test results indicate that all but two of these samples have a NAGpH < 4.5. Figure 12 is the geochemical classification plot for these samples according to the different seams. This plot shows that all but two of the samples plot in the lower right quadrate, being NAPP positive with NAGpH values < 4.5, and are classified as PAF. Two coal reject samples representing the M4 ply (WIL/M4) and B2 ply (WIL/B2), plot in the upper left quadrate, being NAPP negative with NAGpH values > 4.5, and these samples are classified as NAF.

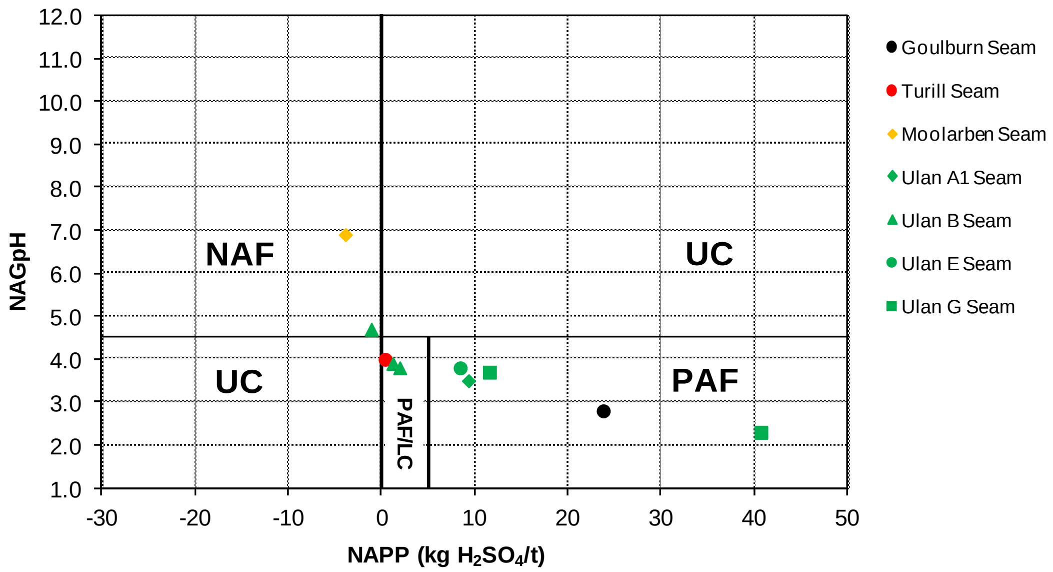


Figure 12: Geochemical classification plot for coal rejects from the different seams.

The NAPP of the PAF samples ranges from 0 to 41 kg H_2SO_4/t and the NAG capacities when titrated to pH 4.5 range from 1 to 37 kg H_2SO_4/t. These results and the expectation that less than 50% of the contained ANC will be available to neutralise the sulfide generated acidity, indicate that the materials represented by a number of these samples are likely to only have a low capacity to generate acid (i.e. < 10 kg H_2SO_4/t). Table 10 provides a summary of the geochemical classification and salinity ranking for the different seams and plies based on the presented test results.

Table 10: Geochemical classification and salinity ranking for coal rejects from the different Project seams and plies.

Seam/Ply		Geochemical Classification	Salinity Ranking
Goulburn Seam*		PAF	Non-Saline
Turill Seam*		PAF/LC	Non-Saline
Moolarben Member		NAF	Non-Saline
Ulan Seam	A1 Seam/A12 Ply	PAF	Non-Saline
	B Seam/B1 Ply	PAF/LC	Non-Saline
	B Seam/B2 Ply	NAF	Slightly Saline
	B Seam/B3 Ply	PAF/LC	Non-Saline
	E Seam/E12:E22 Ply	PAF/LC	Slightly Saline
	G Seam/G1 Ply	PAF	Slightly Saline
	G Seam/G1:G22 Ply	PAF	Non-Saline

* These seams would not be mined as part of the Project (refer to Section 5.3.2).

Kinetic NAG tests were performed on three of the coal reject samples, including the PAF/LC B1 ply (WIL/B1) coal reject sample and the PAF A12 ply (WIL/A12) and G1 to G22 ply (WIL/G) coal reject samples. The pH and temperature profile plots for these samples are provided in Attachment D (Figures D-3 to D-5). These results indicate that the PAF/LC B1 ply and the PAF A12 ply coal reject samples are moderately reactive and the coal rejects represented by these samples are likely to develop acid conditions if left exposed to oxidation for a period exceeding 2 to 4 months. The results for the PAF G1 to G22 ply coal reject sample indicate that it is highly reactive and the material represented by this sample is likely to develop acid conditions within weeks of exposure to oxidation.

7.3 Metal Enrichment and Solubility

Four of the coal reject samples were selected for multi-element analysis including the individual Goulburn, Turill and Moolarben Member coal reject samples and a composited sample of the Ulan Seam coal reject samples. The results of the scans and the geochemical abundance indices are provided in Attachment B (Table B-7). These results show that As is significantly enriched (i.e. GAI > 3) in the Goulburn and Turill coal reject seam samples, and that Se is significantly enriched in the Goulburn and Ulan seam samples.

The results of multi-element scans performed on the water extracts (1 part sample:2 parts deionised water) from these samples are presented in Attachment B (Table B-8). Similar to the overburden and interburden samples, and typical of coal deposits in the region, Mo and Se are found to be readily soluble in some of the coal reject samples. The dissolved Mo and Se concentrations are compared to the ANZECC livestock drinking water quality guidelines (ANZECC, 2000) in Table 11. These results indicate that the dissolved Mo concentrations are below the guideline value for all of the coal reject samples, and that the dissolved Se concentrations exceed the guideline value in the Goulburn, Moolarben and Ulan seam coal reject samples, but do not exceed it in the Turill seam coal reject sample.

Table 11: Dissolved Mo and Se concentrations in the coal reject samples compared to the ANZECC (2000) livestock drinking water guideline values.

Element	**Dissolved Concentration (µg/L)**				**Livestock Drinking Water Guideline (ANZECC, 2000)**
	Goulburn*	Turill*	Moolarben	Ulan	
Mo	22.21	25.62	83.59	1.02	150 (µg/L)
Se	60.5	14.1	37.2	26.2	20 (µg/L)

* These seams would not be mined as part of the Project (refer to Section 5.3.2).

8.0 Conclusions and Recommendations

This assessment has involved the geochemical characterisation of 92 overburden and interburden samples, including the coal seam partings, and 2 coal reject samples (from the Goulburn and Turill Seams) to identify any geochemical implications for waste rock management. An additional eight coal reject samples have been characterised to identify the geochemical implications for coarse reject and tailings management. The results and findings of this assessment are compared to those of the EGi (2005) geochemistry assessment prepared for the *Wilpinjong Coal Project Environmental Impact Statement* (WCPL, 2005) (Section 3.1.1) and the EGi (2006 and 2008) geochemistry assessments, prepared for the *Environmental Assessment for the Moolarben Coal Project Stage 1* and *Environmental Assessment for the Moolarben Coal Project Stage 2*, respectively (Section 3.1.2).

8.1 Waste Rock

EGi (2005) reported that the overburden and interburden materials from the Wilpinjong Coal Project were expected to be non-saline and, apart from a small quantity of PAF/LC (i.e. < 10 kg H_2SO_4/t) material occurring in the floor rock of the G Seam, the bulk of this material was expected to be NAF. EGi (2006, 2008) also reported that the overburden and interburden from the Moolarben Coal Complex was expected to be non-saline and the majority of these materials were expected to be NAF. However, a small quantity of PAF/LC material, restricted to carbonaceous materials occurring as roof or floor rock of the coal seams, was identified. The results of the current investigations for the Project are consistent with these investigations. The overburden and interburden, including the coal seam partings material, is typically expected to be non-saline and NAF with a significant proportion of this material being barren in terms of acid generation and neutralisation. However, a small quantity of PAF/LC material was confirmed to occur in the floor rock of the G Seam within the Project area.

Based on the geochemical characteristics of the coal reject samples, the coal from the Goulburn and Turill Seams is expected to be PAF or PAF/LC. These seams are both considered to be uneconomic to mine and therefore, where they occur in the Project pit extensions, would be excavated and disposed of with the waste rock.

A sodicity assessment was not conducted by EGi (2005). However, the sodicity assessment conducted for the geochemical assessment of the Moolarben Coal Complex Stage 1 (EGi, 2006) reported that the Quaternary/Tertiary alluvials and weathered Permian materials have a risk of being sodic. Consistent with EGi (2006) findings, the current investigations for the Project indicate that the fresh overburden and interburden is likely to be non-sodic and that some of the weathered and alluvial materials may be slightly to moderately sodic.

If these materials are exposed on the outer surface of any waste rock emplacements or engineered structures, they may become highly dispersive causing problems with increased erosion potential and stability concerns, and potentially impacting water quality due to increased Total Suspended Solids (TSS).

Recommendations

Based on these findings the following recommendations are provided for the overburden and interburden from the Project area:

- Because the bulk of the waste rock is expected to be NAF and barren in terms of acid generation and neutralisation, no selective handling would be required for geochemically secure disposal of this material within the backfilled mine voids or the elevated waste rock emplacement.
- Where encountered, the PAF and PAF/LC (i.e. < 10 kg H_2SO_4/t) materials identified within the Goulburn Seam, Turill Seam and floor rock of the G Seam, would need to be managed so that no zones of PAF or PAF/LC material are exposed near the surface of the backfilled mine voids or the elevated waste rock emplacement. The PAF and PAF/LC material would either need to be well blended with NAF or AC waste rock, producing an overall NAF material, or encapsulated with NAF waste rock.

  Due to the expected reactivity of the PAF coal seam material (i.e. Goulburn Seam and Turill Seam), this material would need to be managed as described above within a relatively short timeframe (i.e. 1 to 2 weeks) in order to minimise the potential for developing acid conditions prior to disposal.

  In order to ensure that the PAF or PAF/LC materials are not exposed to atmospheric oxidation, the outer 2 m of the backfilled mine voids or outer 5 m of the elevated waste rock emplacement should be restricted to NAF waste rock.
- If the PAF/LC material identified within the floor rock of the G Seam is exposed in the floor of any of the final voids, it would need to be either:
  - covered with NAF waste rock to a minimum depth of 5 m;
  - excavated and disposed as PAF/LC waste rock (see above); or
  - flooded with water from the site water management system.
- In order to reduce the risk of decreased stability and increased erosion potential for the waste rock emplacements and any engineered structures, potentially resulting in rehabilitation failure and water quality impacts (i.e. increased TSS), the weathered and alluvial materials, identified as potentially sodic, should be excluded from the surface of any engineered structures. If the sodic materials occur within any of the final waste rock emplacement surfaces they may require treatment with materials containing soluble calcium such as gypsum, calcium chloride or limestone, in order to promote successful rehabilitation.

- A testing program should be developed to confirm the waste rock scheduled to be placed within the final outer surface of the back-filled mine voids (i.e. outer 2 m) and the elevated waste rock emplacement (i.e. outer 5 m) is NAF. The testing program should be included in the Mining Operations Plan for the Project.

8.2 Coal Rejects

EGi (2005) reported that the coarse rejects from the Wilpinjong Coal Project were typically expected to be non-saline and PAF/LC and the tailings were expected to be saline and either PAF or PAF/LC. Similarly, the coal rejects (combined coarse reject and tailings) from the Moolarben Coal Complex Stage 1 and Stage 2 (EGi, 2006, 2008) were expected to be non-saline and PAF. The results of the current investigations conducted on the coal rejects from the different seams of the Project are generally consistent with those reported for the Wilpinjong Coal Project and Moolarben Coal Complex.

The coal rejects from the Moolarben Member (M4) are expected to be non-saline and NAF, and those from the Ulan Seam are expected to range from non-saline to slightly saline, and from PAF/LC to PAF. Due to the high specific gravity of the contained sulfides and the preferential segregation of the sulfides to the finer fraction, it is expected that the tailings produced from these coal rejects would have a higher acid potential compared to the coarse rejects, as was reported for the samples assessed by EGi (2005).

Kinetic NAG testing indicates that the coal rejects range from moderately reactive for the lower S material, which is expected to be PAF/LC with a geochemical lag period of 2 to 4 months, to highly reactive for the higher S material, which is expected to be PAF and likely to develop acid conditions within weeks of exposure to oxidation.

Recommendations
Based on these findings it is recommended that the current management strategies for the tailings and coarse rejects (Section 4.2) be adopted for the tailings and coarse rejects from the Project. This would involve the following:

- The coarse rejects would be deposited in the mined-out pit voids and may also be deposited within the elevated waste rock emplacement (Pit 2). The PAF coarse rejects (i.e. Ulan Seam coarse rejects) would need to be encapsulated with NAF waste rock in order to reduce the risk of developing acid conditions. In order to ensure that no PAF or PAF/LC materials are exposed on the final surfaces, the outer 2 m of the backfilled mine voids and outer 5 m of the elevated waste rock emplacement would need to be restricted to NAF waste rock.

- Due to the high reactivity and expected short geochemical lag period of the PAF tailings (i.e. Ulan Seam tailings), the tailings would need to be excluded from potential oxidation during disposal. This can be achieved by either:
  - maintaining the tailings in a saturated state with a water cover, or continually covering the deposited tailings with progressive tailings deposition on an approximate weekly cycle;
  - maintaining the tailings in a saturated state either under a static water cover or by the continual application of water to the surface of the tailings; or
  - application of alkali material (i.e. crushed limestone, agricultural lime) to the surface of the deposited tailings at an application rate adequate to extend the geochemical lag period for the expected duration of the exposure period.
- For the dewatered tailings from the tailings filter press, it is recommended that it be co-disposed with the coarse rejects and encapsulated with NAF waste rock within the back-filled mine voids or elevated waste rock emplacement, as recommended for the current PAF coarse reject material.
- For the temporary tailings holding cell (if constructed), it is recommended that the pH of the decant water be monitored and if acid generation is observed, alkali material (i.e. crushed limestone, agricultural lime) should be added to the surface of the tailings at an application rate adequate to neutralise the generated acid. The tailings should then be co-disposed with coarse rejects as described above.
- When samples of the coarse reject and tailings are available it is recommended that a testing program be undertaken to confirm the geochemical characteristics of these materials and the co-disposal material. The testing program should be included in the Mining Operations Plan for the Project.

8.3 Water Quality Monitoring Program

No testing to evaluate the element enrichment and/or solubility status of the overburden and interburden, and coal reject materials was conducted for the Wilpinjong Coal Project (EGi, 2005). However, the Stage 1 and 2 assessments for the Moolarben Coal Complex included element enrichment testing and no significant element enrichments were reported (EGi, 2006, 2008). In contrast, the current investigations indicate that As, Pb and Se are likely to be significantly enriched in some of the overburden and interburden materials and coal rejects from the Project and that Mo and Se are likely to be readily soluble in these materials.

Recommendations

Due to the identified element enrichments and solubilities in the overburden and interburden, and coal rejects, and the presence of PAF and/or sodic materials, it is recommended that the following parameters continue to be monitored for the surface water quality monitoring program:

- pH, EC, TSS, SO_4, Pb and Se.

It is also recommended that the following parameters be added to the existing surface water quality monitoring program on a routine (monthly) basis:

- total alkalinity/acidity, As and Mo.

The data generated should be periodically reviewed and it is recommended that this be carried out 12-monthly. The review should determine if exposure of sodic or PAF materials within the waste rock emplacements or pit walls is impacting water quality and should assess if the release of any soluble elements is adversely impacting the quality of water in the receiving environment. The recommended parameter list for this program should also be reviewed 12-monthly.

The potential surface water impacts associated with the Project are assessed and reported in the Surface Water Assessment (WRM Water and Environment, 2015).

9.0 References

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Attachment A

Geochemical Sample Details

Table A-1: Overburden and interburden drill-hole samples from the Wilpinjong Extension Project.

Sample ID	Drill-Hole	Sample Interval (m)			Weathering	Lithology
		from	to	interval		
GEM/W1	PW1125B	4.00	14.00	10.00	Highly Weath.	Alluvium
GEM/W3	PW1129A	1.00	2.00	1.00	Slightly Weath.	Clay
GEM/W4	PW1129A	2.00	3.00	1.00	Slightly Weath.	Alluvium
GEM/W5	PW1129A	3.00	4.00	1.00	Slightly Weath.	Sandstone
GEM/W7	PW1133	2.00	3.00	1.00	Highly Weath.	Sandstone
GEM/W8	PW1133	3.00	4.00	1.00	Mod. Weath.	Alluvium
GEM/W9	PW1134	4.00	6.00	2.00	Highly Weath.	Gravel
GEM/W12	PW1135	3.00	4.50	1.50	Highly Weath.	Claystone
GEM/W14	PW1136	3.00	6.00	3.00	Highly Weath.	Sand
GEM/W15	PW1136	8.00	17.00	9.00	Highly Weath.	Clay
GEM21/2	PW1121	4.30	4.55	0.25	Fresh	Sandstone, Carb. Mudstone
GEM21/3	PW1121	5.20	5.38	0.18	Fresh	Sandstone
GEM21/4	PW1121	6.82	7.00	0.18	Fresh	Conglomerate
GEM21/5	PW1121	10.37	10.56	0.19	Fresh	Sandstone, Siltstone, Mudstone
GEM21/6	PW1121	13.79	14.07	0.28	Fresh	Siltstone, Mudstone
GEM21/7	PW1121	23.88	24.08	0.20	Fresh	Carb. Mudstone
GEM21/8	PW1121	26.77	27.06	0.29	Fresh	Sandstone, Siltstone, Mudstone
GEM21/10	PW1121	28.62	28.87	0.25	Fresh	Sandstone, Mudstone
GEM21/11	PW1121	30.07	30.32	0.25	Fresh	Carb. Mudstone
GEM21/12	PW1121	32.29	32.52	0.23	Fresh	Tuff
GEM21/14	PW1121	44.26	44.40	0.14	Fresh	Tuff
GEM21/17	PW1121	45.88	46.08	0.20	Fresh	Sandstone, Siltstone
GEM21/18	PW1121	48.96	49.29	0.33	Fresh	Sandstone
GEM25/2	PW1125A	16.98	17.25	0.27	Slightly Weath.	Sandstone, Siltstone
GEM25/3	PW1125A	17.200	17.398	0.20	Slightly Weath.	Siltstone
GEM25/4	PW1125A	20.749	21.050	0.30	Fresh	Carb. Siltstone
GEM25/5	PW1125A	21.610	21.780	0.17	Fresh	Siltstone
GEM25/6	PW1125A	22.650	22.879	0.23	Fresh	Tuff
GEM25/7	PW1125A	27.759	27.900	0.14	Fresh	Tuff
GEM25/10	PW1125A	29.98	30.15	0.17	Fresh	Sandstone
GEM25/11	PW1125A	30.64	30.85	0.21	Fresh	Sandstone,Siltstone
GEM27/3	PW1127	12.57	16.97	4.40	Fresh	Sandstone
GEM27/6	PW1127	23.91	24.45	0.54	Fresh	Sandstone,Siltstone
GEM27/7	PW1127	29.09	33.56	4.47	Fresh	Sandstone, Siltstone, Mudstone
GEM27/8	PW1127	42.92	43.41	0.49	Fresh	Sandstone, Siltstone
GEM27/9	PW1127	48.93	49.95	1.02	Fresh	Siltstone, Mudstone
GEM27/16	PW1127	80.32	81.24	0.92	Fresh	Sandstone, Mudstone
GEM27/17	PW1127	83.14	86.35	3.21	Fresh	Conglomerate
GEM29/1	PW1129	3.280	4.519	1.24	Slightly Weath.	Sandstone
GEM29/2	PW1129	4.519	4.849	0.33	Highly Weath.	Sandstone
GEM29/3	PW1129	5.379	8.289	2.91	Fresh	Sandstone
GEM29/4	PW1129	14.379	15.580	1.20	Fresh	Carb. Siltstone, Carb. Mudstone
GEM29/6	PW1129	18.019	18.429	0.41	Fresh	Siltstone
GEM29/7	PW1129	18.429	21.079	2.65	Fresh	Sandstone, Siltstone, Mudstone
GEM29/8	PW1129	21.449	22.939	1.49	Fresh	Sandstone, Siltstone
GEM29/9	PW1129	22.939	26.969	4.03	Fresh	Sandstone
GEM29/10	PW1129	29.679	30.478	0.80	Fresh	Sandstone

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Table A-1: Overburden and interburden drill-hole samples from the Wilpinjong Extension Project. CONTINUED

Sample ID	Drill-Hole	Sample Interval (m)			Weathering	Lithology
		from	to	interval		
GEM29/11	PW1129	30.478	33.697	3.22	Fresh	Sandstone, Siltstone
GEM29/12	PW1129	48.487	48.897	0.41	Fresh	Sandstone, Siltstone, Mudstone
GEM29/15	PW1129	55.411	55.641	0.23	Fresh	Siltstone, Mudstone
GEM29/18	PW1129	59.360	59.900	0.54	Fresh	Carb. Siltstone, Carb. Mudstone
GEM29/20	PW1129	71.671	74.612	2.94	Fresh	Conglomerate
GEM30/1	PW1130	2.93	3.14	0.20	Slightly Weath.	Sandstone,Siltstone
GEM30/2	PW1130	3.50	3.57	0.07	Slightly Weath.	Carb. Mudstone
GEM30/3	PW1130	9.81	10.03	0.22	Fresh	Conglomerate
GEM30/4	PW1130	10.70	10.98	0.28	Fresh	Tuff
GEM30/5	PW1130	14.84	15.08	0.24	Fresh	Sandstone, Siltstone
GEM30/7	PW1130	20.02	20.18	0.16	Fresh	Sandstone, Siltstone, Mudstone
GEM30/8	PW1130	21.29	21.49	0.20	Fresh	Siltstone, Claystone
GEM30/9	PW1130	25.87	26.10	0.23	Fresh	Siltstone, Mudstone
GEM30/10	PW1130	26.34	26.52	0.18	Fresh	Carb. Mudstone
GEM30/11	PW1130	27.97	28.15	0.18	Fresh	Siltstone, Mudstone
GEM30/12	PW1130	32.42	32.65	0.23	Fresh	Tuff
GEM30/13	PW1130	33.13	33.33	0.20	Fresh	Siltstone, Mudstone
GEM30/14	PW1130	35.82	36.04	0.22	Fresh	Sandstone, Siltstone, Mudstone
GEM30/15	PW1130	36.22	36.41	0.19	Fresh	Carb. Mudstone
GEM30/18	PW1130	43.78	44.00	0.22	Fresh	Carb. Mudstone
GEM30/19	PW1130	45.34	45.61	0.27	Fresh	Conglomerate
GEM30/20	PW1130	46.51	46.77	0.26	Fresh	Sandstone
GEM30/23	PW1130	59.15	59.39	0.24	Fresh	Sandstone,Siltstone
GEM31/2	PW1131	0.97	1.14	0.17	Highly Weath.	Siltstone
GEM31/3	PW1131	2.31	2.51	0.20	Mod. Weath.	Sandstone, Siltstone
GEM31/6	PW1131	4.44	4.70	0.26	Highly Weath.	Carb. Mudstone
GEM31/9	PW1131	13.56	13.75	0.19	Fresh	Sandstone, Siltstone, Mudstone
GEM33/1	PW1133	21.230	23.341	2.111	Fresh	Sandstone
GEM33/2	PW1133	34.540	35.090	0.550	Fresh	Carb. Siltstone
GEM33/3	PW1133	35.090	45.279	10.189	Fresh	Sandstone, Siltstone
GEM33/4	PW1133	47.968	49.017	1.049	Fresh	Carb. Siltstone
GEM33/5	PW1133	54.908	55.491	0.583	Fresh	Siltstone
GEM33/8	PW1133	62.597	63.005	0.408	Fresh	Tuff
GEM33/9	PW1133	68.793	69.846	1.053	Fresh	Conglomerate
GEM34/1	PW1134	13.750	16.262	2.512	Fresh	Sandstone, Siltstone
GEM34/2	PW1134	17.547	18.421	0.874	Fresh	Siltstone
GEM34/3	PW1134	18.421	18.893	0.472	Fresh	Carb. Siltstone
GEM34/5	PW1134	26.115	26.485	0.370	Fresh	Tuff
GEM34/6	PW1134	29.240	32.117	2.877	Fresh	Sandstone
GEM35/2	PW1135	31.721	32.809	0.530	Fresh	Carb. Claystone
GEM35/3	PW1135	36.061	37.071	1.010	Fresh	Siltstone
GEM36/2	PW1136	30.829	33.809	2.980	Fresh	Sandstone
GEM36/3	PW1136	37.587	37.797	0.210	Fresh	Tuff
GEM36/4	PW1136	71.308	71.795	0.487	Fresh	Tuff
GEM36/5	PW1136	74.521	77.476	2.955	Fresh	Sandstone

Table A-2: Weathered material composite sample detail for the Wilpinjong Extension Project.

Drill-Hole	Sample Interval (m)			Sample ID	Weathering	Lithology
	from	to	interval			
PW1125B	5	6	1	GEM/W1	Extreme	Alluvium
	9	10	1			
	12	13	1			
PW1129A	1	2	1	GEM/W3	Slight	Clay
PW1129A	2	3	1	GEM/W4	Slight	Alluvium
PW1129A	3	4	1	GEM/W5	Slight	Sandstone
PW1133	2	3	1	GEM/W7	High	Sandstone
PW1133	3	4	1	GEM/W8	Moderate	Alluvium
PW1134	4	5	1	GEM/W9	Extreme	Gravel
	5	6	1			
PW1135	3	4	1	GEM/W12	Extreme	Claystone
PW1136	3	4	1	GEM/W14	Extreme	Sand
	4	5	1			
	5	6	1			
PW1136	8	9	1	GEM/W15	Extreme	Clay
	9	10	1			
	10	11	1			
	11	12	1			
	12	13	1			
	14	15	1			
	15	16	1			
	16	17	1			

Table A-3: Coal reject composite sample detail for the Wilpinjong Extension Project.

Seam		Ply	Drill-Hole ID	Interval ID (S1.8)	Sample ID
Goulburn		GLB1: GLB12: GLB	PW1127	48659-48661	WIL/GLB
		GLB2: GLB22: GLB	PW1127	48662-48663	
		GLB3: GLB4: GL	PW1127	48664-48665	
Turill		TUR1: TUR2: TUR	PW1127	48668-48670	WIL/TUR
		TUR1: TUR2	PW1135	050312-050314	
		TUR1: TUR2	PW1136	050364-050367	
Moolarben		M4	PW1121	44849	WIL/M4
		M4	PW1128	48435	
		M4	PW1129	48491	
		M4	PW1130	50049	
		M4	PW1135	50320	
Ulan	A1	A12	PW1121	44859	WIL/A12
		A12	PW1123	48539	
		A12	PW1130	50057	
Ulan	B	B1	PW1121	44867	WIL/B1
		B1	PW1122	48506	
		B1	PW1123	48549	
		B1	PW1127	48692-48693	
		B1	PW1130	50062	
		B1	PW1133	50248	
		B1	PW1134	50279	
		B1	PW1135	50334	
		B1	PW1136	50388	
Ulan	B	B2	PW1121	44868-44869	WIL/B2
		B2	PW1122	48507-48508	
		B2	PW1124	48576	
		B2	PW1127	48694	
		B2	PW1128	48449	
		B2	PW1129	50006-50008	
		B2	PW1130	50063	
		B2	PW1132	50124-50125	
		B2	PW1133	50249	
		B2	PW1135	050335-050336	
		B2	PW1136	050389-050390	
Ulan	B	B3	PW1121	44870	WIL/B3
		B3	PW1122	48509	
		B3	PW1128	48450	
		B3	PW1129	50009	
		B3	PW1130	50064	
		B3	PW1132	50126	
		B3	PW1133	50250	
		B3	PW1134	50283-50284	
		B3	PW1136	50391	

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Table A-3: Coal reject composite sample detail for the Wilpinjong Extension Project. CONTINUED

Seam		Ply	Drill-Hole ID	Interval ID (S1.8)	Sample ID
Ulan	E	E12: E22	PW1121	44885-44887	WIL/E
		E12: E22	PW1122	48524-48526	
		E12: E22	PW1123	48563-48565	
		E12: E22	PW1124	48588-48590	
		E12: E22	PW1125A	48618-48620	
		E12: E22	PW1126	48645-48647	
		E12: E22	PW1127	48410-48412	
		E12: E22	PW1128	48465-48467	
		E12: E22	PW1129	50024-50025	
		E12: E22	PW1130	50079-50081	
		E12: E22	PW1132	50137-50139	
		E12: E22	PW1133	050264-050266	
		E12: E22	PW1134	50299-50300	
		E12: E22	PW1135	050352-050354	
		E12: E22	PW1136	050404-050406	
Ulan	G	G1	PW1123	48571-48572	WIL/G1
		G1	PW1125A	48625-48626	
		G1	PW1127	48418-48420	
		G1	PW1136	050412-050413	
Ulan	G	G1: G22	PW1126	48653-48656	WIL/G
		G1: G22	PW1128	48474-48477	
		G1: G22	PW1129	50032-50034	
		G1: G22	PW1130	50087-50090	
		G1: G22	PW1131	50108-50111	
		G1: G22	PW1132	50145-50149	
		G1: G22	PW1133	050272-050275	
		G1: G22	PW1134	50307-50309	

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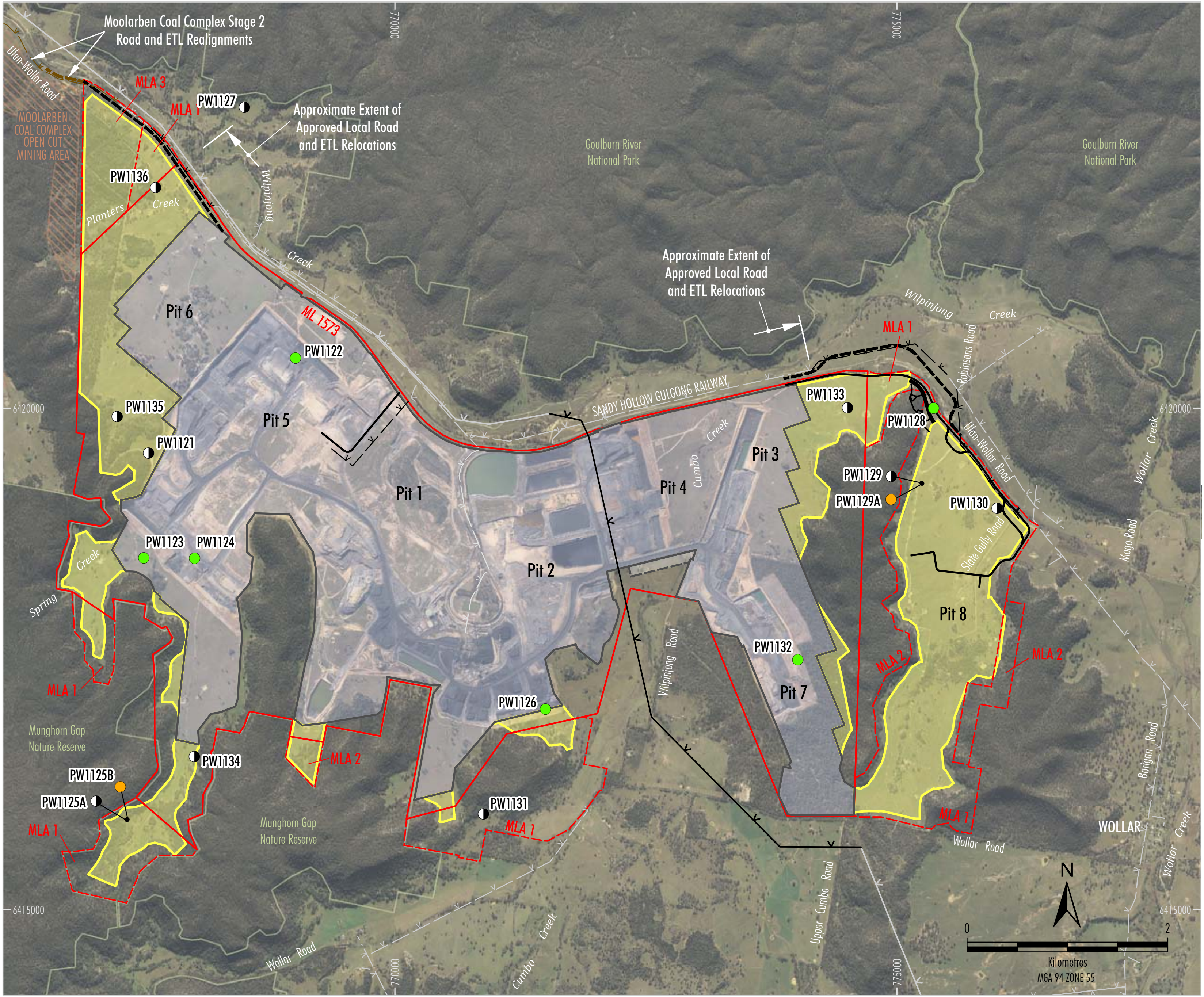

LEGEND

- Mining Lease Boundary
- Mining Lease Application Boundary
- Approved/Existing Open Cut and Contained Infrastructure Area
- Relocated Block Bank and Cumbo Creek Disturbance Area
- Proposed Open Cut Extension Area
- Proposed Public Road Realignment
- Proposed Pit 3/8 Haul Road
- Proposed Service Road
- Proposed Local ETL Realignment/Relocation
- Proposed Relocated TransGrid 330 kV ETL
- Existing Local ETL
- Existing TransGrid 330 kV ETL

Geochemical Assessment Program

- Overburden Sampling Drill-hole
- Coal Reject Sampling Drill-hole
- Coal Reject and Overburden Sampling Drill-hole

Peabody ENERGY

WILPINJONG EXTENSION PROJECT

Drill-hole Locations for the Geochemical Assessment Program

Figure A-1

WIL-12-12_WEP_EIS_Geochem_203E

Attachment B

Geochemical Test Results

Table B-1: Acid forming characteristics of overburden and interburden samples from the Wilpinjong Extension Project.

Sample ID	Drill-Hole ID	Depth (m) from	Depth (m) to	Depth (m) inter.	Lithology	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	Sulfide %S	MPA	ANC	NAPP (tot S)	NAPP (sulfide)	ANC/ MPA	NAG TEST NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Geochem. Class.
GEM/W1	PW1125B	4.00	14.00	10.00	Alluvium (HW)	7.4	0.658	0.03		1	2	-1		1.7	7.1	0	0	NAF
GEM/W3	PW1129A	1.00	2.00	1.00	Clay (SW)	7.9	1.053	0.04		1	2	-1		1.8	7.0	0	0	NAF
GEM/W4	PW1129A	2.00	3.00	1.00	Alluvium (SW)	7.6	0.858	0.03		1	3	-2		2.9	7.0	0	0	NAF
GEM/W5	PW1129A	3.00	4.00	1.00	Sandstone (SW)	7.4	0.788	0.03		1	3	-2		3.1	7.2	0	0	NAF
GEM/W7	PW1133	2.00	3.00	1.00	Sandstone (HW)	8.7	1.002	0.04		1	3	-2		2.4	7.1	0	0	NAF
GEM/W8	PW1133	3.00	4.00	1.00	Alluvium (MW)	8.2	1.104	0.03	<0.005	1	1	0	-1	1.5	6.9	0	0	NAF
GEM/W9	PW1134	4.00	6.00	2.00	Gravel (HW)	8.1	1.395	0.04		1	2	-1		1.6	7.1	0	0	NAF
GEM/W12	PW1135	3.00	4.50	1.50	Claystone (HW)	5.1	1.723	0.06	<0.005	2	0	2	0	0.0	6.8	0	0	UC(NAF)
GEM/W14	PW1136	3.00	6.00	3.00	Sand (HW)	6.9	0.847	0.03	<0.005	1	0	1	0	0.0	6.2	0	1	UC(NAF)
GEM/W15	PW1136	8.00	17.00	9.00	Clay (HW)	6.0	1.130	0.04	<0.005	1	0	1	0	0.0	5.8	0	1	UC(NAF)
GEM21/2	PW1121	4.30	4.55	0.25	Sandstone,Carb. Mudstone	6.9	0.335	0.04		1	2	-1		1.6	7.3	0	0	NAF
GEM21/3	PW1121	5.20	5.38	0.18	Sandstone	8.6	0.305	0.02		1	99	-98		161.8	9.3	0	0	NAF
GEM21/4	PW1121	6.82	7.00	0.18	Conglomerate	8.8	0.253	0.02		1	64	-63		104.4	8.9	0	0	NAF
GEM21/5	PW1121	10.37	10.56	0.19	Sandstone,Siltstone,Mudstone	7.6	0.231	0.03		1	8	-7		9.0	7.9	0	0	NAF
GEM21/6	PW1121	13.79	14.07	0.28	Siltstone,Mudstone	7.1	0.234	0.04		1	11	-9		8.7	8.1	0	0	NAF
GEM21/7	PW1121	23.88	24.08	0.20	Carb. Mudstone	6.2	0.477	0.13		4	3	1		0.9	6.4	0	1	UC(NAF)
GEM21/8	PW1121	26.77	27.06	0.29	Sandstone,Siltstone,Mudstone	6.8	0.192	0.05		2	17	-15		10.9	8.3	0	0	NAF
GEM21/10	PW1121	28.62	28.87	0.25	Sandstone,Mudstone	7.7	0.254	0.06		2	31	-29		16.7	8.6	0	0	NAF
GEM21/11	PW1121	30.07	30.32	0.25	Carb. Mudstone	6.5	0.556	0.20	0.032	6	4	2	-3	0.7	4.5	0	8	UC(NAF)
GEM21/12	PW1121	32.29	32.52	0.23	Tuff	7.1	0.205	0.09		3	29	-26		10.3	8.6	0	0	NAF
GEM21/14	PW1121	44.26	44.40	0.14	Tuff	6.9	0.087	0.15		5	5	-1		1.2	7.3	0	0	NAF
GEM21/17	PW1121	45.88	46.08	0.20	Sandstone,Siltstone	7.3	0.078	0.06	0.006	2	2	0	-2	1.1	7.4	0	0	NAF
GEM21/18	PW1121	48.96	49.29	0.33	Sandstone	7.3	0.190	0.03		1	3	-2		2.7	7.2	0	0	NAF
GEM25/2	PW1125A	16.98	17.25	0.27	Sandstone,Siltstone (SW)	6.7	0.354	0.02		1	2	-2		3.8	7.4	0	0	NAF
GEM25/3	PW1125A	17.20	17.40	0.20	Siltstone (SW)	7.6	0.511	0.03		1	4	-3		4.0	8.0	0	0	NAF
GEM25/4	PW1125A	20.75	21.05	0.30	Carb. Siltstone	6.4	0.154	0.05	<0.005	2	1	1	-1	0.5	7.2	0	0	UC(NAF)
GEM25/5	PW1125A	21.61	21.78	0.17	Siltstone	6.5	0.094	0.05	<0.005	2	0	2	0	0.0	7.4	0	0	UC(NAF)
GEM25/6	PW1125A	22.65	22.88	0.23	Tuff	6.5	0.203	0.05		2	4	-2		2.3	7.5	0	0	NAF
GEM25/7	PW1125A	27.76	27.90	0.14	Tuff	5.5	0.429	0.08		2	6	-3		2.2	8.1	0	0	NAF
GEM25/10	PW1125A	29.98	30.15	0.17	Sandstone	6.8	0.139	0.03		1	2	-1		1.7	7.3	0	0	NAF
GEM25/11	PW1125A	30.64	30.85	0.21	Sandstone,Siltstone	6.6	0.126	0.02	0.006	1	1	0	-1	1.8	7.2	0	0	NAF

KEY

$pH_{1:2}$ = pH of 1:2 extract

$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)

MPA = Maximum Potential Acidity (kgH_2SO_4/t)

ANC = Acid Neutralising Capacity (kgH_2SO_4/t)

NAPP = Net Acid Producing Potential (kgH2SO4/t)

NAGpH = pH of NAG liquor

$NAG_{pH4.5}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)

$NAG_{pH7.0}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

Weathering Key

HW = Highly Weathered

MW = Moderately Weathered

SW = Slightly Weathered

ARD Classification Key

AC = Acid Consuming

NAF = Non-Acid Forming

PAF/LC = Potentially Acid Forming/Low Capacity

UC = Uncertain (expected classification)

Table B-1: Acid forming characteristics of overburden and interburden samples from the Wilpinjong Extension Project. CONTINUED

Sample ID	Drill-Hole ID	Depth (m)			Lithology	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS							NAG TEST			Geochem. Class.
		from	to	inter.				Total %S	Sulfide %S	MPA	ANC	NAPP (tot S)	NAPP (sulfide)	ANC/ MPA	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	
GEM27/3	PW1127	12.57	16.97	4.40	Sandstone	7.6	0.262	0.03		1	23	-22		25.2	8.5	0	0	NAF
GEM27/6	PW1127	23.91	24.45	0.54	Sandstone,Siltstone	6.6	0.186	0.02		1	2	-1		2.5	6.8	0	1	NAF
GEM27/7	PW1127	29.09	33.56	4.47	Sandstone,Siltstone,Mudstone	7.8	0.108	0.04		1	13	-12		10.6	8.3	0	0	NAF
GEM27/8	PW1127	42.92	43.41	0.49	Sandstone,Siltstone	7.2	0.081	0.02	<0.005	1	1	0	-1	1.6	6.6	0	1	NAF
GEM27/9	PW1127	48.93	49.95	1.02	Siltstone,Mudstone	7.0	0.428	0.10		3	6	-3		1.9	7.2	0	0	NAF
GEM27/16	PW1127	80.32	81.24	0.92	Sandstone,Mudstone	8.2	0.087	0.15	0.107	5	1	4	2	0.2	4.2	1	4	PAF/LC
GEM27/17	PW1127	83.14	86.35	3.21	Conglomerate	8.1	0.272	0.03		1	4	-3		4.6	7.5	0	0	NAF
GEM29/1	PW1129	3.28	4.52	1.24	Sandstone (SW)	7.7	0.585	0.02		1	1	-1		2.0	6.0	0	2	NAF
GEM29/2	PW1129	4.52	4.85	0.33	Sandstone (HW)	8.5	0.648	0.02		1	65	-64		105.4	9.8	0	0	NAF
GEM29/3	PW1129	5.38	8.29	2.91	Sandstone	8.7	0.548	0.03		1	56	-55		61.1	8.7	0	0	NAF
GEM29/4	PW1129	14.38	15.58	1.20	Carb. Siltstone,Carb. Mudstone	8.2	0.332	0.05		2	4	-2		2.5	7.0	0	0	NAF
GEM29/6	PW1129	18.02	18.43	0.41	Siltstone	8.1	0.241	0.04		1	5	-4		4.0	7.2	0	0	NAF
GEM29/7	PW1129	18.43	21.08	2.65	Sandstone,Siltstone,Mudstone	8.2	0.132	0.06		2	24	-22		13.2	8.4	0	0	NAF
GEM29/8	PW1129	21.45	22.94	1.49	Sandstone,Siltstone	8.4	0.278	0.03		1	30	-29		32.5	8.4	0	0	NAF
GEM29/9	PW1129	22.94	26.97	4.03	Sandstone	8.1	0.275	0.02		1	8	-7		12.9	8.1	0	0	NAF
GEM29/10	PW1129	29.68	30.48	0.80	Sandstone	8.2	0.188	0.02		1	6	-6		10.5	8.0	0	0	NAF
GEM29/11	PW1129	30.48	33.70	3.22	Sandstone,Siltstone	7.8	0.251	0.04		1	3	-2		2.6	7.3	0	0	NAF
GEM29/12	PW1129	48.49	48.90	0.41	Sandstone,Siltstone,Mudstone	8.5	0.310	0.05		2	53	-51		34.6	8.8	0	0	NAF
GEM29/15	PW1129	55.41	55.64	0.23	Siltstone,Mudstone	8.5	0.139	0.03		1	4	-3		3.9	7.3	0	0	NAF
GEM29/18	PW1129	59.36	59.90	0.54	Carb. Siltstone,Carb. Mudstone	8.6	0.226	0.14		4	52	-47		12.0	8.7	0	0	NAF
GEM29/20	PW1129	71.67	74.61	2.94	Conglomerate	8.7	0.197	0.12		4	53	-50		14.5	8.7	0	0	NAF
GEM30/1	PW1130	2.93	3.14	0.20	Sandstone,Siltstone (SW)	7.8	0.072	0.04		1	2	-1		1.6	7.5	0	0	NAF
GEM30/2	PW1130	3.50	3.57	0.07	Carb. Mudstone (SW)	7.7	0.094	0.06	<0.005	2	2	0	-2	1.3	3.8	3	13	UC(NAF)
GEM30/3	PW1130	9.81	10.03	0.22	Conglomerate	8.7	0.243	0.04		1	22	-20		17.6	8.4	0	0	NAF
GEM30/4	PW1130	10.70	10.98	0.28	Tuff	8.3	0.204	0.33		10	31	-21		3.1	7.8	0	0	NAF
GEM30/5	PW1130	14.84	15.08	0.24	Sandstone,Siltstone	8.1	0.207	0.02		1	47	-46		76.3	9.5	0	0	NAF
GEM30/7	PW1130	20.02	20.18	0.16	Sandstone,Siltstone,Mudstone	7.7	0.265	0.03		1	19	-18		20.3	8.5	0	0	NAF
GEM30/8	PW1130	21.29	21.49	0.20	Siltstone,Claystone	7.9	0.403	0.05		2	249	-247		162.7	10.8	0	0	AC
GEM30/9	PW1130	25.87	26.10	0.23	Siltstone,Mudstone	7.2	0.776	0.11		3	6	-3		1.8	6.7	0	1	NAF
GEM30/10	PW1130	26.34	26.52	0.18	Carb. Mudstone	6.2	0.889	0.20	0.026	6	6	1	-5	0.9	6.3	0	1	UC(NAF)
GEM30/11	PW1130	27.97	28.15	0.18	Siltstone,Mudstone	7.9	0.221	0.04		1	6	-5		5.1	7.1	0	0	NAF

KEY

$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)
NAPP = Net Acid Producing Potential (kgH2SO4/t)
NAGpH = pH of NAG liquor
$NAG_{pH4.5}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{pH7.0}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

Weathering Key

HW = Highly Weathered
MW = Moderately Weathered
SW = Slightly Weathered

ARD Classification Key

AC = Acid Consuming
NAF = Non-Acid Forming
PAF/LC = Potentially Acid Forming/Low Capacity
UC = Uncertain (expected classification)

Table B-1: Acid forming characteristics of overburden and interburden samples from the Wilpinjong Extension Project. CONTINUED

Sample ID	Drill-Hole ID	Depth (m)			Lithology	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS							NAG TEST			Geochem. Class.
		from	to	inter.				Total %S	Sulfide %S	MPA	ANC	NAPP (tot S)	NAPP (sulfide)	ANC/ MPA	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	
GEM30/12	PW1130	32.42	32.65	0.23	Tuff	7.8	0.331	0.05		2	10	-9		6.7	8.0	0	0	NAF
GEM30/13	PW1130	33.13	33.33	0.20	Siltstone,Mudstone	7.5	0.352	0.05		2	22	-20		14.1	8.5	0	0	NAF
GEM30/14	PW1130	35.82	36.04	0.22	Sandstone,Siltstone,Mudstone	8.2	0.168	0.03		1	5	-4		5.4	7.1	0	0	NAF
GEM30/15	PW1130	36.22	36.41	0.19	Carb. Mudstone	7.2	0.620	0.12		4	15	-11		4.0	6.9	0	0	NAF
GEM30/18	PW1130	43.78	44.00	0.22	Carb. Mudstone	7.6	0.143	0.11	0.008	3	3	1	-2	0.8	4.3	1	14	UC(NAF)
GEM30/19	PW1130	45.34	45.61	0.27	Conglomerate	7.6	0.120	0.05	<0.005	2	1	1	0	0.4	5.6	0	1	UC(NAF)
GEM30/20	PW1130	46.51	46.77	0.26	Sandstone	9.0	0.175	0.04		1	56	-54		45.4	9.0	0	0	NAF
GEM30/23	PW1130	59.15	59.39	0.24	Sandstone,Siltstone	8.9	0.222	0.03		1	3	-2		2.8	7.4	0	0	NAF
GEM31/2	PW1131	0.97	1.14	0.17	Siltstone (HW)	6.3	0.191	0.02		1	1	-1		2.0	6.6	0	1	NAF
GEM31/3	PW1131	2.31	2.51	0.20	Sandstone,Siltstone (MW)	6.4	0.658	0.11		3	20	-17		6.1	8.6	0	0	NAF
GEM31/6	PW1131	4.44	4.70	0.26	Carb. Mudstone (HW)	6.8	0.219	0.03		1	2	-1		1.7	7.3	0	0	NAF
GEM31/9	PW1131	13.56	13.75	0.19	Sandstone,Siltstone,Mudstone	6.5	0.085	0.03	<0.005	1	0	1	0	0.0	6.9	0	0	UC(NAF)
GEM33/1	PW1133	21.23	23.34	2.11	Sandstone	6.6	0.307	0.03	0.005	1	1	0	-1	1.0	7.2	0	0	NAF
GEM33/2	PW1133	34.54	35.09	0.55	Carb. Siltstone	7.6	0.186	0.15	0.008	5	3	2	-3	0.6	4.4	1	11	UC(NAF)
GEM33/3	PW1133	35.09	45.28	10.19	Sandstone,Siltstone	8.2	0.339	0.04		1	21	-20		17.3	8.7	0	0	NAF
GEM33/4	PW1133	47.97	49.02	1.05	Carb. Siltstone	7.9	0.197	0.24	0.021	7	2	6	-1	0.2	4.8	0	4	UC(NAF)
GEM33/5	PW1133	54.91	55.49	0.58	Siltstone	5.9	0.772	0.08		2	3	-1		1.3	6.4	0	1	NAF
GEM33/8	PW1133	62.60	63.01	0.41	Tuff	7.2	0.174	0.25		8	13	-5		1.7	8.2	0	0	NAF
GEM33/9	PW1133	68.79	69.85	1.05	Conglomerate	8.3	0.379	0.05		2	2	-1		1.4	7.4	0	0	NAF
GEM34/1	PW1134	13.75	16.26	2.51	Sandstone,Siltstone	8.4	0.210	0.03		1	21	-20		22.7	8.4	0	0	NAF
GEM34/2	PW1134	17.55	18.42	0.87	Siltstone	7.8	0.244	0.08		2	4	-2		1.7	6.5	0	1	NAF
GEM34/3	PW1134	18.42	18.89	0.47	Carb. Siltstone	7.8	0.169	0.15		5	11	-6		2.4	7.9	0	8	NAF
GEM34/5	PW1134	26.12	26.49	0.37	Tuff	7.8	0.094	0.11		3	9	-5		2.6	7.3	0	0	NAF
GEM34/6	PW1134	29.24	32.12	2.88	Sandstone	8.8	0.263	0.04		1	83	-81		67.5	9.8	0	0	NAF
GEM35/2	PW1135	31.72	32.81	0.53	Carb. Claystone	6.9	0.596	0.11		3	7	-3		2.0	6.5	0	1	NAF
GEM35/3	PW1135	36.06	37.07	1.01	Siltstone	7.5	0.922	0.10		3	13	-10		4.2	8.4	0	0	NAF
GEM36/2	PW1136	30.83	33.81	2.98	Sandstone	7.5	0.178	0.02		1	7	-6		11.1	8.2	0	0	NAF
GEM36/3	PW1136	37.59	37.80	0.21	Tuff	5.4	0.529	0.06		2	5	-4		2.9	7.7	0	0	NAF
GEM36/4	PW1136	71.31	71.80	0.49	Tuff	7.9	0.134	0.11		3	12	-9		3.6	7.9	0	0	NAF
GEM36/5	PW1136	74.52	77.48	2.96	Sandstone	8.5	0.201	0.04		1	23	-21		18.5	8.4	0	0	NAF

KEY

$pH_{1:2}$ = pH of 1:2 extract

$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)

MPA = Maximum Potential Acidity (kgH_2SO_4/t)

ANC = Acid Neutralising Capacity (kgH_2SO_4/t)

NAPP = Net Acid Producing Potential (kgH2SO4/t)

NAGpH = pH of NAG liquor

$NAG_{pH4.5}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)

$NAG_{pH7.0}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

Weathering Key

HW = Highly Weathered

MW = Moderately Weathered

SW = Slightly Weathered

ARD Classification Key

AC = Acid Consuming

NAF = Non-Acid Forming

PAF/LC = Potentially Acid Forming/Low Capacity

UC = Uncertain (expected classification)

Table B-2: pH and EC, exchangeable cations and exchangeable sodium percent for selected overburden and interburden samples from the Wilpinjong Extension Project.

Sample ID	Material Type	Weathering	$pH_{1:2}$	$EC_{1:2}$	Exch. Cations (meq/100g)				ESP
					Ca	Mg	K	Na	
GEM/W1	Alluvium	Highly Weathered	7.4	0.658	3.0	4.0	0.6	1.2	13.2
GEM/W3	Clay	Slightly Weathered	7.9	1.053	2.7	5.9	1.0	1.9	16.7
GEM/W4	Alluvium	Slightly Weathered	7.6	0.858	2.2	5.0	1.1	1.4	14.8
GEM/W5	Sandstone	Slightly Weathered	7.4	0.788	1.7	3.6	1.2	0.8	11.4
GEM/W7	Sandstone	Highly Weathered	8.7	1.002	0.9	4.6	1.0	2.4	26.7
GEM/W8	Alluvium	Mod. Weathered	8.2	1.104	0.9	5.0	1.1	2.2	23.7
GEM/W9	Gravel	Highly Weathered	8.1	1.395	0.7	5.6	0.7	2.8	28.4
GEM/W12	Claystone	Highly Weathered	5.1	1.723	1.0	7.5	1.0	2.3	19.3
GEM/W14	Sand	Highly Weathered	6.9	0.847	0.8	2.2	0.1	1.3	28.6
GEM/W15	Clay	Highly Weathered	6.0	1.130	1.1	3.7	0.2	1.9	27.6
GEM21/14	Tuff	Fresh	6.9	0.087	2.7	2.0	0.6	0.2	2.8
GEM25/2	Sandstone,Siltstone	Slightly Weathered	6.7	0.354	2.3	6.5	1.0	0.5	4.6
GEM25/3	Siltstone	Slightly Weathered	7.6	0.511	3.4	9.9	1.0	0.8	5.3
GEM25/5	Siltstone	Fresh	6.5	0.094	0.5	1.9	0.6	0.4	11.1
GEM27/9	Siltstone,Mudstone	Fresh	7.0	0.428	4.3	2.5	1.2	0.2	2.3
GEM29/3	Sandstone	Fresh	8.7	0.548	6.0	6.3	1.1	0.9	6.1
GEM29/20	Conglomerate	Fresh	8.7	0.197	6.3	4.1	0.5	0.4	3.8
GEM30/2	Carb. Mudstone	Slightly Weathered	7.7	0.094	1.8	4.8	1.5	0.6	6.9
GEM30/10	Carb. Mudstone	Fresh	6.2	0.889	4.8	4.2	1.6	0.4	3.4
GEM30/18	Carb. Mudstone	Fresh	7.6	0.143	2.9	2.6	1.0	0.3	4.3
GEM30/20	Sandstone	Fresh	9.0	0.175	7.9	4.4	0.6	0.1	1.1
GEM31/2	Siltstone	Highly Weathered	6.3	0.191	0.8	10.3	1.6	1.0	7.7
GEM31/3	Sandstone,Siltstone	Mod. Weathered	6.4	0.658	0.2	62.6	2.1	7.9	10.9
GEM31/6	Carb. Mudstone	Highly Weathered	6.8	0.219	<0.1	12.1	1.3	2.2	14.2
GEM33/9	Conglomerate	Fresh	8.3	0.379	1.2	0.8	0.3	0.6	19.6
GEM34/1	Sandstone,Siltstone	Fresh	8.4	0.210	4.3	5.6	1.1	0.3	2.4
GEM34/3	Carb. Siltstone	Fresh	7.8	0.169	1.2	3.1	0.7	0.3	5.0
GEM35/2	Carb. Claystone	Fresh	6.9	0.596	4.3	2.7	1.4	0.2	2.1
GEM35/3	Siltstone	Fresh	7.5	0.922	5.0	3.4	1.5	0.2	1.7
GEM36/3	Tuff	Fresh	5.4	0.529	2.6	1.7	0.6	0.1	2.1

KEY

$pH_{1:2}$ = pH of 1:2 extract

$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)

CEC = Cation Exchange Capacity (meq/100g)

ESP = Exchangeable Sodium Percent (%)

Table B-3: Acid forming characteristics of coal reject samples from the Wilpinjong Extension Project.

Sample ID	Seam/Ply		$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS							NAG TEST			Geochem. Class.
					Total %S	Sulfide %S	MPA	ANC	NAPP (tot S)	NAPP (sulfide)	ANC/ MPA	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	
WIL/GLB	Goulburn Seam		6.7	0.286	0.97	0.824	30	6	24	19	0.2	2.8	10	25	PAF
WIL/TUR	Turill Seam		7.1	0.143	0.44	0.336	13	13	0	-3	1.0	4.0	1	11	PAF/LC
WIL/M4	Moolarben Seam		7.1	0.214	0.17	0.14	5	9	-4	-5	1.7	6.9	0	0	NAF
WIL/A12	Ulan Seam	A1 Seam/A12	4.7	0.292	0.36	0.172	11	2	9	4	0.2	3.5	10	28	PAF
WIL/B1		B Seam/B1	5.6	0.328	0.22	0.098	7	5	2	-2	0.7	3.8	2	18	PAF/LC
WIL/B2		B Seam/B2	6.0	0.563	0.31	0.243	9	11	-1	-3	1.1	4.7	0	3	NAF
WIL/B3		B Seam/B3	5.5	0.372	0.34	0.263	10	9	1	-1	0.9	3.9	2	17	PAF/LC
WIL/E		E Seam/E12:E22	5.2	0.534	0.54	0.402	17	8	8	4	0.5	3.8	2	19	PAF/LC
WIL/G1		G Seam/G1	3.3	1.072	1.33	1.04	41	0	41	32	0.0	2.3	37	50	PAF
WIL/G		G Seam/G1:G22	4.8	0.408	0.61	0.502	19	7	12	8	0.4	3.7	2	18	PAF

KEY

$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kgH_2SO_4/t)

NAPP = Net Acid Producing Potential (kgH2SO4/t)
NAGpH = pH of NAG liquor
$NAG_{pH4.5}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{pH7.0}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

ARD Classification Key

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
PAF/LC = PAF Low Capacity
UC = Uncertain (expected classification)

Table B-4: Multi-element composition of selected overburden and interburden samples from the Wilpinjong Extension Project.

Parameter		Detect. Limit	Element Concentration												
			GEM21/4	GEM30/19	GEM29/10	GEM34/6	GEM35/3	GEM33/2	GEM34/3	GEM30/15	GEM30/18	GEM36/4	GEM33/3	GEM27/7	GEM27/9
			Conglomerate		Sandstone		Siltstone	Carb. Siltstone		Carb. Mudstone		Tuff	Sandstone, Siltstone	Sandstone, Siltstone, Mudstone	Siltstone, Mudstone
Ag	mg/kg	0.01	0.06	0.08	<	<	0.07	0.08	0.12	0.11	0.11	0.31	0.08	0.08	0.1
Al	%	0.005%	4.460%	4.368%	6.215%	3.494%	7.948%	6.883%	7.787%	8.072%	7.717%	12.991%	8.031%	7.113%	8.659%
As	mg/kg	0.5	2.3	1.6	4.3	3.2	11.9	2.5	4.7	23.7	8.8	6.6	13.1	12.8	16.5
B	mg/kg	50	<	<	<	<	53	<	<	<	<	<	54	<	<
Ba	mg/kg	0.1	375.5	256.1	349.8	1024.1	281.2	321.7	145.1	1043.0	236.0	83.7	415.4	356.3	369.9
Be	mg/kg	0.05	0.73	1.13	1.53	0.83	2.43	2.80	3.83	2.90	3.29	2.11	2.31	2.27	3.07
Ca	%	0.005%	1.862%	0.032%	0.103%	2.200%	0.343%	0.120%	0.105%	0.204%	0.083%	0.187%	0.364%	0.195%	0.143%
Cd	mg/kg	0.02	<	0.05	0.03	0.03	0.16	<	0.28	0.24	0.29	0.14	0.13	0.08	0.26
Co	mg/kg	0.1	2.6	2.6	1.9	3.3	23.8	7.3	6.0	39.9	14.7	2.5	12.6	8.4	21.9
Cr	mg/kg	5	12	17	47	17	138	96	34	78	51	6	101	66	63
Cu	mg/kg	1	6	9	14	4	39	24	22	38	21	11	25	15	35
Fe	%	0.01%	1.15%	0.52%	1.53%	1.21%	7.16%	1.63%	2.54%	5.95%	0.65%	2.95%	3.90%	2.30%	1.63%
Hg	mg/kg	0.001	0.011	0.029	0.012	0.008	0.086	0.027	0.081	0.099	0.067	0.157	0.035	0.032	0.082
K	%	0.002%	2.112%	2.162%	1.891%	1.409%	2.763%	2.293%	1.672%	2.677%	2.176%	0.414%	2.338%	2.254%	2.595%
Mg	%	0.002%	0.730%	0.042%	0.279%	0.797%	0.445%	0.215%	0.266%	0.295%	0.164%	0.267%	0.473%	0.332%	0.236%
Mn	mg/kg	1	92	116	164	193	1294	306	588	2114	155	317	570	349	383
Mo	mg/kg	0.1	0.5	0.8	0.3	1.5	1.9	0.6	0.9	5.2	1.7	0.7	0.9	0.7	1.1
Na	%	0.002%	0.078%	0.110%	0.042%	0.040%	0.042%	0.047%	0.036%	0.049%	0.037%	0.021%	0.052%	0.036%	0.047%
Ni	mg/kg	1	4	14	9	4	268	44	24	145	33	10	53	31	52
P	mg/kg	50	<	53	85	62	449	104	104	376	116	164	187	164	231
Pb	mg/kg	0.5	14.7	19.3	14.6	7.0	19.6	19.6	37.5	28.9	36.2	81.4	20.9	21.9	24.3
Sb	mg/kg	0.05	0.24	0.31	0.33	0.29	0.81	1.27	0.62	1.06	0.79	1.42	0.62	0.67	1.35
Se	mg/kg	0.01	0.03	0.15	0.06	0.04	0.37	0.08	0.65	0.70	0.53	0.12	0.14	0.13	0.30
Si	%	0.1%	40.1%	38.8%	34.6%	38.3%	28.3%	24.8%	21.3%	25.1%	25.9%	28.0%	30.4%	33.8%	28.3%
Sn	mg/kg	0.1	1.6	2.1	2.9	1.3	2.8	3.1	5.5	3.9	5.3	13.8	3.8	3.5	3.9
Th	mg/kg	0.01	5.71	8.73	11.49	4.53	11.51	10.58	22.70	16.87	20.64	48.36	14.79	14.43	15.82
U	mg/kg	0.01	1.44	2.23	2.76	1.19	2.67	2.57	5.43	4.61	5.52	12.78	3.66	3.86	3.76
V	mg/kg	1	17	17	44	46	118	69	55	93	59	7	89	56	86
Zn	mg/kg	1	17	30	23	18	94	23	105	114	120	109	78	70	89

< element at or below analytical detection limit.

Table B-5: Geochemical abundance indices for selected overburden and interburden samples from the Wilpinjong Extension Project.

Parameter	*Mean Crustal Abundance	Geochemical Abundance Indices (GAI)												
		GEM21/4	GEM30/19	GEM29/10	GEM34/6	GEM35/3	GEM33/2	GEM34/3	GEM30/15	GEM30/18	GEM36/4	GEM33/3	GEM27/7	GEM27/9
		Conglomerate		Sandstone		Siltstone	Carb. Siltstone		Carb. Mudstone		Tuff	Sandstone, Siltstone	Sandstone, Siltstone, Mudstone	Siltstone, Mudstone
Ag	0.07	-	-	-	-	-	-	-	-	-	2	-	-	-
Al	8.2%	-	-	-	-	-	-	-	-	-	-	-	-	-
As	1.5	-	-	1	1	2	-	1	**3**	2	2	**3**	**3**	**3**
B	10	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	2	<2	<2
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-	-
Be	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca	4.0%	-	-	-	-	-	-	-	-	-	-	-	-	-
Cd	0.11	-	-	-	-	-	-	1	1	1	-	-	-	1
Co	20	-	-	-	-	-	-	-	-	-	-	-	-	-
Cr	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	50	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe	4.1%	-	-	-	-	-	-	-	-	-	-	-	-	-
Hg	0.05	-	-	-	-	-	-	-	-	-	1	-	-	-
K	2.1%	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn	950	-	-	-	-	-	-	-	1	-	-	-	-	-
Mo	1.5	-	-	-	-	-	-	-	1	-	-	-	-	-
Na	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	80	-	-	-	-	1	-	-	-	-	-	-	-	-
P	1000	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	14	-	-	-	-	-	-	1	-	1	2	-	-	-
Sb	0.2	-	-	-	-	1	2	1	2	1	2	1	1	2
Se	0.05	-	1	-	-	2	-	**3**	**3**	**3**	1	1	1	2
Si	27.7%	-	-	-	-	-	-	-	-	-	-	-	-	-
Sn	2.2	-	-	-	-	-	-	1	-	1	2	-	-	-
Th	12	-	-	-	-	-	-	-	-	-	1	-	-	-
U	2.4	-	-	-	-	-	-	1	-	1	2	-	-	-
V	160	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	75	-	-	-	-	-	-	-	-	-	-	-	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table B-6: Chemical composition of water extracts from selected overburden and interburden samples from the Wilpinjong Extension Project.

Parameter		Detect. Limit	Chemical Composition												
			GEM21/4	GEM30/19	GEM29/10	GEM34/6	GEM35/3	GEM33/2	GEM34/3	GEM30/15	GEM30/18	GEM36/4	GEM33/3	GEM27/7	GEM27/9
			Conglomerate		Sandstone		Siltstone	Carb. Siltstone		Carb. Mudstone		Tuff	Sandstone, Siltstone	Sandstone, Siltstone, Mudstone	Siltstone, Mudstone
pH		0.1	8.8	7.6	8.2	8.8	7.5	7.6	7.8	7.2	7.6	7.9	8.2	7.8	7.0
EC	dS/m	0.001	0.253	0.120	0.188	0.263	0.922	0.186	0.169	0.620	0.143	0.134	0.339	0.108	0.428
Cl	mg/l	2	33	8	18	10	<	3	6	<	3	2	2	<	<
SO4	mg/l	0.3	22.3	27.5	31.2	65.1	458.4	37.3	34.8	273.5	36.4	36.1	96.9	24.8	199.5
Al	mg/l	0.01	<	0.01	0.06	<	0.02	0.06	0.11	0.02	0.06	<	0.03	0.17	0.03
B	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<
Ca	mg/l	0.01	2.83	3.74	3.94	17.24	92.81	4.28	2.59	47.10	3.39	4.93	16.20	6.44	36.19
Cr	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<
Cu	mg/l	0.01	<	0.01	<	<	<	<	<	<	<	<	<	<	<
Fe	mg/l	0.01	<	0.04	0.01	0.01	<	0.04	0.02	<	<	<	0.02	0.02	<
K	mg/l	0.1	6.4	4.9	7.6	8.2	31.7	7.1	6.0	19.8	5.3	3.8	12.1	7.1	14.5
Mg	mg/l	0.01	4.68	2.66	3.04	8.93	45.83	1.70	4.67	21.40	2.17	2.40	5.84	2.29	14.32
Mn	mg/l	0.01	<	0.38	<	0.01	0.53	<	0.02	0.45	<	0.01	<	<	0.25
Na	mg/l	0.1	38.1	14.5	26.0	18.2	18.0	30.0	23.9	31.9	21.3	18.6	38.1	9.3	19.1
Ni	mg/l	0.01	<	0.05	<	0.34	1.64	0.05	0.04	2.30	0.02	<	0.07	0.01	0.29
P	mg/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<
Si	mg/l	0.05	1.01	1.18	1.83	0.96	1.30	1.63	1.48	1.15	1.48	1.13	0.94	1.90	1.28
V	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<
Zn	mg/l	0.01	<	0.09	<	0.03	0.04	0.01	<	0.05	<	<	<	<	0.04
Ag	µg/l	0.01	<	<	<	<	<	<	<	<	0.01	<	<	<	<
As	µg/l	0.1	0.3	3.3	27.0	14.7	0.4	4.2	2.0	4.2	28.1	0.1	7.6	77.0	1.9
Ba	µg/l	0.05	2.42	18.23	2.15	11.27	39.60	5.82	3.17	20.78	6.33	6.88	7.25	53.93	42.93
Be	µg/l	0.10	<	<	<	<	<	<	<	<	<	<	<	<	<
Cd	µg/l	0.02	<	0.27	<	0.10	0.08	0.06	0.09	0.12	0.07	<	<	0.02	0.11
Co	µg/l	0.1	0.1	13.5	0.2	125.4	220.4	5.8	10.1	916.1	3.6	1.8	14.1	0.8	208.7
Hg	µg/l	0.1	<	<	<	<	<	<	<	<	0.1	<	<	<	<
Mo	µg/l	0.05	3.91	33.12	21.70	184.79	5.24	30.47	22.02	19.56	90.03	7.46	53.93	98.87	2.65
Pb	µg/l	0.5	<	134.5	<	11.0	<	16.4	2.2	<	<	0.7	<	<	<
Sb	µg/l	0.01	0.1	0.4	0.5	1.9	0.2	0.4	0.4	0.6	0.6	0.2	1.2	3.1	0.4
Se	µg/l	0.5	<	3.7	16.1	8.0	63.2	42.8	48.4	159.5	77.6	6.3	39.2	36.1	61.8
Sn	µg/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<
Th	µg/l	0.005	0.011	0.020	0.011	<	<	0.297	0.132	<	0.092	0.013	<	0.020	0.007
U	µg/l	0.005	0.205	0.117	0.030	1.411	0.043	0.151	0.083	0.017	0.073	0.109	0.385	0.145	0.020

< element at or below analytical detection limit.

Table B-7: Multi-element composition and geochemical abundance indices of selected weathered overburden and coal reject samples from the Wilpinjong Extension Project.

Parameter		Detect. Limit	Element Concentration									*Mean Crustal Abund.	Geochemical Abundance Indices (GAI)								
			Weathered Overburden Material					Coal Rejects					Weathered Overburden Material					Coal Rejects			
			GEM/W1	GEM/W9	GEM/W15	GEM/W7	GEM 25/3	WIL/GLB	WIL/TUR	WIL/MOR	WIL/ULA		GEM/W1	GEM/W9	GEM/W15	GEM/W7	GEM 25/3	WIL/GLB	WIL/TUR	WIL/MOR	WIL/ULA
			Highly Weathered				Slightly	Goulburn	Turill	Moolarb.	Ulan		Highly Weathered				Slightly	Goulburn	Turill	Moolarb.	Ulan
			Alluvium	Gravel	Clay	Sandst.	Siltst.	Seam	Seam	Seam	Seam		Alluvium	Gravel	Clay	Sandst.	Siltst.	Seam	Seam	Seam	Seam
Ag	mg/kg	0.01	0.12	0.06	0.97	0.14	0.08	0.13	0.13	0.1	0.14	0.07	-	-	**3**	-	-	-	-	-	-
Al	%	0.005%	5.212%	7.083%	7.265%	6.612%	8.627%	11.555%	10.852%	13.893%	7.613%	8.2%	-	-	-	-	-	-	-	-	-
As	mg/kg	0.5	10.4	20.0	8.2	18.5	13.2	29.2	27.2	6.5	2.8	1.5	2	**3**	2	**3**	**3**	**4**	**4**	2	-
B	mg/kg	50	<	<	<	<	<	<	<	<	<	10	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ba	mg/kg	0.1	303.3	336.6	230.5	289.3	285.1	207.3	185.9	227.3	190.9	500	-	-	-	-	-	-	-	-	-
Be	mg/kg	0.05	1.69	2.03	1.45	2.01	2.65	3.06	2.94	2.70	2.99	2.6	-	-	-	-	-	-	-	-	-
Ca	%	0.005%	0.090%	0.031%	0.038%	0.033%	0.129%	0.204%	0.191%	0.141%	0.104%	4.0%	-	-	-	-	-	-	-	-	-
Cd	mg/kg	0.02	<	<	0.02	0.04	0.08	0.22	0.20	0.07	0.23	0.11	-	-	-	-	-	-	-	-	-
Co	mg/kg	0.1	4.8	6.2	25.8	9.4	8.9	6.3	5.4	4.7	2.8	20	-	-	-	-	-	-	-	-	-
Cr	mg/kg	5	66	75	193	44	130	11	<	7	48	100	-	-	-	-	-	-	-	-	-
Cu	mg/kg	1	15	21	30	11	22	15	10	17	10	50	-	-	-	-	-	-	-	-	-
Fe	%	0.01%	1.48%	3.72%	8.65%	1.97%	0.64%	2.33%	2.96%	1.69%	2.52%	4.1%	-	-	-	-	-	-	-	-	-
Hg	mg/kg	0.001	0.026	0.022	0.288	0.156	0.050	0.307	0.140	0.140	0.101	0.05	-	-	2	1	-	2	1	1	-
K	%	0.002%	1.014%	1.941%	0.098%	1.771%	2.555%	0.946%	0.674%	0.944%	0.489%	2.1%	-	-	-	-	-	-	-	-	-
Mg	%	0.002%	0.158%	0.215%	0.157%	0.180%	0.311%	0.183%	0.330%	0.257%	0.149%	2.3%	-	-	-	-	-	-	-	-	-
Mn	mg/kg	1	239	166	282	130	300	157	143	140	447	950	-	-	-	-	-	-	-	-	-
Mo	mg/kg	0.1	1.7	1.8	1.6	0.9	1.8	2.7	2.2	2.2	4.1	1.5	-	-	-	-	-	-	-	-	-
Na	%	0.002%	0.063%	0.118%	0.062%	0.099%	0.059%	0.026%	0.017%	0.030%	0.023%	2.3%	-	-	-	-	-	-	-	-	-
Ni	mg/kg	1	21	30	92	28	44	18	25	21	23	80	-	-	-	-	-	-	-	-	-
P	mg/kg	50	119	134	656	88	181	97	182	163	123	1000	-	-	-	-	-	-	-	-	-
Pb	mg/kg	0.5	19.4	24.2	9.8	18.1	23.0	33.1	57.2	54.5	22.2	14	-	-	-	-	-	1	1	1	-
Sb	mg/kg	0.05	0.94	0.98	0.39	0.54	0.60	0.81	1.12	0.81	1.57	0.2	2	2	-	1	1	1	2	1	2
Se	mg/kg	0.01	0.05	0.29	0.24	0.06	0.13	1.25	0.35	0.42	0.72	0.05	-	2	2	-	1	**4**	2	2	**3**
Si	%	0.1%	29.1%	35.9%	30.8%	36.0%	33.1%	21.0%	22.6%	22.0%	22.0%	27.7%	-	-	-	-	-	-	-	-	-
Sn	mg/kg	0.1	2.5	3.3	2.4	3.0	4.3	3.6	7.4	7.1	4.3	2.2	-	-	-	-	-	-	1	1	-
Th	mg/kg	0.01	11.18	13.93	7.20	9.21	16.89	20.86	35.40	30.63	17.50	12	-	-	-	-	-	-	1	1	-
U	mg/kg	0.01	3.27	3.61	1.85	2.28	5.15	5.14	5.79	5.52	4.38	2.4	-	-	-	-	1	1	1	1	-
V	mg/kg	1	46	67	149	46	63	23	8	27	18	160	-	-	-	-	-	-	-	-	-
Zn	mg/kg	1	38	45	69	65	40	31	114	50	53	75	-	-	-	-	-	-	-	-	-

< element at or below analytical detection limit.

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table B-8: Chemical composition of water extracts from selected weathered overburden and coal reject samples from the Wilpinjong Extension Project.

Parameter		Detect. Limit	Chemical Composition								
			Weathered Overburden Material					Coal Rejects			
			GEM/W1	GEM/W9	GEM/W15	GEM/W7	GEM25/3	WIL/GLB	WIL/TUR	WIL/MOR	WIL/ULA
			Alluvium	Gravel	Clay	Sandstone	Siltstone	Goulburn	Turill	Moolarben	Ulan
			Highly Weathered				Slightly	Seam	Seam	Seam	Seam
pH		0.1	7.4	8.1	6.0	8.7	7.6	6.7	7.1	7.1	5.0
EC	dS/m	0.001	0.658	1.395	1.130	1.002	0.511	0.286	0.143	0.214	0.609
Cl	mg/l	2	41	81	129	72	6	16	7	15	9
SO4	mg/l	0.3	183.3	436.1	256.4	295.2	185.8	124.4	55.0	77.3	258.2
Al	mg/l	0.01	0.44	0.03	0.02	0.63	0.10	<	0.01	0.03	0.40
B	mg/l	0.01	0.07	<	<	<	<	<	<	<	0.02
Ca	mg/l	0.01	13.71	16.66	9.44	2.77	5.31	29.80	9.29	10.30	31.53
Cr	mg/l	0.01	<	<	<	<	<	<	<	<	<
Cu	mg/l	0.01	<	0.98	0.14	0.16	<	0.05	<	0.01	0.03
Fe	mg/l	0.01	0.16	1.93	6.79	0.90	0.10	0.10	<	0.02	20.08
K	mg/l	0.1	3.1	7.0	3.5	10.1	3.8	8.9	9.2	9.6	9.6
Mg	mg/l	0.01	14.32	25.79	20.71	8.48	19.11	12.53	4.26	7.12	19.71
Mn	mg/l	0.01	0.14	5.67	0.39	1.33	0.09	0.05	0.03	0.02	1.30
Na	mg/l	0.1	89.9	258.2	174.4	202.2	64.3	27.9	16.2	27.0	36.3
Ni	mg/l	0.01	0.01	0.35	0.56	0.40	0.09	0.20	0.03	0.06	0.10
P	mg/l	0.1	<	<	<	<	<	<	<	<	<
Si	mg/l	0.05	4.28	1.89	4.28	3.16	3.88	2.01	2.45	1.91	2.61
V	mg/l	0.01	<	<	<	<	<	<	<	<	<
Zn	mg/l	0.01	<	1.08	0.22	0.53	0.02	0.05	<	0.01	0.29
Ag	µg/l	0.01	<	<	<	<	<	<	<	<	<
As	µg/l	0.1	1.2	2.3	0.5	4.5	2.5	0.4	0.3	1.0	0.6
Ba	µg/l	0.05	40.20	14.09	17.39	11.83	7.60	58.86	59.83	18.62	23.36
Be	µg/l	0.10	<	<	<	<	<	<	<	<	8.60
Cd	µg/l	0.02	0.10	1.22	0.24	1.44	0.05	0.61	0.03	0.03	0.87
Co	µg/l	0.1	5.0	707.2	718.7	443.7	10.5	43.1	2.6	6.8	40.9
Hg	µg/l	0.1	<	<	<	<	<	<	<	<	<
Mo	µg/l	0.05	1.20	2.10	0.07	5.64	2.08	22.21	25.62	83.59	1.02
Pb	µg/l	0.5	<	1332.6	3.1	29.4	0.60	19.80	2.60	6.80	10.40
Sb	µg/l	0.01	0.16	0.05	<	0.35	0.16	0.19	0.52	0.95	0.15
Se	µg/l	0.5	<	3.2	0.7	1.7	2.1	60.5	14.1	37.2	26.2
Sn	µg/l	0.1	<	<	<	<	<	<	<	<	<
Th	µg/l	0.005	0.174	0.507	0.020	0.157	0.099	0.008	0.050	0.025	15.234
U	µg/l	0.005	0.101	0.159	0.007	0.335	0.055	0.185	0.023	0.031	4.855

< element at or below analytical detection limit.

Attachment C

Acid Buffering Characteristic Curves

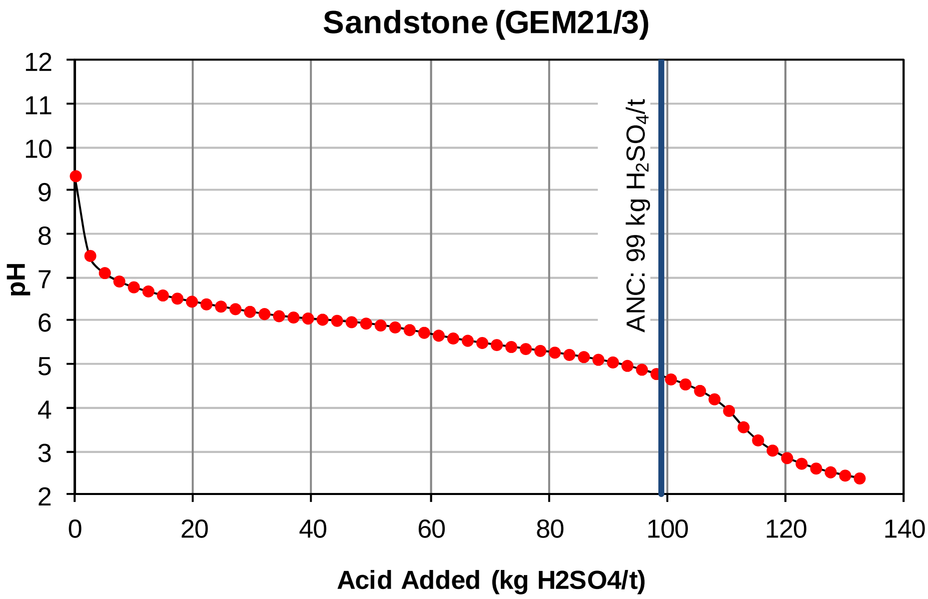

Figure C-1: Acid buffering characteristic curve for the overburden/partings sandstone sample (GEM21/3).

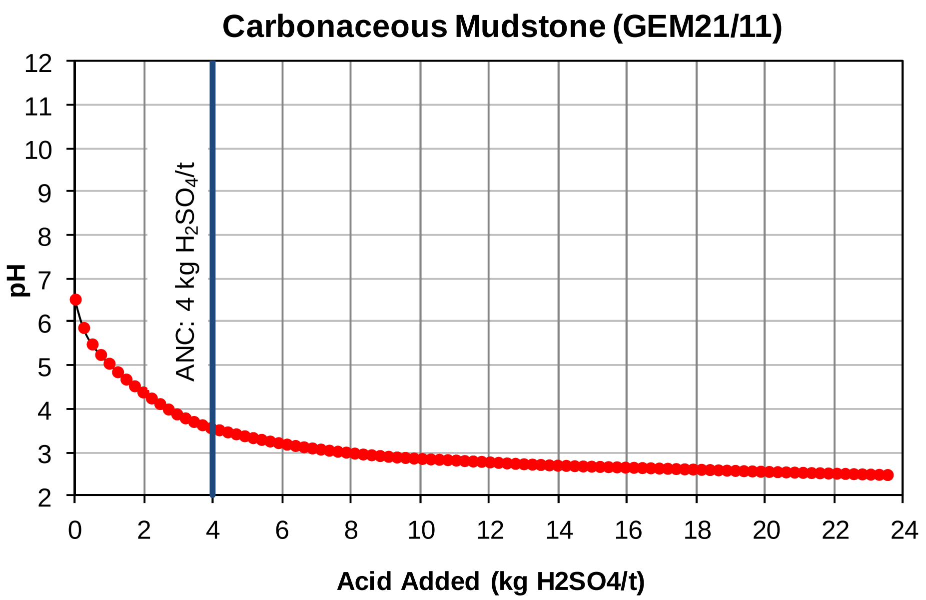

Figure C-2: Acid buffering characteristic curve for the overburden/partings carbonaceous mudstone sample (GEM21/11).

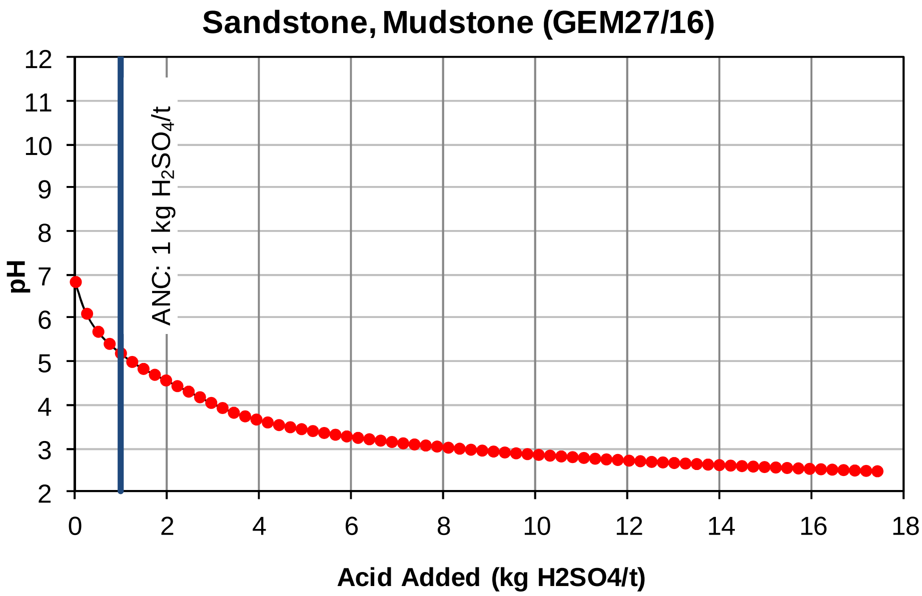

Figure C-3: Acid buffering characteristic curve for the overburden/partings sandstone, mudstone sample (GEM27/16).

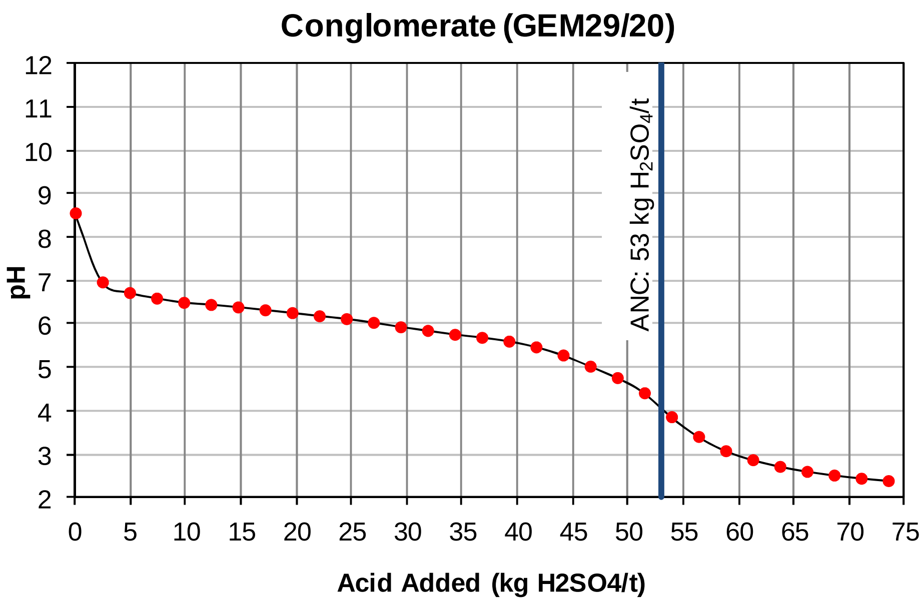

Figure C-4: Acid buffering characteristic curve for the overburden/partings conglomerate sample (GEM29/20).

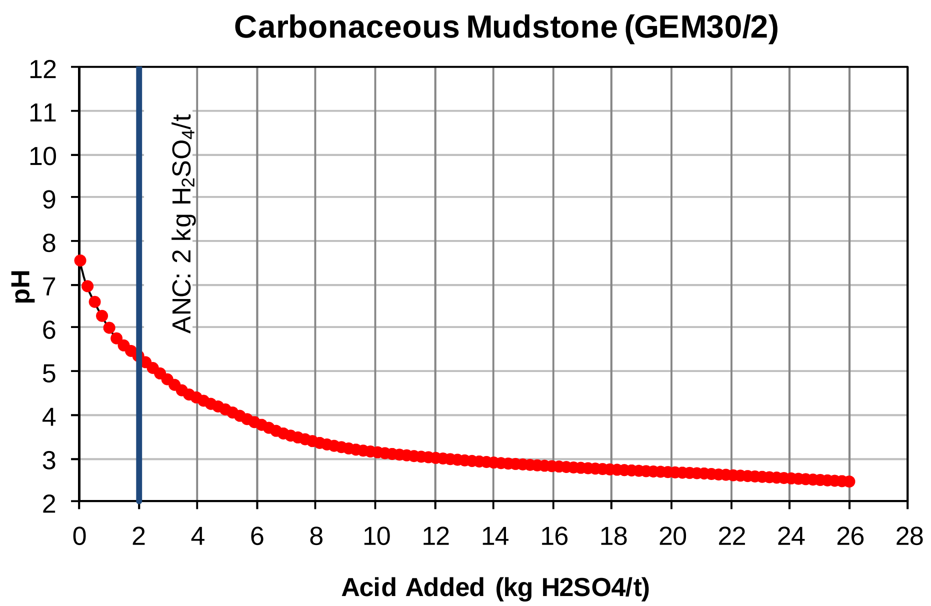

Figure C-5: Acid buffering characteristic curve for the overburden/partings carbonaceous mudstone sample (GEM30/2).

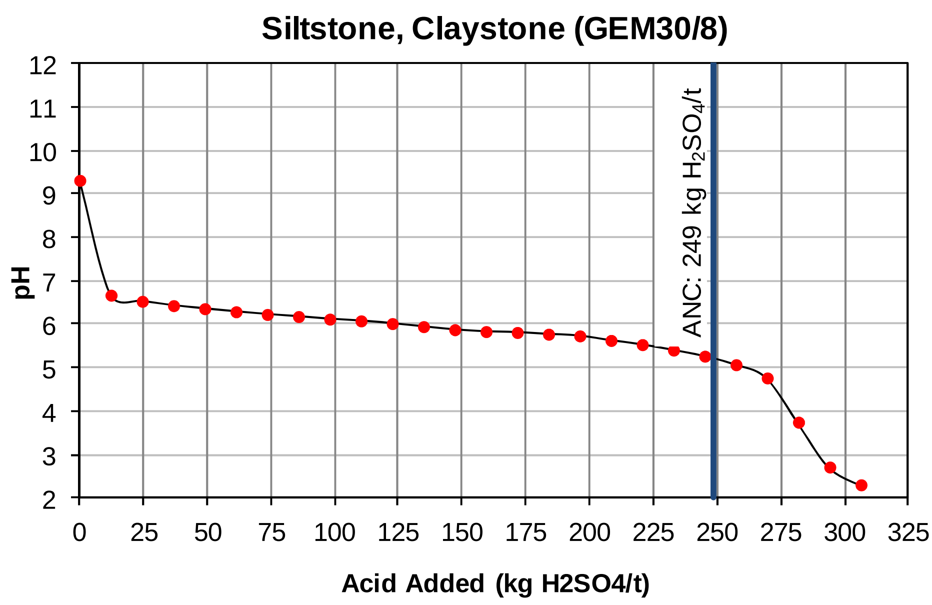

Figure C-6: Acid buffering characteristic curve for the overburden/partings siltstone, claystone sample (GEM30/8).

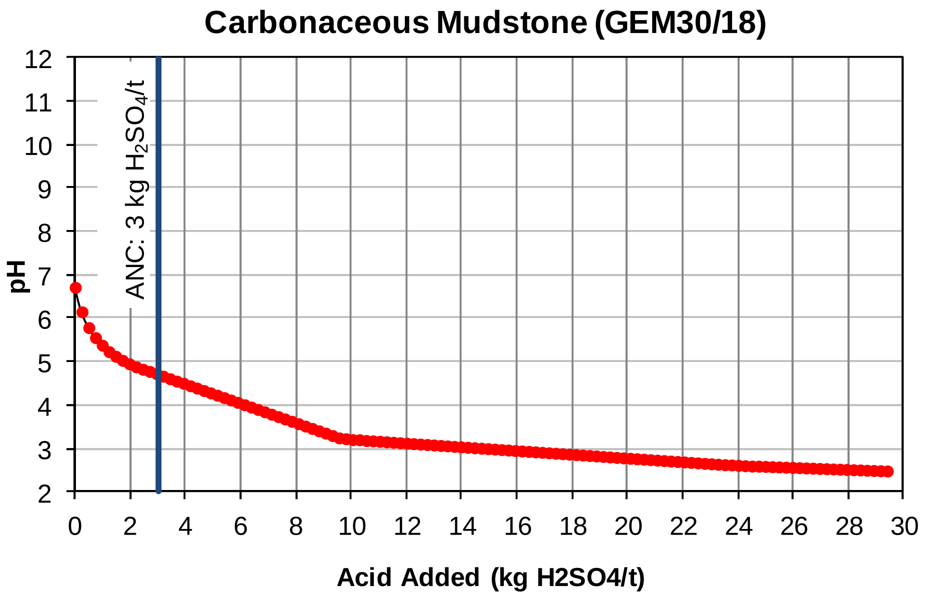

Figure C-7: Acid buffering characteristic curve for the overburden/partings carbonaceous mudstone sample (GEM30/18).

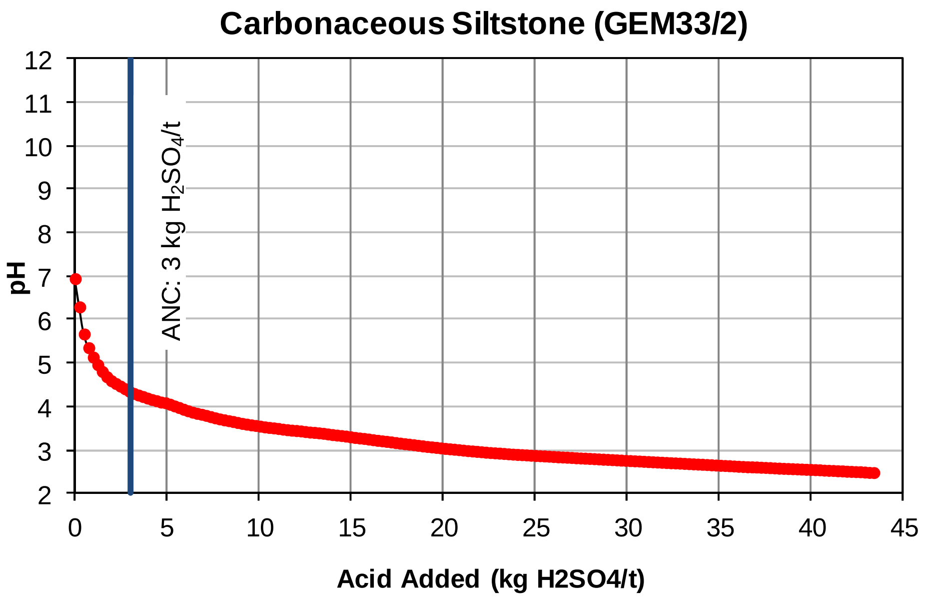

Figure C-8: Acid buffering characteristic curve for the overburden/partings carbonaceous siltstone sample (GEM33/2).

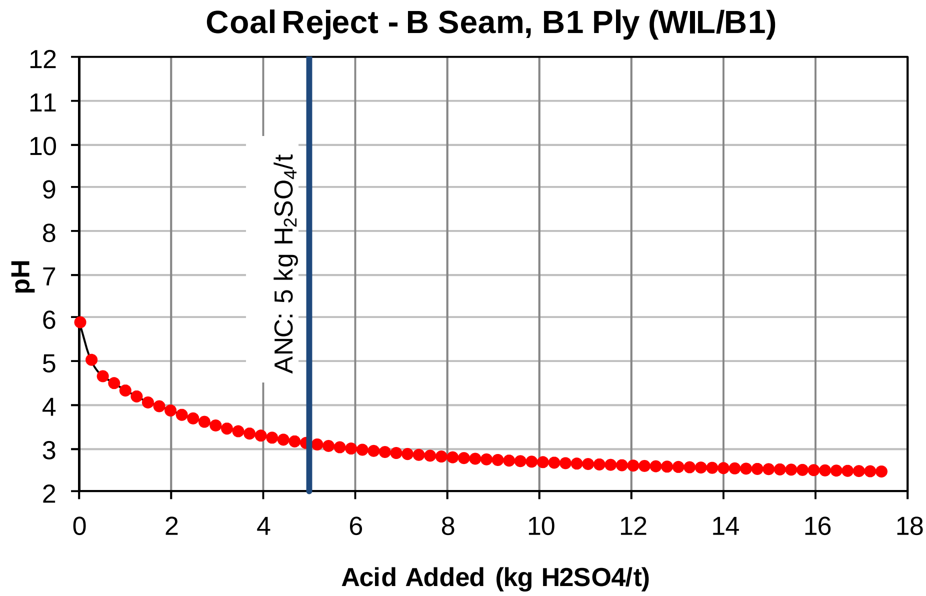

Figure C-9: Acid buffering characteristic curve for the coal reject sample from the B1 Ply of the Ulan, B Seam (WIL/B1).

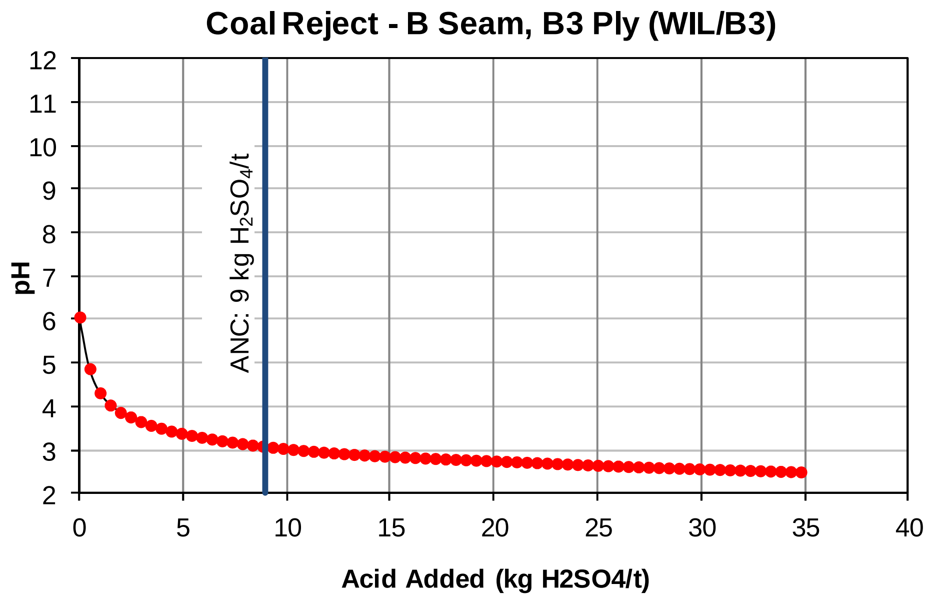

Figure C-10: Acid buffering characteristic curve for the coal reject sample from the B3 Ply of the Ulan, B Seam (WIL/B3).

Attachment D

Kinetic NAG Test Profiles

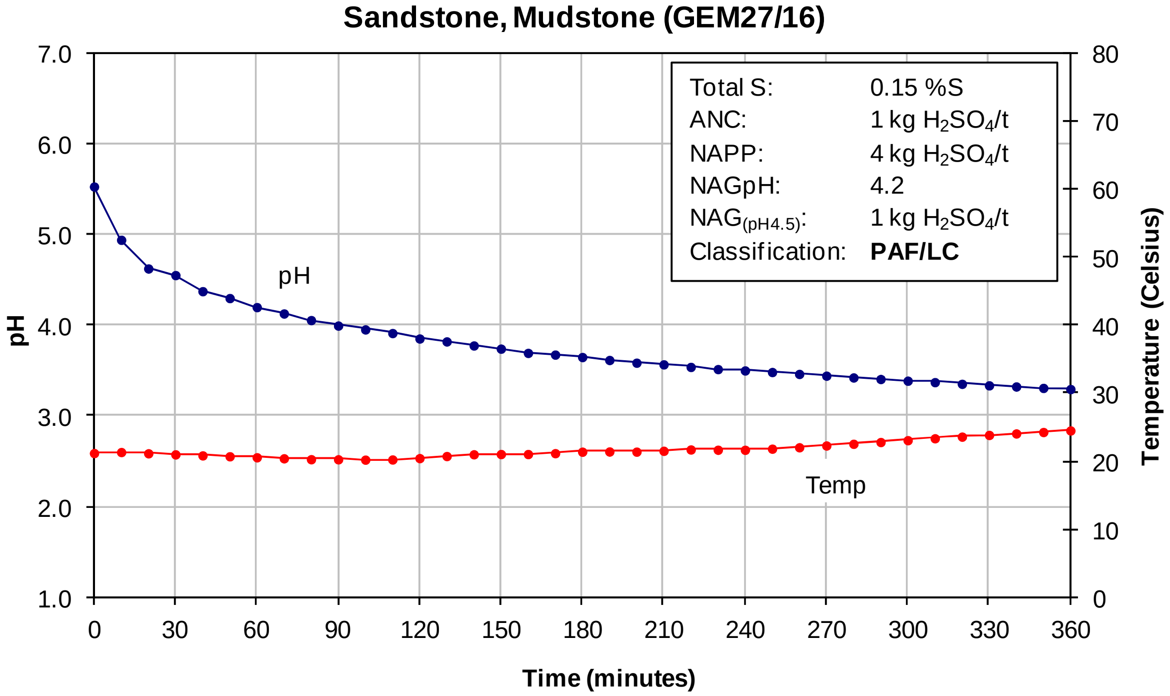

Figure D-1: Kinetic NAG test profiles for the overburden/partings sandstone, mudstone sample (GEM27/16).

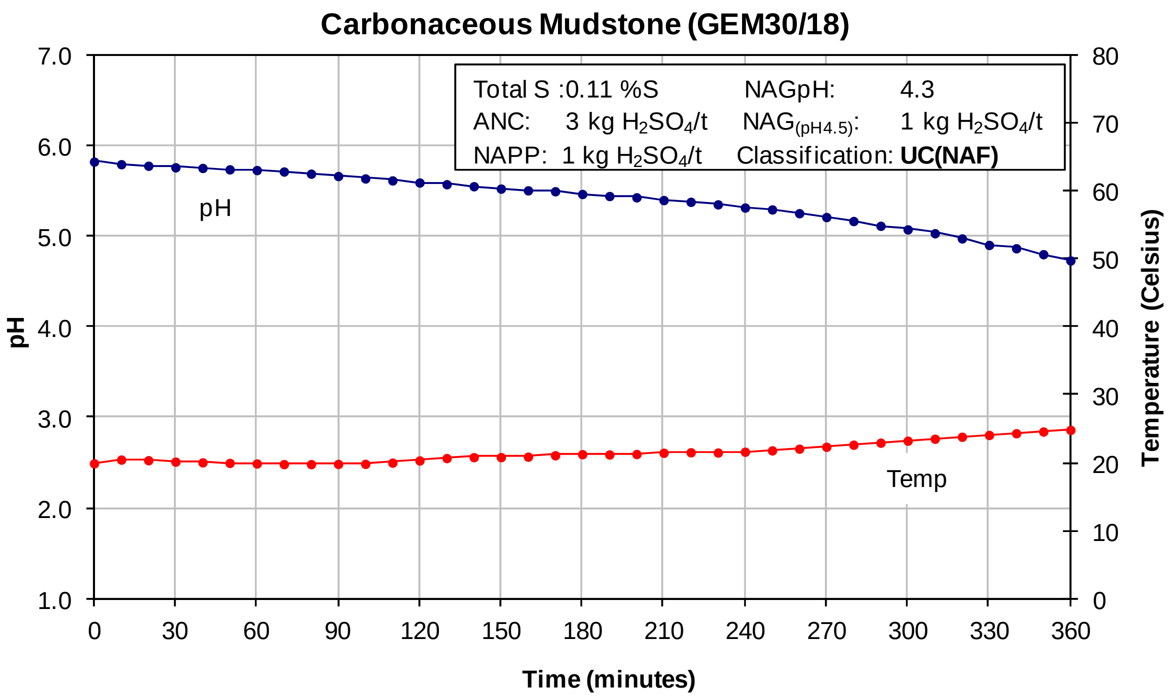

Figure D-2: Kinetic NAG test profiles for the overburden/partings carbonaceous mudstone sample (GEM30/18).

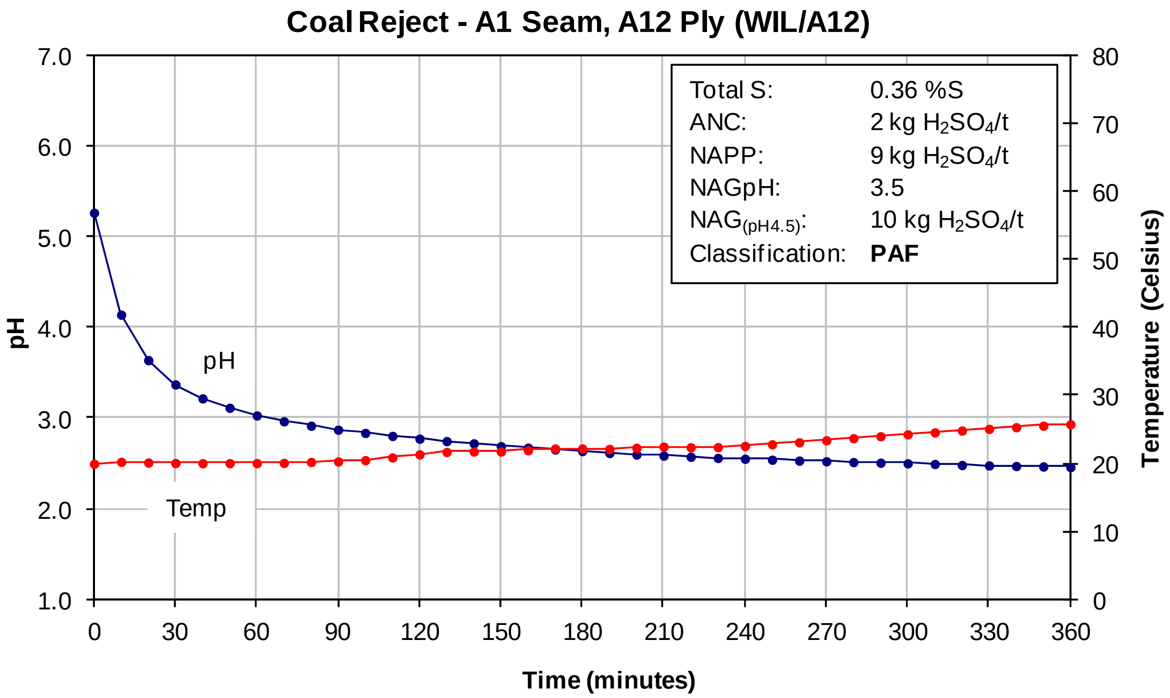

Figure D-3: Kinetic NAG test profiles for the coal reject sample from the A12 Ply of the Ulan, A Seam (WIL/A12).

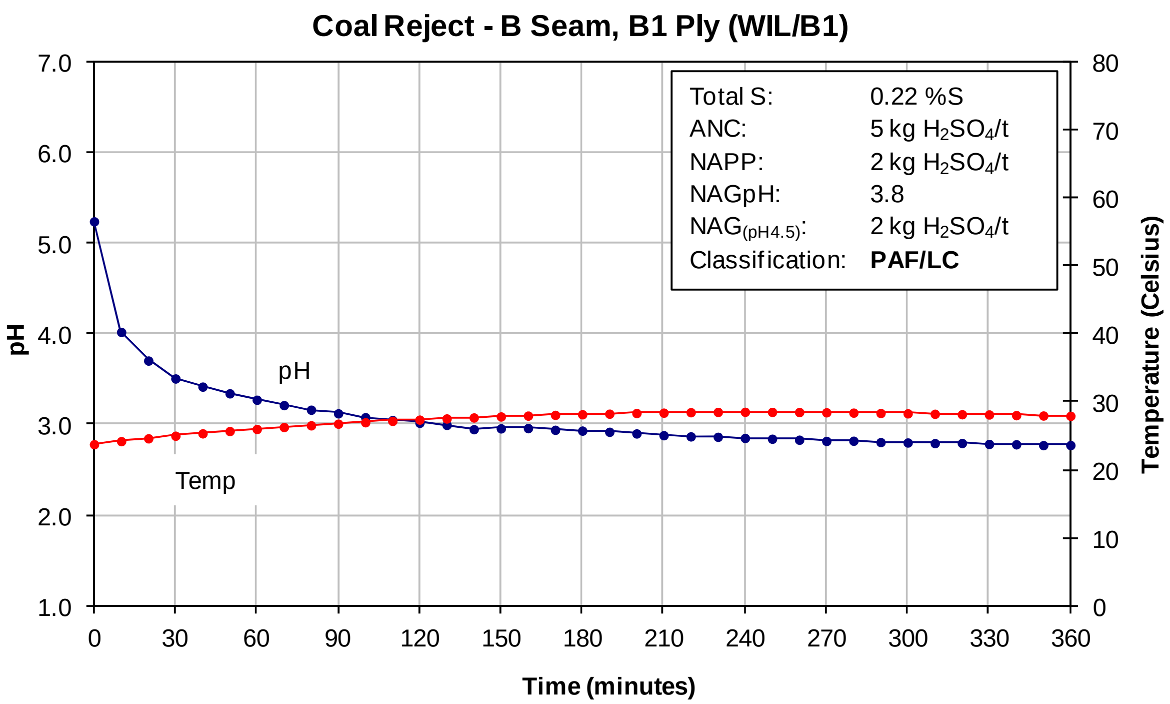

Figure D-4: Kinetic NAG test profiles for the coal reject sample from the B1 Ply of the Ulan, B Seam (WIL/B1).

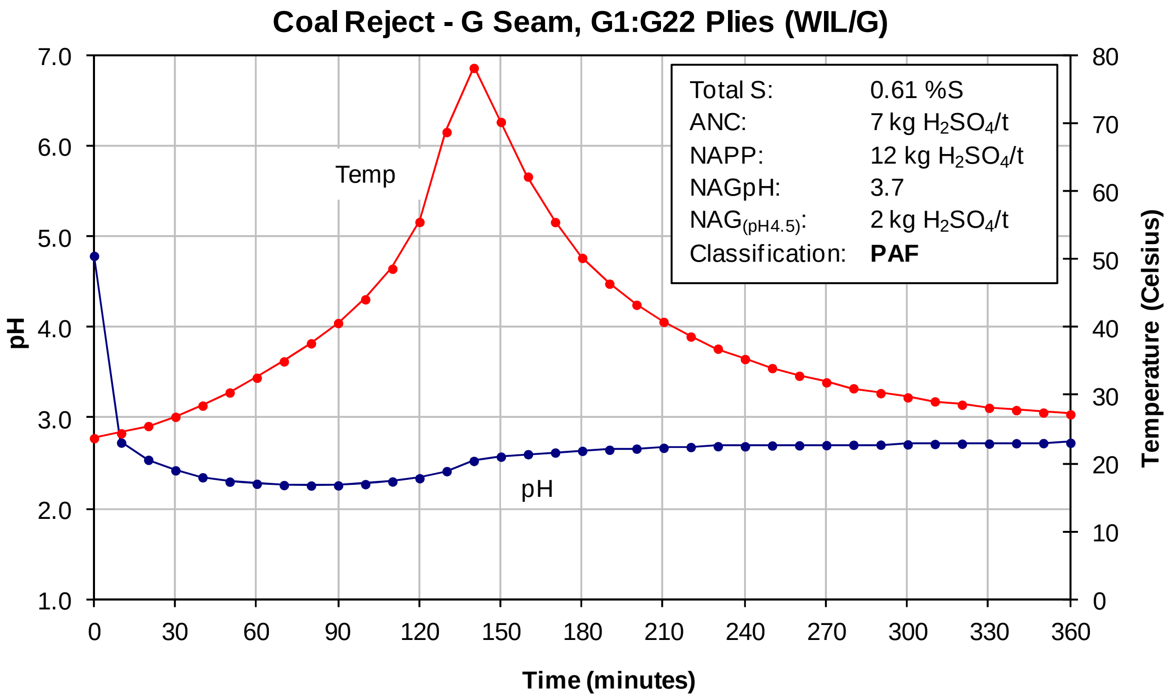

Figure D-5: Kinetic NAG test profiles for the coal reject sample from the G1:G22 Plies of the Ulan, G Seam (WIL/G).