Vickery Coal Project

Environmental Impact Statement

APPENDIX L

GEOCHEMISTRY ASSESSMENT

Resource Strategies

WHITEHAVEN COAL

VICKERY COAL PROJECT –

GEOCHEMISTRY ASSESSMENT OF OVERBURDEN, INTERBURDEN AND COAL REJECTS

October 2012

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1.0 Introduction

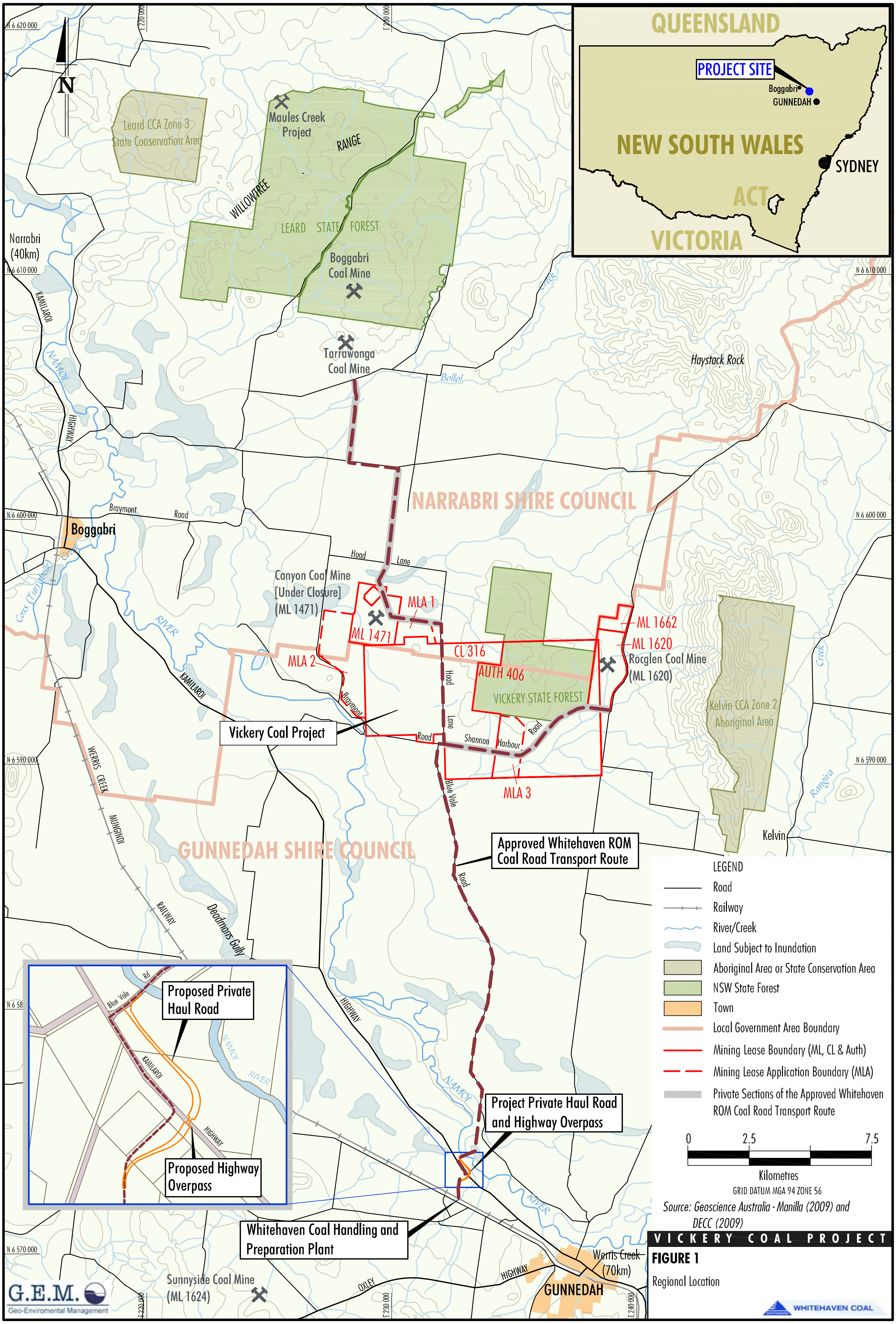
Geo-Environmental Management Pty Ltd (GEM) was commissioned by Whitehaven Coal Limited (Whitehaven) to carry out a Geochemistry Assessment for the proposed Vickery Coal Project (referred to herein as the Project). The Project area, as shown on Figure 1, is located within the Gunnedah Basin and is approximately 25 kilometres (km) north of Gunnedah in central northern New South Wales (NSW). Resource Strategies Pty Ltd is assisting Whitehaven with the preparation and lodgment of an Environmental Impact Statement for the Project, and this Geochemistry Assessment is required for, and will be provided as an appendix to the Environmental Impact Statement.

This report presents the results and findings of the geochemical assessment, identifies the geochemical implications for the Project, and provides any recommendations for environmental management and any future geochemical testing requirements for the Project.

1.1 Project Description

The Vickery Coal Mine was previously operated as an open-cut mine from 1991 to 1996 and it is understood that Whitehaven proposes to recommence open-cut mining activities during 2013, subject to obtaining the necessary approvals. Whitehaven also owns and operates the nearby Tarrawonga and Rocglen open-cut coal mines, located approximately 10 km to the north and 5 km to the east of the Project area, respectively (Figure 1). The Sunnyside Coal Mine, located approximately 25 km south of the Project, is also owned by Whitehaven. For this Project a total of approximately 1,132 million bank cubic metres (Mbcm) of waste rock (overburden and interburden) will be produced which will be disposed using a combination of surface waste rock emplacements and pit backfilling. The coal reserve for the Project is approximately 160 million tonnes of run-of-mine (ROM) coal. The ROM coal will be produced at a rate of 4.5 million tonnes per annum (Mtpa), and will be crushed and stockpiled on-site prior to being trucked to the Whitehaven Coal Handling and Processing Plant (CHPP) in Gunnedah for processing. At the Whitehaven CHPP the coal will either be washed to achieve the required coal quality or bypassed as product coal for direct rail load-out. Figure 2 shows the general arrangement of the proposed Project.

Coarse rejects generated at the Whitehaven CHPP would be returned via truck to the Project for disposal within an in-pit emplacement area. A small volume of the ROM coal (up to 150,000 tonnes [t]) and gravel (90,000 cubic metres) would be crushed and screened on-site for domestic (local) use, and the coarse rejects produced from these operations would also be emplaced on-site.



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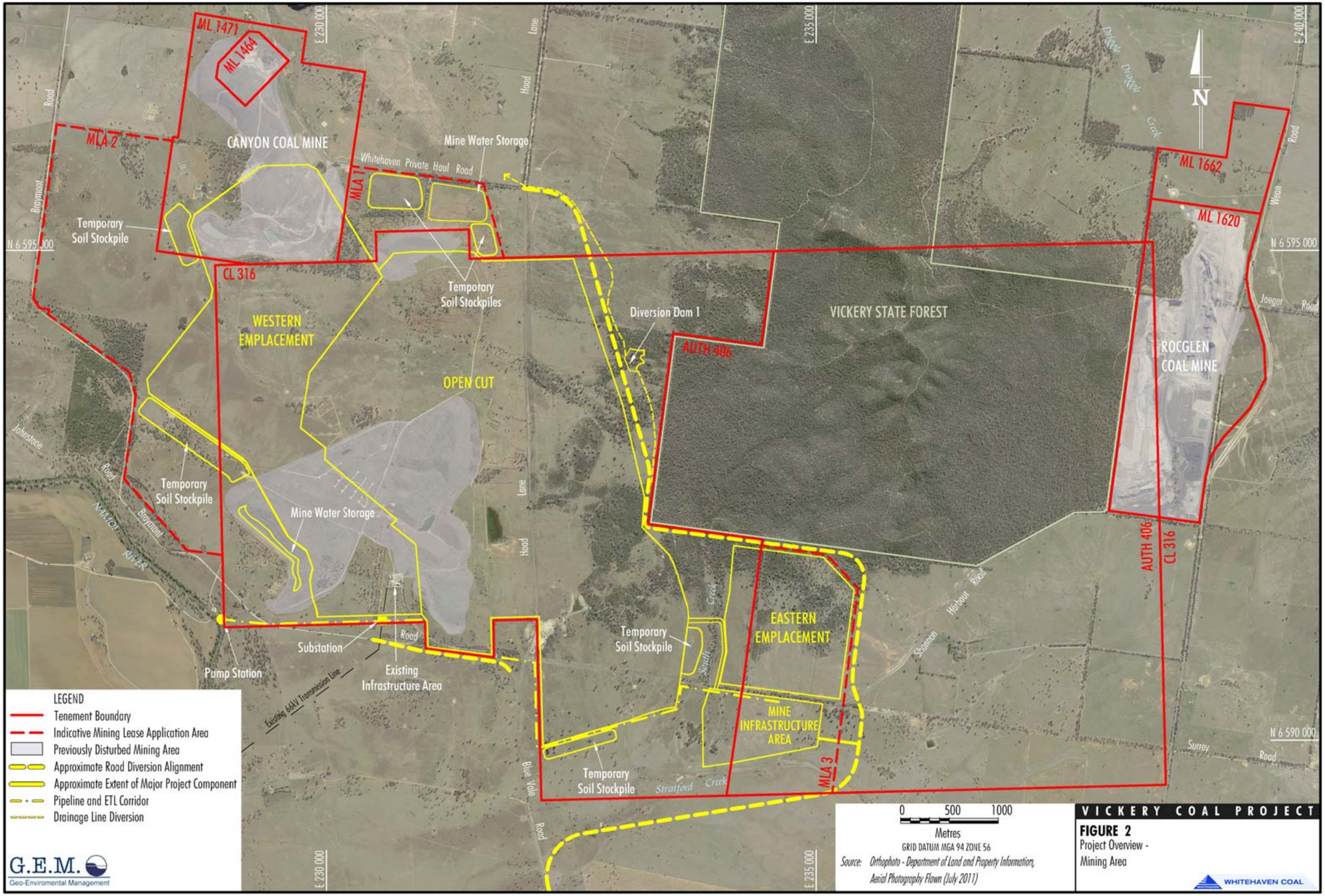

VICKERY COAL PROJECT

FIGURE 2
Project Overview - Mining Area

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Tailings (fine rejects) generated at the Whitehaven CHPP would continue to be disposed within the approved reject emplacement area to the west of Gunnedah known as the Brickworks Pit. When the approved capacity at the Brickworks Pit is reached the tailings would be returned by truck to the Project and co-disposed with coarse rejects and/or waste rock within an in-pit emplacement area. Prior to the existing approved capacity at the Brickworks Pit being exceeded, Whitehaven would evaluate the feasibility of disposing future tailings in the Brickworks Pit or other potential disposal sites, and if appropriate, seek the necessary planning and environmental approvals.

Key activities associated with the proposed development of the Project include:

- recommencement of open cut mining activities targeting seven coal seams within the Maules Creek Formation to a maximum depth of approximately 250 metres (m) below ground level using a conventional truck and shovel mining methods;
- production of ROM coal at a rate up to 4.5 Mtpa for a 30 year mine life;
- excavation of approximately 48 Mbcm of waste rock per annum (overburden and interburden);
- development of two out of pit waste rock emplacements as well as backfilling parts of the open-cut pit with waste rock;
- on-site crushing of ROM coal and small quantities of waste rock to produce gravel for domestic sale;
- development of a mine infrastructure area (MIA) and associated ROM coal handling infrastructure (including stockpiles);
- transport of ROM coal from the mine infrastructure area to the Whitehaven CHPP located in Gunnedah via trucks on public and private roads for processing (i.e. no on-site ROM coal processing besides crushing);
- backfilling parts of the pit with rejects (coarse rejects and potentially fine rejects) from the Whitehaven CHPP; and
- ongoing exploration and monitoring activities within existing and future tenements.

1.2 Study Objectives

The objectives of this study were to:

1. Review the relevant available information including previous geochemical test work results, local geology/stratigraphy and drill-hole logs for the proposed pit area.

2. Select the drill-holes and intervals to be sampled for inclusion in the geochemical testing program that are representative of:
   - the major overburden and interburden rock types;
   - the ROM coal that will potentially be stockpiled on-site; and
   - the reject materials that will be generated at the Whitehaven CHPP.
3. Select the required test work parameters and preferred analytical laboratories to be utilised to assess the salinity, sodicity, acid forming potential, and element enrichment and solubility of the selected waste rock and coal seam samples.
4. Provide clear instructions to enable Whitehaven's on-site personnel to collect, prepare and dispatch the selected samples.
5. Manage the testing programs identified in item 3.
6. Receive and interpret the test work results.
7. Prepare a Geochemistry Assessment report which describes in detail the sampling and test work programs adopted for the assessment (Items 1 to 6 above) and provides a discussion and evaluation of the test results in regard to salinity, sodicity, acid forming potential, and metal enrichment and solubility of the overburden and interburden from the proposed pit area, ROM coal and reject materials.

2.0 Deposit Stratigraphy

The Project coal deposits occur within the Early Permian Maules Creek sub-basin. The Boggabri Volcanics, consisting of dacite, rhyolite, basalt and pyroclastic rocks (acid volcanics), form the basement of the sub-basin and are unconformably overlain by the sub-basin sediments of the Maules Creek Formation. The Maules Creek Formation is the primary coal bearing unit and consists of interbedded coal, conglomerate, sandstone, siltstone and mudstones. The basement Boggabri Volcanics within the Project area consists of acid volcanics (dacite, rhyolite).

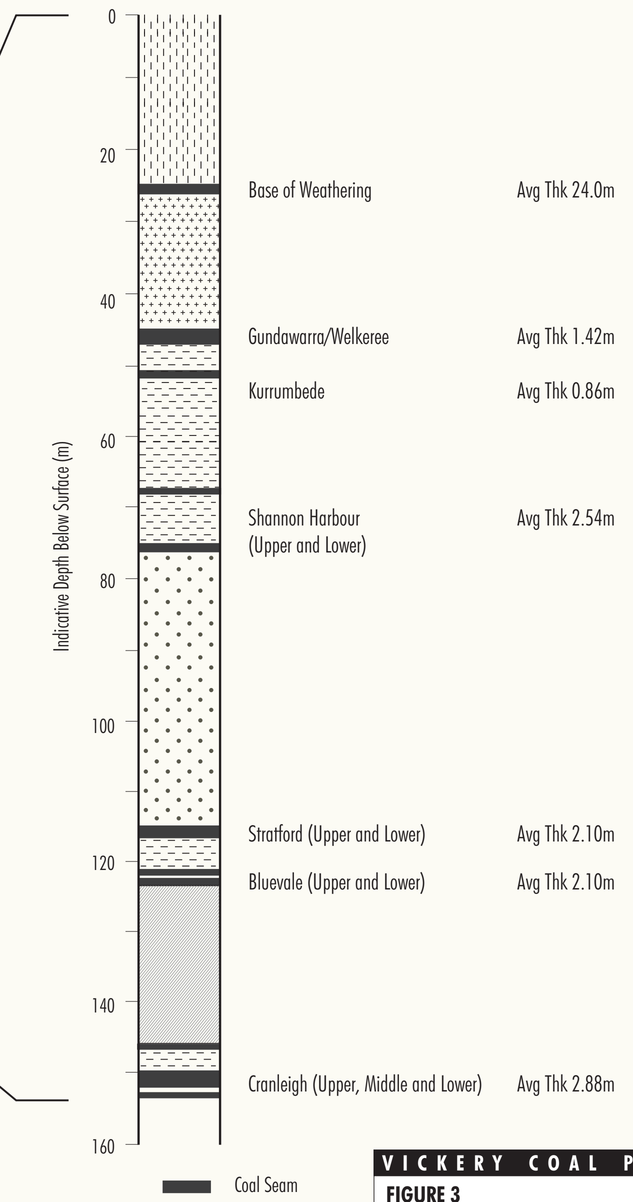
Sedimentation during the development of the Maules Creek Formation was influenced by the topography of the underlying Boggabri Volcanics, with some of the lower coal seams onlapping a structural feature known as the Boggabri Ridge. The Karu and Woodlands Faults generally form the eastern extent of the proposed open-cut pit, while the Whitehaven Fault generally defines the western extent. The average depth of weathering across the site is approximately 24 m.

There are seven coal seams of economic interest within the Project area. The seams generally dip to the east and range in thickness from approximately 0.5 m to greater than 3 m. The Cranleigh (CN) Seam marks the base of the targeted open-cut mining and ranges in depth from 100 to 250 m. The seam names and codes are provided on Table 1 and Figure 3 is a stratigraphic section of the coal measures showing the average depth and thickness of each seam.

Table 1: Economic coal seams of the Maules Creek Formation.

Seam Name		Seam Code
Tralee		
Gundawarra		
Kurrumbede		KUR
Shannon Harbour	Upper	SHU
	Lower	SHL
Stratford	Upper	STU
	Lower	STL
Bluevale	Upper	BLU
	Mid	BLM
	Lower	BLL
Cranleigh	Upper	CNU
	Mid	CNM
	Lower	CNL

BASIN	PERIOD		GROUP/FORMATION	
GUNNEDAH	TRIASSIC	MIDDLE	Napperby Formation	
		EARLY	Digby Formation	
	PERMIAN	LATE	Black Jack Group	
		EARLY	Millie Group	
			Bellata Group	Maules Creek Formation
				Goonbri Formation
				Leard Formation
			Boggabri Volcanics	



Source: Engenicom (2012) and NSW Industry and Investment (2011)

G.E.M. Geo-Environmental Management

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FIGURE 3

Indicative Stratigraphy of the Project Area

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3.0 Geochemical Assessment Program

3.1 Testing Methodology and Program

The laboratory program included the following tests and procedures:

- pH and electrical conductivity (EC) determination;
- total sulfur (S) assay;
- acid neutralising capacity (ANC) determination;
- net acid producing potential (NAPP) calculation;
- single addition net acid generation (NAG) test;
- kinetic NAG test;
- sulfide sulfur (sulfide S) analysis (chromium reducible sulfur [CRS]);
- acid buffering characteristic curve (ABCC) determination;
- exchangeable cation analysis; and
- multi-element scans on solids and water extracts.

The acid-base analyses (total S assays and ANC determinations), NAG testing, sulfide S analyses, ABCC determinations and exchangeable cation analyses were performed by Australian Laboratory Services Pty Ltd (ALS) in Brisbane, and the multi-element analyses were performed by Genalysis Laboratories Pty Ltd in Perth.

An overview of the tests and procedures used for the assessment is presented below.

3.1.1 pH, Salinity and Sodicity Determination

pH and Electrical Conductivity Determination

The pH and EC of a sample is determined by equilibrating a solid sample in deionised water for a minimum of 2 hours. Variations to this test include mixing the solids with water at a ratio of 1:2 or 1:5 by weight (w/w), or as a saturated paste. Typically a ratio of 1:2 is used for providing an indication of the inherent acidity and salinity of a material when it is initially exposed. The salinity rankings based on EC values from 1:5 extracts ($EC_{1:5}$), 1:2 extracts ($EC_{1:2}$) and saturation extracts (EC_{sat}) are provided below:

$EC_{1:5}$ (dS/m)	$EC_{1:2}$ (dS/m)	EC_{sat} (dS/m)	Salinity
< 0.2	< 0.5	< 2.0	Non-Saline
0.2 to 0.3	0.5 to 1.5	2 to 4.0	Slightly Saline
0.3 to 0.4	1.5 to 2.5	3 to 8.0	Moderately Saline
> 0.4	> 2.5	> 8.0	Highly Saline

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 Ca and Mg concentrations. The ESP is used to rank materials according to sodicity and likely dispersion characteristics as shown below:

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

3.1.2 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 maximum potential acidity (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 sulfur 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 kilograms of H_2SO_4 per tonne of material (i.e. 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 sulfur may occur in forms other than pyrite. Sulfate-sulfur and native sulfur, for example, are non-acid generating sulfur forms. Also, some sulfur 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 proportion of total S within a sample that occurs as 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 same units as the MPA, which is kg H_2SO_4/t.

Determination of the ANC using the Modified Sobek[1] method 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. Careful evaluation of 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 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.

[1] Sobek, A.A., Schuller, W.A., Freeman, J.R., and Smith, R.M., 1978. *Field and Laboratory Methods Applicable to Overburdens and Minesoils*., EPA-600/2-78-054, p.p. 47-50.

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 4 is an ABA plot which is commonly used to provide a graphical representation of the distribution of sulfur 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 4 also shows the plotted lines corresponding to ANC/MPA ratios of 2 and 3.

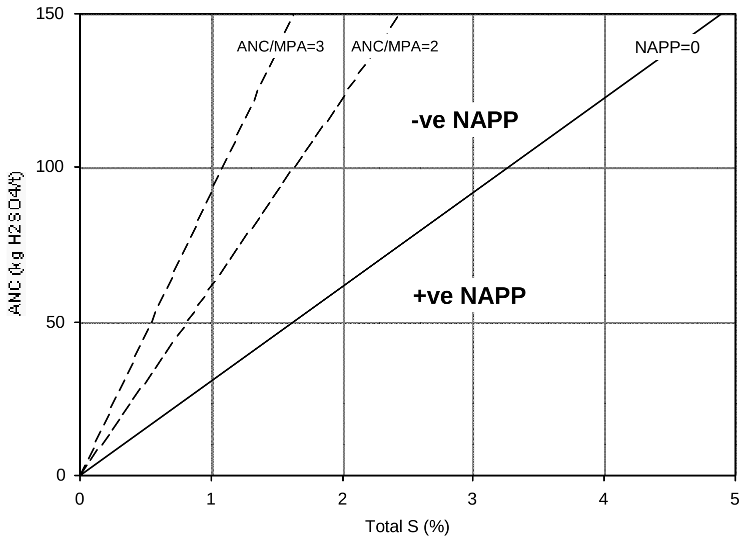


Figure 4: Typical Acid-Base Account Plot.

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 (Al). 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.

3.1.3 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 and revegetation. 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 revegetation, water quality, 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 warrants further investigation.

3.2 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);
- Acid Forming (AF); or
- 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 S 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 ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any 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 acid neutralising capacity 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 usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5.

Acid Forming
A sample classified as AF has the same characteristics as the PAF samples however these samples also have an existing pH of less than 4.5. This indicates that acid conditions have already been developed, confirming the acid forming nature of the sample.

Uncertain

A UC 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 5 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 greater than 4.5, are classified as NAF. Those that plot on the lower right quadrate, with positive NAPP values and NAGpH values of 4.5 or less, are classified as PAF. Samples that plot in the upper right or lower left quadrates of this plot have a UC classification 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.

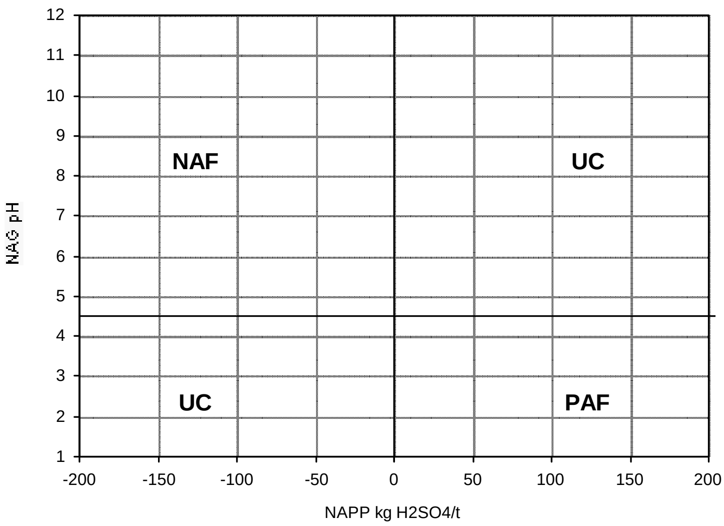


Figure 5: Typical Geochemical Classification Plot.

3.3 Sample Selection and Preparation

The samples for this assessment include overburden, interburden and coal seam samples collected from selected drill-holes throughout the Project area, and coal reject samples, including coarse rejects and fines (tailings), collected from the Whitehaven CHPP. These samples were collected by Whitehaven personnel under instruction from GEM. The sample details are provided in Attachment A.

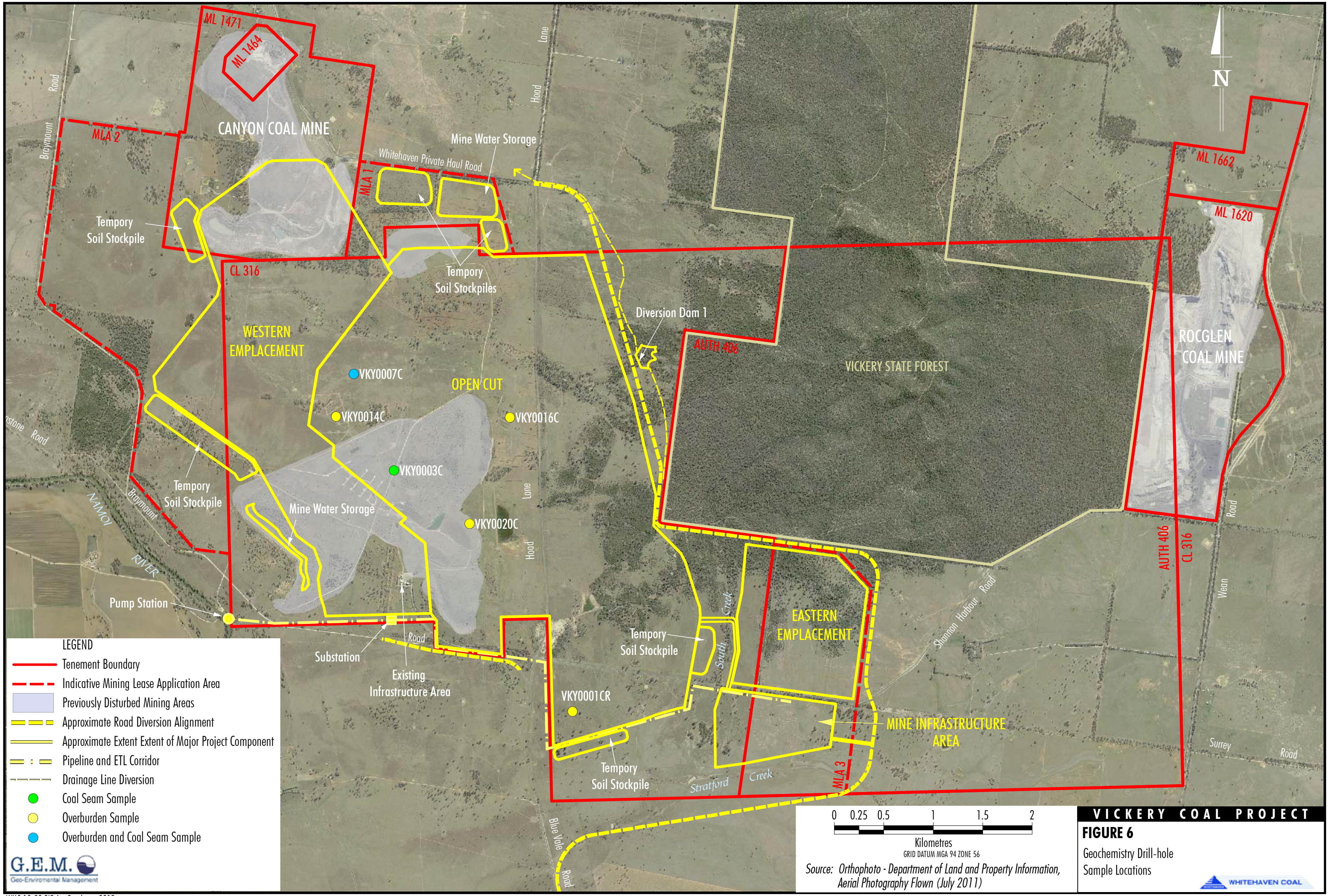
3.3.1 Drill-Hole Samples

A total of 121 drill-hole samples, comprising 107 overburden and interburden samples, and 14 coal seam samples, were provided for inclusion in the geochemical testing program. These samples were collected from 6 drill-holes distributed across the proposed pit area. Figure 6 shows the area limits for the proposed pit and the location of the sampled drill-holes.

Selection of the overburden and interburden sample intervals through each drill-hole was based on the lithology and proximity to the coal seams using the provided stratigraphic drill-logs. The selected sample intervals comprise either strata of discrete lithology or of mixed lithology where the strata were logged as such. The samples were collected continuously through each selected interval providing representative samples of the major overburden and interburden material types occurring within the proposed pit area. However, the majority of the samples collected from the oxidised zone (weathered material) were of insufficient volume for the geochemical testing program and therefore the samples with similar lithology and degree of weathering (highly, moderately and slightly weathered) were combined to produce a number of composite samples representing the different material types through the oxidised zone. The individual drill-hole intervals used to produce the composite samples are provided in Attachment A (Table A-6).

Coal seam samples from the Project had previously been collected by Whitehaven for coal quality test work conducted by ALS in Mayfield (Coal Division). Excess sample material from this program was provided to GEM for geochemical characterisation testing. This program involved the compositing of a number of interval samples from each seam in order to produce representative samples of the different coal seams. The sample intervals and coal seams sampled for this program are provided in Attachment A (Table A-7).

The overburden, interburden and coal seam drill-hole samples were sent to ALS in Brisbane for preparation where they were crushed to minus 4 millimetres (mm) and a 200 gram (g) split was pulverised to minus 75 micrometres (µm) prior to testing.



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3.3.2 Coal Reject Samples

The coal reject samples included 10 samples of the coarse reject and 5 samples of the fines (tailings) collected from the Whitehaven CHPP over a period of several weeks in order to obtain a representative range of geochemical material types. These samples were collected by Whitehaven personnel and it is understood that the coarse reject samples were collected as grab samples from the consolidated stockpiles and the fines samples were collected directly from the fines settling ponds. These samples were sent direct to ALS in Brisbane for preparation which involved drying the samples and taking a 200 g split for pulverising to minus 75 µm prior to testing.

4.0 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. Summaries of the $pH_{(1:2)}$ and $EC_{(1:2)}$, acid-base characteristics and NAG test results for the different overburden and interburden material types are provided on Table 2.

4.1 pH, Salinity and Sodicity

Apart from 1 sample (VCM14/21) which has a moderately acidic $pH_{1:2}$ value of 4.8, the overburden and interburden samples range from slightly acidic to moderately alkaline with $pH_{1:2}$ values of 6.2 to 9.3. The median pH of these samples is moderately alkaline with a $pH_{1:2}$ value of 8.4.

The $EC_{1:2}$ values range from 0.073 to 1.348 dS/m indicating that the overburden and interburden represented by these samples is expected to range from non-saline to slightly saline. The majority of the samples (92%) are classified as non-saline with $EC_{1:2}$ values less than 0.5 dS/m and only 9 of the samples (8%) are classified as slightly saline with $EC_{1:2}$ greater 0.5 dS/m. The slightly saline materials include samples of the highly weathered material, conglomerate, mudstone, and mixed lithology samples of the conglomerate/sandstone and carbonaceous mudstone/mudstone. However, only 3 of the samples have $EC_{1:2}$ values greater than 1.0 dS/m and these include the 2 highly weathered samples (VCM/Comp2 and VCM/Comp4) and the previously identified moderately acidic mudstone sample (VCM14/21) with a $pH_{1:2}$ value of 4.8. All of the moderately and slightly weathered samples are classified as non-saline.

Twenty-five of the overburden and interburden samples were selected for exchangeable cation analysis and determination of the ESP in order to assess the sodicity risk presented by the different overburden and interburden material types. The results from these analyses are provided in Attachment B (Table B-7).

Figure 7 is a plot of the ESP values compared to the $EC_{1:2}$ values showing the salinity and sodicity ranking for the different overburden and interburden material types. This plot shows that the selected samples range from non-sodic to highly sodic with ESP values ranging from 2.8 to 70.1 %. The majority of the samples (i.e. 14 samples or 56%) are slightly sodic, with 3 samples (12%) being non-sodic, 4 samples (16%) being moderately sodic and 4 samples (16%) being highly sodic. The moderately and highly sodic materials were not restricted to any particular material types and included samples of the moderately weathered material, siltstone, conglomerate, mudstone, carbonaceous mudstone, and mixed lithology samples.

Table 2: Summary of the pH, EC, acid-base characteristics and NAG test results for the overburden and interburden drill-hole samples.

Material Type		**$pH_{1:2}$***	**$EC_{1:2}$ (dS/m)**	**Total S (%S)**	**MPA (kg H_2SO_4/t)**	**ANC (kg H_2SO_4/t)**	**NAPP (kg H_2SO_4/t)**	**NAGpH**
Highly Weathered	*Min*	8.2	1.006	0.02	1	18	-31	9.2
(2 samples)	*Max*	8.3	1.014	0.02	1	31	-17	9.9
	Average	8.3	1.010	0.02	1	25	-24	9.6
Moderately Weathered	*Min*	6.8	0.233	0.01	0	4	-15	6.6
(5 samples)	*Max*	9.0	0.388	0.06	2	17	-2	9.3
	Average	8.2	0.300	0.03	1	7	-7	7.6
Slightly Weathered	*Min*	6.2	0.153	0.01	0	5	-10	6.2
(5 samples)	*Max*	8.6	0.330	0.06	2	10	-3	8.4
	Average	6.5	0.249	0.03	1	6	-5	6.9
Conglomerate	*Min*	6.5	0.158	0.01	0	7	-55	7.7
(19 samples)	*Max*	9.2	0.639	0.28	9	56	-5	11.0
	Average	8.3	0.334	0.06	2	29	-27	9.8
Mudstone	*Min*	4.8	0.113	0.03	1	7	-16	2.2
(10 samples)	*Max*	9.2	1.348	2.10	64	18	51	9.4
	Average	8.2	0.345	0.41	13	10	3	7.0
Sandstone	*Min*	7.2	0.073	0.02	1	4	-109	5.4
(21 samples)	*Max*	9.3	0.372	0.32	10	110	-1	10.9
	Average	8.5	0.211	0.06	2	37	-35	9.5
Siltstone	*Min*	7.4	0.077	0.06	2	5	-11	3.7
(3 samples)	*Max*	8.9	0.206	0.11	3	13	-2	7.4
	Average	8.2	0.137	0.08	2	10	-7	6.7
Carb. Mudstone	*Min*	7.7	0.081	0.02	1	5	-104	5.7
(5 samples)	*Max*	9.1	0.361	0.12	4	107	-4	9.8
	Average	8.7	0.226	0.07	2	30	-27	7.2
Acid Volcanic	*Min*	8.3	0.215	0.14	4	102	-133	10.9
(2 samples)	*Max*	8.4	0.245	0.17	5	137	-97	11.2
	Average	8.4	0.230	0.16	5	120	-115	11.1
Conglomerate/	*Min*	6.3	0.079	0.01	0	4	-71	2.8
Sandstone/Siltstone	*Max*	9.2	0.718	1.12	34	76	18	10.8
(26 samples)	*Average*	8.5	0.250	0.14	4	28	-23	8.9
Carb. Mudstone/	*Min*	6.9	0.110	0.04	1	5	-37	4.2
Mudstone/Siltstone	*Max*	9.2	0.520	0.11	3	39	-1	9.2
(9 samples)	*Average*	8.9	0.245	0.07	2	15	-13	8.1
All Samples	*Min*	4.8	0.073	0.01	0	4	-133	2.2
(107 Samples)	*Max*	9.3	1.348	2.10	64	137	51	11.2
	Average	8.4	0.277	0.11	3	26	-23	8.3

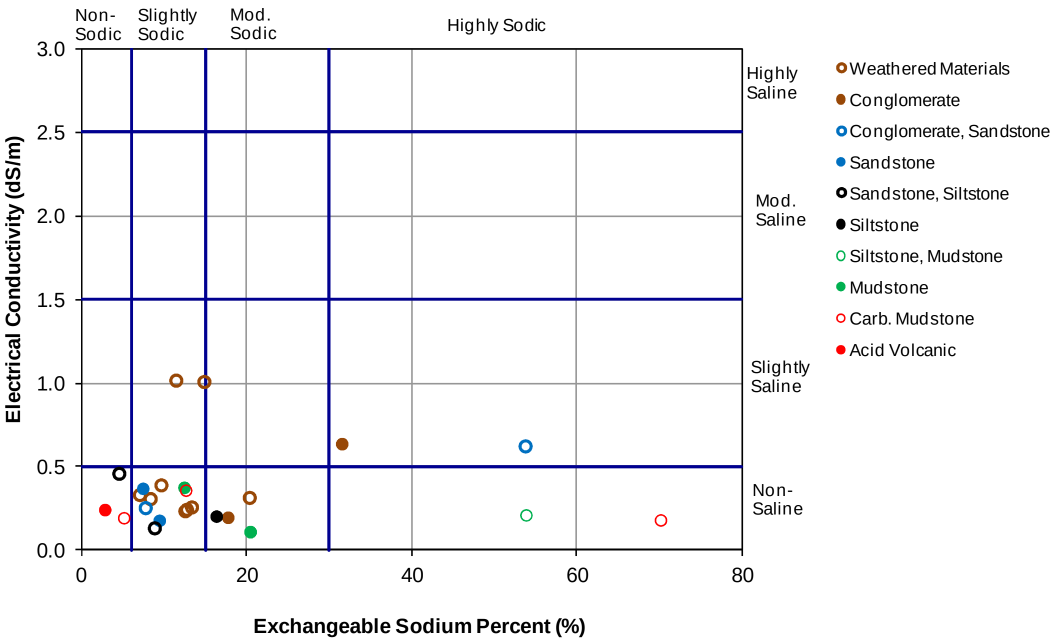

Figure 7: Salinity and Sodicity Ranking for Selected Overburden and Interburden Drill-Hole Samples.

4.2 Acid Forming Characteristics

The total S content of the overburden and interburden samples ranges from 0.01 to 2.10%S with an average of only 0.11%S. The majority of the samples have a relatively low sulfur content with 86 samples (80%) having a total S content of less than 0.1%S and only 3 samples (3%) having a content greater than 1.0%S.

Eight samples, ranging in total S content from 0.11 to 2.10%S, were selected for sulfide S analysis (Tables B-2 to B-6 in Attachment B). The sulfide S content of these samples ranges from 0.016 to 0.827%S and the proportion of the total S that occurs as sulfide S is relatively low ranging from 3 to 66%. These results indicate that a relatively high proportion of the contained sulfur in the higher sulfur samples (i.e. total S content > 0.1%S) occurs in a non-sulfide form (e.g. sulfate).

The ANC of the overburden and interburden samples varies widely from 4 to 137 kg H_2SO_4/t with an average of 26 kg H_2SO_4/t. The majority of the samples (57%) have a moderate ANC (10 to 50 kg H_2SO_4/t) while 27% of the samples have a low ANC (i.e. < 10 kg H_2SO_4/t) and only 16 % of the samples have a relatively high ANC (i.e. > 50 kg H_2SO_4/t). The higher ANC samples (i.e. > 50 kg H_2SO_4/t) typically include the acid volcanics, sandstone and mixed lithology sandstone samples, and less commonly include the conglomerate and carbonaceous mudstone samples.

Figure 8 is a plot of the total S content compared to the ANC for the different overburden and interburden material types. Samples that plot above the NAPP = 0 (ANC/MPA = 1) line are NAPP negative, indicating an excess in acid buffering capacity over potential acidity. Samples that plot above the ANC/MPA=2 line have at least a two-fold excess in acid buffering over acid potential and those that plot above the ANC/MPA=3 line have a three-fold excess. This plot shows that the majority of the samples (96%) are NAPP negative and that 87% of the samples have ANC/MPA ratios of 3 or greater. Four of the samples, including two mudstone samples (VCM14/8 and VCM14/21), a sandstone/siltstone sample (VCM16/21) and a conglomerate/sandstone sample (VCM20/17), are NAPP positive with NAPP values ranging from 15 to 51 kg H_2SO_4/t.

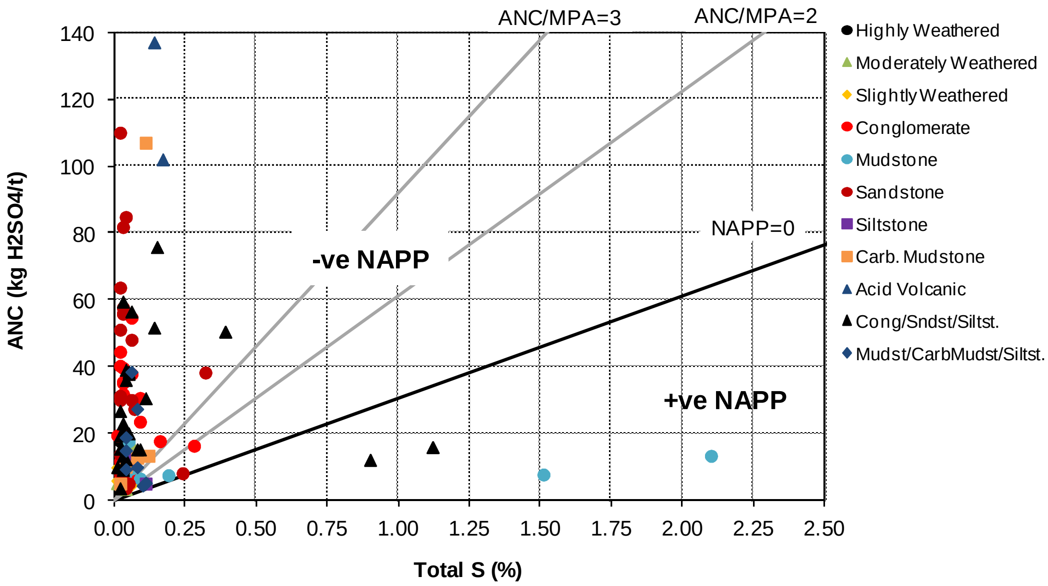

Figure 8: Acid-Base Account Plot for the Different Overburden and Interburden Material Types.

The single addition NAG test results indicate that the majority of the samples (94%) have NAGpH values of 4.5 or greater and that 7 of the samples (6%) have NAGpH values below 4.5 (Tables B-2 to B-6 in Attachment B). Figure 9 is a geochemical classification plot where the NAPP values are compared to the NAGpH values for the different overburden and interburden material types. This plot shows that the majority of the samples plot in the upper left quadrate with negative NAPP values and NAGpH values greater than 4.5, and these samples are confirmed as NAF. Only 4 of the samples tested plot in the lower right quadrate with positive NAPP values and NAGpH values less than 4.5, and these samples are confirmed as PAF. Three samples plot in the lower left quadrate with slightly negative NAPP values (-2 kg H_2SO_4/t) and NAGpH values less than 4.5, and these samples have an UC geochemical classification.

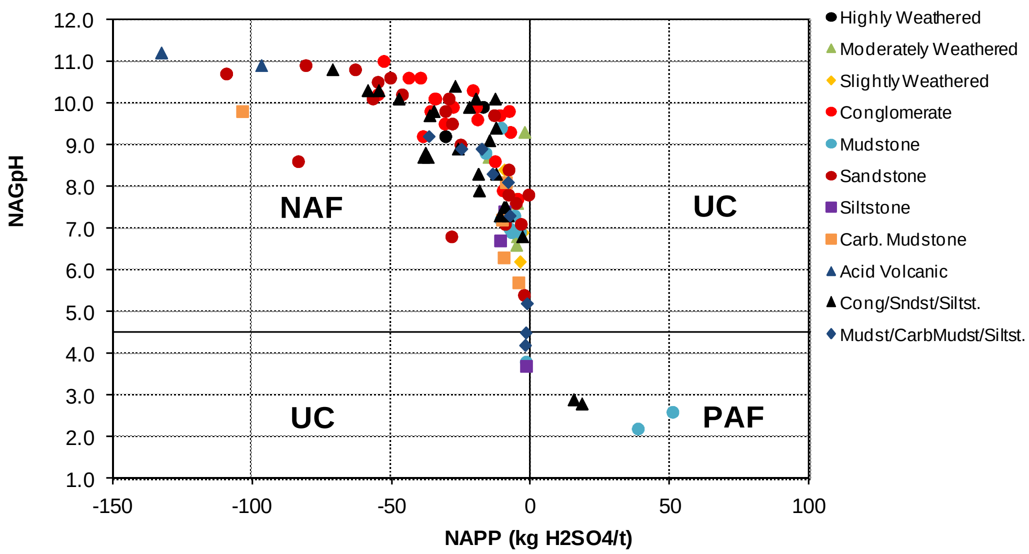

Figure 9: Geochemical Classification Plot for the Different Overburden and Interburden Material Types.

The 3 samples with an UC geochemical classification include 1 sample of siltstone (VCM16/12), 1 sample of mudstone (VCM7/27) and 1 sample of carbonaceous mudstone (VCM14/23). These samples have ANC values ranging from 5 to 8 kg H_2SO_4/t and the ABCC results for these samples, provided in Attachment C (Figures C-1 to C-3), indicate a range in the proportion of available ANC. Samples VCM16/12 and VCM14/23 have total ANC values of 5 kg H_2SO_4/t and the ABCC results indicate an available ANC of less than 2 kg H_2SO_4/t for both of these samples. Whereas sample VCM7/27 has a total ANC of 8 kg H_2SO_4/t and the ABCC results indicate that all of this is likely to be available to neutralise sulfide generated acidity. Based on these results and the sulfide S content of these samples, it is expected that the 3 UC samples are PAF. However, the NAPP values and NAG test results indicate that the materials represented by these samples only have a low capacity to generate acid (i.e. 1 to 3 kg H_2SO_4/t) and therefore these samples are expected to be PAF Low Capacity (i.e. PAF/LC),

The samples classified as PAF include 2 samples of mudstone, and 1 sample each of the mixed lithology conglomerate/sandstone and sandstone/siltstone. The mudstone samples (VCM14/8 and VCM14/21) have NAPP values of 38 and 51 kg H_2SO_4/t, and $NAG_{(pH4.5)}$ capacity values of 44 and 35 kg H_2SO_4/t, respectively. Whereas the conglomerate/sandstone (VCM20/17) and sandstone/siltstone (VCM16/21) samples have NAPP values of 18 and 15 kg H_2SO_4/t, and $NAG_{(pH4.5)}$ capacity values of 8 and 9 kg H_2SO_4/t, respectively.

These results indicate relative consistency between the NAPP values and $NAG_{(pH4.5)}$ capacity results and confirm that the PAF mudstone samples have a relatively high capacity to generate acid (approx. 40 kg H_2SO_4/t) while the PAF mixed lithology samples have a significantly lower capacity to generate acid (approx. 8 kg H_2SO_4/t).

The identified PAF mudstone strata occur as roof rock to the SHU seam and as interburden of the Bluevale (BL) and CN seams, and the PAF conglomerate/sandstone and sandstone/siltstone strata occur as roof rock to the STF and STL seams. The identified PAF/LC strata occur as floor rock to the SHU and CNL seams and as roof rock to the CNU seams. However, the occurrence of the identified PAF and PAF/LC strata as roof and floor rock, and interburden of the various seams was not found to be continuous across the site.

Kinetic NAG tests were conducted on the PAF mudstone sample (VCM14/21), and the PAF/LC mudstone (VCM/7/27), siltstone (VCM16/12) and carbonaceous mudstone (VCM14/23) samples, and the temperature and pH profiles for these tests are provided in Attachment D (Figures D-1 to D-4). These profiles show that, although there were no evident temperature peaks throughout the 6 hour monitoring period for any of the samples, the pH of the NAG liquor for the PAF mudstone sample (Figure D-1) decreased to below 3.5 within 15 minutes. These results indicate that the PAF mudstone material is likely to be relatively reactive with a short geochemical lag period and it is expected that acid conditions could develop within weeks of exposure of this material to atmospheric oxidation. The reactive nature and short geochemical lag period of this material is also evident from the low pH of the water extract ($pH_{1:2}$ value of 4.8) reported for sample VCM14/21.

The pH of the NAG liquors from the PAF/LC samples remained above 4.5 throughout the monitoring period and it is expected that the materials represented by these samples are only slow reacting with relatively long geochemical lag periods. Based on these results it is expected that acid conditions would only develop if these materials were left exposed to atmospheric oxidation for a period ranging from a year to a number of years.

4.3 Metal Enrichment and Solubility

Twenty samples, including 3 samples from the oxidised zone (weathered rock) and 17 samples from below the oxidised zone (fresh rock), were selected for multi-element analyses based on their stratigraphic location, lithology and geochemical characteristics. The results from these analyses and the geochemical abundances indices for the selected samples are provided in Attachment B.

These results indicate that arsenic (As) is significantly enriched, and boron (B) and antimony (Sb) are slightly enriched in a number of the fresh rock samples compared to the average crustal abundance of these elements. Additionally B and selenium (Se) are significantly enriched and As is slightly enriched in 1 or more of the weathered rock samples. The enrichment of As, Sb and Se compared to average crustal abundances is a relatively common characteristic of coal deposits of this region. The concentration ranges and average crustal abundance of these elements are summarised in Table 3.

Table 3: Concentration range and average crustal abundance for enriched elements in selected overburden and interburden drill-hole samples.

Element	*Average Crustal Abundance (mg/kg)	Concentration Range (mg/kg)	
		Weathered Rock	Fresh Rock
As	1.5	7.3 to 8.9	2.1 to 30.8
B	10	<50 to 424	<50 to 66
Sb	0.2	0.54 to 0.82	0.46 to 1.37
Se	0.05	0.09 to 0.45	0.02 to 0.19

mg/kg = milligrams per kilogram *Bowen (1979)

Multi-element scans were performed on the water extracts (1 part sample/2 parts deionised water) from the selected overburden and interburden samples in order to provide an indication of relative element solubility in these materials under the existing pH conditions. The results from these scans are presented in Attachment B and indicate that Al, As, molybdenum (Mo) and Se are relatively soluble under the quasi-neutral to moderately alkaline test pH conditions. Although enriched to varying degrees in some of the overburden and interburden samples, B and Sb were not found to be readily soluble in the samples tested. The concentration ranges of Al, As, Mo and Se are compared to Australian and New Zealand Environment Conservation Council (ANZECC) irrigation water quality guidelines (ANZECC, 2000) in Table 4 in order to provide an indication of the relative solubility of these elements.

Table 4: Concentration ranges and ANZECC (2000) irrigation water quality guideline values for readily soluble elements in selected overburden and interburden drill-hole samples.

Element	Units	Concentration Range	Irrigation Water Quality Guideline (ANZECC, 2000)	
			Short-Term Exposure	Long-Term Exposure
Al	mg/L	0.3 - 11.37	20	5
As	µg/L	3.2 - 73.1	2000	100
Mo	µg/L	0.56 - 94.81	50	10
Se	µg/L	1.0 - 95.9	50	10

mg/L = milligrams per litre

µg/L = micrograms per litre

These results indicate that the dissolved Al concentrations exceed the long-term exposure guidelines and the dissolved Se concentrations exceed both the short-term and long-term exposure guidelines in a number of the weathered and fresh rock samples. The dissolved Mo concentrations also exceed the short-term and long-term exposure guidelines, but only in the fresh rock samples. Although relatively soluble in the majority of the samples, the dissolved As concentrations do not exceed the short-term or long-term exposure guidelines in any of these samples.

One of the mudstone samples analysed (VCM14/21) is classified as PAF and has a water extract pH of 4.8. The multi-element composition of the water extract from this sample provides an indication relative element solubility if acid conditions are allowed to develop in this material (Attachment B, Table B-8). These results indicate that, as expected, the solubility of most of the contained metals increases, with significant increases in cobalt (Co), nickel (Ni), lead (Pb) and zinc (Zn) solubility expected. However, these results also indicate the deceased solubility of Al and Mo under the decreased pH conditions of this sample (pH 4.8) compared to the quasi-neutral to moderately alkaline pH conditions of the other samples (pH 6.2 to 9.1).

5.0 Coal and Coal Reject Geochemistry

The geochemical test results for the coal seam and 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 $EC_{(1:2)}$, acid-base characteristics and NAG test results for the coal seam, coarse rejects and fines are provided on Table 5.

Table 5: Summary of the pH, EC, acid-base characteristics and NAG test results for the coal seam and coal reject samples.

Material Type		$pH_{1:2}$*	$EC_{1:2}$ (dS/m)	Total S (%S)	Sulfide S	MPA (kg H_2SO_4/t)	ANC	NAPP	NAGpH	NAG (pH4.5)	NAG (pH7.0)
Coal Seam**	*Min*	4.2	0.208	0.07	0.019	2	2	-93	2.4	0	0
	Max	8.3	0.710	1.05	0.356	32	95	27	10.2	112	168
14 samples	*Aver.*	7.7	0.403	0.45	0.104	14	20	-6	3.4	31	52
Coarse Rejects***	*Min*	6.8	0.337	0.18	0.065	6	3	-14	2.0	0	0
	Max	8.1	0.698	3.49	3.120	107	20	104	7.8	57	88
10 samples	*Aver.*	7.6	0.457	0.58	0.436	18	11	6	5.8	6	12
Fines***	*Min*	7.8	0.493	0.35	0.056	11	4	-9	2.4	0	1
	Max	8.4	2.046	0.44	0.122	13	21	7	6.2	103	169
5 samples	*Aver.*	8.0	1.276	0.39	0.091	12	15	-3	5.4	21	36

* Average pH and NAGpH values reported are median values.

** Samples taken from the Project coal deposit.

*** Samples taken from the existing Whitehaven CHPP and are considered likely to be representative of the rejects that would be generated during the life of the Project.

5.1 pH and Salinity

The coal seam samples range from acidic to slightly alkaline with $pH_{1:2}$ values ranging from 4.2 to 8.3. Three of the samples are acidic with $pH_{1:2}$ values below 4.5, including samples from the SHU, SHL and STU/L seams. The $EC_{1:2}$ values range from 0.208 to 0.710 dS/m indicating that the seams represented by these samples are likely to range from non-saline to slightly saline. The majority of the samples are non-saline with $EC_{1:2}$ values of less than 0.5 dS/m and only 3 of the samples are slightly saline with $EC_{1:2}$ greater 0.5 dS/m. The slightly saline materials include samples from the SHL and BLU/M seams.

The coarse reject samples range from pH neutral to slightly alkaline with $pH_{1:2}$ values ranging from 6.8 to 8.1 and the fines samples are slightly alkaline with $pH_{1:2}$ values of 7.8 to 8.4. The $EC_{1:2}$ values range from 0.337 to 0.698 dS/m for the coarse rejects indicating that the materials represented by these samples are likely to range from non-saline to slightly saline. However, the $EC_{1:2}$ values for the fines samples are significantly higher ranging from 0.493 to 2.046 dS/m and indicating a range in the salinity of this material from slightly to moderately saline.

5.2 Acid Forming Characteristics

The total S content of the coal seam samples ranges from 0.07 to 1.05%S with the majority of the samples (79%) having a content of between 0.35 and 0.55%S. However, the sulfide S contents are significantly lower, ranging from 0.019 to 0.356%S. The proportion of total S occurring as sulfide in these samples ranges from 5 to 37% indicating that most of the sulfur in these samples occurs in a non-sulfide form, such as sulfate or organic sulfur.

The total S content of the coal reject samples generally ranges from 0.18 to 0.38%S with one of the samples (CR7) having a significantly higher content of 3.49%S. The sulfide S content of these samples ranges from 0.065 to 0.184%S indicating that 40 to 60% of the contained sulfur in these samples typically occurs as sulfide. The high sulfur sample (CR7) has a sulfide S content of 3.12%S indicating that most 89% of the contained sulfur occurs as sulfide. The total S content of the fines samples is relatively consistent ranging from 0.35 to 0.44%S. However, the sulfide S contents are significantly lower with contents ranging from 0.056 to 0.122%S indicating that only 16 to 31% of the contained sulfur occurs as sulfide.

The ANC of the coal seam samples varies widely from a low of 2 to a high of 95 kg H_2SO_4/t. The distribution of ANC values is bimodal with one population having relatively low values ranging from 2 to 7 kg H_2SO_4/t and the other population having moderate to high values ranging from 26 to 95 kg H_2SO_4/t. The ANC of the coarse reject samples ranges from a low of 3 to a moderate value of 20 kg H_2SO_4/t. The ANC of the fines is generally moderate, ranging from 10 to 21 kg H_2SO_4/t, apart from one sample (F5) which has a relatively low ANC of 4 kg H_2SO_4/t.

Figure 10 is a plot of the total S content compared to the ANC for the coal seam, coarse reject and fines samples. This plot shows that a number of samples of each material type are NAPP positive, including 8 (57%) of the coal seam samples, 3 (30%) of the coarse reject samples and 2 (40%) of the fines samples. The NAPP positive coal seam samples are restricted to the identified population of low ANC samples and the NAPP values for these samples range from 4 to 27 kg H_2SO_4/t. The NAPP positive coarse reject samples comprise the identified high sulfur sample (CR7), with a NAPP of 104 kg H_2SO_4/t, and 2 other samples (CR1 and CR2), both with a NAPP value of 2 kg H_2SO_4/t.

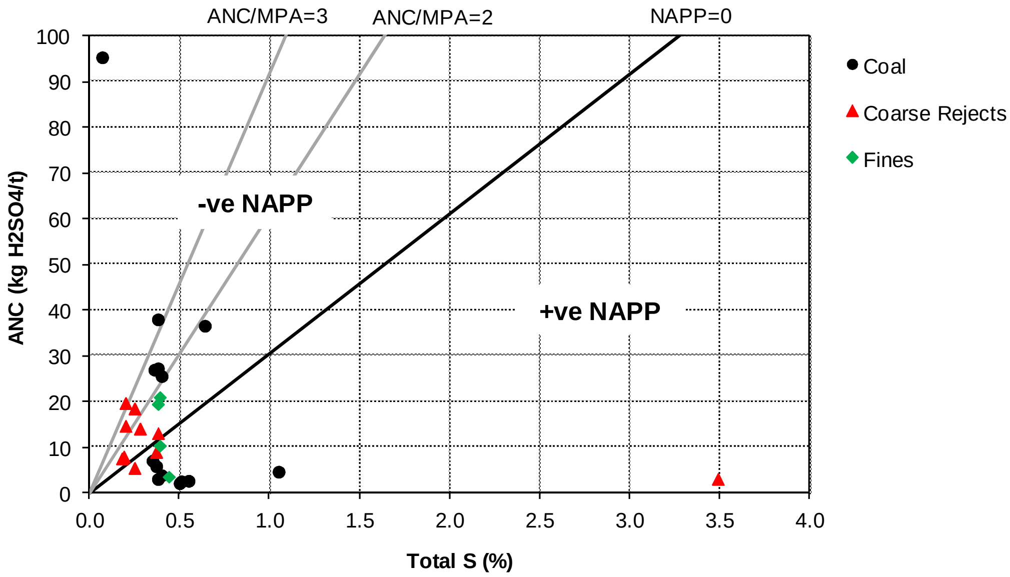

Figure 10: Acid-Base Account Plot for the Coal Seam and Coal Reject Samples.

The single addition NAG test results indicate that a number of samples of each material type have NAGpH values of less than 4.5, including 8 of the coal seam samples, 4 of the coarse reject samples and 1 of the fines samples. Figure 11 is a geochemical classification plot where the NAPP values are compared to the NAGpH values for these samples. This plot shows that the majority of the samples either plot in the upper left quadrate and are confirmed to be NAF, or in the lower right quadrate and are confirmed to be PAF. However, one of the fines samples (F4) plots in the upper right quadrate being borderline NAPP positive with a NAGpH of 4.6 and this sample has a UC classification. This sample has a NAPP of -7 kg H_2SO_4/t when calculated using the sulfide S content and therefore it is expected that this sample is NAF. Additionally, one of the coarse reject samples (CR4) plots in the lower left quadrate being borderline NAPP negative with a NAGpH of 4.4 and this sample also has an UC classification. This sample remains borderline NAPP negative when calculated using the sulfide S content and, based on the NAGpH of 4.4, it is expected that this sample is PAF.

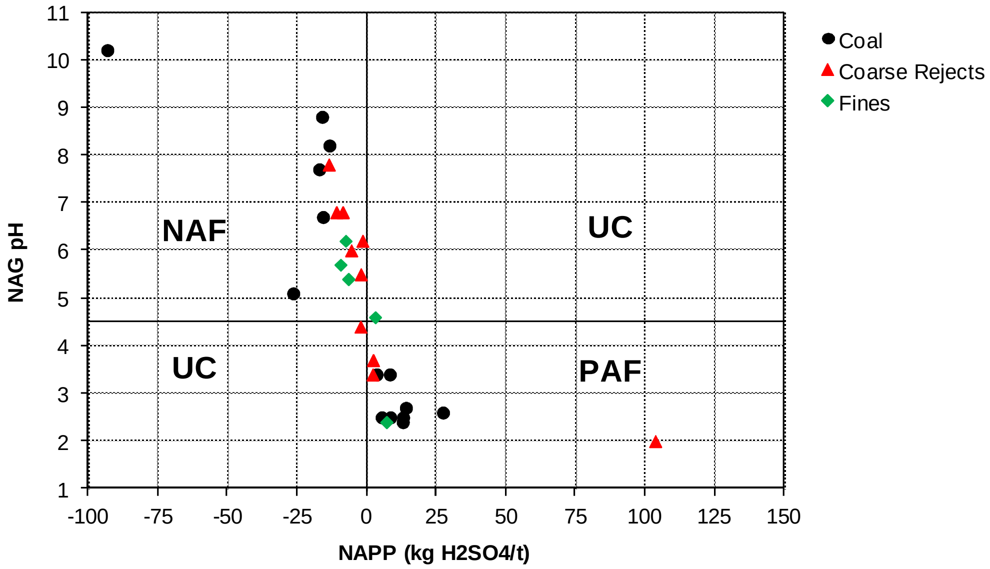

Figure 11: Geochemical Classification Plot for the Coal Seam and Coal Reject Samples.

The ABA and NAG test results indicate that 8 of the coal seam samples are PAF and these samples, representing the KUR, SHU, SHL, STU/L, BLU, BLU/M and BLL seams, have $NAG_{(pH4.5)}$ capacities ranging from 5 to 112 kg H_2SO_4/t.

The majority of the coarse reject samples (6 samples) are classified as NAF. However, one sample (CR7) with an anomalously high sulfur content is classified as PAF and has a $NAG_{(pH4.5)}$ capacity of 57 kg H_2SO_4/t. The remaining 3 samples (CR1, CR2 and CR4) are classified as PAF with a low capacity to generate acid (i.e. PAF/LC) of < 5 kg H_2SO_4/t.

The majority of the fines samples (4 samples) have moderate ANC values (10 to 21 kg H_2SO_4/t) and are classified as NAF. However, one of these samples (F5) has a relatively low ANC (4 kg H_2SO_4/t) and this sample is classified as PAF.

Kinetic NAG tests were conducted on the PAF fines sample (F/5) and 3 of the coarse reject samples, including 2 PAF/LC samples (CR/1 and CR/4) and 1 PAF sample (CR/7). The temperature and pH profiles for these samples are provided in Attachment D (Figures D-5 to D-8). The profiles for the PAF coarse reject sample (Figure D-7) show a sharp temperature peak at 30 minutes and a dramatic pH decrease within the first 10 minutes indicating that this sample is highly reactive. These trends indicate that the material represented by this sample has a short geochemical lag period and acid conditions would be expected to develop within weeks of exposure to atmospheric oxidation.

The profiles for the PAF/LC coarse reject samples (Figures D-5 and D-6) and the PAF fines sample (Figure D-8) do not show a temperature peak and show a relatively gradual decrease in pH indicating that these samples are only slow reacting. Based on these profiles it is expected that the material types represented by these samples are expected to have a relatively long geochemical lag periods and acid conditions would only be expected to occur if these material types were left exposed to atmospheric oxidation for a period of several months to a number of years.

5.3 Metal Enrichment and Solubility

Multi-element scans were performed on the solids and water extracts (1 part solid/ 2 parts deionised water) for all of the coal seam samples, 3 selected coarse reject samples (CR1, CR7 and CR8) and 2 selected fines samples (F2 and F5). The results of these scans and the geochemical abundance indices are provided in Attachment B (Tables B-12, B-13 and B-14). These results indicate the significant enrichment of B in one of the coal seam samples and the slight enrichment of As, B, mercury (Hg), Sb and Se in a number of the samples. These results also indicate the significant enrichment of As, B, Hg and Se in one of the coarse reject samples and the slight enrichment of As, B, Sb and Se in the other coarse reject samples and the fines samples. The concentrations of these enriched elements and the respective average crustal abundances are provided for the different material types on Table 6.

Table 6: Concentration range and average crustal abundance for enriched elements in the coal seam, and selected coarse rejects and fines samples.

Element	*Average Crustal Abundance (mg/kg)	Concentration Range (mg/kg)		
		Coal Seam	Coarse Reject	Fines
As	1.5	<0.5 to 9.8	4.2 to 40.4	2.1 to 3.8
B	10	<50 to 90	74 to 95	73 to 77
Hg	0.05	<0.001 to 0.367	0.039 to 0.480	0.027 to 0.070
Sb	0.2	0.09 to 0.30	0.39 to 1.58	0.31 to 1.08
Se	0.05	0.09 to 0.30	0.18 to 0.52	0.20 to 0.22

*Bowen(1979)

The results of the multi-element scans performed on the water extracts indicate a range in pH values from 4.2 to 8.3 for the coal seam samples, and from 6.8 to 8.1 for the coarse reject and fines samples. These results indicate that As, Mo and Se are relatively soluble in the coal seam samples with a quasi-neutral to moderately alkaline pH (i.e. pH >6), and that Mo and Se are also relatively soluble in the coarse reject and fines samples.

The concentration ranges of these elements are compared to ANZECC (2000) irrigation water quality guidelines in Table 7 in order to provide an indication of the relative solubility of these elements. Although enriched to varying degrees in some of the coal seam, coarse reject and fines samples, B, Hg and Sb were not found to be readily soluble in the samples tested.

Table 7: Concentration ranges and ANZECC (2000) irrigation water quality guideline values for readily soluble elements in the coal seam and selected coarse reject and fines samples.

Element	Units	Concentration Range			Irrigation Water Quality Guideline (ANZECC, 2000)	
		Coal Seam	Coarse Rejects	Fines	Short-Term Exposure	Long-Term Exposure
As	µg/L	1.5 – 21.2	2.9 – 4.6	1.1 – 3.7	2000	100
Mo	µg/L	0. 5 – 500.5	6.29 – 45.42	59.05 – 63.91	50	10
Se	µg/L	6.8 – 46.0	8.9 – 30.7	4.4 – 11.5	50	10

These results indicate that, although relatively soluble in a number of the samples, the dissolved As concentrations do not exceed the short-term or long-term exposure guidelines in any of the selected samples. However, the dissolved Se concentrations exceed the long-term exposure guidelines in a number of the coal seam, coarse rejects and fines samples, and the dissolved Mo concentrations exceed both the long-term and short-term exposure guidelines in these samples.

The water extracts from a number of the PAF coal seam samples have acidic to slightly acidic pH values ranging from 4.2 to 5.6. These samples are characterised by the increased solubility of Be, Cd, Co, Ni, Pb and Zn, and the decreased solubility of Mo compared to the coal seam samples with a quasi-neutral to moderately alkaline pH (i.e. pH >6).

6.0 Conclusions and Recommendations

6.1 Overburden and Interburden

The overburden and interburden that will be excavated as waste rock will be disposed within two dedicated surface waste rock emplacements as well as being used to back-fill mined out areas of the proposed pit. A total of 107 drill-hole samples representing the overburden and interburden from throughout the proposed pit area were geochemically characterised for this assessment.

The results of this assessment indicate that the overburden and interburden generally has a low sulfur content and is expected to be NAF with a low salinity risk. Although the bulk of the overburden and interburden is expected to be relatively barren, a small quantity of the strata contains increased sulfur concentrations and these materials present a risk of being PAF. The identified PAF strata typically occur as non-continuous units of mixed (finely interbedded) lithology located immediately adjacent to some of the coal seams (i.e. roof and floor rock) and most of these materials are expected to only have a low capacity to generate acid (<10 kg H_2SO_4/t). These materials are also expected to have a relatively long geochemical lag period and acid conditions are only likely to develop if these materials are left exposed to atmospheric oxidation for a period ranging from a year to a number of years. However, it is also expected that some of the mudstone interburden will be PAF, due to increased sulfur concentrations, and this material has a significantly higher capacity to generate acid (40 kg H_2SO_4/t). These investigations indicate that this material type is likely to occur as roof rock to the Shannon Harbour and Cranleigh Seams. This material is expected to have a relatively short geochemical lag period, and acid conditions are likely to develop within weeks of exposure of this material to atmospheric oxidation.

This assessment also indicates the presence of sodic materials within the overburden and interburden. Although the majority of the overburden and interburden is expected to be non- or slightly sodic a relatively small amount of this material is expected to be moderately to highly sodic. Moderate to high sodicity was identified within most of the different material types sampled including the weathered and fresh siltstone, conglomerate, mudstone, carbonaceous mudstone, and mixed lithology materials. If the identified sodic materials are left exposed on the final dump surfaces they may become highly dispersive with the potential of causing problems with dump stability and increased erosion potential.

The overburden and interburden is typically expected to contain significantly enriched concentrations of As and slightly enriched concentrations of B, Sb and Se compared to the average crustal abundance of these elements. Under the prevailing quasi-neutral to moderately alkaline pH conditions of the overburden and interburden Al, As, Mo and Se are expected to be readily soluble. If acid conditions are allowed to develop in these materials is expected that the resulting decrease in pH would cause an increase in the solubility of the contained elements including As, Co, Ni, Pb, Se and Zn.

Based on these findings the following recommendations are made:

1. Although the overall ROM blended waste rock (overburden and interburden) is expected to be NAF, the management strategy will need to ensure that the identified PAF overburden and interburden is not left exposed within the final surfaces of the waste rock emplacements. It is therefore recommended that no PAF materials are placed within the outer 10 m (i.e. final lift) of the final surfaces or within the outer 10 m of the basal footprint for each emplacement. In order to conservatively identify the PAF overburden and interburden for selective placement within the emplacements it is recommended that the mudstone and the strata occurring within 1 m of the coal seams (i.e. immediate roof and floor rock) be treated as PAF. It is also recommended that any sub-economic coal that will report to the waste rock emplacements be treated as PAF material. If there is a requirement to refine these general management strategies to reduce the quantity of material treated as PAF, it is recommended that a detailed geochemical characterisation program targeted at the mudstone be undertaken in order to identify the NAF and PAF strata ahead of mining.

2. In order to ensure long-term stability and erosion control for the waste rock emplacements the final surfaces (top and batter slopes) will need to be treated with gypsum and/or constructed using materials that have low sodicity. It is therefore recommended that a sufficient quantity of suitable material be identified prior to completion of the emplacements which can either be used to construct the final lift or can be placed as a cover over the completed emplacements.

3. It is recommended that the water quality monitoring program for the potentially impacted areas include the following parameters:

   - pH, EC, TSS, total alkalinity/acidity, SO_4, Al, As, Mo and Se.

   It is assumed that sample collection for the water quality monitoring program will be performed quarterly. The data generated should be periodically reviewed and it is recommended that this be carried out 12-monthly. The reviews should be able to identify if exposure of sodic or PAF materials within the waste rock emplacements or pit walls is impacting water quality and will also indicate if the release of any of the enriched or 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 and if relatively low pH conditions are identified (i.e. pH < 6) the parameter list should be expanded to include; Co, Ni, Pb, and Zn.

4. It is recommended that a detailed geochemical characterisation assessment be conducted on the overburden and interburden from any expanded or new mining areas not covered by this assessment.

6.2 ROM Coal

The ROM coal will be crushed and stockpiled on-site prior to being loaded onto trucks for haulage to the Whitehaven CHPP. A total of 14 drill-hole samples representing the economic coal seams through two drill-holes were geochemically characterised for this assessment. The results of this assessment indicate that the coal seams have a relatively consistent and moderate total S content with an average of 0.45%S, and a bimodal population in ANC values. The samples with relatively high ANC values (26 to 95 kg H_2SO_4/t) are classified as NAF, while those with low ANC values (2 to 7 kg H_2SO_4/t) are classified as PAF. The samples classified as PAF include the KUR, SHU, STU/L, BLU and BLU/M seams, and the samples classified as NAF include the STU, BLM and CNW seams. The SHL and BLL seams include both NAF and PAF samples.

The presented test results indicate that the ROM coal stockpile is expected to contain a significant quantity of PAF material which is likely to be relatively reactive with a short geochemical lag period. The ROM coal is also expected to be enriched in a number of environmentally significant metals including As, B, Hg, Sb and Se. Additionally, As, Mo and Se are expected to be readily soluble under the near-neutral pH conditions and the solubility of additional metals including Be, Cd, Co, Ni, Pb and Zn is expected to increase if lower pH conditions (i.e. pH >6) are allowed to develop within the stockpile.

Based on these findings the following recommendations are made:

1. The surface drainage and seepage from the ROM coal stockpile facility should be contained. Allowance may need to be made for the monitoring and treatment of this water in order to meet the required water quality criteria if it is to be released or re-used in areas of the mine site where it may result in environmental harm.
2. If the water is to be treated and released, or re-used in potentially sensitive areas, it is recommended that water quality monitoring program includes the following parameters:

   - pH, EC, total alkalinity/acidity, SO_4, As, Mo and Se.

   The monitoring of these parameters will assist in ongoing assessment of acid generation reactions and the release of any identified elements of potential concern to the receiving environment.

If the monitored pH values decrease to pH <6.0 the parameter list should be expanded to include; Be, Cd, Co, Ni, Pb and Zn. It is recommended that the sample collection for the water quality monitoring program be performed monthly or quarterly. The data generated should be periodically reviewed and it is recommended that this be carried out 12-monthly. Due to their potential enrichment in some of the coal seams it is recommended that B, Hg and Sb be included in the suite of analytes monitored on a 12-monthly basis.

6.3 Coal Rejects

The ROM coal will be washed and processed, as required, at the Whitehaven CHPP along with the ROM coal from the nearby Tarrawonga, Rocglen and Sunnyside Coal Mine operations. The coal rejects currently being produced at the Whitehaven CHPP from these operations, including coarse rejects and fines (tailings), were geochemically characterised as part of this assessment. This assessment included 10 samples of the coarse rejects, collected from the consolidated coarse reject stockpiles, and 5 samples of the fines, collected from the fines settling ponds. These samples were collected over a period of several weeks in order to obtain a representative range of geochemical material types. The results from this assessment indicate that the coarse reject material is expected to be non-saline and the fines material is expected to be slightly to moderately saline.

Apart from 1 sample with an anomalously high sulfur content, the coarse reject samples typically have a relatively low to moderate total S content, ranging from 0.18 to 0.38%S, and low to moderate ANC, ranging from 3 to 20 kg H_2SO_4/t, and this material is typically expected to be NAF. However, due to the low ANC in some of these materials there is a risk that some of the coarse reject materials will be PAF with a low capacity to generate acid (i.e. <5 kg H_2SO_4/t). The fines typically have a moderate total S content, ranging from 0.35 to 0.44%S, and moderate ANC, ranging from 10 to 21 kg H_2SO_4/t, and this material is also typically expected to be NAF. However, 1 fines sample with a low ANC (4 kg H_2SO_4/t) is classified as PAF indicating that there is a risk of some of the fines material being PAF.

Based on the results of the coal seam geochemical characterisation it is expected that the ROM coal from the proposed Project would have a moderate sulfur content (approx 0.5%S) and relatively low ANC (<10 kg H_2SO_4/t), and although the proportion of sulfur and ANC that will report to the coal product, coarse reject and fines is not known, these characteristics indicate that the coarse rejects and fines will have a risk of being PAF.

The coarse rejects and fines currently being produced at the Whitehaven CHPP are typically expected to be slightly enriched in As, B, Sb and Se, and one of the coarse reject samples was found to be significantly enriched in As, B, Hg and Se. Additionally, Mo and Se are expected to be readily soluble in these materials under the prevailing quasi-neutral pH conditions. Similarly, the ROM coal from the proposed Project is expected to be slightly enriched in As, B, Hg, Sb and Se, and As, Mo and Se are expected to be readily soluble under quasi-neutral pH conditions.

Based on the presented test results it is expected that the coarse rejects and fines from the proposed Project will have similar geochemical characteristics to those that are currently being produced at the Whitehaven CHPP.

It is proposed that some of the coarse rejects and fines materials from the Whitehaven CHPP will be disposed within mined out areas of the proposed pit. The disposal strategy being assessed involves the co-disposal of this material. Although the bulk of these materials are expected to be NAF, the management strategy for the in-pit disposal of these materials will need to address the potential risk that some of these materials may be PAF and that the fines materials are expected to be slightly to moderately saline. It is therefore expected that the closure plan for the in-pit disposal of this material will require a cover system designed to sufficiently reduce oxygen diffusion and/or water infiltration into the coal rejects material and provide a suitable growth medium to support successful long-term revegetation.

If the coal rejects from the Whitehaven CHPP are disposed in-pit it is recommended that the water quality monitoring program adopted for the ROM coal stockpile be expanded to include the potentially impacted waters, including pit water and contacted groundwater.

7.0 References

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Bowen, H.J.M. (1979) *Environmental Chemistry of the Elements*. Academic Press, London.

Sobek, A.A., Schuller, W.A., Freeman, J.R. and Smith, R.M. (1978) *Field and Laboratory Methods Applicable to Overburdens and Minesoils*. EPA-600/2-78-054, p.p. 47-50.

Attachment A

Geochemical Sample Details

Table A-1: Drill-hole VKY0001CR sample details, Vickery Coal Project.

Table A-2: Drill-hole VKY0007C sample details, Vickery Coal Project.

Table A-3: Drill-hole VKY0014C sample details, Vickery Coal Project.

Table A-4: Drill-hole VKY0016C sample details, Vickery Coal Project.

Table A-5: Drill-hole VKY0020C sample details, Vickery Coal Project.

Table A-6: Drill-hole composite sample details, Vickery Coal Project.

Table A-7: Coal seam sample details, Vickery Coal Project.

Table A-1: Drill-hole VKY0001CR sample details, Vickery Coal Project.

Sample ID	Depth (m)			Lithology
	from	to	interval	
VCM01/6	24.42	25.51	1.09	Sandstone, Siltstone
VCM01/7	25.51	25.73	0.22	Mudstone
	25.78	26.50	0.72	KUR
VCM01/8	26.53	27.07	0.54	Mudstone
VCM01/9	33.68	44.16	10.48	Conglomerate
	44.22	45.35	1.13	SHU
VCM01/10	45.35	45.99	0.64	Carb. Mudstone
VCM01/11	45.99	61.56	15.57	Conglomerate
	61.56	62.58	1.03	SHL
VCM01/12	62.58	62.82	0.24	Carb. Mudstone
VCM01/13	63.83	74.02	10.19	Conglomerate, Sandstone
VCM01/14	74.07	90.07	16.00	Conglomerate, Sandstone
VCM01/15	93.36	94.39	1.03	Conglomerate
	94.57	95.56	0.99	BLU
VCM01/16	95.56	96.31	0.75	Siltstone, Mudstone
VCM01/17	96.38	96.62	0.24	Mudstone
	96.62	97.54	0.92	BLM
VCM01/18	97.54	98.06	0.52	Siltstone, Mudstone
VCM01/19	98.06	100.07	2.01	Sandstone, Siltstone
	100.43	101.24	0.81	BLL
VCM01/20	101.24	101.82	0.58	Mudstone
VCM01/21	102.34	110.81	8.47	Conglomerate, Sandstone
VCM01/22	113.97	116.15	2.18	Conglomerate
VCM01/23	118.34	119.45	1.11	Sandstone, Siltstone
VCM01/24	120.12	122.15	2.02	Siltstone, Mudstone
	122.15	123.08	0.94	CNU
VCM01/25	123.08	125.03	1.95	Siltstone, Mudstone, Carb. Mudstone
	125.03	126.72	1.69	CNM
	126.84	128.17	1.33	CNL
VCM01/27	128.17	129.61	1.44	Sandstone, Siltstone

Table A-2: Drill-hole VKY0007C sample details, Vickery Coal Project.

Sample ID	Depth (m)			Lithology
	from	to	interval	
	30.93	32.42	1.49	KUR
VCM07/7	32.42	35.74	3.32	Sandstone
VCM07/8	35.36	39.89	4.53	Conglomerate
VCM07/9	43.37	45.45	2.08	Conglomerate
VCM07/10	45.48	46.13	0.65	Sandstone
VCM07/11	46.13	48.74	2.61	Conglomerate
VCM07/12	48.74	50.15	1.41	Sandstone
VCM07/13	50.15	50.73	0.58	Carb. Mudstone
	50.99	52.39	1.40	SHU
VCM07/14	52.39	53.70	1.31	Sandstone, Siltstone
VCM07/15	53.64	57.47	3.83	Sandstone
VCM07/16	57.47	66.05	8.58	Conglomerate, Sandstone
VCM07/17	66.05	69.90	3.85	Sandstone, Siltstone
VCM07/18	69.90	70.20	0.30	Carb. Mudstone
VCM07/19	73.61	77.32	3.71	Sandstone
VCM07/20	77.59	80.02	2.43	Conglomerate, Sandstone
	80.28	81.17	0.89	BLU
VCM07/21	81.17	81.41	0.24	Sandstone
VCM07/22	84.09	86.07	1.98	Conglomerate, Sandstone
	86.07	86.65	0.58	BLM
VCM07/23	87.10	87.82	0.72	Siltstone
	87.82	88.52	0.70	BLL
VCM07/24	88.52	89.50	0.98	Sandstone
VCM07/25	89.50	105.31	15.81	Sandstone
VCM07/26	105.31	107.44	2.13	Sandstone
	107.65	108.32	0.67	CNU
	108.43	108.99	0.56	CNM
	109.07	110.02	0.95	CNL
VCM07/27	110.02	110.23	0.21	Mudstone
VCM07/28	110.32	114.10	3.78	Acid Volcanic

Table A-3: Drill-hole VKY0014C sample details, Vickery Coal Project.

Sample ID	Depth (m)			Lithology
	from	to	interval	
VCM14/8	31.90	32.40	0.50	Mudstone
	32.40	32.82	0.42	SHU
	32.89	33.74	0.85	SHL
VCM14/9	33.74	35.25	1.51	Siltstone, Mudstone, Carb. Mudstone
	35.25	35.69	0.44	STU
VCM14/10	35.69	36.24	0.55	Carb. Mudstone
	36.24	37.35	1.12	STL
VCM14/11	37.35	39.03	1.68	Sandstone, Siltstone
VCM14/12	39.03	40.48	1.45	Sandstone
VCM14/13	40.48	48.22	7.74	Conglomerate
VCM14/14	48.22	50.04	1.82	Sandstone, Siltstone
	50.04	50.85	0.81	BLU
VCM14/15	50.85	51.66	0.81	Mudstone
VCM14/16	53.73	56.20	2.47	Siltstone, Mudstone, Carb. Mudstone
	56.20	57.59	1.39	BLM
VCM14/17	57.59	59.49	1.90	Mudstone, Carb. Mudstone
	59.49	60.13	0.65	BLL
VCM14/18	60.13	62.26	2.13	Sandstone, Siltstone
VCM14/19	62.27	63.90	1.64	Mudstone, Carb. Mudstone
VCM14/20	63.90	68.66	4.76	Sandstone, Siltstone
VCM14/21	68.66	70.13	1.47	Mudstone
VCM14/22	70.13	73.50	3.37	Sandstone, Siltstone
VCM14/23	73.50	73.87	0.37	Mudstone, Carb. Mudstone
	73.87	75.47	1.60	CNW
	75.48	76.53	1.05	CNL
VCM14/24	76.59	87.55	10.96	Acid Volcanic

Table A-4: Drill-hole VKY0016C sample details, Vickery Coal Project.

Sample ID	Depth (m)			Lithology
	from	to	interval	
VCM16/7	21.47	25.00	3.53	Conglomerate
VCM16/8	25.00	27.37	2.37	Conglomerate
	27.37	27.89	0.52	KUR
VCM16/9	28.00	30.04	2.04	Sandstone, Siltstone
VCM16/10	30.04	32.42	2.38	Conglomerate
VCM16/11	36.31	40.27	3.96	Sandstone, Siltstone
	40.27	41.10	0.83	SHU
VCM16/12	41.25	41.83	0.58	Siltstone
VCM16/13	41.83	43.38	1.55	Sandstone
VCM16/14	43.80	45.88	2.08	Conglomerate
VCM16/15	45.92	56.03	10.11	Conglomerate
VCM16/16	56.03	62.03	6.00	Sandstone
	62.09	63.78	1.69	SHL
VCM16/17	63.78	64.88	1.10	Sandstone, Siltstone
	64.88	66.16	1.28	STU
VCM16/18	66.16	66.99	0.83	Sandstone
VCM16/19	66.99	85.41	18.42	Conglomerate
VCM16/20	85.44	95.24	9.80	Conglomerate
VCM16/21	95.24	95.86	0.62	Sandstone, Siltstone
	95.86	97.85	1.99	STL
VCM16/22	97.85	103.60	5.75	Sandstone, Siltstone
VCM16/23	103.60	114.85	11.25	Conglomerate
	114.85	115.48	0.63	BLU
VCM16/24	115.48	117.04	1.56	Sandstone, Siltstone
	117.04	118.03	0.99	BLM
VCM16/25	118.13	118.66	0.53	Siltstone
	118.66	119.39	0.73	BLL
VCM16/26	119.39	120.65	1.26	Sandstone
VCM16/27	120.65	132.04	11.39	Conglomerate
VCM16/28	132.04	141.25	9.21	Sandstone
	141.25	142.59	1.34	CNU
	142.59	143.03	0.44	CNM
	143.32	144.30	0.98	CNL
VCM16/29	144.30	145.47	1.17	Sandstone, Siltstone

Table A-5: Drill-hole VKY0020C sample details, Vickery Coal Project.

Sample ID	Depth (m)			Lithology
	from	to	interval	
VCM20/7	23.28	23.70	0.42	Mudstone (Weathered)
VCM20/8	26.70	27.50	0.80	Siltstone (Weathered)
VCM20/9	27.80	28.50	0.70	Mudstone (Weathered)
	28.62	29.48	0.86	KUR
VCM20/10	29.58	31.70	2.12	Siltstone, Mudstone (Weathered)
VCM20/11	32.25	40.00	7.75	Conglomerate
VCM20/12	40.00	42.75	2.75	Sandstone
VCM20/13	42.75	45.46	2.71	Mudstone
	45.69	47.11	1.42	SHU
	47.90	49.00	1.10	SHL
VCM20/15	49.10	51.00	1.90	Sandstone
VCM20/16	51.00	73.08	22.08	Conglomerate
VCM20/17	73.08	75.33	2.25	Conglomerate, Sandstone
	75.43	77.03	1.60	STF
VCM20/18	77.17	82.30	5.13	Sandstone
VCM20/19	82.30	100.61	18.31	Conglomerate
	100.61	100.90	0.29	BLU
	101.22	102.00	0.78	BLM
	102.45	103.00	0.55	BLL
VCM20/22	103.00	104.96	1.96	Sandstone
VCM20/23	104.96	109.20	4.24	Sandstone
VCM20/24	109.20	118.65	9.45	Conglomerate
VCM20/25	118.65	122.95	4.30	Sandstone
VCM20/26	122.95	123.50	0.55	Mudstone
	123.50	125.05	1.55	CNW
	125.10	126.15	1.05	CNL
VCM20/27	126.20	128.00	1.80	Sandstone, Mudstone

Table A-6: Drill-hole composite sample details, Vickery Coal Project.

Composite ID	Drill-Hole	Depth (m)			Lithology	Weathering
		from	to	interval		
VCM/Comp1	VKY0001CR	11.0	13.0	2.0	Sandstone	Moderate
	VKY0007C	17.0	18.0	1.0	Sandstone	Moderate
	VKY0014C	13.0	14.0	1.0	Sandstone	High
	VKY0014C	14.0	15.0	1.0	Sandstone	Moderate
	VKY0020C	5.0	10.0	5.0	Sandstone	Moderate
	VKY0020C	11.5	22.4	10.9	Sandstone	Moderate
VCM/Comp2	VKY0014C	1.5	5.0	3.5	Clay	High
	VKY0016C	1.0	2.0	1.0	Clay	High
	VKY0016C	14.0	15.0	1.0	Sandstone	High
	VKY0020C	1.0	3.0	2.0	Sand	High
	VKY0020C	3.0	5.0	2.0	Clay	High
VCM/Comp3	VKY0007C	18.0	26.0	8.0	Conglomerate	Slight
	VKY0014C	25.0	29.0	4.0	Conglomerate	Slight
VCM/Comp4	VKY0014C	5.0	11.0	6.0	Conglomerate	High
	VKY0016C	2.0	14.0	12.0	Conglomerate	High
	VKY0016C	15.0	18.0	3.0	Conglomerate	High
VCM/Comp5	VKY0001CR	1.0	11.0	10.0	Conglomerate/ Sandstone	High
	VKY0001CR	13.0	18.0	5.0	Conglomerate/ Sandstone	Moderate
	VKY0001CR	18.0	23.1	5.1	Conglomerate/ Sandstone	Slight
VCM/Comp6	VKY0007C	1.0	17.0	16.0	Conglomerate	Moderate
	VKY0014C	15.0	25.0	10.0	Conglomerate	Moderate

Table A-7: Coal seam sample details, Vickery Coal Project.

Drill-Hole	Sample Code	Depth (m)			Coal Seam
		from	to	interval	
VKY0003C	3C/S1	39.88	41.27	1.39	SHU
	3C/S2	41.75	43.55	1.8	SHL
	3C/S3	67.09	69.63	2.54	STU/STL
	3C/S4	83.72	85.51	1.79	BLU/BLM
	3C/S5	86.08	86.88	0.8	BLL
	3C/S6	111.62	115.03	3.41	CNW
VKY0007C	7C/S1	30.63	32.74	2.11	KUR
	7C/S2	50.73	52.7	1.97	SHU
	7C/S3	70.2	70.47	0.27	SHL
	7C/S4	71.02	73.7	2.68	STU
	7C/S5	80.02	81.41	1.39	BLU
	7C/S6	85.82	86.9	1.08	BLM
	7C/S7	87.58	88.57	0.99	BLL
	7C/S8	107.44	110.23	2.79	CNW

Attachment B

Geochemical Test Results

Table B-1: Acid forming characteristics of composited drill-hole samples from the oxidised zone, Vickery Coal Project.

Table B-2: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0001CR, Vickery Coal Project.

Table B-3: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0007C, Vickery Coal Project.

Table B-4: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0014C, Vickery Coal Project.

Table B-5: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0016C, Vickery Coal Project.

Table B-6: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0020C, Vickery Coal Project.

Table B-7: pH and EC, exchangeable cations, cation exchange capacity and exchangeable sodium percent for selected overburden and interburden drill-hole samples, Vickery Coal Project.

Table B-8: Multi-element composition of selected overburden and interburden drill-hole samples, Vickery Coal Project.

Table B-9: Geochemical abundance indices for selected overburden and interburden drill-hole samples, Vickery Coal Project.

Table B-10: Chemical composition of water extracts from selected overburden and interburden drill-hole samples, Vickery Coal Project.

Table B-11: Acid forming characteristics of coal seam samples from the Vickery Coal Project, and coarse rejects and fines from the Whitehaven CHPP (Gunnedah).

Table B-12: Multi-element composition of coal seam samples from the Vickery Coal Project, and coarse reject and fines samples from the Whitehaven CHPP (Gunnedah).

Table B-13: Geochemical abundance indices for coal seam samples from the Vickery Coal Project, and coarse reject and fines samples from the Whitehaven CHPP (Gunnedah).

Table B-14: Chemical composition of water extracts from coal seam samples from the Vickery Coal Project, and coarse reject and fines samples from the Whitehaven CHPP (Gunnedah).

Table B-1: Acid forming characteristics of composited drill-hole samples from the oxidised zone, Vickery Coal Project.

Sample Code	Drill-Hole Interval	Lithology	Weathering	$pH_{1:2}$	$EC_{1:2}$		ACID-BASE ANALYSIS				NAG TEST			ARD Classification
						Total %S	MPA	ANC	NAPP	ANC/ MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
Composite 2	(Ref Table A1)	Clay, Sandstone	Highly Weathered	8.2	1.014	0.02	1	31	-31	51.1	9.2	0	0	NAF
Composite 4	(Ref Table A1)	Conglomerate	Highly Weathered	8.3	1.006	0.02	1	18	-17	29.1	9.9	0	0	NAF
Composite 6	(Ref Table A1)	Conglomerate	Moderately Weathered	8.7	0.388	0.01	0	5	-5	17.0	7.6	0	0	NAF
VCM16/7	VKY0016C (21.47 - 25.00m)	Conglomerate	Moderately Weathered	6.8	0.258	0.02	1	6	-5	9	6.6	0	1	NAF
Composite 5	(Ref Table A1)	Conglomerate, Sandstone	Moderately Weathered	9.0	0.306	0.06	2	17	-15	9.3	8.7	0	0	NAF
Composite 1	(Ref Table A1)	Sandstone	Moderately Weathered	8.2	0.313	0.04	1	4	-2	2.9	9.3	0	0	NAF
VCM20/8	VKY0020C (26.70 - 27.50m)	Siltstone	Moderately Weathered	7.1	0.233	0.01	0	5	-5	17	6.8	0	1	NAF
Composite 3	(Ref Table A1)	Conglomerate	Slightly Weathered	8.6	0.330	0.01	0	10	-10	32.4	8.4	0	0	NAF
VCM16/8	VKY0016C (25.00 - 27.37m)	Conglomerate	Slightly Weathered	6.5	0.262	0.01	0	6	-6	20	7.7	0	0	NAF
VCM20/7	VKY0020C (23.28 - 23.70m)	Mudstone	Slightly Weathered	8.0	0.153	0.06	2	5	-3	3	6.9	0	0	NAF
VCM20/9	VKY0020C (27.80 - 28.50m)	Mudstone	Slightly Weathered	6.2	0.242	0.02	1	5	-4	8	6.9	0	0	NAF
VCM20/10	VKY0020C (29.58 - 31.70m)	Siltstone, Mudstone	Slightly Weathered	6.2	0.256	0.05	2	5	-4	4	6.2	0	1	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)

ARD Classification Key

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
PAF/LC = PAF Low Capacity
UC = Uncertain Classification
expected class. shown in brackets

Table B-2: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0001CR, Vickery Coal Project.

Sample Code	Depth (m) From	Depth (m) To	Depth (m) Interv.	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/ MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
VCM01/6	24.42	25.51	1.09	Sandstone, Siltstone	8.9	0.139	0.01		0	10	-10	32.7	7.5	0	0	NAF
VCM01/7	25.51	25.73	0.22	Mudstone	9.0	0.140	0.03		1	7	-6	7.4	7.3	0	0	NAF
	25.78	26.50	0.72	Seam (KUR)												
VCM01/8	26.53	27.07	0.54	Mudstone	8.9	0.175	0.09		3	7	-4	2.4	6.9	0	0	NAF
VCM01/9	33.68	44.16	10.48	Conglomerate	8.6	0.258	0.03		1	21	-20	22.4	9.9	0	0	NAF
	44.22	45.35	1.13	Seam (SHU)												
VCM01/10	45.35	45.99	0.64	Carb. Mudstone	8.7	0.081	0.02		1	5	-4	8.3	5.7	0	1	NAF
VCM01/11	45.99	61.56	15.57	Conglomerate	9.1	0.355	0.09		3	24	-21	8.6	10.3	0	0	NAF
	61.56	62.58	1.03	Seam (SHL)												
VCM01/12	62.58	62.82	0.24	Carb. Mudstone	9.1	0.183	0.04		1	10	-9	8.3	8.1	0	0	NAF
VCM01/13	63.83	74.02	10.19	Conglomerate, Sandstone	8.9	0.621	0.09		3	15	-13	5.6	9.4	0	0	NAF
VCM01/14	74.07	90.07	16.00	Conglomerate, Sandstone	8.9	0.440	0.08		2	15	-13	6.3	10.1	0	0	NAF
VCM01/15	93.36	94.39	1.03	Conglomerate	8.6	0.247	0.06		2	7	-5	3.6	7.7	0	0	NAF
	94.57	95.56	0.99	Seam (BLU)												
VCM01/16	95.56	96.31	0.75	Siltstone, Mudstone	8.9	0.213	0.08		2	10	-8	4.1	7.3	0	0	NAF
VCM01/17	96.38	96.62	0.24	Mudstone	9.2	0.285	0.06		2	10	-8	5.2	7.0	0	0	NAF
	96.62	97.54	0.92	Seam (BLM)												
VCM01/18	97.54	98.06	0.52	Siltstone, Mudstone	9.0	0.110	0.04		1	9	-8	7.7	8.1	0	0	NAF
VCM01/19	98.06	100.07	2.01	Sandstone, Siltstone	8.9	0.131	0.03		1	13	-12	14.6	8.3	0	0	NAF
	100.43	101.24	0.81	Seam (BLL)												
VCM01/20	101.24	101.82	0.58	Mudstone	8.8	0.148	0.04		1	8	-7	6.7	6.9	0	0	NAF
VCM01/21	102.34	110.81	8.47	Conglomerate, Sandstone	8.9	0.266	0.03		1	23	-22	25.2	9.9	0	0	NAF
VCM01/22	113.97	116.15	2.18	Conglomerate	9.0	0.541	0.06		2	55	-53	29.8	11.0	0	0	NAF
VCM01/23	118.34	119.45	1.11	Sandstone, Siltstone	9.2	0.244	0.11		3	31	-27	9.1	10.4	0	0	NAF
VCM01/24	120.12	122.15	2.02	Siltstone, Mudstone	9.2	0.195	0.04		1	15	-14	12.3	8.3	0	0	NAF
	122.15	123.08	0.94	Seam (CNU)												
VCM01/25	123.08	125.03	1.95	Siltstone, Mudstone, Carb. Mudstone	9.1	0.227	0.04		1	19	-18	15.4	8.9	0	0	NAF
	125.03	126.72	1.69	Seam (CNM)												
	126.84	127.41	0.57	Seam (CNLU)												
I/S	127.41	127.75	0.34	Carb. Mudstone	-	-	-	-	-	-	-	-	-	-	-	-
	127.75	128.17	0.42	Seam (CNLL)												
VCM01/27	128.17	129.61	1.44	Sandstone, Siltstone	8.8	0.175	0.03		1	21	-20	22.5	10.1	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)

ARD Classification Key
NAF = Non-Acid Forming
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PAF/LC = PAF Low Capacity
UC = Uncertain Classification
expected class. shown in brackets

NOTE: I/S indicates insufficient sample.

Table B-3: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0007C, Vickery Coal Project.

Sample Code	Depth (m) From	Depth (m) To	Depth (m) Interv.	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
I/S	28.00	29.80	1.80	Siltstone	-	-	-	-	-	-	-	-	-	-	-	-
	30.93	32.42	1.49	Seam (KUR)												
VCM07/7	32.42	35.74	3.32	Sandstone	7.5	0.215	0.24		7	8	-1	1.1	7.8	0	0	NAF
VCM07/8	35.36	39.89	4.53	Conglomerate	8.1	0.158	0.02		1	12	-11	19.3	9.7	0	0	NAF
VCM07/9	43.37	45.45	2.08	Conglomerate	8.3	0.268	0.03		1	56	-55	60.9	10.2	0	0	NAF
VCM07/10	45.48	46.13	0.65	Sandstone	8.4	0.272	0.03		1	82	-81	89.1	10.9	0	0	NAF
VCM07/11	46.13	48.74	2.61	Conglomerate	8.3	0.214	0.09		3	31	-28	11.1	9.9	0	0	NAF
VCM07/12	48.74	50.15	1.41	Sandstone	8.0	0.181	0.32		10	38	-29	3.9	6.8	0	0	NAF
VCM07/13	50.15	50.73	0.58	Carb. Mudstone	8.1	0.267	0.12		4	13	-10	3.6	6.3	0	1	NAF
	50.99	52.39	1.40	Seam (SHU)												
VCM07/14	52.39	53.70	1.31	Sandstone, Siltstone	8.4	0.218	0.05		2	20	-19	13.1	7.9	0	0	NAF
VCM07/15	53.64	57.47	3.83	Sandstone	8.6	0.329	0.07		2	27	-25	12.8	9.0	0	0	NAF
VCM07/16	57.47	66.05	8.58	Conglomerate, Sandstone	8.4	0.286	0.14		4	52	-47	12.1	10.1	0	0	NAF
VCM07/17	66.05	69.90	3.85	Sandstone, Siltstone	8.5	0.164	0.05		2	39	-37	25.2	8.7	0	0	NAF
VCM07/18	69.90	70.20	0.30	Carb. Mudstone	8.7	0.240	0.11		3	107	-104	31.8	9.8	0	0	NAF
VCM07/19	73.61	77.32	3.71	Sandstone	8.0	0.163	0.03		1	9	-8	9.8	7.8	0	0	NAF
VCM07/20	77.59	80.02	2.43	Conglomerate, Sandstone	8.7	0.252	0.04		1	36	-35	29.5	9.8	0	0	NAF
	80.28	81.17	0.89	Seam (BLU)												
VCM07/21	81.17	81.41	0.24	Sandstone	8.7	0.240	0.03		1	58	-57	62.9	10.1	0	0	NAF
VCM07/22	84.09	86.07	1.98	Conglomerate, Sandstone	8.8	0.334	0.05		2	38	-36	24.8	9.7	0	0	NAF
	86.07	86.65	0.58	Seam (BLM)												
VCM07/23	87.10	87.82	0.72	Siltstone	8.9	0.206	0.06		2	13	-11	7.0	6.7	0	0	NAF
	87.82	88.52	0.70	Seam (BLL)												
VCM07/24	88.52	89.50	0.98	Sandstone	9.1	0.218	0.02		1	31	-31	51.1	9.8	0	0	NAF
VCM07/25	89.50	105.31	15.81	Sandstone	9.2	0.272	0.02		1	51	-50	83.5	10.6	0	0	NAF
VCM07/26	105.31	107.44	2.13	Sandstone	9.3	0.271	0.06		2	30	-28	16.4	9.5	0	0	NAF
	107.65	108.32	0.67	Seam (CNU)												
	108.43	108.99	0.56	Seam (CNM)												
	109.07	109.62	0.55	Seam (CNL1)												
	109.72	110.02	0.30	Seam (CNL2)												
VCM07/27	110.02	110.23	0.21	Mudstone	8.0	0.378	0.19	0.054	6	8	-2	1.3	3.8	1	4	UC(PAF/LC)
VCM07/28	110.32	114.10	3.78	Acid Volcanic	8.3	0.245	0.17		5	102	-97	19.6	10.9	0	0	NAF

KEY

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expected class. shown in brackets

NOTE: I/S indicates insufficient sample.

Table B-4: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0014C, Vickery Coal Project.

Sample Code	Depth (m)			Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS						NAG TEST			ARD Classification
	From	To	Interv.				Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
VCM14/8	31.90	32.40	0.50	Mudstone	7.8	0.527	1.51	0.207	46	8	38	0.2	2.2	44	53	PAF
	32.40	32.82	0.42	Seam (SHU)												
	32.89	33.74	0.85	Seam (SHL)												
VCM14/9	33.74	35.25	1.51	Siltstone, Mudstone, Carb. Mudstone	7.6	0.390	0.11	0.048	3	5	-2	1.5	4.5	0	6	NAF
	35.25	35.69	0.44	Seam (STU)												
VCM14/10	35.69	36.24	0.55	Carb. Mudstone	7.7	0.361	0.08		2	13	-10	5.2	7.2	0	0	NAF
	36.24	37.35	1.12	Seam (STL)												
VCM14/11	37.35	39.03	1.68	Sandstone, Siltstone	8.6	0.175	0.02		1	4	-3	6.0	6.8	0	0	NAF
VCM14/12	39.03	40.48	1.45	Sandstone	8.5	0.185	0.02		1	30	-29	49.2	10.1	0	0	NAF
VCM14/13	40.48	48.22	7.74	Conglomerate	8.2	0.349	0.03		1	32	-31	34.7	9.5	0	0	NAF
VCM14/14	48.22	50.04	1.82	Sandstone, Siltstone	7.7	0.320	0.39		12	51	-39	4.2	8.7	0	0	NAF
	50.04	50.85	0.81	Seam (BLU)												
VCM14/15	50.85	51.66	0.81	Mudstone	8.2	0.187	0.03		1	12	-11	12.9	7.2	0	0	NAF
VCM14/16	53.73	56.20	2.47	Siltstone, Mudstone, Carb. Mudstone	9.0	0.221	0.08		2	27	-25	11.2	8.9	0	0	NAF
	56.20	57.59	1.39	Seam (BLM)												
VCM14/17	57.59	59.49	1.90	Mudstone, Carb. Mudstone	8.7	0.196	0.06		2	39	-37	21.0	9.2	0	0	NAF
	59.49	60.13	0.65	Seam (BLL)												
VCM14/18	60.13	62.26	2.13	Sandstone, Siltstone	8.2	0.275	0.06		2	57	-55	30.8	10.3	0	0	NAF
VCM14/19	62.27	63.90	1.64	Mudstone, Carb. Mudstone	6.9	0.520	0.10		3	5	-1	1.5	5.2	0	2	NAF
VCM14/20	63.90	68.66	4.76	Sandstone, Siltstone	7.9	0.457	0.15		5	76	-71	16.5	10.8	0	0	NAF
VCM14/21	68.66	70.13	1.47	Mudstone	4.8	1.348	2.10	0.827	64	13	51	0.2	2.6	35	41	PAF
VCM14/22	70.13	73.50	3.37	Sandstone, Siltstone	8.6	0.131	0.02		1	27	-26	43.8	8.9	0	0	NAF
VCM14/23	73.50	73.87	0.37	Mudstone, Carb. Mudstone	8.5	0.130	0.11	0.016	3	5	-2	1.6	4.2	1	9	UC(PAF/LC)
	73.87	75.47	1.60	Seam (CNU)												
	75.48	76.53	1.05	Seam (CNL)												
VCM14/24	76.59	87.55	10.96	Acid Volcanic	8.4	0.215	0.14		4	137	-133	32.0	11.2	0	0	NAF

KEY

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ARD Classification Key
NAF = Non-Acid Forming
PAF = Potentially Acid Forming
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expected class. shown in brackets

Table B-5: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0016C, Vickery Coal Project.

Sample Code	Depth (m) From	Depth (m) To	Depth (m) Interv.	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/ MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
	27.37	27.89	0.52	Seam (KUR)												
VCM16/9	28.00	30.04	2.04	Sandstone, Siltstone	6.8	0.293	0.03		1	10	-9	10.8	7.5	0	0	NAF
VCM16/10	30.04	32.42	2.38	Conglomerate	8.0	0.316	0.03		1	11	-10	12.0	7.9	0	0	NAF
VCM16/11	36.31	40.27	3.96	Sandstone, Siltstone	8.1	0.178	0.04		1	39	-38	31.9	8.8	0	0	NAF
	40.27	41.10	0.83	Seam (SHU)												
VCM16/12	41.25	41.83	0.58	Siltstone	7.4	0.129	0.11	0.020	3	5	-2	1.5	3.7	3	17	UC(PAF/LC)
VCM16/13	41.83	43.38	1.55	Sandstone	7.8	0.125	0.06		2	11	-9	6.0	7.1	0	0	NAF
VCM16/14	43.80	45.88	2.08	Conglomerate	8.1	0.312	0.01		0	20	-19	63.7	9.6	0	0	NAF
VCM16/15	45.92	56.03	10.11	Conglomerate	8.3	0.330	0.03		1	36	-35	38.7	10.1	0	0	NAF
VCM16/16	56.03	62.03	6.00	Sandstone	8.4	0.137	0.04		1	85	-84	69.3	8.6	0	0	NAF
	62.09	63.78	1.69	Seam (SHL)												
VCM16/17	63.78	64.88	1.10	Sandstone, Siltstone	7.5	0.093	0.03		1	9	-8	10.0	7.3	0	0	NAF
	64.88	66.16	1.28	Seam (STU)												
VCM16/18	66.16	66.99	0.83	Sandstone	7.7	0.073	0.04		1	4	-2	3.0	5.4	0	2	NAF
VCM16/19	66.99	85.41	18.42	Conglomerate	6.5	0.439	0.03		1	40	-39	43.2	9.2	0	0	NAF
VCM16/20	85.44	95.24	9.80	Conglomerate	9.0	0.302	0.02		1	40	-40	65.8	10.6	0	0	NAF
VCM16/21	95.24	95.86	0.62	Sandstone, Siltstone	8.3	0.105	0.90	0.031	28	12	15	0.4	2.9	9	13	PAF
	95.86	97.85	1.99	Seam (STL)												
VCM16/22	97.85	103.60	5.75	Sandstone, Siltstone	8.6	0.184	0.02		1	20	-19	31.9	8.3	0	0	NAF
VCM16/23	103.60	114.85	11.25	Conglomerate	7.2	0.639	0.16		5	18	-13	3.6	8.6	0	0	NAF
	114.85	115.48	0.63	Seam (BLU)												
VCM16/24	115.48	117.04	1.56	Sandstone, Siltstone	8.1	0.079	0.04		1	12	-11	10.1	7.3	0	0	NAF
	117.04	118.03	0.99	Seam (BLM)												
VCM16/25	118.13	118.66	0.53	Siltstone	8.2	0.077	0.07		2	12	-9	5.4	7.4	0	0	NAF
	118.66	119.39	0.73	Seam (BLL)												
VCM16/26	119.39	120.65	1.26	Sandstone	8.5	0.082	0.02		1	9	-8	14.1	8.4	0	0	NAF
VCM16/27	120.65	132.04	11.39	Conglomerate	9.2	0.381	0.02		1	45	-44	72.7	10.6	0	0	NAF
VCM16/28	132.04	141.25	9.21	Sandstone	9.0	0.228	0.02		1	64	-63	104.1	10.8	0	0	NAF
	141.25	142.59	1.34	Seam (CNU)												
	142.59	143.03	0.44	Seam (CNM)												
	143.32	143.81	0.49	Seam (CNL1)												
	143.84	144.30	0.46	Seam (CNL2)												
VCM16/29	144.30	145.47	1.17	Sandstone, Siltstone	8.4	0.082	0.02		1	16	-15	25.3	9.1	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)

ARD Classification Key
NAF = Non-Acid Forming
PAF = Potentially Acid Forming
PAF/LC = PAF Low Capacity
UC = Uncertain Classification
expected class. shown in brackets

Table B-6: Acid forming characteristics of overburden and interburden samples from drill-hole VKY0020C, Vickery Coal Project.

Sample Code	Depth (m) From	Depth (m) To	Depth (m) Interv.	Sample Description	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
VCM20/11	32.25	40.00	7.75	Conglomerate	8.3	0.456	0.03		1	35	-34	38.3	10.1	0	0	NAF
VCM20/12	40.00	42.75	2.75	Sandstone	8.4	0.372	0.06		2	48	-46	26.2	10.2	0	0	NAF
VCM20/13	42.75	45.46	2.71	Mudstone	8.2	0.147	0.05		2	18	-16	11.6	8.8	0	0	NAF
	45.69	46.10	0.41	Seam (SHUU)												
	46.23	47.11	0.88	Seam (SHUL)												
I/S	47.11	47.90	0.79	Carb. Mudstone	-	-	-	-	-	-	-	-	-	-	-	-
	47.90	49.00	1.10	Seam (SHL)												NAF
VCM20/15	49.10	51.00	1.90	Sandstone	7.2	0.248	0.05		2	5	-4	3.3	7.1	0	0	NAF
VCM20/16	51.00	73.08	22.08	Conglomerate	8.6	0.323	0.06		2	38	-36	20.6	9.8	0	0	NAF
VCM20/17	73.08	75.33	2.25	Conglomerate, Sandstone	6.3	0.718	1.12	0.741	34	16	18	0.5	2.8	8	15	PAF
	75.43	77.03	1.60	Seam (STF)												
VCM20/18	77.17	82.30	5.13	Sandstone	7.5	0.193	0.03		1	6	-5	6.9	7.6	0	0	NAF
VCM20/19	82.30	100.61	18.31	Conglomerate	8.3	0.199	0.28		9	16	-8	1.9	9.8	0	0	NAF
	100.61	100.90	0.29	Seam (BLU)												
I/S	100.90	101.22	0.32	Siltstone	-	-	-	-	-	-	-	-	-	-	-	-
	101.22	102.00	0.78	Seam (BLM)												
I/S	102.00	102.45	0.45	Mudstone	-	-	-	-	-	-	-	-	-	-	-	-
	102.45	103.00	0.55	Seam (BLL)												
VCM20/22	103.00	104.96	1.96	Sandstone	8.5	0.179	0.02		1	14	-13	22.5	9.7	0	0	NAF
VCM20/23	104.96	109.20	4.24	Sandstone	8.8	0.262	0.02		1	110	-109	179.7	10.7	0	0	NAF
VCM20/24	109.20	118.65	9.45	Conglomerate	8.0	0.259	0.02		1	8	-7	13.1	9.3	0	0	NAF
VCM20/25	118.65	122.95	4.30	Sandstone	8.6	0.179	0.03		1	56	-55	60.9	10.5	0	0	NAF
VCM20/26	122.95	123.50	0.55	Mudstone	8.2	0.113	0.03		1	12	-11	12.6	9.4	0	0	NAF
	123.50	125.05	1.55	Seam (CNU)												
	125.10	126.15	1.05	Seam (CNL)												
VCM20/27	126.20	128.00	1.80	Sandstone, Mudstone	8.4	0.145	0.03		1	60	-59	64.8	10.3	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)

ARD Classification Key
NAF = Non-Acid Forming
PAF = Potentially Acid Forming
PAF/LC = PAF Low Capacity
UC = Uncertain Classification
expected class. shown in brackets

NOTE: I/S indicates insufficient sample.

Table B-7: pH and EC, exchangeable cations, cation exchange capacity and exchangeable sodium percent for selected overburden and interburden drill-hole samples, Vickery Coal Project.

Sample Code	Sample Description	$pH_{1:2}$	$EC_{1:2}$	Exch. Cations (meq/100g)				CEC	ESP
				Ca	Mg	K	Na		
VCM/Comp1	Sandstone (Mod. Weathered)	8.2	0.313	20.4	3.4	4.1	0.5	2.0	10.1
VCM/Comp2	Clay (Highly Weathered)	8.2	1.014	11.5	21.7	9.7	0.8	4.2	36.5
VCM/Comp3	Conglomerate (Slightly Weathered)	8.6	0.330	7.1	9.8	4.1	0.6	1.1	15.6
VCM/Comp4	Conglomerate (Highly Weathered)	8.3	1.006	14.9	15.1	7.6	0.7	4.1	27.5
VCM/Comp5	Conglomerate, Sandstone (Mod. Weathered)	9.0	0.306	8.4	14.3	3.8	0.6	1.7	20.5
VCM/Comp6	Conglomerate (Mod. Weathered)	8.7	0.388	9.7	10.8	4.3	0.8	1.7	17.5
VCM01/12	Carb. Mudstone	9.1	0.183	70.1	2.1	0.7	0.5	7.8	11.2
VCM01/13	Conglomerate, Sandstone	8.9	0.621	53.8	4.2	1.4	0.5	7.1	13.2
VCM01/16	Siltstone, Mudstone	8.9	0.213	53.8	3.8	1.6	0.5	6.8	12.7
VCM07/12	Sandstone	8.0	0.181	9.4	4.8	7.2	0.5	1.3	13.8
VCM07/20	Conglomerate, Sandstone	8.7	0.252	7.8	14.3	4.9	0.4	1.6	21.3
VCM07/23	Siltstone	8.9	0.206	16.3	3.5	4.8	0.4	1.7	10.5
VCM07/27	Mudstone	8.0	0.378	12.4	8.4	2.9	0.2	1.6	13.1
VCM07/28	Acid Volcanic	8.3	0.245	2.8	18.8	1.4	<0.1	0.6	20.8
VCM14/10	Carb. Mudstone	7.7	0.361	12.6	5.1	4.2	0.3	1.4	11.1
VCM14/17	Mudstone, Carb. Mudstone	8.7	0.196	5.1	20.5	2.6	0.2	1.3	24.6
VCM14/20	Sandstone, Siltstone	7.9	0.457	4.6	15.5	2.2	0.2	0.8	18.8
VCM14/22	Sandstone, Siltstone	8.6	0.131	8.9	9.5	3.1	0.4	1.3	14.2
VCM16/23	Conglomerate	7.2	0.639	31.5	5.4	3.9	0.5	4.5	14.2
VCM20/8	Siltstone (Mod. Weathered)	7.1	0.233	12.6	4.3	7.4	0.4	1.7	13.7
VCM20/9	Mudstone (Slightly Weathered)	6.2	0.242	12.8	4.5	7.4	0.4	1.8	14.1
VCM20/10	Siltstone, Mudstone (Slightly Weathered)	6.2	0.256	13.4	3.1	6.7	0.4	1.6	11.8
VCM20/12	Sandstone	8.4	0.372	7.4	12.2	7.4	0.4	1.6	21.7
VCM20/19	Conglomerate	8.3	0.199	17.7	7.5	3.4	0.4	2.4	13.8
VCM20/26	Mudstone	8.2	0.113	20.4	5.5	3.1	0.5	2.3	11.4

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-8: Multi-element composition of selected overburden and interburden drill-hole samples, Vickery Coal Project.

Element	Unit	Detect. Limit	Sample Description/Code																			
			Weathered Rock			Fresh Rock																
			Conglom	Mudstone	Siltstone	Conglomerate		Conglom, Sandstone		Sandstone		Sandstone, Siltstone		Siltstone	Siltstone, Mudstone	Siltst, Carb. Mudst	Mudstone		Mudst, Carb. Mudst	Carb. Mudstone		Acid Volcanic
			VCM16/7	VCM20/9	VCM20/8	VCM16/23	VCM20/19	VCM07/20	VCM20/17	VCM07/12	VCM20/12	VCM14/20	VCM16/21	VCM07/23	VCM01/16	VCM14/9	VCM14/21	VCM20/26	VCM14/17	VCM01/12	VCM14/10	VCM07/28
Ag	mg/kg	0.01	0.11	0.07	0.12	0.08	0.08	0.07	0.15	0.16	0.11	0.08	0.10	0.21	0.10	0.09	0.13	0.11	0.08	0.16	0.07	0.07
Al	%	0.005%	6.275%	8.900%	8.565%	6.168%	6.598%	7.145%	6.627%	7.290%	6.605%	6.348%	7.830%	8.219%	8.387%	7.670%	7.279%	7.875%	8.092%	9.445%	8.515%	8.243%
As	mg/kg	0.5	7.3	7.7	8.9	15.1	3.5	4.1	30.8	5.3	6.9	7.3	25.6	2.6	3.1	4.5	8.6	7.7	5.1	2.1	3.5	23.0
B	mg/kg	50	424	<	60	<	64	<	59	<	<	<	<	<	66	<	<	<	<	<	<	<
Ba	mg/kg	0.1	608.1	281.6	319.1	733.2	718.3	445.7	828.8	515.2	498.4	560.0	519.5	240.2	343.6	251.8	338.8	474.5	454.2	413.8	292.5	193.3
Be	mg/kg	0.05	1.53	2.14	2.07	1.70	2.71	1.84	1.95	2.77	1.88	1.50	3.04	1.75	2.04	1.47	2.56	2.78	1.84	3.72	1.84	1.38
Ca	%	0.005%	0.142%	0.115%	0.106%	0.410%	0.552%	1.106%	0.502%	0.168%	1.193%	2.935%	0.091%	0.126%	0.181%	0.124%	0.289%	0.217%	1.356%	0.120%	0.151%	3.310%
Cd	mg/kg	0.02	0.04	0.06	0.09	0.04	0.03	0.14	0.10	0.10	0.06	0.08	0.10	0.15	0.17	0.14	0.08	0.12	0.11	0.16	0.17	0.08
Co	mg/kg	0.1	5.9	4.1	4.4	5.0	3.1	5.0	16.4	4.8	8.4	8.6	6.8	5.2	6.2	4.7	10.0	7.2	4.9	4.6	3.1	11.1
Cr	mg/kg	5	33	47	38	35	61	38	32	46	35	32	40	46	52	48	42	32	46	73	41	17
Cu	mg/kg	1	15	24	23	10	14	19	11	18	8	9	17	33	32	27	24	24	26	33	27	15
Fe	%	0.01%	1.19%	1.94%	1.74%	1.10%	0.63%	1.30%	1.83%	1.96%	1.34%	1.04%	2.60%	1.72%	2.30%	0.98%	4.52%	2.41%	2.47%	2.13%	2.05%	5.47%
Hg	mg/kg	0.001	0.027	0.033	0.008	0.038	0.019	0.044	0.13	0.017	0.025	0.010	0.041	0.038	0.069	0.026	0.036	0.034	0.037	0.077	0.056	0.068
K	%	0.002%	2.814%	1.967%	1.923%	2.582%	3.091%	2.784%	3.342%	3.062%	2.583%	2.496%	3.500%	2.087%	2.311%	1.877%	2.554%	3.094%	2.202%	2.250%	2.199%	0.167%
Mg	%	0.002%	0.148%	0.272%	0.248%	0.249%	0.274%	0.351%	0.264%	0.333%	0.513%	0.412%	0.313%	0.423%	0.472%	0.283%	0.417%	0.418%	0.442%	0.288%	0.364%	0.584%
Mn	mg/kg	1	193	46	51	125	90	127	87	164	147	108	172	74	100	43	424	238	98	95	225	990
Mo	mg/kg	0.1	0.9	0.6	0.8	0.8	0.6	0.7	2.2	0.8	0.9	1.5	1.8	0.5	0.5	0.5	0.8	0.5	0.4	0.6	0.7	0.7
Na	%	0.002%	0.752%	0.081%	0.081%	1.095%	1.182%	0.202%	1.061%	0.337%	0.647%	0.224%	0.606%	0.109%	0.371%	0.136%	0.328%	0.425%	0.209%	0.517%	0.132%	0.051%
Ni	mg/kg	1	16	17	19	13	10	13	39	14	24	17	17	24	24	24	28	24	25	17	15	15
P	mg/kg	50	237	310	372	329	372	292	226	262	314	234	283	242	298	240	430	526	360	246	254	748
Pb	mg/kg	0.5	22.5	23.0	19.5	15.1	13.4	17.0	23.6	18.9	13.2	15.5	22.7	20.6	20.9	21.9	24.8	20.8	21.1	25.2	20.8	11.8
Sb	mg/kg	0.05	0.82	0.58	0.54	0.66	0.59	0.71	1.37	0.61	0.50	0.63	0.94	0.88	0.60	0.73	0.95	0.53	0.75	0.65	0.46	0.83
Se	mg/kg	0.01	0.13	0.45	0.09	0.02	0.02	0.07	0.19	0.06	0.03	0.02	0.10	0.15	0.18	0.16	0.12	0.17	0.19	0.09	0.15	0.05
Si	%	0.1%	34.8%	32.6%	33.4%	36.6%	33.8%	32.8%	34.1%	31.6%	34.6%	34.2%	32.5%	29.5%	28.5%	27.6%	31.4%	32.1%	29.7%	28.7%	29.6%	26.9%
Sn	mg/kg	0.1	2.8	3.2	3.1	1.8	2.3	2.9	2.6	2.4	1.9	2.0	2.7	3.6	3.5	3.0	2.9	8.1	3.0	3.4	3.0	2.1
Th	mg/kg	0.01	11.8	14.5	11.6	9.9	10.6	11.0	10.1	8.1	9.2	9.5	8.9	13.4	12.5	9.6	10.8	11.9	11.7	11.6	11.9	2.8
U	mg/kg	0.01	3.33	3.94	2.52	2.13	2.34	2.98	2.39	2.10	2.27	2.33	2.78	3.09	3.08	3.03	2.40	2.64	2.78	3.49	2.86	0.66
V	mg/kg	1	27	118	84	33	42	58	38	64	48	32	73	115	124	93	105	100	134	107	88	87
Zn	mg/kg	1	63	99	106	68	46	92	51	95	40	46	112	103	91	63	111	109	95	143	134	61

< element at or below analytical detection limit.

Table B-9: Geochemical abundance indices for selected overburden and interburden drill-hole samples, Vickery Coal Project.

Element	*Mean Crustal Abundance	**Sample Description/Code**																			
		Weathered Rock			Fresh Rock																
		Conglom	Mudstone	Siltstone	Conglomerate		Conglom, Sandstone		Sandstone		Sandstone, Siltstone		Siltstone	Siltstone, Mudstone	Siltst, Carb. Mudst	Mudstone		Mudst, Carb. Mudst	Carb. Mudstone		Acid Volcanic
		VCM16/7	VCM20/9	VCM20/8	VCM16/23	VCM20/19	VCM07/20	VCM20/17	VCM07/12	VCM20/12	VCM14/20	VCM16/21	VCM07/23	VCM01/16	VCM14/9	VCM14/21	VCM20/26	VCM14/17	VCM01/12	VCM14/10	VCM07/28
Ag	0.07	-	-	-	-	-	-	1	1	-	-	-	1	-	-	-	-	-	1	-	-
Al	8.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	1.5	2	2	2	**3**	1	1	**4**	1	2	2	**4**	-	-	1	2	2	1	-	1	**3**
B	10	**5**	<2	2	<2	2	<2	2	<2	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Be	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca	4.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cd	0.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cr	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe	4.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hg	0.05	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
K	2.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn	950	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mo	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Na	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sb	0.2	1	1	1	1	1	1	2	1	1	1	2	2	1	1	2	1	1	1	1	1
Se	0.05	1	**3**	-	-	-	-	1	-	-	-	-	1	1	1	1	1	1	-	1	-
Si	27.7%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sn	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Th	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

Table B-10: Chemical composition of water extracts from selected overburden drill-hole and interburden samples, Vickery Coal Project.

Parameter		**Detect. Limit**	**Sample Description/Code**																			
			Weathered Rock			Fresh Rock																
			Conglom	Mudstone	Siltstone	Conglomerate		Conglom, Sandstone		Sandstone		Sandstone, Siltstone		Siltstone	Siltstone, Mudstone	Siltst, Carb. Mudst	Mudstone		Mudst, Carb. Mudst	Carb. Mudstone		Acid Volcanic
			VCM16/7	VCM20/9	VCM20/8	VCM16/23	VCM20/19	VCM07/20	VCM20/17	VCM07/12	VCM20/12	VCM14/20	VCM16/21	VCM07/23	VCM01/16	VCM14/9	VCM14/21	VCM20/26	VCM14/17	VCM01/12	VCM14/10	VCM07/28
pH		0.1	6.8	6.2	7.1	7.2	8.3	8.7	6.3	8.0	8.4	7.9	8.3	8.9	8.9	7.6	4.8	8.2	8.7	9.1	7.7	8.3
EC	dS/m	0.001	0.258	0.242	0.233	0.639	0.199	0.252	0.718	0.181	0.372	0.457	0.105	0.206	0.213	0.390	1.348	0.113	0.196	0.183	0.361	0.245
SO4	mg/l	0.3	13.9	48.1	25.2	225.9	60.8	53.9	385.8	59.1	108.6	222.8	28.6	31.6	34.0	114.1	726.0	13.5	26.2	17.6	96.6	48.2
Cl	mg/l	5	65	30	46	15	7	12	11	<	20	18	<	6	<	13	8	<	8	<	13	11
Al	mg/l	0.01	0.38	11.37	0.44	0.11	0.30	0.14	0.03	0.06	0.09	0.04	1.42	0.26	1.12	0.13	0.06	0.53	1.14	5.83	0.11	0.08
B	mg/l	0.01	<	0.03	0.02	<	<	<	<	<	<	<	<	<	0.02	<	0.04	<	<	0.07	<	0.04
Ca	mg/l	0.01	1.04	1.19	0.54	1.47	1.17	1.77	13.11	1.65	6.20	28.35	0.11	0.52	0.22	5.94	119.42	0.38	1.20	0.71	4.19	13.18
Cr	mg/l	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Cu	mg/l	0.01	<	0.03	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Fe	mg/l	0.01	0.16	7.31	0.12	0.02	0.02	<	<	<	<	<	0.08	0.02	0.20	<	28.04	0.06	0.10	0.42	<	<
K	mg/l	0.1	1.0	4.0	1.0	1.0	0.4	1.5	2.1	1.9	2.9	3.4	0.9	1.8	0.6	2.8	8.5	1.0	1.5	1.5	1.8	2.1
Mg	mg/l	0.01	0.56	1.39	0.65	0.94	0.51	1.46	6.19	1.93	6.30	13.19	0.12	0.48	0.11	4.05	46.53	0.17	0.62	0.30	2.64	3.64
Mn	mg/l	0.01	0.01	0.02	<	<	<	<	0.02	<	<	0.01	<	<	<	<	0.54	<	<	<	<	<
Na	mg/l	0.1	54.6	49.5	49.8	184.0	68.1	69.1	180.4	44.1	88.7	76.8	38.8	53.6	74.2	71.7	118.9	46.2	59.2	53.8	75.0	46.7
Ni	mg/l	0.01	<	0.05	<	<	<	<	0.04	<	<	<	<	<	<	<	1.46	<	<	<	<	<
P	mg/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Si	mg/l	0.05	4.84	18.11	2.73	0.95	1.43	1.67	1.70	2.21	1.76	1.15	3.49	2.32	3.17	2.30	3.54	1.95	3.16	10.01	2.09	1.20
V	mg/l	0.01	<	0.04	<	<	<	<	<	<	<	<	<	0.01	0.01	<	<	<	<	0.06	<	<
Zn	mg/l	0.01	0.01	0.07	0.01	<	<	0.02	<	<	<	0.01	<	<	<	0.01	0.63	<	0.02	<	<	<
Ag	ug/l	0.01	<	0.02	0.05	<	<	<	0.01	<	<	0.02	0.02	<	0.02	0.03	0.01	0.04	0.02	0.03	0.02	0.02
As	ug/l	0.1	3.2	20.1	9.4	14.8	12.1	36.4	4.3	8.1	25.8	14.9	8.6	36.5	71.4	22.8	13.5	16.7	28.7	73.1	15.2	6.3
Ba	ug/l	0.05	9.19	5.39	4.49	16.69	23.74	3.49	48.64	6.83	7.50	35.08	6.97	3.41	18.94	18.14	87.07	14.84	5.10	69.54	8.08	19.48
Be	ug/l	0.1	0.1	0.7	<	<	0.2	<	0.1	<	<	<	0.1	<	0.1	<	2.0	0.2	<	0.7	<	<
Cd	ug/l	0.02	0.14	0.40	0.14	0.11	0.14	0.16	0.28	0.10	0.45	0.38	0.06	0.15	0.09	0.32	1.38	0.14	0.14	3.05	0.15	0.15
Co	ug/l	0.1	5.1	4.4	0.7	2.2	2.3	0.5	49.9	1.2	2.6	23.0	0.9	0.5	0.7	0.9	1182.0	1.1	0.3	1.0	0.8	0.3
Hg	ug/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Mo	ug/l	0.05	0.66	1.07	0.81	33.67	40.14	50.00	10.23	51.96	82.06	73.86	51.85	50.13	45.94	30.55	0.56	31.10	42.13	46.24	94.81	14.40
Pb	ug/l	0.5	2.5	7.7	2.8	1.1	0.6	1.4	<	<	<	<	0.6	1.4	1.5	1.7	16.0	1.5	0.7	4.8	0.7	0.6
Sb	ug/l	0.01	0.09	0.31	0.07	1.44	1.47	3.55	0.67	1.96	3.47	1.52	1.84	3.59	2.64	1.26	0.63	2.31	2.31	2.06	1.11	0.33
Se	ug/l	0.5	3.4	95.9	1.0	4.4	2.2	16.9	14.5	11.6	4.9	7.6	14.0	16.0	59.5	64.6	24.8	34.0	63.5	30.6	61.7	4.7
Sn	ug/l	0.1	<	<	<	<	<	<	0.1	<	<	<	<	<	<	<	<	<	0.5	<	<	0.1
Th	ug/l	0.005	0.033	0.471	0.096	<	0.006	0.017	0.007	0.006	0.019	0.012	0.062	0.015	0.044	0.010	0.010	0.036	0.079	0.135	0.016	0.009
U	ug/l	0.005	0.288	0.552	0.054	2.484	0.727	0.793	0.161	0.182	1.943	0.243	0.290	0.781	2.136	0.395	0.269	0.444	0.500	0.413	0.353	0.113

Table B-11: Acid forming characteristics of coal seam samples from the Vickery Coal Project, and coarse rejects and fines from the Whitehaven CHPP (Gunnedah).

Sample Type	Sample Code	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS						NAG TEST			ARD Classification
				Total %S	Sulfide %S	MPA	ANC	NAPP	ANC/ MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
Coal Seam	VKY0007C/S1 (KUR)	5.6	0.332	0.38	0.116	12	3	9	0.3	2.5	74	128	PAF
	VKY0003C/S1 (SHU)	7.7	0.237	0.40	0.036	12	4	8	0.3	3.4	5	21	PAF
	VKY0007C/S2 (SHU)	4.3	0.441	0.51	0.147	16	3	13	0.2	2.4	103	168	PAF
	VKY0003C/S2 (SHL)	4.2	0.628	0.55	0.206	17	3	14	0.2	2.7	15	24	PAF
	VKY0007C/S3 (SHL)	8.3	0.411	0.07	0.024	2	95	-93	44.5	10.2	0	0	NAF
	VKY0007C/S4 (STU)	8.2	0.260	0.38	0.038	12	27	-16	2.3	6.7	0	0	NAF
	VKY0003C/S3 (STU/L)	4.2	0.427	0.50	0.064	15	2	13	0.1	2.5	90	156	PAF
	VKY0007C/S5 (BLU)	7.6	0.208	0.35	0.019	11	7	4	0.7	3.4	7	22	PAF
	VKY0003C/S4 (BLU/M)	4.9	0.617	1.05	0.356	32	5	27	0.1	2.6	28	43	PAF
	VKY0007C/S6 (BLM)	7.9	0.710	0.40	0.144	12	26	-13	2.1	8.2	0	0	NAF
	VKY0003C/S5 (BLL)	7.3	0.295	0.37	0.028	11	6	5	0.5	2.5	112	156	PAF
	VKY0007C/S7 (BLL)	8.2	0.419	0.36	0.056	11	27	-16	2.5	8.8	0	0	NAF
	VKY0003C/S6 (CNW)	7.9	0.228	0.38	0.034	12	38	-26	3.3	5.1	0	9	NAF
	VKY0007C/S8 (CNW)	8.1	0.429	0.64	0.190	20	37	-17	1.9	7.7	0	0	NAF
Coarse Rejects	CR1	7.4	0.512	0.37	0.178	11	9	2	0.8	3.7	4	14	PAF/LC
	CR2	7.4	0.487	0.25	0.164	8	6	2	0.7	3.4	4	11	PAF/LC
	CR3	7.9	0.698	0.25	0.106	8	19	-11	2.4	6.8	0	0	NAF
	CR4	7.8	0.357	0.19	0.118	6	8	-2	1.4	4.4	1	5	UC(PAF/LC)
	CR5	8.1	0.339	0.28	0.169	9	14	-6	1.6	6.0	0	1	NAF
	CR6	7.6	0.468	0.20	0.138	6	15	-9	2.4	6.8	0	0	NAF
	CR7	6.8	0.668	3.49	3.120	107	3	104	0.0	2.0	57	88	PAF
	CR8	7.6	0.350	0.38	0.184	12	13	-1	1.1	6.2	0	1	NAF
	CR9	7.7	0.337	0.20	0.117	6	20	-14	3.2	7.8	0	0	NAF
	CR10	7.6	0.349	0.18	0.065	6	8	-2	1.4	5.5	0	1	NAF
Fines	F1	8.4	2.046	0.39	0.075	12	19	-7	1.6	5.4	0	2	NAF
	F2	8.1	1.671	0.38	0.088	12	21	-9	1.8	5.7	0	1	NAF
	F3	8.0	1.055	0.39	0.122	12	20	-8	1.6	6.2	0	1	NAF
	F4	7.8	1.117	0.44	0.115	13	10	3	0.8	4.6	0	6	UC(NAF)
	F5	7.8	0.493	0.35	0.056	11	4	7	0.3	2.4	103	169	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 (kgH_2SO_4/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-12: Multi-element composition of coal seam samples from the Vickery Coal Project, and coarse reject and fines samples from the Whitehaven CHPP (Gunnedah).

Element	Unit	Detect. Limit	Sample Description/Code																		
			Coal Seam Samples														Coarse Rejects			Fines	
			VKY3C/S1	VKY3C/S2	VKY3C/S3	VKY3C/S4	VKY3C/S5	VKY3C/S6	VKY7C/S1	VKY7C/S2	VKY7C/S3	VKY7C/S4	VKY7C/S5	VKY7C/S6	VKY7C/S7	VKY7C/S8	VCM/CR1	VCM/CR7	VCM/CR8	VCM/F2	VCM/F5
Ag	mg/kg	0.01	0.09	0.1	0.06	0.02	0.12	0.05	0.1	0.05	0.1	0.04	0.05	0.04	0.04	0.05	0.09	0.11	0.08	0.09	0.06
Al	%	0.005%	1.844%	2.868%	0.395%	0.559%	3.355%	1.289%	3.747%	2.933%	5.624%	0.609%	1.743%	0.885%	4.224%	3.139%	6.350%	8.600%	6.849%	5.723%	4.036%
As	mg/kg	0.5	0.8	9.8	1.4	4.3	2.4	0.7	5.3	7.1	2.4	<	0.8	0.9	6.1	1.3	4.2	40.4	10.5	3.8	2.1
B	mg/kg	50	90	76	76	77	67	<	69	61	<	58	84	73	<	82	74	95	83	77	73
Ba	mg/kg	0.1	212.1	201.4	52.6	49.7	318.0	76.5	156.0	176.5	928.0	36.3	105.7	103.7	1113.1	235.6	219.2	254.6	201.2	185.3	101.4
Be	mg/kg	0.05	0.95	3.25	1.08	1.03	4.69	0.91	5.31	1.77	2.14	0.42	1.89	1.24	3.25	1.90	1.45	2.19	1.11	1.32	2.25
Ca	%	0.005%	0.049%	0.050%	0.027%	0.098%	0.130%	2.316%	0.072%	0.046%	3.822%	0.189%	0.049%	0.216%	1.990%	1.119%	0.253%	0.165%	0.471%	0.579%	0.084%
Cd	mg/kg	0.02	0.12	0.07	0.03	0.02	0.08	0.05	0.06	0.05	0.23	0.02	0.05	0.03	0.08	0.08	0.09	0.09	0.09	0.12	0.09
Co	mg/kg	0.1	7.9	10.1	3.1	2.6	14.3	10.1	9.4	5.1	21.3	1.4	4.4	3.9	22.2	8.4	5.8	9.7	7.0	10.1	12.0
Cr	mg/kg	5	13	24	<	5	23	10	51	17	72	<	13	16	69	18	26	37	29	32	23
Cu	mg/kg	1	21	10	11	6	16	13	25	14	41	5	8	7	25	18	30	34	32	36	18
Fe	%	0.01%	1.65%	0.77%	0.41%	0.65%	0.37%	0.22%	0.45%	0.41%	4.38%	0.61%	0.94%	1.40%	2.28%	0.88%	1.46%	3.83%	8.80%	1.32%	0.39%
Hg	mg/kg	0.001	0.050	0.349	0.067	0.367	<	<	0.182	0.256	<	<	<	<	0.039	0.026	0.039	0.480	0.100	0.070	0.027
K	%	0.002%	0.338%	0.515%	0.227%	0.120%	0.572%	0.143%	1.158%	0.829%	1.541%	0.134%	0.480%	0.288%	0.676%	0.401%	0.929%	1.580%	0.824%	0.417%	0.528%
Mg	%	0.002%	0.045%	0.105%	0.017%	0.038%	0.086%	0.095%	0.128%	0.082%	1.128%	0.052%	0.061%	0.101%	0.851%	0.234%	0.266%	0.243%	0.429%	0.367%	0.117%
Mn	mg/kg	1	252	31	6	14	15	22	16	14	650	20	35	33	174	107	232	117	1821	170	20
Mo	mg/kg	0.1	0.4	1.2	0.2	0.4	0.7	1.3	1.4	0.8	4.1	0.2	0.3	0.4	2.3	1.3	1.2	1.4	1.7	2.4	1.2
Na	%	0.002%	0.027%	0.032%	0.014%	0.034%	0.056%	0.015%	0.075%	0.060%	0.585%	0.014%	0.064%	0.062%	0.070%	0.074%	0.063%	0.165%	0.066%	0.173%	0.053%
Ni	mg/kg	1	18	31	9	13	27	31	31	15	34	4	11	12	50	17	16	30	18	30	26
P	mg/kg	50	96	<	<	<	53	<	65	<	758	<	51	106	422	82	302	241	951	793	97
Pb	mg/kg	0.5	4.5	8.7	4.3	1.3	9.6	4.4	10.4	6.5	8.8	2.0	3.8	3.2	9.1	8.5	12.0	24.8	11.9	8.6	8.9
Sb	mg/kg	0.05	0.14	0.41	0.29	0.20	0.77	0.36	0.66	0.23	0.24	0.08	0.23	0.20	1.24	0.92	0.39	1.58	0.46	0.31	1.08
Se	mg/kg	0.01	0.25	0.17	0.09	0.18	0.14	0.30	0.20	0.14	0.15	0.26	0.10	0.12	0.22	0.23	0.18	0.52	0.26	0.20	0.22
Si	%	0.1%	8.3%	8.2%	8.5%	6.0%	7.9%	3.3%	13.8%	10.2%	20.8%	8.3%	11.0%	14.3%	10.4%	8.8%	17.1%	28.0%	19.8%	10.7%	9.9%
Sn	mg/kg	0.1	0.5	2.0	0.5	0.3	2.1	0.7	1.5	1.1	8.7	1.0	0.6	0.5	2.0	1.3	2.4	3.2	2.2	1.6	1.8
Th	mg/kg	0.01	2.34	4.63	1.47	1.67	5.42	1.90	5.99	3.65	6.20	0.94	2.41	1.58	5.68	4.00	9.50	11.91	8.90	6.14	5.87
U	mg/kg	0.01	0.72	1.42	0.64	0.53	1.99	0.67	2.26	1.29	1.75	0.30	0.97	0.48	1.65	1.10	2.94	7.10	3.95	2.12	1.65
V	mg/kg	1	26	44	15	11	43	19	113	26	119	8	27	21	70	43	54	67	59	67	51
Zn	mg/kg	1	17	40	12	7	28	14	39	22	83	6	18	10	72	33	45	33	45	38	29

< element at or below analytical detection limit.

Table B-13: Geochemical anundance indices for coal seam samples from the Vickery Coal Project, and coarse reject and fines samples from the Whitehaven CHPP (Gunnedah).

Element	*Mean Crustal Abundance	Sample Description/Code																		
		Coal Seam Samples														Coarse Rejects			Fines	
		VKY3C/S1	VKY3C/S2	VKY3C/S3	VKY3C/S4	VKY3C/S5	VKY3C/S6	VKY7C/S1	VKY7C/S2	VKY7C/S3	VKY7C/S4	VKY7C/S5	VKY7C/S6	VKY7C/S7	VKY7C/S8	VCM/CR1	VCM/CR7	VCM/CR8	VCM/F2	VCM/F5
Ag	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Al	8.2%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	1.5	-	2	-	1	-	-	1	2	-	-	-	-	1	-	1	**4**	2	1	-
B	10	**3**	2	2	2	2	<2	2	2	<2	2	2	2	<2	2	2	**3**	2	2	2
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Be	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca	4.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cd	0.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cr	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe	4.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Hg	0.05	-	2	-	2	-	-	1	2	-	-	-	-	-	-	-	**3**	-	-	-
K	2.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn	950	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mo	1.5	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Na	2.3%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sb	0.2	-	-	-	-	1	-	1	-	-	-	-	-	2	2	-	2	1	-	2
Se	0.05	2	1	-	1	1	2	1	1	1	2	-	1	2	2	1	**3**	2	1	2
Si	27.7%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sn	2.2	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Th	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
U	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
V	160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

Table B-14: Chemical composition of water extracts from coal seam samples from the Vickery Coal Project, and coarse reject and fines samples from the Whitehaven CHPP (Gunnedah).

Parameter		Detect. Limit	Sample Description/Code																		
			Coal Seam Samples														Coarse Rejects			Fines	
			VKY3C/S1	VKY3C/S2	VKY3C/S3	VKY3C/S4	VKY3C/S5	VKY3C/S6	VKY7C/S1	VKY7C/S2	VKY7C/S3	VKY7C/S4	VKY7C/S5	VKY7C/S6	VKY7C/S7	VKY7C/S8	VCM/CR1	VCM/CR7	VCM/CR8	VCM/F2	VCM/F5
pH		0.1	7.7	4.2	4.2	4.9	7.3	7.9	5.6	4.3	8.3	8.2	7.6	7.9	8.2	8.1	7.4	6.8	7.6	8.1	7.8
EC	dS/m	0.001	0.237	0.628	0.427	0.617	0.295	0.228	0.332	0.441	0.411	0.26	0.208	0.71	0.419	0.429	0.512	0.668	0.35	1.671	0.493
SO4	mg/l	0.3	47.5	316.3	177.2	378.5	80.4	27.6	165.5	220.5	67.8	24.9	52.8	269.4	112.3	116	174.3	320	106.6	431.9	100.9
Cl	mg/l	5	15	23	<	<	5	7	7	<	<	<	6	6	<	<	<	6	6	181	54
Al	mg/l	0.01	0.08	0.14	0.04	<	<	<	<	0.04	0.09	0.09	0.06	<	0.05	<	0.06	<	0.11	0.09	0.28
B	mg/l	0.01	0.05	0.01	0.02	<	0.02	<	0.02	0.02	0.02	0.02	0.03	<	0.02	0.03	0.02	0.04	0.04	0.02	0.05
Ca	mg/l	0.01	3.95	29.40	17.55	75.47	13.99	23.37	18.52	19.19	6.54	7.93	2.46	30.89	10.86	16.23	15.77	31.52	8.38	23.41	10.84
Cr	mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	<	0.01	<	0.01	0.01	0.01	0.01	0.01	<	0.01	0.01
Cu	mg/l	0.01	<	0.03	0.03	<	<	<	<	0.02	<	<	<	<	<	<	<	<	<	<	<
Fe	mg/l	0.01	0.03	28.73	2.01	6.45	0.02	<	0.02	4.47	0.01	0.01	0.02	<	<	<	0.01	0.01	0.03	0.01	0.02
K	mg/l	0.1	3.7	5.2	4.2	2.7	3.5	2.3	5.3	5.1	4.4	4.2	2.9	5.7	4.0	2.8	7.5	17.9	5.6	6.7	7.1
Mg	mg/l	0.01	2.81	26.36	9.54	32.49	4.98	5.48	18.56	21.08	6.90	6.10	2.43	27.94	8.17	5.78	10.73	21.90	6.34	23.84	9.12
Mn	mg/l	0.01	0.01	0.37	0.06	0.67	<	<	0.06	0.18	<	<	<	0.03	<	<	0.02	0.08	0.04	0.02	<
Na	mg/l	0.1	42.5	41.2	42.7	24.2	46.7	18.5	23.3	34.7	81.6	41.8	47.5	84.6	78.0	69.5	63.0	74.1	57.5	278.0	93.5
Ni	mg/l	0.01	<	0.62	0.17	0.60	0.01	<	0.19	0.17	<	<	<	0.01	<	<	<	0.08	<	<	<
P	mg/l	0.1	0.1	0.1	<	0.1	<	0.1	<	<	<	0.1	0.1	0.1	0.1	0.1	0.1	<	0.1	<	0.1
Si	mg/l	0.05	3.27	5.12	4.47	1.05	2.16	1.32	3.91	5.06	2.32	2.46	1.87	1.52	1.68	1.49	3.00	3.52	2.65	1.06	1.65
V	mg/l	0.01	0.01	<	<	<	<	<	<	<	<	<	<	<	<	<	0.01	0.01	0.01	<	0.01
Zn	mg/l	0.01	0.01	0.22	0.09	0.06	0.02	<	0.08	0.22	<	<	0.01	<	<	0.01	0.01	0.02	0.01	<	<
Ag	ug/l	0.01	0.03	0.01	<	<	0.01	0.02	<	0.05	0.05	0.02	0.03	0.08	0.01	0.01	0.02	0.05	<	<	<
As	ug/l	0.1	5.1	3.2	1.5	2.0	9.8	3.4	6.3	1.8	3.4	3.6	2.6	4.9	21.2	3.2	4.5	2.9	4.6	1.1	3.7
Ba	ug/l	0.05	60.56	30.91	39.41	48.00	53.82	55.76	49.40	37.16	7.91	35.04	17.85	33.83	56.63	66.50	36.23	47.43	23.28	58.25	77.02
Be	ug/l	0.1	<	5.1	1.7	0.5	<	<	0.5	3.1	<	<	<	<	<	<	<	<	<	<	<
Cd	ug/l	0.02	0.03	1.63	0.58	0.93	0.06	0.03	0.34	1.36	<	0.03	0.10	0.08	0.03	0.03	0.09	0.24	0.06	0.06	0.06
Co	ug/l	0.1	0.5	261.4	63.4	137.1	2.6	0.2	44.7	50.9	0.9	0.4	0.5	6.2	1.6	0.2	1.1	41.5	2.2	0.5	0.6
Hg	ug/l	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Mo	ug/l	0.05	20.63	0.20	0.07	0.05	19.06	61.85	0.54	0.13	500.45	60.83	22.58	52.94	175.15	43.18	23.64	6.29	45.42	63.91	59.05
Pb	ug/l	0.5	<	2.5	2.5	0.8	<	<	<	2.4	<	<	0.6	<	<	<	<	<	<	<	<
Sb	ug/l	0.01	0.31	0.04	0.09	0.04	0.56	0.40	0.12	0.05	1.39	0.53	0.59	0.40	1.03	0.23	0.37	0.32	0.44	0.18	1.09
Se	ug/l	0.5	39.6	16.7	20.8	6.8	33.3	23.6	33.2	11.3	19.7	46.0	28.2	34.6	44.4	31.0	30.7	16.7	8.9	4.4	11.5
Sn	ug/l	0.1	<	<	<	<	<	<	0.1	<	<	<	<	<	<	<	<	<	<	<	<
Th	ug/l	0.005	0.007	0.010	<	0.006	0.006	<	<	0.028	<	0.012	<	<	<	0.007	0.011	<	0.025	0.013	0.050
U	ug/l	0.005	0.050	0.665	0.185	0.030	0.238	0.644	0.066	0.765	1.069	3.499	0.461	1.078	0.425	0.375	0.359	0.201	1.424	2.637	0.279

< element at or below analytical detection limit.

Attachment C

Acid Buffering Characteristic Curves

Figure C-1: Acid buffering characteristic curve for sample VCM07/27.

Figure C-2: Acid buffering characteristic curve for sample VCM14/23.

Figure C-3: Acid buffering characteristic curve for sample VCM16/12.

Figure C-4: Acid buffering characteristic curve for sample VCM16/21.

Figure C-5: Acid buffering characteristic curve for sample VCM20/17.

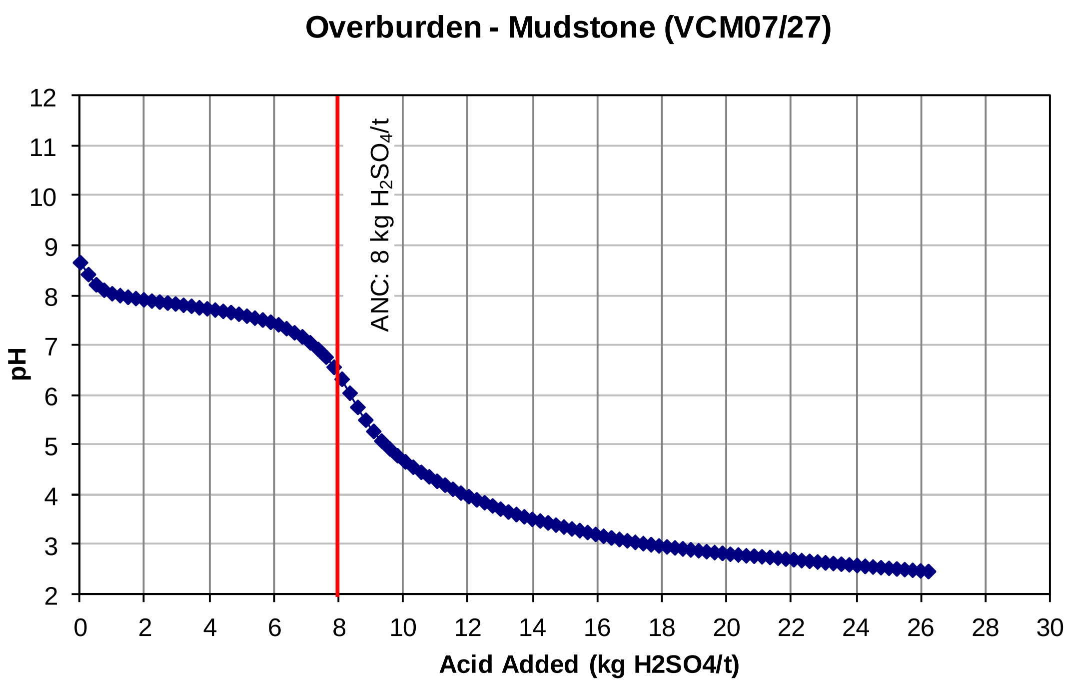

Figure C-1: Acid buffering characteristic curve for sample VCM07/27.

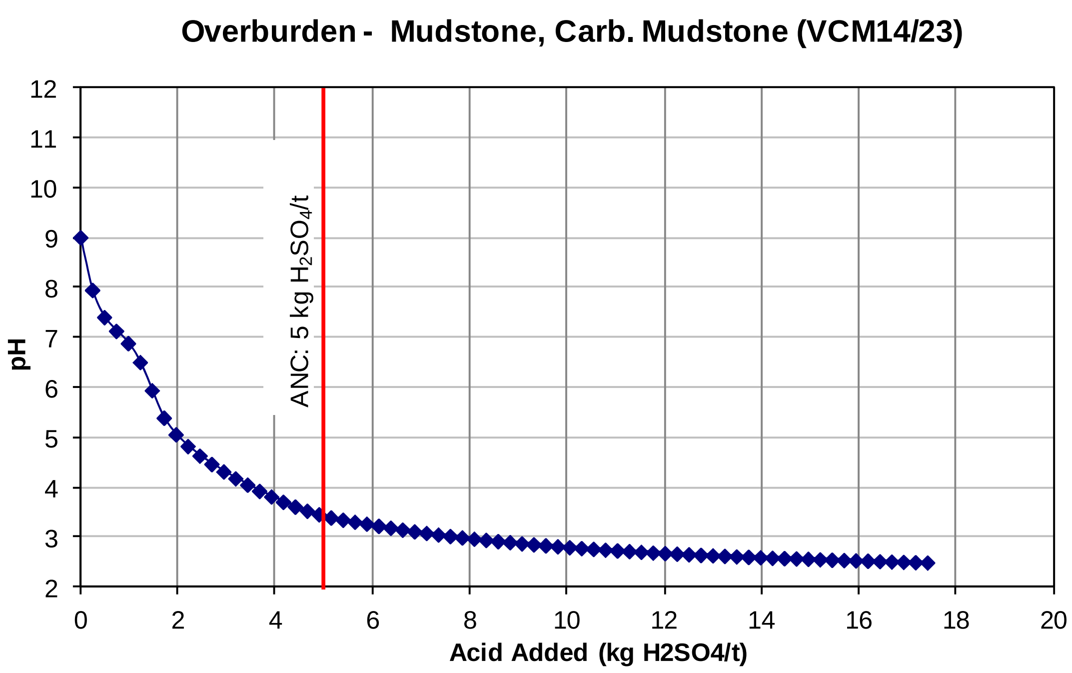

Figure C-2: Acid buffering characteristic curve for sample VCM14/23.

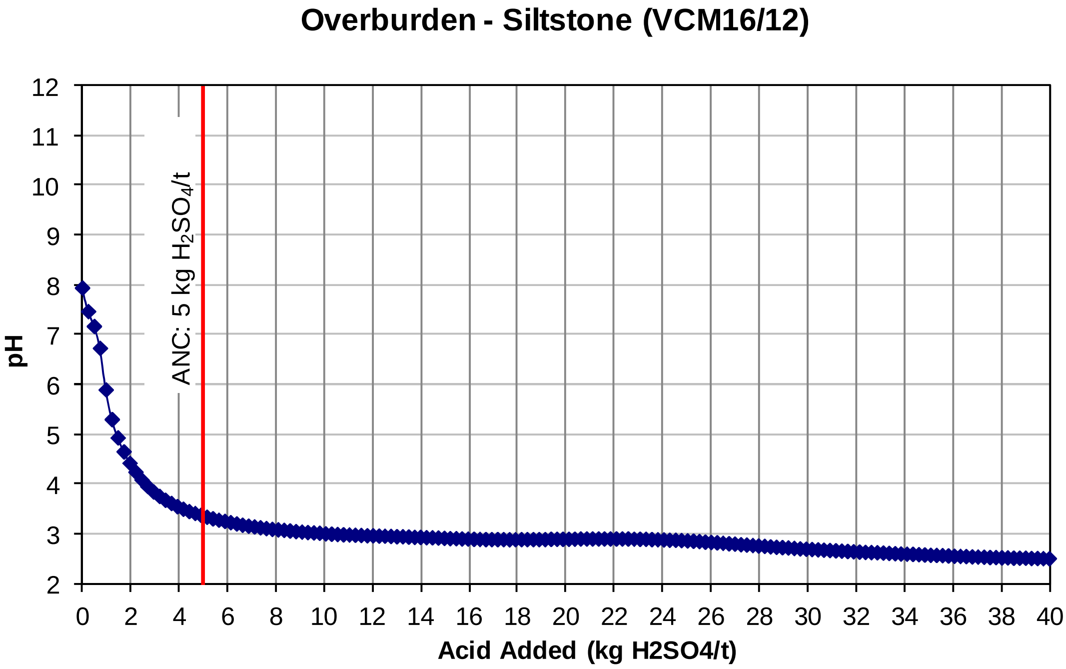

Figure C-3: Acid buffering characteristic curve for sample VCM16/12.

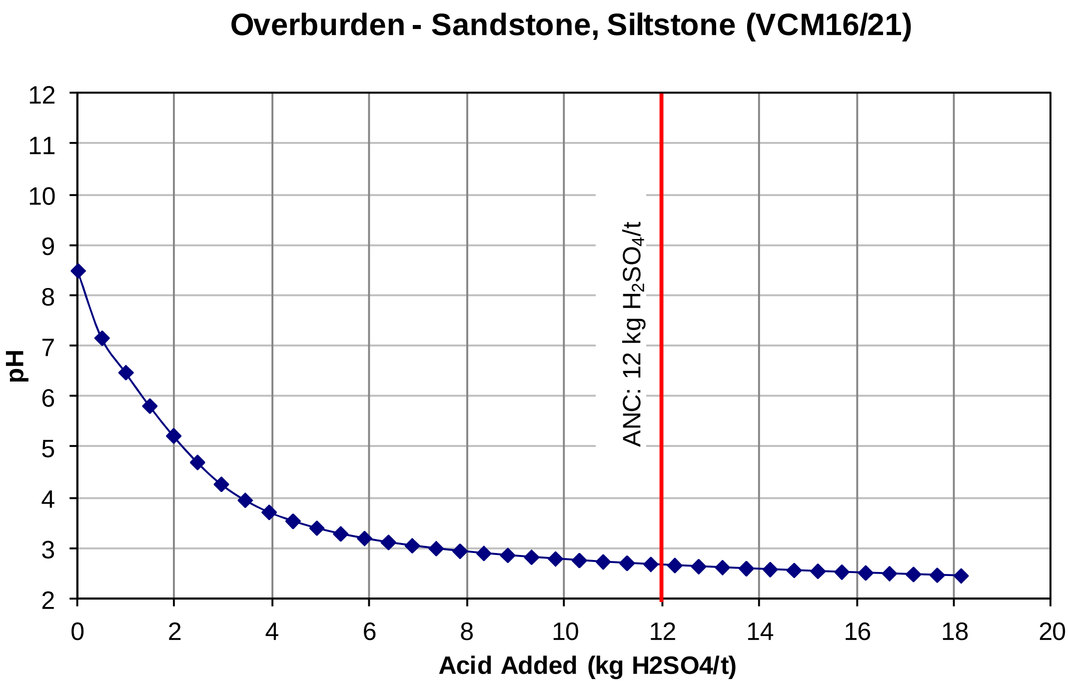

Figure C-4: Acid buffering characteristic curve for sample VCM16/21.

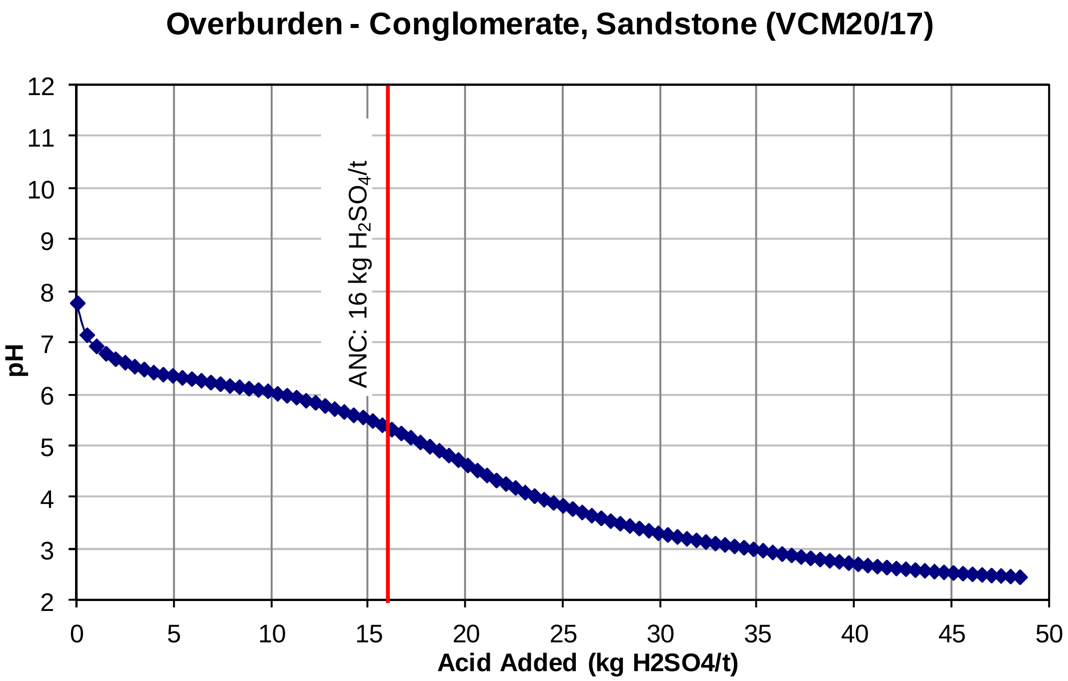

Figure C-5: Acid buffering characteristic curve for sample VCM20/17.

Attachment D

Kinetic NAG Test Plots

Figure D-1: Kinetic NAG test profiles for sample VCM14/21.

Figure D-2: Kinetic NAG test profiles for sample VCM7/27.

Figure D-3: Kinetic NAG test profiles for sample VCM14/23.

Figure D-4: Kinetic NAG test profiles for sample VCM16/12.

Figure D-5: Kinetic NAG test profiles for sample VCM/CR1.

Figure D-6: Kinetic NAG test profiles for sample VCM/CR4.

Figure D-7: Kinetic NAG test profiles for sample VCM/CR7.

Figure D-8: Kinetic NAG test profiles for sample VCM/F5.

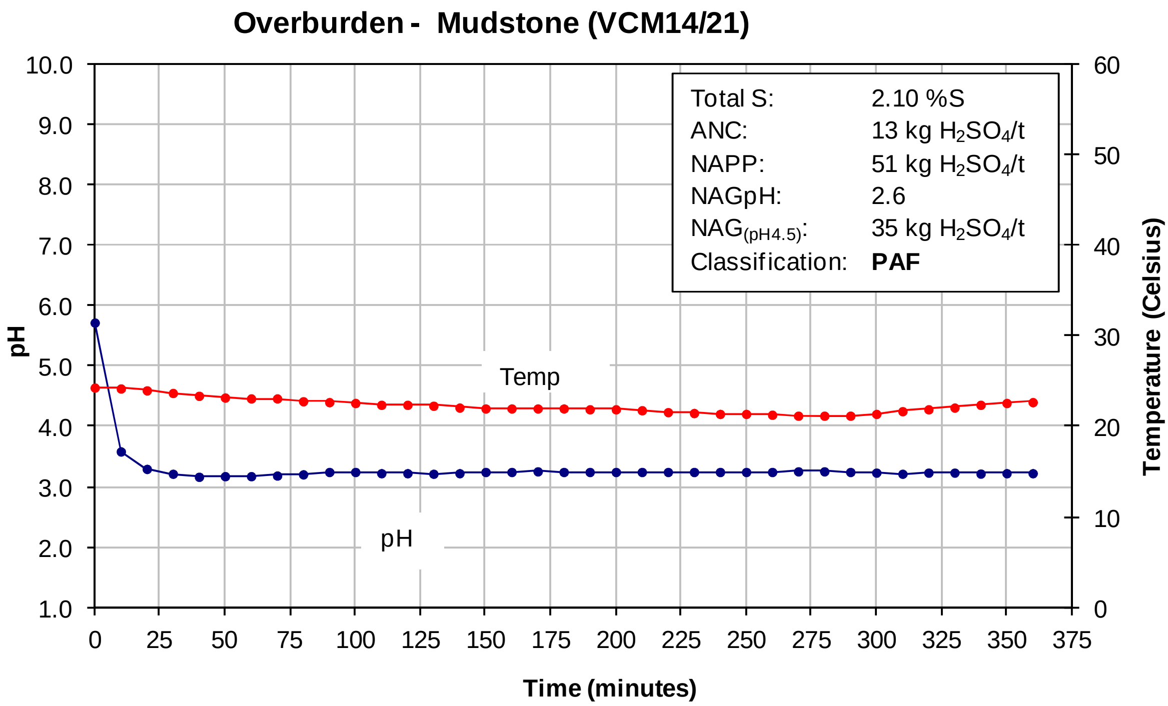

Figure D-1: Kinetic NAG test profiles for sample VCM14/21.

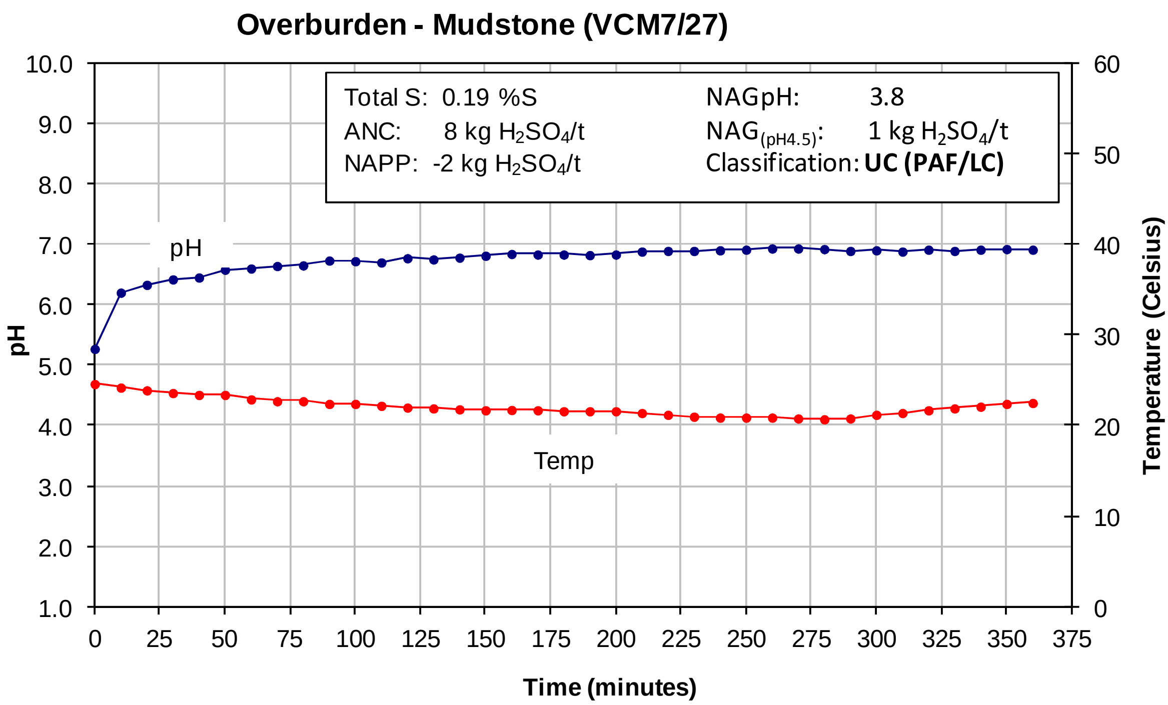

Figure D-2: Kinetic NAG test profiles for sample VCM7/27.

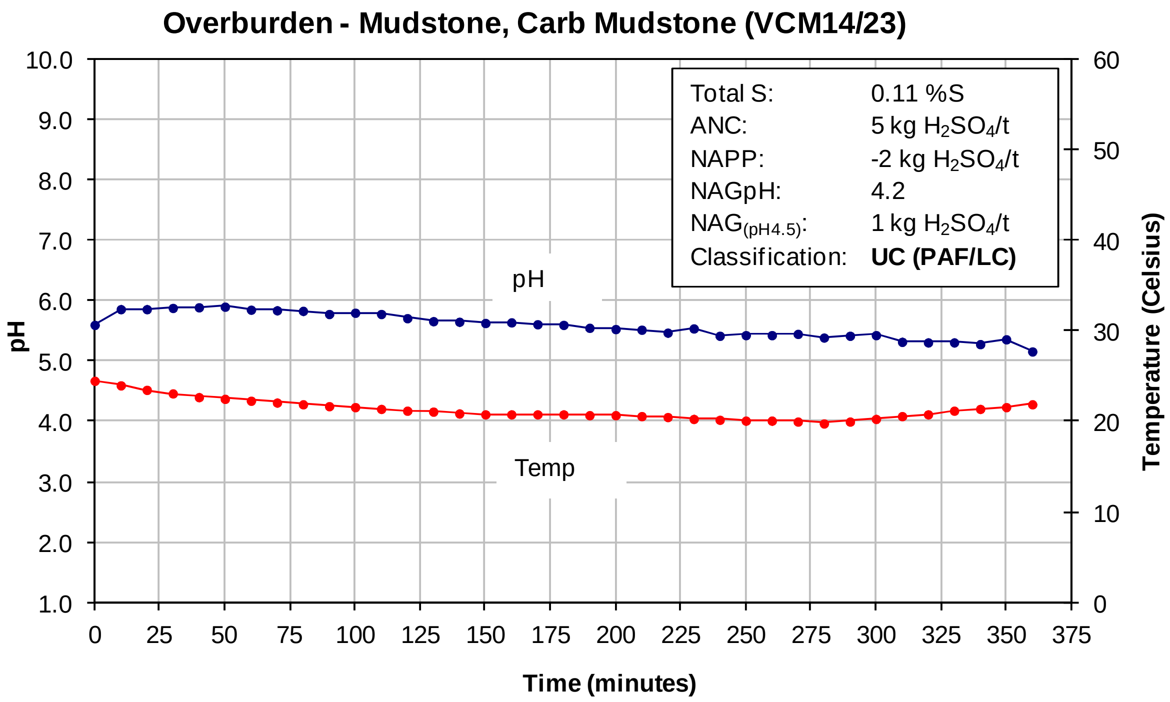

Figure D-3: Kinetic NAG test profiles for sample VCM14/23.

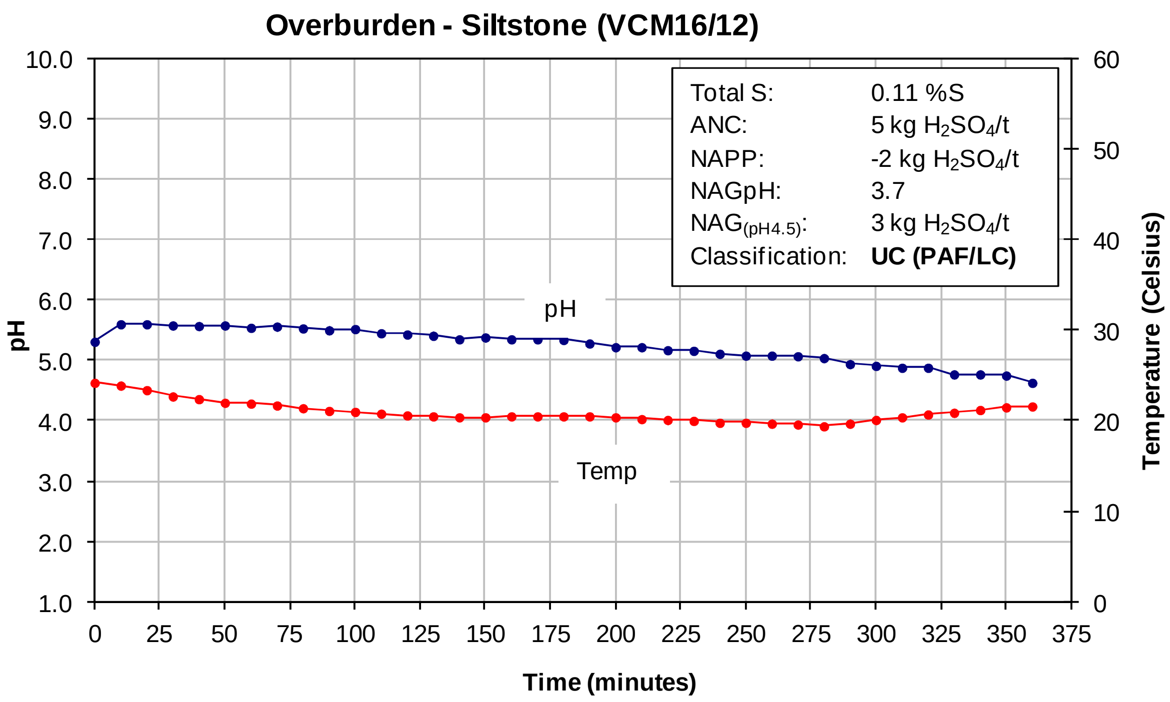

Figure D-4: Kinetic NAG test profiles for sample VCM16/12.

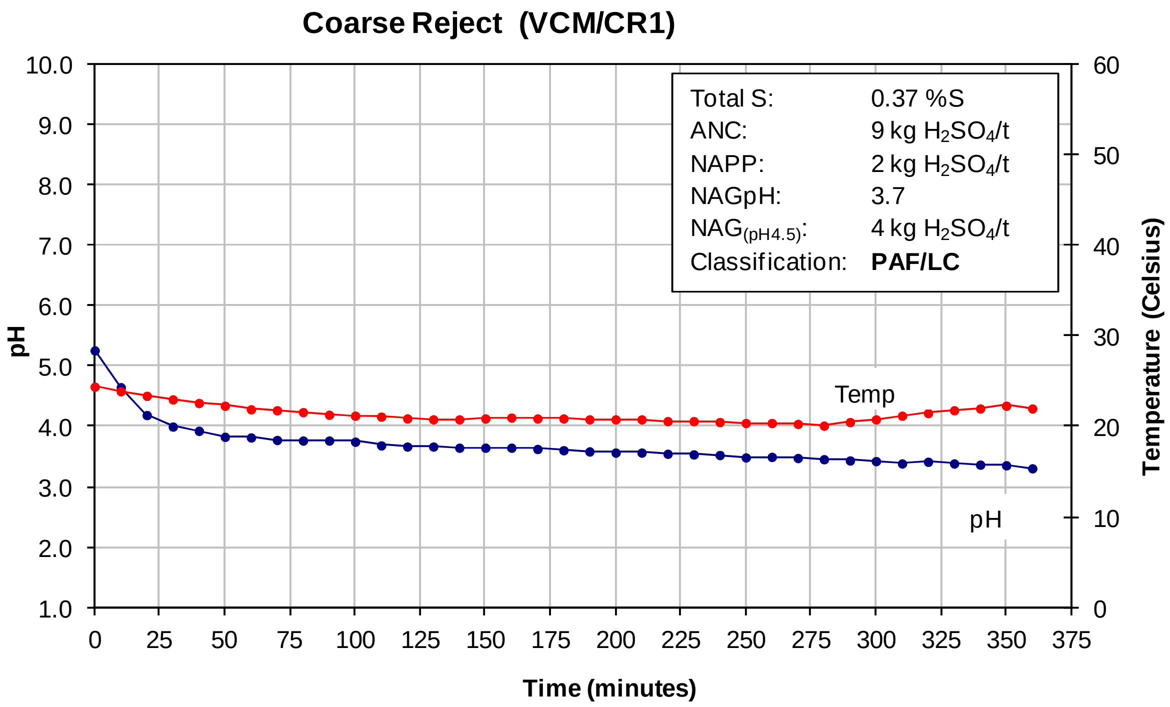

Figure D-5: Kinetic NAG test profiles for sample VCM/CR1.

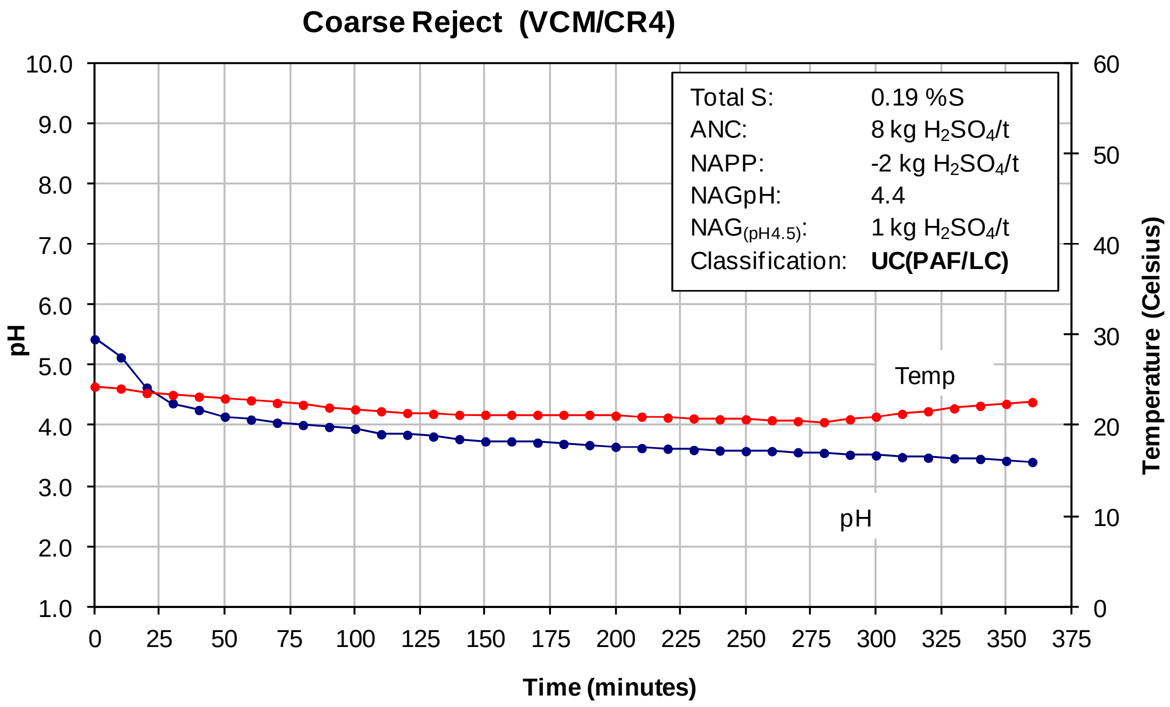

Figure D-6: Kinetic NAG test profiles for sample VCM/CR4.

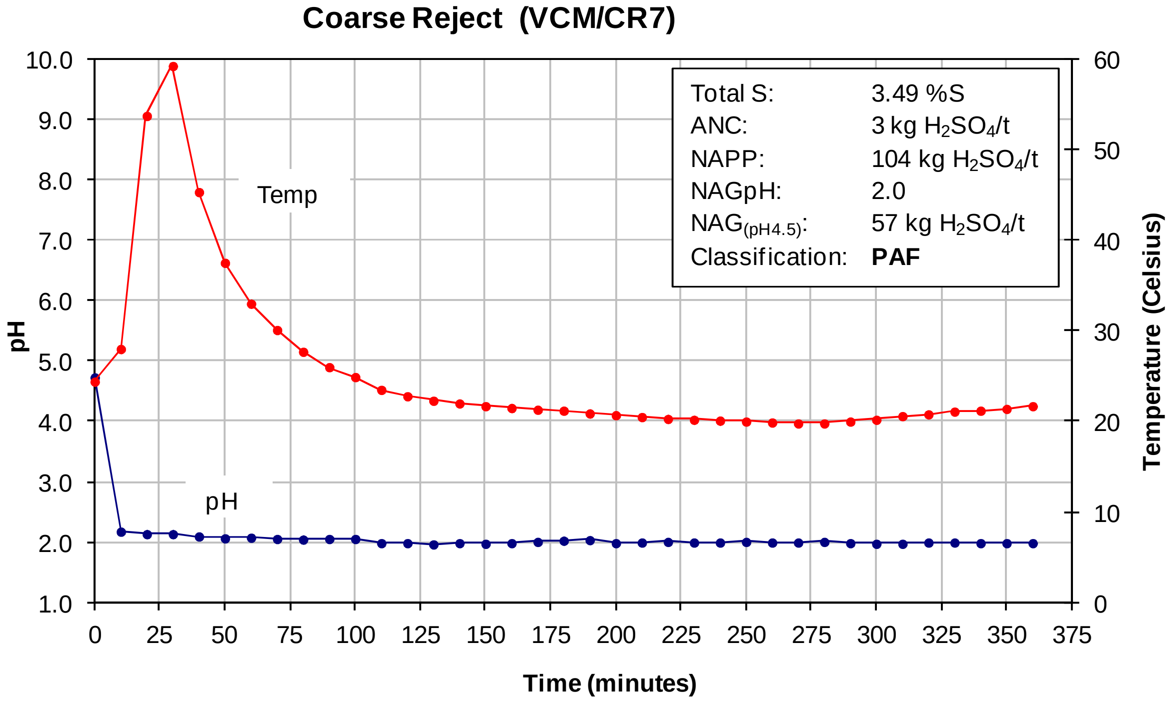

Figure D-7: Kinetic NAG test profiles for sample VCM/CR7.

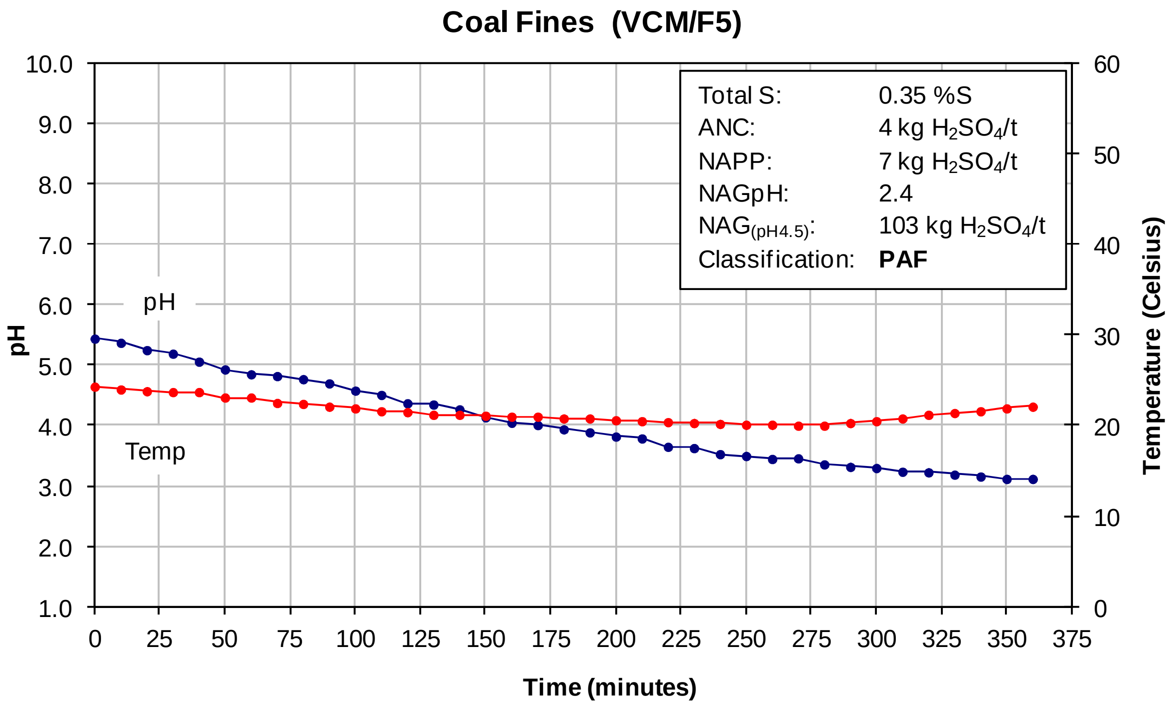

Figure D-8: Kinetic NAG test profiles for sample VCM/F5.