AshtonCoal

Appendix 9

Geo-Chemical Assessment

South East Open Cut Project

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Modification to the

Existing ACP Consent

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May 2009

Document No. 6851/865

Ashton Coal Operations
ARD Assessment
South East Open Cut Project

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Executive Summary

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by Ashton Coal Operations Pty Limited to carry out an acid rock drainage (ARD) assessment of the proposed Ashton Coal Mine South East Open Cut (SEOC) project. The proposed SEOC is located 14 km northwest of Singleton in the Hunter Valley region of New South Wales, and is adjacent to the existing Ashton North East Open Cut (NEOC) and underground operations. The objective of the work was to assess the ARD potential of overburden, coal, floor rock and process wastes expected to be produced from development of the SEOC in support of an Environmental Assessment. This report is consistent with the Director-General of Planning environmental assessment requirements for the project in respect to ARD.

The SEOC deposit is multi-seamed, and will be mined by conventional truck and excavator techniques to a maximum open cut pit depth of around 100m. Initial development spoils will be placed out of pit, followed by in pit dumping as soon as practical. The SEOC mine stratigraphic sequence is essentially an extension of the sequence currently mined as part of the Ashton NEOC and underground operations.

A total of 295 overburden, coal seam, seam roof and seam floor samples, and 66 washery waste samples were geochemically tested. This was supported by examination of core with Ashton geologists during a site visit, focusing on the occurrence of pyrite and carbonate minerals in the mine stratigraphy.

Results of testing indicate that overburden and pit floor materials from the Ashton SEOC are likely to be non acid forming (NAF) overall, and should not require any special handling for ARD control. It is expected that although minor pyritic materials may occur, these are likely to be isolated. Since the remaining spoils have excess alkalinity, mixing of mined materials as part of normal operations is expected to mitigate any isolated ARD generated.

Salinity appears to be low for most overburden materials, with a small portion having moderate salinity, mainly associated with carbonaceous samples.

Washery waste samples from the existing NEOC and underground operations were used as an analogue for the washery wastes expected from processing SEOC coal. Results of geochemical testing of the NEOC samples confirm that significant pyrite may occur in washery waste materials, but this appears to be offset by an excess of buffering capacity, so that washery waste materials represented by the samples tested are expected to be NAF overall with a high factor of safety.

Water quality monitoring of key seepage, pit water and drainage from overburden materials and washery waste materials should be routinely carried out for indicators of ARD and salinity to confirm the expected benign nature of these materials, and provide warning of any anomalously pyritic materials extracted during mining. Monitoring should include pH, EC, SO_4 and acidity/alkalinity, with follow up multi element testing if any low pH conditions are detected.

1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by Ashton Coal Operations Pty Limited to carry out an acid rock drainage (ARD) assessment of the proposed Ashton Coal Mine South East Open Cut (SEOC) project. The proposed SEOC is located 14 km northwest of Singleton in the Hunter Valley region of New South Wales, and is adjacent to existing Ashton North East Open Cut (NEOC) and underground operations. The objective of the work was to assess the ARD potential of overburden, coal, floor rock and process wastes expected to be produced from development of the SEOC in support of an Environmental Assessment. This report is consistent with the Director-General of Planning environmental assessment requirements for the project in respect to ARD.

2.0 Background

The SEOC deposit is multi-seamed, and will be mined by conventional truck and excavator techniques to a maximum open cut pit depth of around 100m. Initial development spoils will be placed out of pit, followed by in pit dumping as soon as practical.

It is understood that the coal will be washed using the existing plant (servicing the current open cut and underground operations) producing both thermal and metallurgical coal. Production from SEOC will reach a maximum of approximately 3.6 million tonnes per annum (Mtpa) of run of mine (ROM) coal and run for approximately 6/7 years at full extraction rates. Currently rejects are trucked to the overburden dump for disposal, and tailings are pumped as a slurry to the old Ravensworth Final Void No. 4, north west of the process plant. It is assumed that rejects and tailings disposal for the SEOC will be carried out in the same way.

The SEOC will produce a final void in the southern corner of the open cut, with potential for further open cut development to the south.

The main possible sources of ARD from the Ashton SEOC project include:

- overburden;
- open pit floors and void;
- washery rejects and tailings; and
- raw coal and product coal stockpiles.

3.0 Geology

The project area is located in the central part of the Hunter coal field. The SEOC coal measure sequence forms part of the Late Permian Foybrook Formation. It is understood that the mine stratigraphic sequence is primarily fluvial in origin, and comprises variously interbedded sandstone, siltstone, conglomerate, mudstone, shale and coal. Many of the sandstone units are massive and include significant wedges and lenses of channel filling pebble and granule, polymictic-conglomerate. The mine stratigraphic sequence is essentially an extension of the sequence currently mined as part of the Ashton NEOC and underground operations.

The formation of pyrite in sedimentary sequences (Berner, 1971[1]) involves the bacterial reduction of sulphate (SO_4^{2-}) to sulphide (S^{2-}), which readily combines with any dissolved iron (Fe) to form pyrite. This process requires the presence of organic materials as an energy source for the bacteria and to provide a reducing environment. Seawater is the main source of sulphate in these systems, and the apparent lack of marine influence on the SEOC mine stratigraphic sequence suggests pyrite formation will be limited, and indicates an overall low ARD potential. However, minor seawater incursions may have occurred during deposition, which could still have produced pyritic horizons. The geochemical testing in progress is aimed at assessing this possibility.

Based on geological data and advice provided by Ashton geologists there are a number of seams and splits to be mined, including Pikes Gully (PGR, PG), Arties (ART), Liddell (ULD, MLD1, MLD2, ULLD, LLLD, LLLD1, LLLD2), Barrett (UB, UBS, LB, LBS) and Hebden (HB1, HB2).

Core from two drill holes WML007 and WML144 was examined during the site visit, covering stratigraphy from the Pikes Gully to Barrett seams. The overburden appeared to be primarily comprised of benign (i.e. non pyritic) sandstone, variously semi-massive, thinly bedded, and with occasional carbonaceous zones (Plate 1 to 3), with lesser quantities of siltstone and mudstone. Siderite bands were relatively common (Plate 3 to 4) and siderite appears to be the main carbonate species present. Thin calcite veins are also commonly observed in coal seams and occasionally in overburden units (Plate 5). Application of acid to some of the logged calcite occurrences resulted in vigorous fizzing, confirming their likely calcitic nature.

Ashton geologists do not commonly observe pyrite in fresh core from the mine stratigraphy, but pyrite can be difficult to detect in core even when present in significant amounts, particularly in coal measures where it is often fine grained and disseminated. However, after the core is left for a time, pyrite oxidation products (jarosite and sulphate salts) are often readily visible due to the generally fast reacting nature of pyrite in coal measures, making identification of pyritic horizons much easier. Hole WML007 passed through most of the SEOC stratigraphic sequence and was drilled over 8 years ago (April 2000), and the pyritic horizons in this hole were readily apparent. The pyritic horizons were restricted to a number of small zones of only a few centimetres thick, with the majority of the hole showing no evidence of pyrite. WMLC144 was drilled more recently (January 2007) and oxidation products were less apparent, but again pyritic zones were infrequent and occurred as thin veins. Pyrite veining was mainly associated with carbonaceous horizons (Plates 6 to 10), with occasional pyrite on partings within sandstone, often associated with thin carbonaceous layers (Plates 11 to 13). The general lack of pyrite and associated oxidation products in hole

[1] Berner, R.A. (1971), *Principals of Chemical Sedimentology*, McGraw-Hill: USA.

WML007 and WML144 indicates that most of the overburden is likely to have a low ARD risk. Note that the coal seams and immediate roof and floor were generally missing from the core in both holes, and the presence or absence of pyrite in these zones could not be confirmed.

Plate 1: Example of semi-massive sandstone from hole WMLC144, 18.54-22.34m depth.

Plate 2: Example of bedded sandstone from hole WMLC144, 41.07-44.87m depth.

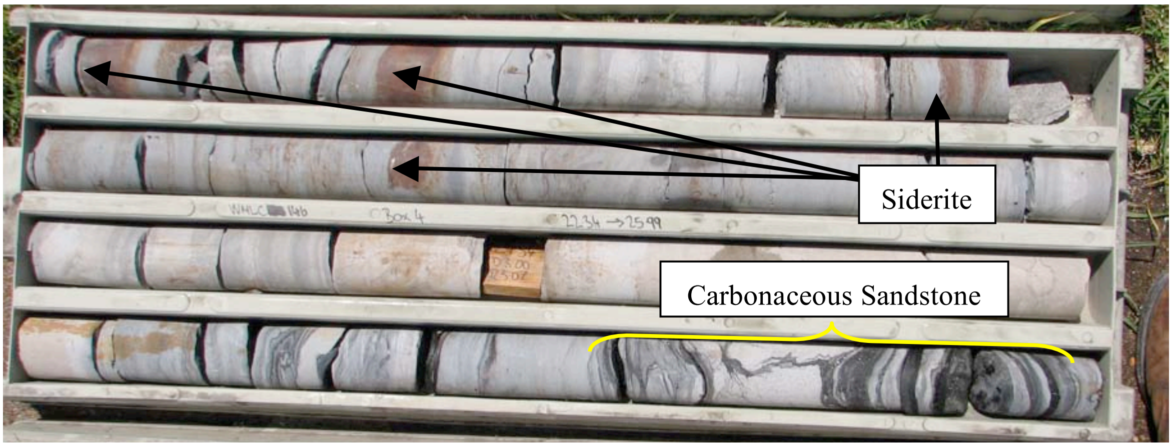

Plate 3: Shows siltstone with siderite bands and carbonaceous sandstone from hole WMLC144, 22.34-25.99m depth.

Plate 4: Shows siltstone with siderite bands from hole WMLC144, 41.81-48.50m depth.

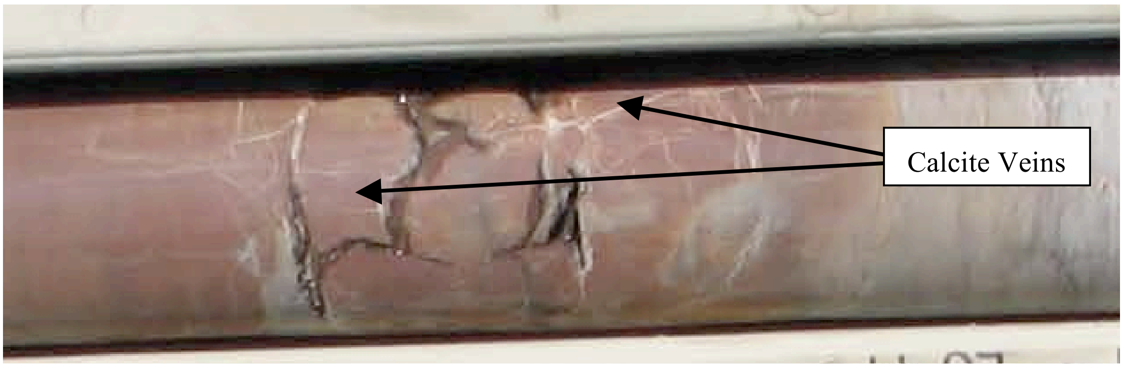

Plate 5: Shows siderite band with thin calcite veining from hole WMLC144, 46.10m depth.

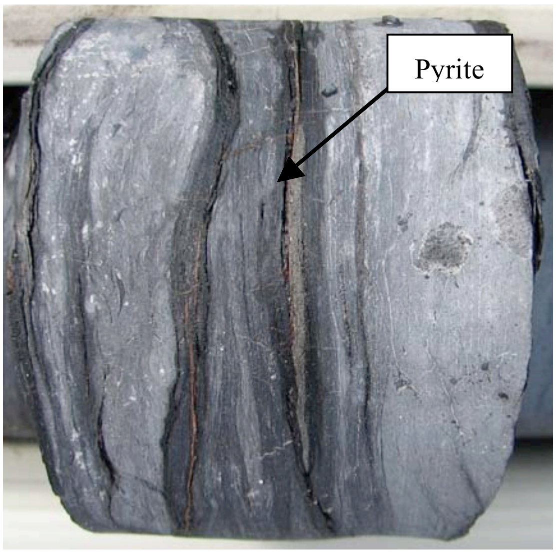

Plate 6: Thin pyrite vein in carbonaceous mudstone from hole WMLC144, 82.50m depth.

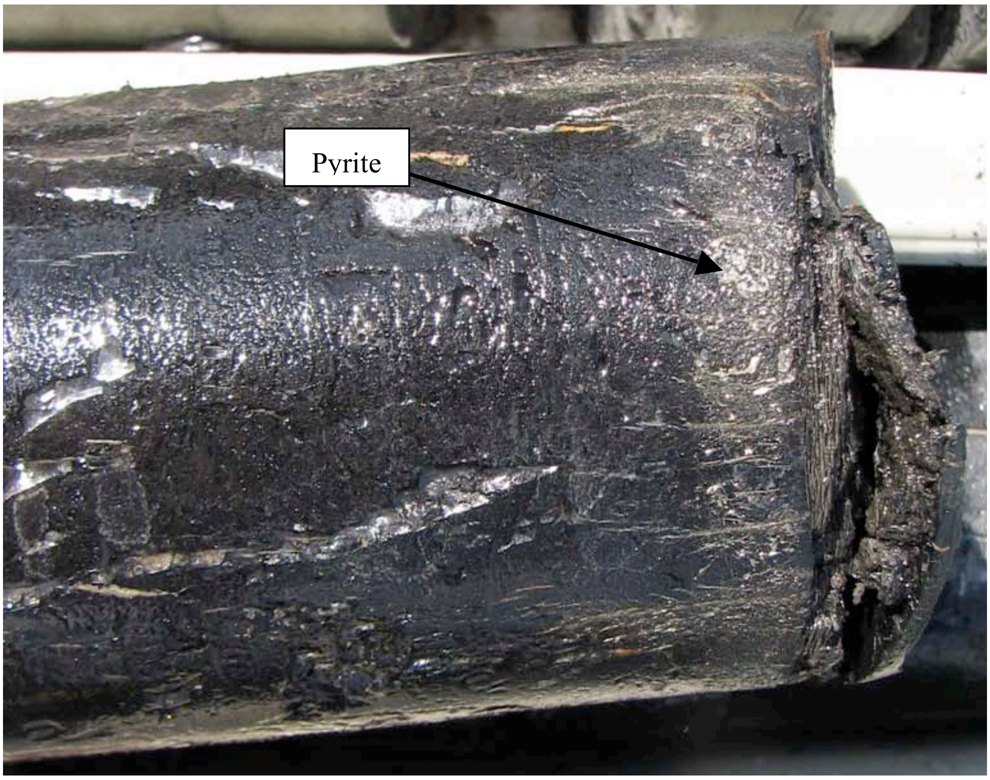

Plate 7: Pyrite vein in coal (Seam LB) from hole WMLC144, 99.45m depth.

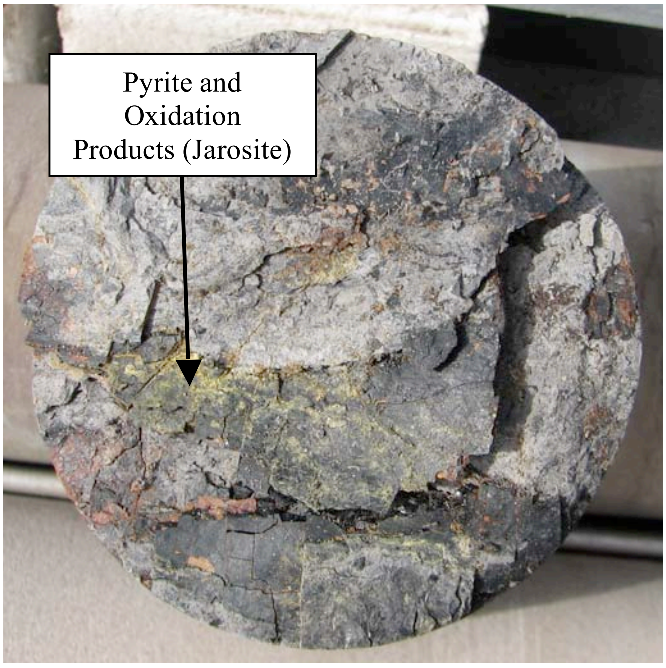

Plate 8: Thin pyrite vein and associated oxidation products in carbonaceous mudstone from hole WMLC007, 48.35m depth.

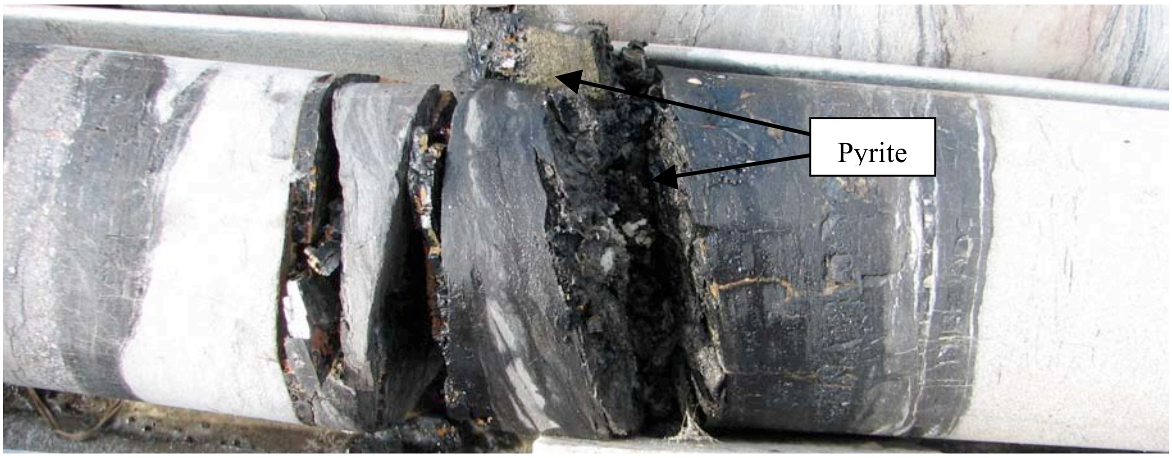

Plate 9: Pyrite vein in carbonaceous mudstone/coal from hole WMLC007, 66.90m depth.

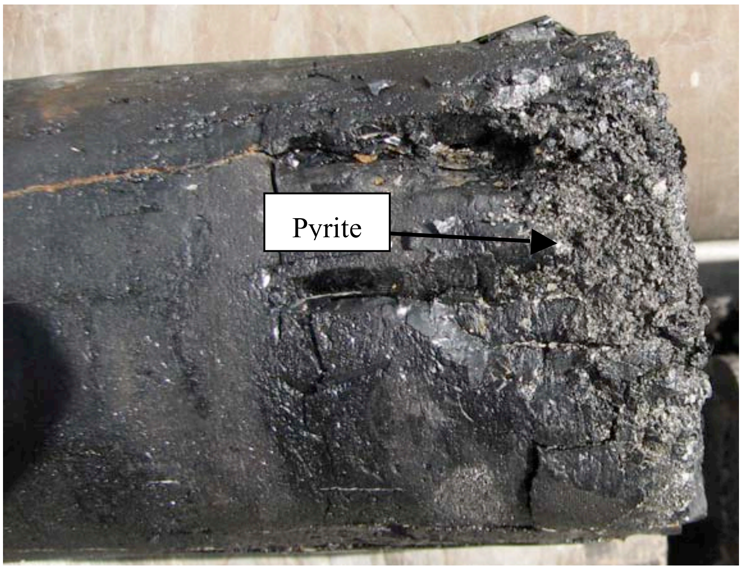

Plate 10: Pyrite vein in coal (Seam MLD1) from hole WMLC007, 75.15m depth.

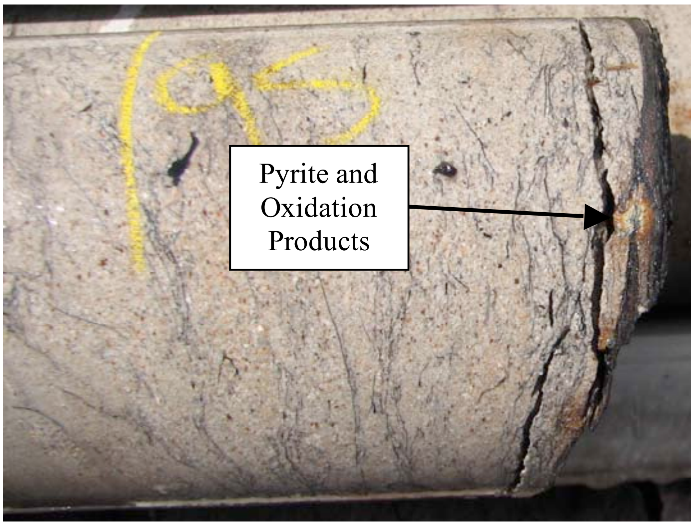

Plate 11: Minor pyrite and associated oxidation products in a thin carbonaceous layer within sandstone from hole WMLC144, 95.00m depth.

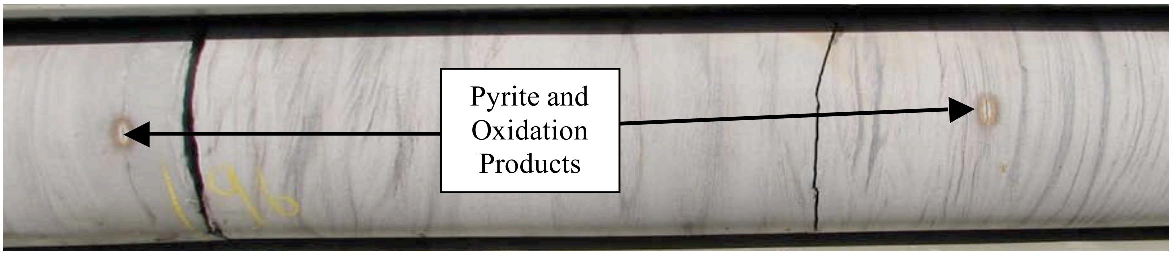

Plate 12: Minor pyrite and associated oxidation products in thin carbonaceous layers within sandstone from hole WMLC144, 96.30m depth.

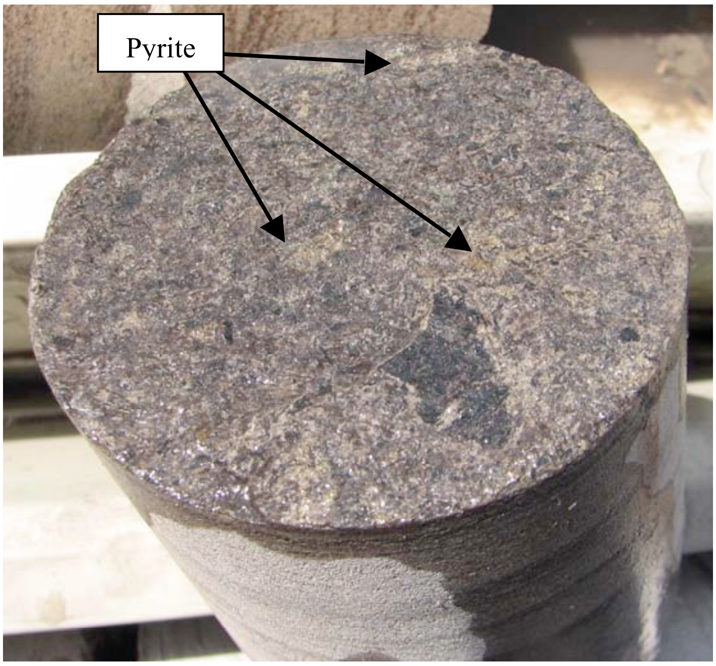

Plate 13: Minor pyrite on sandstone parting from hole WMLC144, 93.40m depth.

4.0 Sample Selection and Preparation

Continuous intervals from the top to bottom of holes WMLC170, WMLC130, WMLC133 (deeper portion only) and WMLC135 were sampled for geochemical testing. The holes were selected by site geologists to best represent the full mine stratigraphic sequence, from above the Pikes Gully Seam to below the Hebden 2 Seam. Note that hole WMLC130 ended at the base of the lower Barrett seam (LB), and the lower section of hole WMLC133 was selected to provide up-dip stratigraphic overlap to the base of the Hebden 2 Seam. Sample intervals were selected by Ashton geologists in conjunction with EGi. The core in each hole was intact apart from: open hole pre-collar sections (top 3-14m) through mainly weathered overburden; core loss; and coal seam, roof and floor intervals previously sampled by Ashton for coal quality testing.

Core samples were collected by Ashton personnel and sent to SGS Australia Pty Ltd in Carrington, NSW for sample preparation, with advice from EGi. Sample preparation involved crushing (two stages), splitting, and pulverising as detailed in the flow chart shown in Figure 1. EGi were provided with 300-500g of both -75µm pulverised and -4mm crushed material for each sample, with all sample reserves stored at Ashton in case follow up testing is required. A total of 156 overburden samples (including roof and floor samples not sampled for quality testing) were received at EGi.

Reserves of many of the sampled coal seam, roof and floor intervals were recovered and sent to EGi to provide a more complete sample stratigraphic coverage. Of the 139 coal quality samples collected from holes WMLC170, WMLC130, WMLC133 (deeper portion) and WMLC135, a total of 54 reserves were available for testing. These samples were mainly from roof and floor intercepts rather than coal intervals, and no reserves for hole WMLC170 were available. However, total S testing had been carried out on all 139 coal quality samples for Ashton by SGS Australia Pty Ltd in Carrington. The 54 coal seam, roof and floor samples were received as -10mm crushed samples, 37 of which were dispatched to Sydney Environmental and Soil Laboratory (SESL) for crushing to -4mm, splitting, and pulverising to -75µm. Since total S had already been carried out, only those samples requiring follow up work by EGi were prepared for testing.

Washery waste samples from the current Ashton Mine operations are routinely dispatched to SGS Australia Pty Ltd in Carrington as part of quality checks, and 66 of these samples collected between August 2008 to November 2008 were selected for testing by SGS as a guide to the likely ARD potential and variation of washery wastes likely to be produced from SEOC coal washing. Samples comprised drain and rinse screen (D&R) rejects from dense medium processing, spiral rejects and tailings. Of the 66 samples tested by SGS, 20 samples were selected for follow up work by EGi. These 20 samples were dispatched to SESL for crushing to -4mm (D&R rejects only), splitting, and pulverising to -75µm.

5.0 Methodology

Total S by Leco or Leco equivalent methods were carried out on all overburden, coal seam, seam roof, seam floor, and washery waste samples. All available samples with greater than 0.05%S and selected samples with less than or equal to 0.05%S were analysed for the following:

- pH and electrical conductivity (EC) of deionised water extracts at a ratio of 1 part solid to 2 parts water ($pH_{1:2}$ and $EC_{1:2}$);
- acid neutralising capacity (ANC); and
- standard single addition net acid generation (NAG) test.

Specialised testing was carried out on selected samples to help resolve uncertainties in the above test results, as follows:

- extended boil and calculated NAG testing to account for high organic carbon contents;
- sulphur speciation testing;
- kinetic NAG test; and
- acid buffering characteristic curve (ABCC) test.

A general description of ARD test methods and calculations used is provided in Appendix A.

Crushed -4mm overburden, coal seam roof and floor, and as received rejects and tailings samples were used for $pH_{1:2}$ and $EC_{1:2}$ testing. Pulverised samples were used for all other tests.

The sulphur speciation procedure involved Leco total S, chromium reducible sulphur (CRS) and potassium chloride (KCl) digestion to help differentiate pyritic S, acid forming sulphate, non-acid forming sulphate and other lower risk S forms (including organic S, jarosite S and elemental S).

Leco total sulphur assays for overburden samples were carried out by SESL. Total S testing of coal seam, roof, floor and washery waste samples was arranged by Ashton personnel and was carried out by SGS Australia Pty Ltd in Carrington using Leco equivalent techniques. CRS of sample solids were carried out by ALS Laboratory Group (Brisbane) and KCl digest solutions were carried out by ALS Laboratory Group (Sydney). Analyses of NAG solutions were carried out by Levay & Co. Environmental Services (Adelaide). All other analyses were carried out by EGi.

6.0 Results For Overburden and Coal

6.1 Standard Geochemical Characterisation Results

Results of standard geochemical characterisation are presented in Table 1, comprising $pH_{1:2}$ and $EC_{1:2}$, total S, maximum potential acidity (MPA), ANC, NAPP, ANC/MPA ratio and single addition NAG.

A total of 295 overburden, coal and roof and floor samples were assayed for total S. Testing of $pH_{1:2}$, $EC_{1:2}$, ANC and single addition NAG was carried out on 107 of the samples, accounting for all available overburden, roof, floor and coal samples with S greater than 0.05%S, and selected samples with less than or equal to 0.05%S. Note that most of the roof, floor and coal samples tested for total S by Ashton were no longer available for further testing.

6.1.1 pH and EC

The $pH_{1:2}$ and $EC_{1:2}$ results were determined by equilibrating the sample in deionised water for approximately 16 hours, at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

The $pH_{1:2}$ values ranged from 3.4 to 8.4, with most samples (90%) showing no inherent acidity with a pH greater than 6. Only 8 of the samples tested had a slightly acidic pH of less than 5.0, mainly associated with carbonaceous samples, and only one sample (carbonaceous mudstone sample 37465) had an acidic pH value of 3.4.

$EC_{1:2}$ values ranged from 0.1 to 2.2 dS/m with most samples (90%) having a non-saline to slightly saline EC of less than or equal to 0.8 dS/m. Only two samples tested had a saline EC of greater than 1.6 dS/m, and 7% of samples had a moderately saline EC of 0.8 to 1.6 dS/m. The sample with the highest EC value of 2.28 dS/m is also the sample with the low pH. The moderately saline to saline EC values are mainly associated with carbonaceous samples.

Results indicate overburden represented by the samples tested generally do not contain significant existing acidity or salinity, with a small proportion of materials potentially having moderate salinity. Only one sample (37465) had significant acidity and salinity, but this represented only a thin interval of 9 cm. The sample was from hole WMLC130 at 33.46 m depth and also had high S of 7.46%S (see Table 1), and appears to be due to local pyrite enrichment at the floor of coal seam MLD2.

6.1.2 Acid Base (NAPP) Results

Total S ranged from below detection to 7.46%S. Of the 295 samples tested, 125 samples recorded S values of less than or equal to 0.05%S, which have a negligible risk of acid formation, and were classified NAF in Table 1. Figure 2 is a box plot of the distribution of S, split by lithology. The plot shows that S content generally increases with sediment grain size and carbonaceous content, with conglomerate and sandstone having low median S values of less than 0.05%S, and carbonaceous mudstone and coal having the highest median S values of just over 0.5%S. The highest S values occur in the carbonaceous mudstone samples.

ANC (107 samples) ranged up to 264 kg H_2SO_4/t. Figure 3 is a box plot of the distribution of ANC, split by lithology, which shows most rock types have a broad range of ANC values from low (<10 kg H_2SO_4/t) to high (>80 kg H_2SO_4/t), although median values are generally less than 20 kg H_2SO_4/t.

The net acid producing potential (NAPP) value is an acid-base account calculation using measured total S and ANC values. It represents the balance between the maximum potential acidity (MPA) and ANC. A negative NAPP value indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, a positive NAPP value indicates that the material may be acid generating.

Figure 4 is an acid-base account plot of ANC verses total S, with samples split according to lithology. Figure 5 is the same as Figure 4, but re-scaled to exclude the high S samples and to better represent ANC below 100 kg H_2SO_4/t. The NAPP zero line is shown which defines the NAPP positive and NAPP negative domains, and the line representing an ANC/MPA ratio value of 2 is also plotted. Note that the NAPP = 0 line is equivalent to an ANC/MPA ratio of l. The ANC/MPA ratio is used as an indication of the relative factor of safety within the NAPP negative domain. Usually a ratio of 2 or more signifies a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to ARD. Results show that 90% of samples are NAPP negative, and 80% of samples have ANC/MPA ratios of greater than 2.

6.1.3 Single Addition NAG Results

Generally a NAGpH value less than 4.5 indicates a sample may be acid forming. However, samples with high organic carbon contents (such as coal and carbonaceous sedimentary materials) can cause interference with standard NAG tests due to partial oxidation of carbonaceous materials. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulphides.

The bulk of the NAGpH values (90%) are greater than 4.5, indicating that most of these samples will be non acid forming (NAF). Only 12 samples have NAGpH values less than 4.5. Many of these are associated with carbonaceous horizons and coal seams, and results are inconclusive in isolation due to potential organic acid effects.

NAG test results are used in conjunction with NAPP values to classify samples according to acid forming potential. Figure 6 is an ARD classification plot showing NAGpH versus NAPP value, with results split according to major rock unit groupings. Figure 7 is the same plot rescaled to better represent the NAPP range from -100 to 50 kg H_2SO_4/t. Potentially acid forming (PAF), non-acid forming (NAF) and uncertain (UC) classification domains are indicated. A sample is classified PAF when it has a positive NAPP and NAGpH < 4.5, and NAF when it has a negative NAPP and NAGpH ≥ 4.5. Samples are classified uncertain 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.

The plot shows that most samples plot in the NAF domain, with a small proportion of all rock types except conglomerate and tuff plotting in the PAF domain. There are also a few samples that plot in the bottom left hand and top right hand uncertain domains.

Three samples plot in the upper right uncertain domain. One of these samples has low total S of less than 0.05 %S and has a negligible risk of acid formation and is classified NAF consistent with NAG results. The remaining samples have higher total S of up to 0.44 %S and 0.93%S and low ANC up to 10 kg H_2SO_4/t.

There are 2 samples that plot in the bottom left hand uncertain domain. Sample 37453 shows a large difference between the $NAG_{(pH4.5)}$ and $NAG_{(pH7.0)}$ values, which is typical of carbonaceous samples in which organic acids have been generated. The other sample does not show evidence of organic acid generation.

Specialised testing (Section 6.2) was carried out to help resolve the ARD classification of these uncertain samples.

In addition to the above uncertain samples, a number of samples plotting in the PAF domain also show organic acid effects in the NAG test, indicating that the NAG results may overestimate the acid potential in these cases. Standard NAG test results affected by organic acids are highlighted in yellow in Table 1.

6.2 Specialised Geochemical Characterisation Results

6.2.1 Extended Boil and Calculated NAG Results

Extended boil and calculated NAG testing was carried out on 7 selected samples to help resolve the uncertainty in ARD classification based on standard NAG test results, as discussed in the previous section. Results are presented in Table 2.

Results show that the NAGpH value increases after the extended boiling step, which confirms the effects of organic acids. Note that the extended boil NAGpH value can be used to confirm samples are PAF, but does not necessarily mean that samples with a pH greater than 4.5 are NAF, due to some loss of free acid during the extended boiling procedure. To address this issue, a calculated NAG value is determined from assays of anions and cations released to the NAG solution. A calculated NAG value of less than or equal to 0 kg H_2SO_4/t indicates the sample is likely to be NAF, and a value of more than 0 kg H_2SO_4/t indicates the sample may be PAF.

The calculated NAG values for 4 samples are positive, indicating that these samples may be acid producing. The calculated NAG values for the remaining 3 samples are negative, indicating that all acid generated in the standard NAG test for these samples is organic, and that these samples are unlikely to generate acid.

6.2.2 Acid Buffering Characteristic Curve (ABCC) Testing

Acid buffering characteristic curve (ABCC) testing was carried out on 15 selected samples to evaluate the availability of the ANC measured. The ABCC test involves slow titration of a sample with acid while measuring the solution pH. The acid buffering of a sample to pH 4 can be used as an estimate of the proportion of readily available ANC. Results are presented in Figures 8 to 14, with calcite, dolomite, ferroan dolomite and siderite standard curves as reference. Calcite and dolomite readily dissolve in acid and exhibit strongly buffered pH curves in the ABCC test, rapidly dropping once the ANC value is reached. The siderite standard provides very poor acid buffering, exhibiting a very steep pH curve in the ABCC test. Ferroan dolomite is between siderite and dolomite in acid buffering availability.

The ABCC profiles for samples 37744 and 37453 (Figure 11) plot close to the siderite standard curve, and indicate that around 30% of the total ANC measured is readily available.

Profiles for samples 37427 (Figure 8), 37737 (Figure 10) and 37743 (Figure 11) plot close to the ferroan dolomite standard curve, indicating that 30% to 60% of the total ANC is available for acid buffering but it will be slow reacting.

Samples 36792 and 37749 (Figure 8) have profiles that plot between the dolomite and ferroan dolomite standard curves, indicating that 50% to 75% of the total ANC is available for acid buffering but it will be partly slow reacting.

The remaining samples have profiles similar to dolomite standard curves, but many show a drop in the profile before the full measured ANC is reached. Results suggest that the total

ANC is due to a mix of dolomite with sideritic and/or ferroan portions, consistent with observations in core (e.g. Plate 5). Results indicate 50% to 100% of the ANC in these samples is readily available.

ABCC results suggest that the acid buffering minerals within the samples tested generally include a partly dolomitic portion that is readily available, but also include sideritic and poorly reactive carbonate, so that ANC values commonly overestimate the effective ANC.

6.2.3 Kinetic NAG Testing

Kinetic NAG tests provide an indication of the kinetics of sulphide oxidation and acid generation for a sample. Figures 15 to 19 present kinetic NAG test results for 5 selected coal and overburden samples.

Typically, there will be a distinct temperature peak of greater than 50°C in the kinetic NAG profile for samples with pyritic S greater than 0.7%S. Figure 17 shows no temperature excursion for sample 37723 consistent with the total S value of 0.13%S[2].

The total S measured for sample 37743 was 0.74%S, but only a small temperature peak of 30°C was evident in the kinetic NAG temperature profile (Figure 19), indicating a pyritic S content of just over 0.5%S. The pH profile shows a rapid drop to below pH 4 in 7 minutes, indicating a lag time of about 1 month before onset of acid conditions under atmospheric oxidation conditions. Note that this sample had a final NAGpH value of 4.5 after the standard single addition NAG heating step, but remained close to pH 3 before heating. The increase in pH after heating indicates the presence of poorly reactive ANC, which may not be available under atmospheric oxidation conditions.

Sample 36787 shows a distinct but moderate temperature peak of close to 40°C (Figure 15), indicative of a pyritic S content of around 0.5% to 0.7%S, less than the total S of 0.93%S measured. The pH profile shows a rapid pH decease, reaching pH 4 after 7 minutes and indicating a lag of about 1 month.

The remaining 2 samples 37720 and 37742 show distinct temperature peaks (Figures 16 and 18), suggesting that most of the S in these samples is in the form of pyrite. These pyritic samples have short lag times of up to 13 minutes, indicating fast pyrite oxidation rates and lag times of days to weeks.

Results indicate that pyritic materials represented by the PAF samples tested are likely to produce acid conditions in a short time frame (less than 2 months) after exposure to atmospheric oxidation. Results also indicate that a portion of the total S measured in these samples may be in non-pyritic form.

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[2] A 10 fold higher S content of 1.3%S was reported by Ashton for this sample.

6.2.4 Sulphur Speciation

Sulphur speciation testing was carried out on 12 selected samples as a guide to the proportion of the total S present as pyrite. Results are shown in Table 3. Note that the pyritic S value should only be treated as a guide to the pyrite content in the sample due to issues with variability in the chromium reducible sulphur (CRS) method.

Results show that for most samples more than 50% of the total S measured is likely to be present as low risk S forms (which are likely to be mainly organic S) and non-acid sulphates. However, the presence of significant pyritic S was also confirmed in a number of samples, with 0.5%S pyritic S or greater indicated for 4 of the samples tested (36787, 36792, 37427 and 37743).

Results confirm the presence of pyrite in some of these samples but also indicate that MPA values may overestimate the acid potential due to the presence of non-acid generating S forms. Conversely, ABCC testing (Section 6.2.2) indicates that the measured ANC may overestimate the effective ANC.

Table 3 includes a re-calculated NAPP based on the proportion of acid generating S (pyrite and acid sulphate S) and readily available ANC estimated from ABCC testing. Results are generally consistent with the original NAPP values based on total S and ANC, with the exception of 4 samples highlighted in yellow. The original NAPP for samples 36789 and 37499 are positive, but the re-calculated NAPP values are negative, due to the presence of non acid generating S forms. The converse is the case for samples 37737 and 37744, in which the original NAPP values were less than or equal to zero, but recalculated NAPP values are positive, indicating the presence of poorly reactive ANC.

6.3 Sample Classification and Distribution of ARD Rock Types

ARD classifications are provided in Table 1 based on results and discussions above.

Note that although total S values were available for all samples, many of the coal seam, roof and floor samples were not available for follow up testing, and could not be classified where S was greater than 0.05%S. All samples with S values of less than or equal to 0.05%S were classified NAF due to the negligible risk of acid formation.

A total of 94% of classifiable samples (i.e. excluding those samples with total S >0.05%S and not available for testing) were classified NAF or UC(NAF), and 6% of samples were classified PAF or UC(PAF) (Table 1).

Figure 20 shows downhole profile plots of total S for the four holes tested. In addition to total S, the plots also show coal seams, approximate seam correlation between holes, and sample ARD classification with NAF and UC(NAF) samples represented as blue symbols, PAF and UC(PAF) samples as red symbols, and unclassified samples as black symbols. The plots emphasise the close association of PAF/UC(PAF) samples with coal seam units and immediately adjacent roof and floor horizons. There are only two isolated PAF samples within overburden materials, one at approximately 92m depth in hole WMLC130, and one likely to be below the final pit floor in hole WMLC 133 at 112 m depth.

Results indicate that overburden materials will be NAF, with minor isolated horizons of PAF. The two PAF overburden samples had relatively low acid capacities of 10 kg H_2SO_4/t or less, and it is unlikely that these materials would result in ARD due to operational mixing with surrounding higher ANC NAF overburden.

The coal seams and immediate roof and floor appear to include more pyrite materials than overburden. Roof and floor samples are reasonably well represented in the data set, and of the 53 samples tested, only 5 samples (10%) were classified PAF or UC(PAF). The coal seams were not well represented, and it is not possible to check for continuity of the isolated PAF coal seam intercepts.

7.0 Results for Washery Waste Samples

7.1 Standard Geochemical Characterisation Results

Washery waste samples from SEOC coal were not available for testing, but the rejects and tailings currently produced from washing NEOC coal and underground operations are expected to be geochemically similar to those produced from the SEOC, since the coal seams in the SEOC are essentially continuous extensions of those currently mined.

Figure 21 compares S distribution in coal seam, roof and floor samples collected for coal quality analysis from the SEOC and NEOC. The values are based on sampling from 7 holes in the SEOC (WMLC130, WMLC133, WMLC135, WMLC144, WMLC170, WMLC171 and WMLC202) and 4 holes in the NEOC (WMLC124, WMLC125, WMLC126 and WMLC127). The S distributions in seam, roof and floor materials between the two pits are similar, with the median S of 0.37%S in the NEOC close to the median of 0.43%S for the SEOC. These data support the likely geochemical similarity of SEOC washery wastes with those currently produced at the NEOC.

Samples of tailings and rejects streams are collected routinely from the Coal Handling and Preparation Plant (CHPP) for coal quality testing, and a representative set of past samples were selected for testing as an analogue for the likely geochemical characteristics of the SEOC washery wastes. The acid forming characteristics for 66 samples of coarse drain and rinse screen (D&R) rejects from dense medium processing, spiral rejects and tailings collected between August 2008 to November 2008 are presented in Table 4. All samples were analysed for total S, and 20 selected samples were subjected to full geochemical characterisation.

Figure 22 is a plot of the S distribution for the 66 samples split by washery waste type, which shows low median S values of less than 0.4%S for all three materials types, but with the tailings showing higher median S (0.33%S) than the coarse rejects and spiral rejects (0.22%S and 0.12%S, respectively). Outliers with greater than 0.7%S are evident in all three types, and a maximum of 1.9%S was measured for one of the spiral rejects samples.

The $pH_{1:2}$ values for the 20 samples subjected to full geochemical characterisation ranged from 5.0 to 8.4, indicating no significant existing acidity. $EC_{1:2}$ values ranged from 0.1 to 1.3 dS/m with 13 of the 20 samples having a non-saline to slightly saline EC of less than or equal to 0.8 dS/m, and the rest having a moderately saline EC of 0.8 to 1.6 dS/m. Results indicate washery wastes represented by the samples tested do not contain significant existing acidity, but may be partly moderately saline.

Figure 23 is an acid base account plot for the 20 washery waste samples selected for full geochemical characterisation. The plot shows that most samples plot in the NAPP negative domain, with ANC/MPA ratios of around 2 or greater, indicating a low risk of acid production. All but one of the spiral reject samples have high ANC (>120 kg H_2SO_4/t), are strongly NAPP negative and have ANC/MPA ratios much greater than 2 indicating a high factor of safety. Four samples plot in the NAPP positive domain, and have low ANC values of less than 20 kg H_2SO_4/t.

Figure 24 is an ARD classification plot for the same samples. Results show that samples plot either within the NAF or PAF domains, showing consistency in NAPP and NAG results.

7.2 Specialised Geochemical Characterisation Results

Extended boil and calculated NAG testing was carried out on the 4 samples plotting in the PAF domain. Results are presented in Table 5. Results show that three of the samples (37912, 37913 and 37918) have an extended boil NAGpH value less than 4.5 and a positive calculated NAG value, confirming these samples are likely to be PAF. The remaining sample (37922) has a negative calculated NAG value, indicating this sample is likely to be NAF.

Acid buffering characteristic curve (ABCC) testing was carried out on 8 selected samples to evaluate the availability of the ANC measured. Results are presented in Figures 25 to 29, with calcite, dolomite, ferroan dolomite and siderite standard curves as reference.

Profiles for samples 37918 (Figure 25), 37912 (Figure 26), 37911 (Figure 27) and 37914 (Figure 28) indicate that 60% to 100% of the total ANC is available for acid buffering but plot close to the ferroan dolomite standard curve, indicating that the ANC will be slow reacting.

The ABCC profiles for samples 37913 (Figure 25), 37906 and 37909 (Figure 27) also indicate that 60% to 100% of the total ANC is available for acid buffering but plot between the dolomite and ferroan dolomite standard curves, indicating that the acid buffering will be partly slow reacting.

The remaining sample 37910 (Figure 29) has a profile similar to the dolomite standard curve, and indicates all of the ANC in this samples is readily available.

ABCC results suggest that the acid buffering minerals within the samples tested may include ferroan carbonate component, but that 60% to 100% of the total ANC measured in these samples is likely to be effective. This indicates that samples with an ANC/MPA ratio of 2 or more have a high factor of safety and negligible risk of acid formation.

Sulphur speciation testing was carried out on 8 of the washery waste samples as a guide to the proportion of the total S present as pyrite. Results are shown in Table 6, which indicates that apart from samples 37906 and 37992, most of the S measured in these samples is pyritic. Samples 37906 and 37992 have low pyrite S contents of close to 0.2%S, less than half the total S contents.

The re-calculated NAPP values in Table 6 (based on the proportion of acid generating S and readily available ANC estimated from ABCC testing) are generally consistent with the original NAPP values based on total S and ANC. Sample 37922 is the only exception, with a much lower re-calculated NAPP value of 4 kg H_2SO_4/t, compared to an original NAPP value of 19 kg H_2SO_4/t.

S speciation results confirm the presence of pyrite in these samples but ABCC testing also indicates a high proportion of readily available acid buffering, and suggests that NAPP results should be a reasonably reliable guide to acid forming potential.

Figures 30 to 33 present kinetic NAG test results for 4 selected washery waste samples. Figures 30 and 31 shows no temperature excursion for sample 37906 and 37910 consistent with low pyritic S values of less than 0.5%[3]. The temperature excursions for the two remaining samples are more typical of higher pyrite content, indicating pyritic S contents of >1%S for samples 37912 (Figure 32) and 0.6-0.8%S for sample 37913 (Figure 33), which are consistent with pyritic S indicated by S speciation testing. The pH profiles for samples 37912 and 37913 indicate fast reaction rates and a lag time of about 1 month before onset of acid conditions under atmospheric oxidation conditions.

7.3 Classification of Washery Waste Samples

Results of NAPP and single addition NAG testing indicate that 16 of the 20 samples subjected to full geochemical testing were NAF, with negative NAPP values and NAGpH values greater than or equal to 4.5 (Table 4). The remaining four samples had positive NAPP values and NAGpH values less than 4.5, and three of these were confirmed to be PAF based on calculated NAG testing and re-calculated NAPP values (from S speciation and ABCC test results). The calculated NAG value was negative for one of the 4 NAPP positive samples, indicating the sample is NAF.

Results confirm that washery waste materials are more pyritic than overburden materials, but the overall pyritic content of these materials is likely to be relatively low given that 80% of the 66 samples tested had total S values less than 0.5%. The presence of pyrite in washery waste materials is consistent with the occasional observation of pyrite during field inspection (Plate 14), and the apparent higher ARD potential of roof, floor and coal seams indicated in Section 6.

[3] Note that original SGS total S results were 1.65%S and 0.84%S, respectively, for these samples, compared to 0.55% and 0.31%S in repeat analysis as part of S speciation testing.

ABCC testing indicated that most of the ANC measured was likely to be readily available, and hence an ANC/MPA ratio of 2 or more would be an adequate factor of safety. The ratio of the average ANC to the average MPA (calculated from total S) from the 20 samples tested is 6, highlighting the overall excess of ANC in these materials, and a low likelihood of ARD conditions developing from washery wastes represented by these samples.

Plate 14: Example of pyritic reject clast from a reject pile in the NEOC overburden dump.

8.0 Conclusions and Recommendations

Results of testing indicate that overburden and pit floor materials from the Ashton SEOC are likely to be non acid forming (NAF) overall, and should not require any special handling for ARD control. It is expected that although minor pyritic materials may occur, these are likely to be isolated. Since the remaining spoils have excess alkalinity, mixing of mined materials as part of normal operations is expected to mitigate any isolated ARD generated.

Salinity appears to be low for most overburden materials, with a small portion having moderate salinity, mainly associated with carbonaceous samples.

Washery waste samples from the existing NEOC and underground operations were used as an analogue for the washery wastes expected from processing SEOC coal. Results of geochemical testing of the NEOC samples confirm that significant pyrite may occur in washery waste materials, but this appears to be offset by an excess of buffering capacity, so that washery waste materials represented by the samples tested are expected to be NAF overall with a high factor of safety.

Water quality monitoring of key seepage, pit water and drainage from overburden materials and washery waste materials should be routinely carried out for indicators of ARD and salinity to confirm the expected benign nature of these materials, and provide warning of any anomalously pyritic materials extracted during mining. Monitoring should include pH, EC, SO_4 and acidity/alkalinity, with follow up multi element testing if any low pH conditions are detected.

Table 1: Acid forming characteristics of overburden and coal samples.

Hole Name	Depth (m) From	To	Interval	Lithology	Seam	Weathering	Pyrite Occurrence	Carbonate	Comments	Ashton Sample Number	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC/MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
WMLC170	0.00	1.00	1.00	CLAY		HW																
WMLC170	1.00	2.83	1.83	CONGLOMERATE		HW																
WMLC170	2.83	5.05	2.22	CONGLOMERATE		HW					36750			<0.01	0							NAF
WMLC170	5.05	6.54	1.49	SANDSTONE		HW					36751			<0.01	0							NAF
WMLC170	6.54	7.49	0.95	CONGLOMERATE/SANDSTONE		HW					36752			<0.01	0							NAF
WMLC170	7.49	8.80	1.31	CORE LOSS																		
WMLC170	8.80	10.31	1.51	SANDSTONE		HW					36753			0.01	0							NAF
WMLC170	10.31	10.95	0.64	CONGLOMERATE		HW					36754			<0.01	0							NAF
WMLC170	10.95	12.82	1.87	SANDSTONE		SW					36755			0.02	1							NAF
WMLC170	12.82	19.73	6.91	SANDSTONE		HW					36756			0.01	0							NAF
WMLC170	19.73	22.48	2.75	SANDSTONE		HW					36757			<0.01	0							NAF
WMLC170	22.48	23.12	0.64	SILTSTONE		SW		Siderite	160mm Siderite at base		36758			0.04	1							NAF
WMLC170	23.12	23.95	0.83	SANDSTONE							36759	5.2	0.42	0.09	3	9	-6	3.27	7.2	0	0	NAF
WMLC170	23.95	24.30	0.35	MUDSTONE/CARB MUDSTONE	Roof					1				0.20	6							
WMLC170	24.30	25.10	0.80	COAL	MLD1					2				0.72	22							
WMLC170	25.10	25.27	0.17	CARB MUDSTONE	MLD1		Pyrite			3				1.43	44							
WMLC170	25.27	25.63	0.36	COAL	MLD1					4				0.52	16							
WMLC170	25.63	26.48	0.85	SILTSTONE/CARB MUDSTONE	MLD1			Siderite	210mm siderite	5				0.03	1							NAF
WMLC170	26.48	27.18	0.70	COAL	MLD2					6				1.13	35							
WMLC170	27.18	27.51	0.33	SILTSTONE/CARB MUDSTONE	MLD2					7				0.14	4							
WMLC170	27.51	27.88	0.37	CORE LOSS																		
WMLC170	27.88	28.37	0.49	COAL	MLD2					8				1.11	34							
WMLC170	28.37	28.62	0.25	SANDSTONE	Floor					9				0.03	1							NAF
WMLC170	28.62	29.35	0.73	SANDSTONE							36760			0.02	1							NAF
WMLC170	29.35	30.09	0.74	SILTSTONE			Pyrite	Siderite	Pyrite with siderite		36761	7.3	0.22	0.13	4	134	-130	33.69	7.8	0	0	NAF
WMLC170	30.09	32.31	2.22	SANDSTONE							36762			0.03	1							NAF
WMLC170	32.31	34.99	2.68	SILTSTONE				Siderite			36763			0.05	2							NAF
WMLC170	34.99	35.46	0.47	SILTSTONE	Roof						36764			0.04	1							NAF
WMLC170	35.46	35.95	0.49	COAL/MUDSTONE	ULLD		Pyrite			11				0.66	20							
WMLC170	35.95	36.06	0.11	MUDSTONE	ULLD					12				0.18	6							
WMLC170	36.06	36.33	0.27	CORE LOSS																		
WMLC170	36.33	37.10	0.77	COAL/TUFF	ULLD					13				1.31	40							
WMLC170	37.10	37.49	0.39	COAL	ULLD		Pyrite		pyrite at base	14				0.73	22							
WMLC170	37.49	38.09	0.60	SANDSTONE/SILTSTONE	Floor						36765	8.0	0.11	0.07	2	37	-35	17.27	6.2	0	1	NAF
WMLC170	38.09	40.49	2.40	SANDSTONE/SILTSTONE							36766			0.02	1							NAF
WMLC170	40.49	47.50	7.01	SANDSTONE							36767			0.03	1							NAF
WMLC170	47.50	52.76	5.26	SANDSTONE							36768			0.02	1							NAF
WMLC170	52.76	53.01	0.25	SANDSTONE	Roof					16				0.06	2							
WMLC170	53.01	53.12	0.11	TUFF	Roof					17				0.11	3							
WMLC170	53.12	53.59	0.47	COAL/CARB MUDSTONE	LLLD					18				0.55	17							
WMLC170	53.59	53.95	0.36	SILTSTONE/COAL	LLLD					19				0.26	8							
WMLC170	53.95	55.73	1.78	SANDSTONE/SILTSTONE	Floor				carb mudstone at top		36770			0.01	0							NAF
WMLC170	55.73	60.13	4.40	SANDSTONE							36771			0.02	1							NAF
WMLC170	60.13	63.80	3.67	SANDSTONE							36772			0.05	2							NAF
WMLC170	63.80	68.37	4.57	SANDSTONE							36773			0.02	1							NAF
WMLC170	68.37	71.79	3.42	SANDSTONE				Calcite, Siderite			36774			0.02	1							NAF
WMLC170	71.79	71.91	0.12	SANDSTONE							36775	7.7	0.22	0.07	2	14	-12	6.54	7.4	0	0	NAF
WMLC170	71.91	72.23	0.32	SANDSTONE/SILTSTONE	Roof					20				0.07	2							
WMLC170	72.23	72.94	0.71	COAL/SILTSTONE	UB		Pyrite	Calcite		21				0.57	17							
WMLC170	72.94	73.20	0.26	CARB MUDSTONE	UB					22				0.88	27							
WMLC170	73.20	73.62	0.42	COAL/TUFF	UBS					23				0.35	11							
WMLC170	73.62	74.21	0.59	COAL/TUFF	UBS			Calcite		24				0.61	19							
WMLC170	74.21	74.78	0.57	SILTSTONE	Floor					25				0.36	11							
WMLC170	74.78	80.20	5.42	SANDSTONE							36777			0.05	2							NAF
WMLC170	80.20	81.74	1.54	SANDSTONE			Pyrite				36778	6.7	0.53	0.10	3	58	-55	18.95	8.3	0	0	NAF
WMLC170	81.74	85.95	4.21	SANDSTONE							36779	7.2	0.12	0.11	3	18	-15	5.35	8.5	0	0	NAF
WMLC170	85.95	91.31	5.36	SANDSTONE				Calcite, Siderite			36780			0.05	2							NAF
WMLC170	91.31	94.32	3.01	SANDSTONE				Siderite			36781			0.01	0							NAF
WMLC170	94.32	97.40	3.08	SANDSTONE							36782			0.02	1							NAF
WMLC170	97.40	100.20	2.80	SANDSTONE/SILTSTONE							36783			0.02	1							NAF
WMLC170	100.20	101.00	0.80	SILTSTONE			Pyrite	Siderite	230mm siderite at base		36784	6.8	0.43	0.09	3	14	-11	5.08	8.3	0	0	NAF
WMLC170	101.00	102.71	1.71	SANDSTONE							36785	7.1	0.21	0.11	3	12	-9	3.57	7.7	0	0	NAF
WMLC170	102.71	102.81	0.10	CORE LOSS																		
WMLC170	102.81	103.14	0.33	SILTSTONE	Roof						36786	6.6	0.53	0.18	6	11	-5	2.00	5.1	0	2	NAF
WMLC170	103.14	106.91	3.77	COAL	LB		Pyrite		siltstone & tuff partings, pyrite with tuff parting		36787	5.0	0.81	0.93	28	10	18	0.35	4.5	0	5	UC(PAF)
WMLC170	106.91	107.89	0.98	SILTSTONE	Floor/Roof						36788	6.7	0.72	0.10	3	31	-28	10.13	8.3	0	0	NAF

Table 1: Acid forming characteristics of overburden and coal samples.

Hole Name	Depth (m) From	To	Interval	Lithology	Seam	Weathering	Pyrite Occurrence	Carbonate	Comments	Ashton Sample Number	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC/MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
WMLC170	107.89	108.07	0.18	COAL	LBS						36789	7.2	0.15	0.52	16	11	5	0.69	3.1	14	34	NAF
WMLC170	108.07	109.07	1.00	SILTSTONE	Floor		Pyrite	Calcite			36790	6.8	0.32	0.18	6	14	-8	2.54	6.3	0	1	NAF
WMLC170	109.07	109.55	0.48	SILTSTONE				Siderite	mainly siderite		36791	8.4	0.10	0.11	3	189	-186	56.15	8.1	0	0	NAF
WMLC170	109.55	110.93	1.38	CORE LOSS																		
WMLC170	110.93	111.19	0.26	SILTSTONE	Roof						36792	4.8	0.45	0.99	30	6	24	0.20	3.3	5	24	PAF
WMLC170	111.19	112.42	1.23	COAL	HB1		Pyrite		siltstone partings		36793	4.9	0.52	0.21	6	10	-4	1.56	4.5	0	6	NAF
WMLC170	112.42	113.35	0.93	SANDSTONE/SILTSTONE	Floor				mudstone at top		36794	7.8	0.23	0.06	2	14	-12	7.63	7.1	0	0	NAF
WMLC170	113.35	114.05	0.70	SANDSTONE			Pyrite	Calcite, Siderite			36795	8.1	0.32	0.29	9	229	-220	25.81	8.4	0	0	NAF
WMLC170	114.05	117.35	3.30	SANDSTONE							36796			0.02	1							NAF
WMLC170	117.35	117.62	0.27	MUDSTONE	Roof						36797	7.9	0.43	0.07	2	15	-13	7.00	7.6	0	0	NAF
WMLC170	117.62	118.07	0.45	COAL	HB2			Calcite	carb mudstone parting		36798	7.7	0.33	0.66	20	85	-65	4.21	7.1	0	0	NAF
WMLC170	118.07	119.00	0.93	SANDSTONE/SILTSTONE	Floor						36799			0.04	1							NAF
WMLC170	119.00	123.20	4.20	SANDSTONE/SILTSTONE							36800			0.03	1							NAF
WMLC170	123.20	123.77	0.57	SANDSTONE							36801			0.02	1							NAF
WMLC130	0.00	6.00	6.00	SOIL		HW																
WMLC130	6.00	12.00	6.00	ALLUVIUM		HW																
WMLC130	12.00	14.01	2.01	SILTSTONE																		
WMLC130	14.01	15.09	1.08	SANDSTONE							37396	8.2	0.33	0.03	1	45	-44	49.02	8.4	0	0	NAF
WMLC130	15.09	15.25	0.16	SANDSTONE	Roof					1	37719	7.6	0.12	0.39	12	14	-2	1.17	4.7	0	3	NAF
WMLC130	15.25	15.40	0.15	COAL	PGR			Calcite		2				0.27	8							
WMLC130	15.40	15.46	0.06	SILTSTONE	PGR					3	37720	4.6	1.36	1.17	36	9	27	0.25	2.6	24	30	PAF
WMLC130	15.46	16.56	1.10	COAL/CARB MUDSTONE	PG		Pyrite		some pyrite on cleats.	4				0.64	20							
WMLC130	16.56	17.11	0.55	SANDSTONE	PG					5	37721	7.4	0.15	0.10	3	36	-33	11.76	7.6	0	0	NAF
WMLC130	17.11	17.24	0.13	CARB MUDSTONE/COAL	PG			Calcite		6	37722	6.7	0.33	0.07	2	160	-158	74.70	7.7	0	0	NAF
WMLC130	17.24	17.74	0.50	COAL	PG					7				0.64	20							
WMLC130	17.74	18.10	0.36	CARB MUDSTONE/SILTSTONE	PG					8	37723	7.5	0.42	0.13	4	15	-11	3.77	7.2	0	0	NAF
WMLC130	18.10	18.36	0.26	COAL	PG					9				0.45	14							
WMLC130	18.36	18.53	0.17	SILTSTONE/SANDSTONE	Floor					10				0.01	0							NAF
WMLC130	18.53	18.69	0.16	SILTSTONE							37397	7.7	0.53	0.06	2	13	-11	7.08	7.8	0	0	NAF
WMLC130	18.69	18.89	0.20	CORE LOSS																		
WMLC130	18.89	20.82	1.93	SILTSTONE/SANDSTONE				Calcite			37398			0.02	1							NAF
WMLC130	20.82	22.76	1.94	SANDSTONE							37399			0.02	1							NAF
WMLC130	22.76	23.27	0.51	CONGLOMERATE							37400	7.4	0.23	0.03	1	15	-14	16.34	8.2	0	0	NAF
WMLC130	23.27	24.57	1.30	SANDSTONE/SILTSTONE							37401			0.02	1							NAF
WMLC130	24.57	30.59	6.02	SANDSTONE							37402			0.02	1							NAF
WMLC130	30.59	31.70	1.11	SILTSTONE							37403	6.7	0.72	0.04	1	10	-9	8.17	8.3	0	0	NAF
WMLC130	31.70	31.82	0.12	SILTSTONE/CARB MUDSTONE	Roof					11	37724	8.0	0.33	0.07	2	7	-5	3.27	7.0	0	0	NAF
WMLC130	31.82	32.12	0.30	COAL	ART					12				0.54	17							
WMLC130	32.12	32.19	0.07	TUFF	ART					13	37725	7.8	0.18	0.38	12	31	-19	2.67	7.2	0	0	NAF
WMLC130	32.19	32.30	0.11	COAL	ART					14				0.28	9							
WMLC130	32.30	32.38	0.08	TUFF	ART					15	37726	8.1	0.11	0.11	3	26	-23	7.72	7.8	0	0	NAF
WMLC130	32.38	32.89	0.51	COAL	ART					16				0.38	12							
WMLC130	32.89	32.94	0.05	TUFF	ART					17	37727	7.7	0.15	0.16	5	82	-77	16.75	8.5	0	0	NAF
WMLC130	32.94	33.56	0.62	COAL/CARB MUDSTONE	ART					18				0.42	13							
WMLC130	33.56	33.80	0.24	TUFF	ART					19				0.01	0							NAF
WMLC130	33.80	34.34	0.54	COAL	ART					20				0.44	13							
WMLC130	34.34	34.63	0.29	SILTSTONE	Floor					21	37728	8.4	0.25	0.11	3	15	-12	4.46	8.1	0	0	NAF
WMLC130	34.63	35.71	1.08	SILTSTONE				Siderite			37404			0.03	1							NAF
WMLC130	35.71	40.62	4.91	SANDSTONE/SILTSTONE				Calcite/Siderite			37405	7.2	0.41	0.03	1	28	-27	30.50	9.2	0	0	NAF
WMLC130	40.62	42.81	2.19	SANDSTONE				Siderite			37406			0.02	1							NAF
WMLC130	42.81	47.60	4.79	SANDSTONE							37407			0.01	0							NAF
WMLC130	47.60	48.80	1.20	SANDSTONE/CONGLOMERATE							37408			0.02	1							NAF
WMLC130	48.80	53.28	4.48	SANDSTONE				Calcite			37409	8.1	0.12	0.02	1	83	-82	135.62	9.1	0	0	NAF
WMLC130	53.28	55.26	1.98	SANDSTONE/SILTSTONE							37410	7.9	0.22	0.08	2	13	-11	5.31	8.3	0	0	NAF

Table 1: Acid forming characteristics of overburden and coal samples.

Hole Name	Depth (m) From	To	Interval	Lithology	Seam	Weathering	Pyrite Occurrence	Carbonate	Comments	Ashton Sample Number	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC/MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
WMLC130	55.26	55.47	0.21	SANDSTONE	Roof					22				0.01	0							NAF
WMLC130	55.47	55.92	0.45	COAL/TUFF	ULD					23				0.43	13							
WMLC130	55.92	56.64	0.72	COAL	ULD		Pyrite			24				0.88	27							
WMLC130	56.64	57.22	0.58	COAL/SILTSTONE	ULD					25				0.43	13							
WMLC130	57.22	57.90	0.68	COAL/SILTSTONE	ULD					26				0.41	13							
WMLC130	57.90	58.25	0.35	SANDSTONE	ULD					27				0.01	0							NAF
WMLC130	58.25	58.46	0.21	COAL	ULD					28				0.31	9							
WMLC130	58.46	58.60	0.14	COAL	ULD																	
WMLC130	58.60	58.69	0.09	SILTSTONE	Floor					29				0.01	0							NAF
WMLC130	58.69	59.63	0.94	SILTSTONE							37411	6.6	0.56	0.11	3	15	-12	4.46	8.4	0	0	NAF
WMLC130	59.63	59.74	0.11	SILTSTONE	Roof					30	37729	8.2	0.33	0.37	11	22	-11	1.94	7.6	0	0	NAF
WMLC130	59.74	60.45	0.71	COAL	MLD1				sandstone partings	31				1.27	39							
WMLC130	60.45	60.89	0.44	SANDSTONE	Floor			Siderite			37412	7.4	0.23	0.19	6	11	-5	1.89	8.1	0	0	NAF
WMLC130	60.89	61.06	0.17	CARB MUDSTONE/COAL							37413	8.1	0.18	0.04	1	264	-263	215.69	8.3	0	0	NAF
WMLC130	61.06	62.52	1.46	SANDSTONE/SILTSTONE				Siderite	siderite at base		37414			0.02	1							NAF
WMLC130	62.52	67.82	5.30	SANDSTONE							37415	7.5	0.11	0.03	1	58	-57	63.18	9.3	0	0	NAF
WMLC130	67.82	67.92	0.10	CORE LOSS																		
WMLC130	67.92	69.02	1.10	SILTSTONE							37416	8.2	0.18	0.04	1	1	0	0.82	8.4	0	0	NAF
WMLC130	69.02	69.13	0.11	SILTSTONE	Roof					33	37730	7.9	0.42	0.06	2	14	-12	7.63	7.0	0	0	NAF
WMLC130	69.13	69.49	0.36	COAL	MLD2					34				0.65	20							
WMLC130	69.49	69.84	0.35	COAL	MLD2					35				1.52	47							
WMLC130	69.84	69.94	0.10	SILTSTONE	Floor					36				0.05	2							NAF
WMLC130	69.94	70.79	0.85	SANDSTONE/SILTSTONE							37417			0.03	1							NAF
WMLC130	70.79	71.00	0.21	CORE LOSS																		
WMLC130	71.00	76.05	5.05	SANDSTONE/SILTSTONE				Siderite			37418			0.03	1							NAF
WMLC130	76.05	77.22	1.17	SANDSTONE/SILTSTONE							37419			0.05	2							NAF
WMLC130	77.22	77.50	0.28	SILTSTONE	Roof					37				0.05	2							NAF
WMLC130	77.50	77.98	0.48	COAL	ULLD					38				0.49	15							
WMLC130	77.98	79.03	1.05	COAL	ULLD					39				0.55	17							
WMLC130	79.03	79.49	0.46	COAL	ULLD					40				0.43	13							
WMLC130	79.49	79.56	0.07	SANDSTONE	Floor					41				0.04	1							NAF
WMLC130	79.56	81.01	1.45	SILTSTONE/SANDSTONE							37420			0.04	1							NAF
WMLC130	81.01	81.75	0.74	SILTSTONE/CARB MUDSTONE							37421	8.0	0.12	0.10	3	19	-16	6.21	7.0	0	0	NAF
WMLC130	81.75	83.81	2.06	SANDSTONE					minor siltstone		37422			0.02	1							NAF
WMLC130	83.81	84.46	0.65	SILTSTONE				Siderite			37423	7.9	0.25	0.05	2	73	-71	47.71	8.6	0	0	NAF
WMLC130	84.46	84.88	0.42	SILTSTONE	Roof					42				0.03	1							NAF
WMLC130	84.88	85.27	0.39	COAL	LLLD1					43				0.54	17							
WMLC130	85.27	85.39	0.12	TUFF	LLLD1					44				0.04	1							NAF
WMLC130	85.39	85.81	0.42	COAL	LLLD2					45				0.42	13							
WMLC130	85.81	85.91	0.10	SILTSTONE	Floor					46	37731	8.2	0.18	0.06	2	13	-11	7.08	4.7	0	7	NAF
WMLC130	85.91	86.83	0.92	SILTSTONE				Siderite	minor carb mudstone		37424	6.8	0.33	0.03	1	11	-10	11.98	8.3	0	0	NAF
WMLC130	86.83	88.10	1.27	SILTSTONE							37425			0.02	1							NAF
WMLC130	88.10	91.83	3.73	SANDSTONE							37426	6.7	0.53	0.01	0	28	-28	91.50	8.7	0	0	NAF
WMLC130	91.83	92.30	0.47	SILTSTONE				Siderite			37427	4.9	1.02	1.19	36	7	29	0.19	3.0	6	24	PAF
WMLC130	92.30	95.35	3.05	SANDSTONE/CONGLOMERATE							37428	6.8	0.63	0.01	0	18	-18	58.82	8.2	0	0	NAF
WMLC130	95.35	100.03	4.68	SANDSTONE							37429			<0.01	0							NAF
WMLC130	100.03	104.40	4.37	SANDSTONE							37430			0.02	1							NAF
WMLC130	104.40	106.26	1.86	SILTSTONE/SANDSTONE				Siderite			37431	7.5	0.21	0.03	1	15	-14	16.34	8.0	0	0	NAF
WMLC130	106.26	106.95	0.69	SILTSTONE					minor carb mudstone		37432	8.0	0.16	0.03	1	13	-12	14.16	7.7	0	0	NAF
WMLC130	106.95	107.08	0.13	SILTSTONE/COAL	Roof					47	37732	7.7	0.21	0.08	2	17	-15	6.94	7.1	0	0	NAF
WMLC130	107.08	107.92	0.84	COAL	UB					48				0.58	18							
WMLC130	107.92	108.01	0.09	TUFF	UB					49				0.03	1							NAF
WMLC130	108.01	108.10	0.09	COAL	UB					50				0.45	14							
WMLC130	108.10	108.19	0.09	TUFF	UB					51				0.02	1							NAF
WMLC130	108.19	108.77	0.58	COAL	UB					52				0.51	16							
WMLC130	108.77	108.94	0.17	CARB MUDSTONE	Floor					53	37733	8.4	0.23	0.13	4	14	-10	3.52	7.0	0	0	NAF
WMLC130	108.94	109.69	0.75	CARB MUDSTONE							37433	7.9	0.23	0.10	3	12	-9	3.92	7.9	0	0	NAF
WMLC130	109.69	116.30	6.61	SANDSTONE							37434			<0.01	0							NAF
WMLC130	116.30	121.09	4.79	SANDSTONE							37435			0.01	0							NAF
WMLC130	121.09	125.51	4.42	SANDSTONE							37436			0.03	1							NAF
WMLC130	125.51	128.00	2.49	SANDSTONE							37437			0.02	1							NAF
WMLC130	128.00	128.98	0.98	SANDSTONE							37438	8.4	0.31	0.12	4	20	-16	5.45	7.6	0	0	NAF

Table 1: Acid forming characteristics of overburden and coal samples.

Hole Name	Depth (m) From	Depth (m) To	Depth (m) Interval	Lithology	Seam	Weathering	Pyrite Occurrence	Carbonate	Comments	Ashton Sample Number	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC/MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
WMLC130	128.98	129.22	0.24	SANDSTONE	Roof					54	37734	7.6	0.62	0.18	6	16	-10	2.90	5.4	0	2	NAF
WMLC130	129.22	129.79	0.57	COAL/TUFF	LB					55				0.71	22							
WMLC130	129.79	130.39	0.60	COAL	LB					56				0.55	17							
WMLC130	130.39	130.85	0.46	COAL/TUFF	LB					57				0.71	22							
WMLC130	130.85	131.37	0.52	COAL	LB					58				0.78	24							
WMLC130	131.37	131.53	0.16	TUFF/COAL	LB					59	37735	8.2	0.51	0.22	7	16	-9	2.38	7.1	0	0	NAF
WMLC130	131.53	131.68	0.15	COAL	LB					60				0.56	17							
WMLC130	131.68	132.03	0.35	SILTSTONE	Floor					61	37736	7.5	0.42	0.36	11	14	-3	1.27	5.1	0	3	NAF
WMLC130	132.03	132.19	0.16	SILTSTONE/COAL							37439	8.3	0.53	0.30	9	15	-6	1.63	7.3	0	0	NAF
WMLC130	132.19	134.86	2.67	SANDSTONE							37440			0.02	1							NAF
WMLC130	134.86	136.08	1.22	CONGLOMERATE							37441	7.5	0.23	0.02	1	15	-14	24.51	8.2	0	0	NAF
WMLC133	84.17	85.20	1.03	SILTSTONE							37442	8.2	0.15	0.08	2	27	-25	11.03	8.4	0	0	NAF
WMLC133	85.20	85.32	0.12	SILTSTONE/CARB MUDSTONE	Roof					26	37737	7.4	0.34	0.52	16	16	0	1.01	4.5	0	5	UC(PAF)
WMLC133	85.32	86.14	0.82	COAL	LB					27				0.59	18							
WMLC133	86.14	86.46	0.32	COAL/TUFF	LB					28				0.53	16							
WMLC133	86.46	87.09	0.63	COAL/TUFF	LB			Calcite		29				0.63	19							
WMLC133	87.09	87.50	0.41	COAL/TUFF	LB					30				1.02	31							
WMLC133	87.50	87.66	0.16	COAL/TUFF	LB					31	37738	8.0	0.12	0.36	11	17	-6	1.54	4.0	1	5	UC(PAF)
WMLC133	87.66	87.85	0.19	COAL/SILTSTONE	LB					32				0.46	14							
WMLC133	87.85	88.01	0.16	SILTSTONE	Floor					33	37739	7.9	0.22	0.25	8	20	-12	2.61	7.3	0	0	NAF
WMLC133	88.01	88.52	0.50	SILTSTONE/COAL							37443	7.8	0.33	0.28	9	30	-21	3.50	8.1	0	0	NAF
WMLC133	88.52	89.24	0.72	SANDSTONE							37444	7.7	0.35	0.05	2	30	-28	19.61	8.4	0	0	NAF
WMLC133	89.24	89.75	0.52	SILTSTONE/CARB MUDSTONE				Siderite			37445	7.9	0.26	0.17	5	42	-37	8.07	8.4	0	0	NAF
WMLC133	89.75	92.90	3.15	SILTSTONE/SANDSTONE							37446	8.4	0.18	0.05	2	22	-20	14.38	8.3	0	0	NAF
WMLC133	92.90	98.43	5.53	SANDSTONE							37447	7.5	0.63	0.01	0	51	-51	166.67	8.7	0	0	NAF
WMLC133	98.43	98.56	0.13	SILTSTONE							37448	6.7	0.82	0.16	5	22	-17	4.49	7.2	0	0	NAF
WMLC133	98.56	99.02	0.46	SILTSTONE	Roof					34	37740	8.2	0.17	0.16	5	23	-18	4.70	7.6	0	0	NAF
WMLC133	99.02	99.17	0.15	COAL/SILTSTONE	HB1					35				0.29	9							
WMLC133	99.17	100.08	0.91	COAL	HB2					36				0.73	22							
WMLC133	100.08	100.22	0.14	SILTSTONE	Floor					37	37741	7.6	0.18	0.17	5	16	-11	3.08	5.7	0	3	NAF
WMLC133	100.22	101.37	1.15	SILTSTONE				Calcite	minor coal		37449	7.4	0.29	0.12	4	21	-17	5.72	7.3	0	0	NAF
WMLC133	101.37	104.59	3.22	SANDSTONE/SILTSTONE							37450			0.02	1							NAF
WMLC133	104.59	105.82	1.23	SILTSTONE/COAL							37451	7.6	0.28	0.15	5	24	-19	5.23	7.7	0	0	NAF
WMLC133	105.82	105.98	0.16	CORE LOSS																		
WMLC133	105.98	106.05	0.07	SILTSTONE							37452	8.3	0.20	0.02	1	21	-20	34.31	8.4	0	0	NAF
WMLC133	106.05	106.30	0.25	SILTSTONE	Roof				carb mudstone at base	38				0.03	1							NAF
WMLC133	106.30	106.81	0.52	COAL/TUFF	HB1					39				0.88	27							
WMLC133	106.81	106.91	0.10	SILTSTONE	Floor					40				0.12	4							
WMLC133	106.91	107.84	0.93	SILTSTONE/COAL							37453	7.7	0.35	0.14	4	19	-15	4.44	3.7	4	18	NAF
WMLC133	107.84	108.59	0.75	SILTSTONE							37454			0.02	1							NAF
WMLC133	108.59	109.79	1.20	SANDSTONE/SILTSTONE							37455	8.2	0.18	<0.01	0	22	-22	143.79	8.2	0	0	NAF
WMLC133	109.79	110.95	1.16	CONGLOMERATE							37456			0.03	1							NAF
WMLC133	110.95	114.23	3.28	SANDSTONE							37457	5.1	1.46	0.70	21	20	1	0.94	3.4	4	10	PAF
WMLC135	0.00	1.00	1.00	CLAY		EW																
WMLC135	1.00	6.00	5.00	CLAY		EW																
WMLC135	6.00	10.00	4.00	SANDSTONE		EW																
WMLC135	10.00	12.00	2.00	IGNEOUS ROCK		HW																
WMLC135	12.00	12.94	0.94	SILTSTONE/IGNEOUS ROCK		HW																
WMLC135	12.94	13.02	0.08	BASALT																		
WMLC135	13.02	14.03	1.01	MUDSTONE/CARB MUDSTONE							37458	4.9	1.12	0.35	11	19	-8	1.77	4.9	0	3	NAF
WMLC135	14.03	14.23	0.20	MUDSTONE/CARB MUDSTONE	Roof					1	37742	4.5	1.97	0.96	29	1	28	0.03	2.7	16	20	PAF
WMLC135	14.23	14.68	0.45	COAL	ART					2				0.77	24							
WMLC135	14.68	15.11	0.43	COAL/MUDSTONE	ART					3				1.01	31							
WMLC135	15.11	15.31	0.20	COAL/CARB MUDSTONE	ART					4				1.00	31							
WMLC135	15.31	15.74	0.43	COAL	ART					5				0.66	20							
WMLC135	15.74	16.10	0.36	SANDSTONE	Floor/Roof					6	37743	6.5	0.22	0.74	23	20	3	0.88	3.5	2	5	PAF
WMLC135	16.10	16.21	0.11	COAL	ULD					7				0.57	17							
WMLC135	16.21	16.52	0.31	SANDSTONE	ULD					8	37744	6.7	0.15	0.28	9	18	-9	2.10	7.0	0	0	NAF
WMLC135	16.52	16.62	0.09	COAL	ULD					9				0.62	19							
WMLC135	16.62	16.76	0.15	CARB MUDSTONE	ULD					10	37745	4.7	1.21	0.78	24	5	19	0.21	3.8	2	12	PAF
WMLC135	16.76	17.21	0.44	COAL	ULD					11				0.67	21							
WMLC135	17.21	17.41	0.21	SANDSTONE	Floor					12	37746	6.8	0.21	0.20	6	18	-12	2.94	7.0	0	0	NAF
WMLC135	17.41	17.45	0.04	SANDSTONE							37459	6.7	0.42	0.08	2	25	-23	10.21	7.7	0	0	NAF
WMLC135	17.45	18.01	0.56	CARB MUDSTONE/COAL							37460	6.6	0.53	0.34	10	22	-12	2.11	7.1	0	0	NAF
WMLC135	18.01	22.52	4.51	SANDSTONE							37461			0.03	1							NAF
WMLC135	22.52	28.31	5.79	SANDSTONE							37462			0.02	1							NAF

Table 1: Acid forming characteristics of overburden and coal samples.

Hole Name	Depth (m)			Lithology	Seam	Weathering	Pyrite Occurrence	Carbonate	Comments	Ashton Sample Number	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
	From	To	Interval											Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
WMLC135	28.31	29.91	1.60	SILTSTONE				Siderite			37463			0.04	1							NAF
WMLC135	29.91	30.05	0.14	SILTSTONE						13	37747	6.7	0.12	0.10	3	19	-16	6.21	7.2	0	0	NAF
WMLC135	30.05	30.67	0.62	CORE LOSS																		
WMLC135	30.67	31.09	0.42	COAL	MLD1			Calcite		14				0.69	21							
WMLC135	31.09	31.20	0.11	CARB MUDSTONE/SILTSTONE	Floor					15	37748	7.4	0.22	0.16	5	67	-62	13.68	7.5	0	0	NAF
WMLC135	31.20	31.39																				
WMLC135	31.39	32.36	0.97	SILTSTONE				Siderite			37464			0.02	1							NAF
WMLC135	32.36	32.52	0.16	SILTSTONE	Roof					16				0.01	0							NAF
WMLC135	32.52	33.36	0.84	COAL	MLD2					17				0.72	22							
WMLC135	33.36	33.46	0.10	SILTSTONE/CARB MUDSTONE	Floor					18	37749	7.6	0.33	0.44	13	6	7	0.45	4.9	0	4	UC(NAF)
WMLC135	33.46	33.55	0.09	CARB MUDSTONE	Floor						37465	3.4	2.28	7.46	228	0	228	0.00	2.1	125	149	PAF
WMLC135	33.55	35.84	2.29	SANDSTONE				Siderite	620mm siderite at base		37466	7.2	0.15	0.09	3	41	-38	14.89	7.8	0	0	NAF
WMLC135	35.84	37.27	1.43	SILTSTONE/SANDSTONE							37467			0.04	1							NAF
WMLC135	37.27	37.96	0.69	SILTSTONE							37468			0.03	1							NAF
WMLC135	37.96	38.06	0.10	SILTSTONE	Roof					19				0.03	1							NAF
WMLC135	38.06	38.56	0.49	COAL	ULLD					20				0.52	16							
WMLC135	38.56	39.34	0.79	COAL	ULLD					21				0.50	15							
WMLC135	39.34	39.60	0.26	COAL/MUDSTONE	ULLD					22				0.46	14							
WMLC135	39.60	40.07	0.47	COAL	ULLD					23				0.46	14							
WMLC135	40.07	40.26	0.19	SANDSTONE	Floor					24				0.02	1							NAF
WMLC135	40.26	40.61	0.35	SANDSTONE							37469			0.03	1							NAF
WMLC135	40.61	41.98	1.37	SILTSTONE/SANDSTONE/CARB MUDSTONE							37470	6.7	0.33	0.10	3	13	-10	4.25	7.7	0	0	NAF
WMLC135	41.98	44.82	2.84	SANDSTONE							37471			0.03	1							NAF
WMLC135	44.82	46.30	1.48	SILTSTONE				Siderite	includes 420mm siderite		37472			0.02	1							NAF
WMLC135	46.30	46.50	0.20	SILTSTONE/CARB MUDSTONE	Roof			Calcite		25	37750	6.6	0.11	0.09	3	12	-9	4.36	7.0	0	0	NAF
WMLC135	46.50	47.02	0.52	COAL	LLLD				carb mudstone partings	26				0.40	12							
WMLC135	47.02	47.44	0.42	COAL	LLLD					27				0.41	13							
WMLC135	47.44	47.82	0.38	SILTSTONE	Floor						37473			0.01	0							NAF
WMLC135	47.82	51.39	3.57	SANDSTONE				Siderite			37474			0.02	1							NAF
WMLC135	51.39	52.03	0.64	SILTSTONE							37475	7.3	0.14	0.07	2	54	-52	25.21	7.9	0	0	NAF
WMLC135	52.03	54.50	2.47	SANDSTONE							37476			0.03	1							NAF
WMLC135	54.50	56.99	2.49	CONGLOMERATE							37477			0.03	1							NAF
WMLC135	56.99	57.60	0.61	SANDSTONE/SILTSTONE							37478			0.02	1							NAF
WMLC135	57.60	63.05	5.45	SILTSTONE							37479			0.04	1							NAF
WMLC135	63.05	63.36	0.31	SANDSTONE							37480			0.02	1							NAF
WMLC135	63.36	63.69	0.33	CORE LOSS																		
WMLC135	63.69	64.28	0.59	COAL	UB					30				0.55	17							
WMLC135	64.28	64.50	0.22	COAL/TUFF	UB					31				0.54	17							
WMLC135	64.50	64.57	0.07	CORE LOSS																		
WMLC135	64.57	64.73	0.16	SILTSTONE	Floor/Roof					32				0.05	2							NAF
WMLC135	64.73	64.92	0.19	COAL	UBS					33				0.52	16							
WMLC135	64.92	65.15	0.23	TUFF/COAL	UBS					34	37751	7.4	0.13	0.16	5	24	-19	4.90	7.1	0	0	NAF
WMLC135	65.15	65.69	0.54	COAL	UBS					35				0.53	16							
WMLC135	65.69	66.10	0.41	SILTSTONE	Floor					36	37752	8.1	0.11	0.27	8	18	-10	2.18	7.2	0	0	NAF
WMLC135	66.10	67.69	1.59	SILTSTONE				Siderite	220mm siderite at base		37482	6.8	0.24	0.07	2	29	-27	13.54	8.2	0	0	NAF
WMLC135	67.69	70.92	3.23	SILTSTONE/SANDSTONE							37483			0.01	0							NAF
WMLC135	70.92	75.00	4.08	SANDSTONE							37484			0.04	1							NAF
WMLC135	75.00	80.15	5.15	SANDSTONE							37485			<0.01	0							NAF
WMLC135	80.15	84.27	4.12	SANDSTONE				Siderite	300mm siderite at base		37486			0.01	0							NAF
WMLC135	84.27	84.97	0.70	SILTSTONE							37487			0.04	1							NAF
WMLC135	84.97	85.15	0.18	SILTSTONE	Roof					37	37753	7.5	0.18	0.36	11	38	-27	3.45	7.3	0	0	NAF
WMLC135	85.15	85.71	0.56	COAL	LB					38				0.55	17							
WMLC135	85.71	85.90	0.19	SANDSTONE	LB					39	37754	6.7	0.12	0.24	7	18	-11	2.45	7.5	0	0	NAF
WMLC135	85.90	86.56	0.66	COAL	LB					40				0.54	17							
WMLC135	86.56	86.96	0.40	COAL/TUFF	LB					41				0.52	16							
WMLC135	86.96	87.53	0.57	COAL	LB					42				0.60	18							
WMLC135	87.53	87.83	0.30	COAL/TUFF	LB					43	37755	6.8	0.13	0.24	7	27	-20	3.68	7.2	0	0	NAF
WMLC135	87.83	88.06	0.23	SILTSTONE	Floor						37488	7.2	0.13	0.14	4	10	-6	2.33	7.6	0	0	NAF
WMLC135	88.06	93.65	5.59	SANDSTONE/SILTSTONE							37489			0.02	1							NAF
WMLC135	93.65	95.62	1.97	CONGLOMERATE							37490			0.03	1							NAF
WMLC135	95.62	100.32	4.70	SILTSTONE/SANDSTONE				Calcite			37491			0.02	1							NAF
WMLC135	100.32	102.49	2.17	SILTSTONE/SANDSTONE				Siderite			37492			0.03	1							NAF
WMLC135	102.49	103.17	0.68	SANDSTONE/SILTSTONE	Roof			Siderite			37493			0.04	1							NAF
WMLC135	103.17	103.62	0.45	COAL	HB1						37494	6.6	0.73	0.33	10	251	-241	24.86	8.3	0	0	NAF
WMLC135	103.62	104.11	0.49	SANDSTONE	Floor						37495			0.02	1							NAF
WMLC135	104.11	108.22	4.11	SILTSTONE				Calcite, Siderite			37496			0.04	1							NAF

Table 1: Acid forming characteristics of overburden and coal samples.

Hole Name	Depth (m)			Lithology	Seam	Weathering	Pyrite Occurrence	Carbonate	Comments	Ashton Sample Number	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
	From	To	Interval											Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
WMLC135	108.22	113.67	5.45	SANDSTONE/SILTSTONE							37497			0.04	1							NAF
WMLC135	113.67	114.10	0.43	SILTSTONE	Roof				mudstone at base		37498	6.7	0.68	0.08	2	17	-15	6.94	7.9	0	0	NAF
WMLC135	114.10	115.05	0.95	COAL	HB1			Calcite	siltstone & mudstone partings		37499	5.0	1.11	0.52	16	13	3	0.82	3.7	5	23	NAF
WMLC135	115.05	115.30	0.25	SANDSTONE	Floor				carb mudstone at top		37500	6.7	0.23	0.07	2	12	-10	5.60	6.2	0	2	NAF
WMLC135	115.30	117.70	2.40	SANDSTONE							37501			0.02	1							NAF
WMLC135	117.70	120.54	2.84	SANDSTONE				Calcite			37502			0.02	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 (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)

NAF = Non-Acid Forming
UC(NAF) = Uncertain expected to be NAF
PAF = Potentially Acid Forming
UC(PAF) = Uncertain expected to be PAF

Coal seam interval

Intervals from open hole and loss core sections not available for sampling

Standard NAG results overestimate acid potential due to organic acid effects

Table 2: Extended boil NAG and calculated NAG test results for selected samples.

EGi Code	Lithology	Seam	ACID-BASE ANALYSIS					STANDARD NAG TEST			Extended Boil NAGpH	Calculated NAG
			Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$		
36789	COAL	LBS	0.52	16	11	5	0.69	3.1	14	34	7.8	-7
36792	SILTSTONE		0.99	30	6	24	0.20	3.3	5	24	4.9	9
37427	SILTSTONE		1.19	36	7	29	0.19	3.0	6	24	5.2	10
37738	COAL/TUFF	LB	0.36	11	17	-6	1.54	4.0	1	5	6.9	2
37453	SILTSTONE/COAL		0.14	4	19	-15	4.44	3.7	4	18	7.4	-6
37743	SANDSTONE	Floor/Roof	0.74	23	20	3	0.88	3.5	2	5	6.9	1
37499	COAL	HB1	0.52	16	13	3	0.82	3.7	5	23	7.1	-2

<u>KEY</u>

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)

Extended Boil NAGpH = pH of NAG liquor after extended heating

Calculated NAG = The net acid potential based on assay of anions and cations released to the NAG solution (kgH_2SO_4/t)

Table 3: Sulphur speciation results for selected samples.

Hole Name	Depth (m)			Lithology	Seam	EGi Sample No	Total %S	Pyritic S (%)	Acid Sulphate S (%)	Non-Acid Sulphate S (%)	Low Risk S Forms (%)	Original NAPP* (kg H_2SO_4/t)	Readily Available ANC** (kg H_2SO_4/t)	Re-calculated NAPP*** (kg H_2SO_4/t)
	From	To	Interval											
WMLC170	103.14	106.91	3.77	COAL	LB	36787	0.93	0.55	0.00	0.03	0.35	18	10	7
WMLC170	107.89	108.07	0.18	COAL	LBS	36789	0.52	0.07	0.00	0.02	0.43	5	10	-8
WMLC170	110.93	111.19	0.26	SILTSTONE		36792	0.99	0.81	0.00	0.06	0.12	24	5	20
WMLC170	117.62	118.07	0.45	COAL	HB2	36798	0.66	0.07	0.00	0.02	0.57	-65	40	-38
WMLC130	17.74	18.10	0.36	CARB MUDSTONE/SILTSTONE	PG	37723	0.13	0.06	0.00	0.00	0.07	-11	15	-13
WMLC130	91.83	92.30	0.47	SILTSTONE		37427	1.19	0.50	0.00	0.11	0.58	29	2	13
WMLC133	85.20	85.32	0.12	SILTSTONE/CARB MUDSTONE	Roof	37737	0.52	0.45	0.00	0.05	0.02	0	7	7
WMLC133	106.91	107.84	0.93	SILTSTONE/COAL		37453	0.14	0.03	0.00	0.01	0.10	-15	6	-5
WMLC135	15.74	16.10	0.36	SANDSTONE	Floor/Roof	37743	0.74	0.61	0.00	0.15	0.00	3	12	7
WMLC135	16.21	16.52	0.31	SANDSTONE	ULD	37744	0.28	0.22	0.00	0.03	0.03	-9	5	2
WMLC135	33.36	33.46	0.10	SILTSTONE/CARB MUDSTONE	Floor	37749	0.44	0.15	0.00	0.17	0.12	7	3	2
WMLC135	114.10	115.05	0.95	COAL	HB1	37499	0.52	0.18	0.00	0.04	0.30	3	8	-2

Pyritic S (%) = CRS (%)
Acid Sulphate S = KCl Acid Sulphate S
Non-Acid Sulphate S = KCl S – KCl Acid Sulphate S
Low Risk S Forms = Total S - (CRS + KCl S)

* standard NAPP value from Table 1 based on total S and ANC values
** estimated from ABCC testing
***based on acid generating S (pyrite and acid sulphate S) and readily available ANC

Table 4: Acid forming characteristics of NEOC and underground washery waste samples.

Date Sampled	Seam	Process Description	Material Type	SGS Sample Number	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
								Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
12/08/08	ULLD	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7377-007-03	37903	7.6	0.33	0.33	10	21	-11	2.08	7.8	0	0	NAF
12/08/08	ULLD	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7337-008-03	37904	5.9	1.01	0.44	13	123	-110	9.14	8.3	0	0	NAF
12/08/08	ULLD	Mod 1 Tailings	Tailings (<0.1mm)	HL7377-009-02	37905	7.9	0.28	0.44	13	29	-16	2.15	7.2	0	0	NAF
18/08/08	ULLD	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7377-013-03				0.89	27							
18/08/08	ULLD	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7377-014-03				0.91	28							
18/08/08	ULLD	Mod 1 Tailings	Tailings (<0.1mm)	HL7377-015-02	37906	7.4	0.24	0.55	17	34	-17	2.02	6.9	0	0	NAF
06/08/08	LLLD	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7377-004-03	37907	7.2	0.28	0.24	7	14	-7	1.91	5.2	0	3	NAF
06/08/08	LLLD	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7377-005-03				0.15	5							
06/08/08	LLLD	Mod 2 Tailings	Tailings (<0.1mm)	HL7377-006-02	37908	7.4	0.31	0.35	11	26	-15	2.43	7.5	0	0	NAF
11/08/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7377-010-03				0.20	6							
11/08/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7377-011-03				0.14	4							
11/08/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7377-012-02				0.41	13							
22/09/08	PG Underground	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7429-019-03	37909	7.5	0.42	0.18	6	32	-26	5.81	7.9	0	0	NAF
22/09/08	PG Underground	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7429-020-03	37910	5.7	0.91	0.31	9	136	-127	14.34	8.3	0	0	NAF
22/09/08	PG Underground	Mod 1 Tailings	Tailings (<0.1mm)	HL7429-021-02				0.62	19							
22/09/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7429-022-03				0.50	15							
22/09/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7429-023-03				0.52	16							
22/09/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7429-024-02				0.26	8							
07/10/08	PG Underground	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7458-001-03				0.31	9							
07/10/08	PG Underground	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7458-002-03				0.12	4							
07/10/08	PG Underground	Mod 1 Tailings	Tailings (<0.1mm)	HL7458-003-02				0.74	23							
13/10/08	MLD	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7458-007-03	37911	7.5	0.53	0.23	7	30	-23	4.26	8.4	0	0	NAF
13/10/08	MLD	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7458-008-03	37912	5.0	1.31	1.92	59	18	41	0.31	2.8	10	34	PAF
13/10/08	MLD	Mod 1 Tailings	Tailings (<0.1mm)	HL7458-009-02	37913	7.6	0.54	0.85	26	12	14	0.46	3.2	4	21	PAF
21/10/08	UB	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7458-013-03	37914	5.8	1.04	0.43	13	48	-35	3.65	8.3	0	0	NAF
21/10/08	UB	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7458-014-03	37915	7.6	0.38	0.08	2	150	-148	61.27	8.2	0	0	NAF
21/10/08	UB	Mod 1 Tailings	Tailings (<0.1mm)	HL7458-015-02	37916	7.7	0.42	0.28	9	30	-21	3.50	7.6	0	0	NAF
27/10/08	ULLD	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7458-019-03				0.07	2							
27/10/08	ULLD	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7458-020-03	37917	5.4	1.11	0.04	1	157	-156	128.27	8.5	0	0	NAF
27/10/08	ULLD	Mod 1 Tailings	Tailings (<0.1mm)	HL7458-021-02				0.40	12							
07/10/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7458-004-03				0.64	20							
07/10/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7458-005-03				0.03	1							
07/10/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7458-006-02				0.32	10							
13/10/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7458-010-03				0.17	5							
13/10/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7458-011-03				0.04	1							
13/10/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7458-012-02				0.32	10							
21/10/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7458-016-03				0.12	4							
21/10/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7458-017-03				0.06	2							
21/10/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7458-018-02				0.31	9							
27/10/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7458-022-03				0.08	2							
27/10/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7458-023-03				0.04	1							
27/10/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7458-024-02				0.28	9							

Table 4: Acid forming characteristics of NEOC and underground washery waste samples.

Date Sampled	Seam	Process Description	Material Type	SGS Sample Number	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					NAG TEST			ARD Classification
								Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
03/11/08	LB	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7496-001-03				0.20	6							
03/11/08	LB	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7496-002-03				0.10	3							
03/11/08	LB	Mod 1 Tailings	Tailings (<0.1mm)	HL7496-003-02				0.37	11							
10/11/08	UB	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7496-007-03				0.21	6							
10/11/08	UB	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7496-008-03				0.11	3							
10/11/08	UB	Mod 1 Tailings	Tailings (<0.1mm)	HL7496-009-02				0.28	9							
17/11/08	UB	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7496-013-03	37918	8.9	0.12	0.52	16	12	4	0.75	3.7	1	13	PAF
17/11/08	UB	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7496-014-03	37919	6.0	1.09	0.08	2	142	-140	58.01	7.7	0	0	NAF
17/11/08	UB	Mod 1 Tailings	Tailings (<0.1mm)	HL7496-015-02	37920	7.6	0.38	0.18	6	27	-21	4.90	7.7	0	0	NAF
24/11/08	ULLD	Mod 1 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7496-019-03				0.33	10							
24/11/08	ULLD	Mod 1 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7496-020-03	37921	5.8	1.14	0.19	6	161	-155	27.69	8.4	0	0	NAF
24/11/08	ULLD	Mod 1 Tailings	Tailings (<0.1mm)	HL7496-020-02	37922	6.6	0.58	0.67	21	2	19	0.10	2.6	38	67	NAF
03/11/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7496-004-03				0.12	4							
03/11/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7496-005-03				0.05	2							
03/11/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7496-006-02				0.32	10							
10/11/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7496-010-03				0.13	4							
10/11/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7496-011-03				0.11	3							
10/11/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7496-012-02				0.33	10							
17/11/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7496-016-03				0.08	2							
17/11/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7496-017-03				0.17	5							
17/11/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7496-018-02				0.33	10							
24/11/08	PG Underground	Mod 2 Reject D&R Screen	Coarse Reject (>2.0mm)	HL7496-022-03				0.25	8							
24/11/08	PG Underground	Mod 2 Spiral Reject Screen	Spiral Reject (0.1 to 2.0mm)	HL7496-023-03				0.28	9							
24/11/08	PG Underground	Mod 2 Tailings	Tailings (<0.1mm)	HL7496-024-02				0.30	9							

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)

NAF = Non-Acid Forming

UC(NAF) = Uncertain expected to be NAF

PAF = Potentially Acid Forming

UC(PAF) = Uncertain expected to be PAF

Table 5: Extended boil NAG and calculated NAG test results for selected washery waste samples.

EGi Code	Date Sampled	Seam	Material Type	ACID-BASE ANALYSIS					STANDARD NAG TEST			Extended Boil NAGpH	Calculated NAG
				Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$		
37912	13/10/08	MLD	Spiral Reject (0.1 to 2.0mm)	1.92	59	18	41	0.31	2.8	10	34	3.5	34
37913	13/10/08	MLD	Tailings (<0.1mm)	0.85	26	12	14	0.46	3.2	4	21	4.2	6
37918	17/11/08	UB	Coarse Reject (>2.0mm)	0.52	16	12	4	0.75	3.7	1	13	3.9	3
37922	24/11/08	ULLD	Tailings (<0.1mm)	0.67	21	2	19	0.10	2.6	38	67	5.7	-2

KEY

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)

Extended Boil NAGpH = pH of NAG liquor after extended heating

Calculated NAG = The net acid potential based on assay of anions and cations released to the NAG solution (kgH_2SO_4/t)

Table 6: Sulphur speciation results for selected washery waste samples.

EGi Sample No	Date Sampled	Seam	Material Type	Total %S	Pyritic S (%)	Acid Sulphate S (%)	Non-Acid Sulphate S (%)	Low Risk S Forms (%)	Original NAPP* (kg H_2SO_4/t)	Readily Available ANC** (kg H_2SO_4/t)	Re-calculated NAPP*** (kg H_2SO_4/t)
37906	18/08/08	ULLD	Tailings (<0.1mm)	0.55	0.22	0.00	0.02	0.31	-17	28	-21
37909	22/09/08	PG Underground	Coarse Reject (>2.0mm)	0.18	0.12	0.00	0.01	0.05	-26	22	-18
37910	22/09/08	PG Underground	Spiral Reject (0.1 to 2.0mm)	0.31	0.32	0.00	0.00	0.00	-127	140	-130
37911	13/10/08	MLD	Coarse Reject (>2.0mm)	0.23	0.19	0.00	0.00	0.04	-23	22	-16
37912	13/10/08	MLD	Spiral Reject (0.1 to 2.0mm)	1.92	1.99	0.00	0.02	0.00	41	18	43
37913	13/10/08	MLD	Tailings (<0.1mm)	0.85	0.61	0.00	0.01	0.23	14	7	12
37918	17/11/08	UB	Coarse Reject (>2.0mm)	0.52	0.39	0.00	0.03	0.10	4	8	4
37922	24/11/08	ULLD	Tailings (<0.1mm)	0.67	0.18	0.00	0.01	0.48	19	2	4

Pyritic S (%) = CRS (%)

Acid Sulphate S = KCl Acid Sulphate S

Non-Acid Sulphate S = KCl S – KCl Acid Sulphate S

Low Risk S Forms = Total S - (CRS + KCl S)

* standard NAPP value from Table 1 based on total S and ANC values

** estimated from ABCC testing

***based on acid generating S (pyrite and acid sulphate S) and readily available ANC

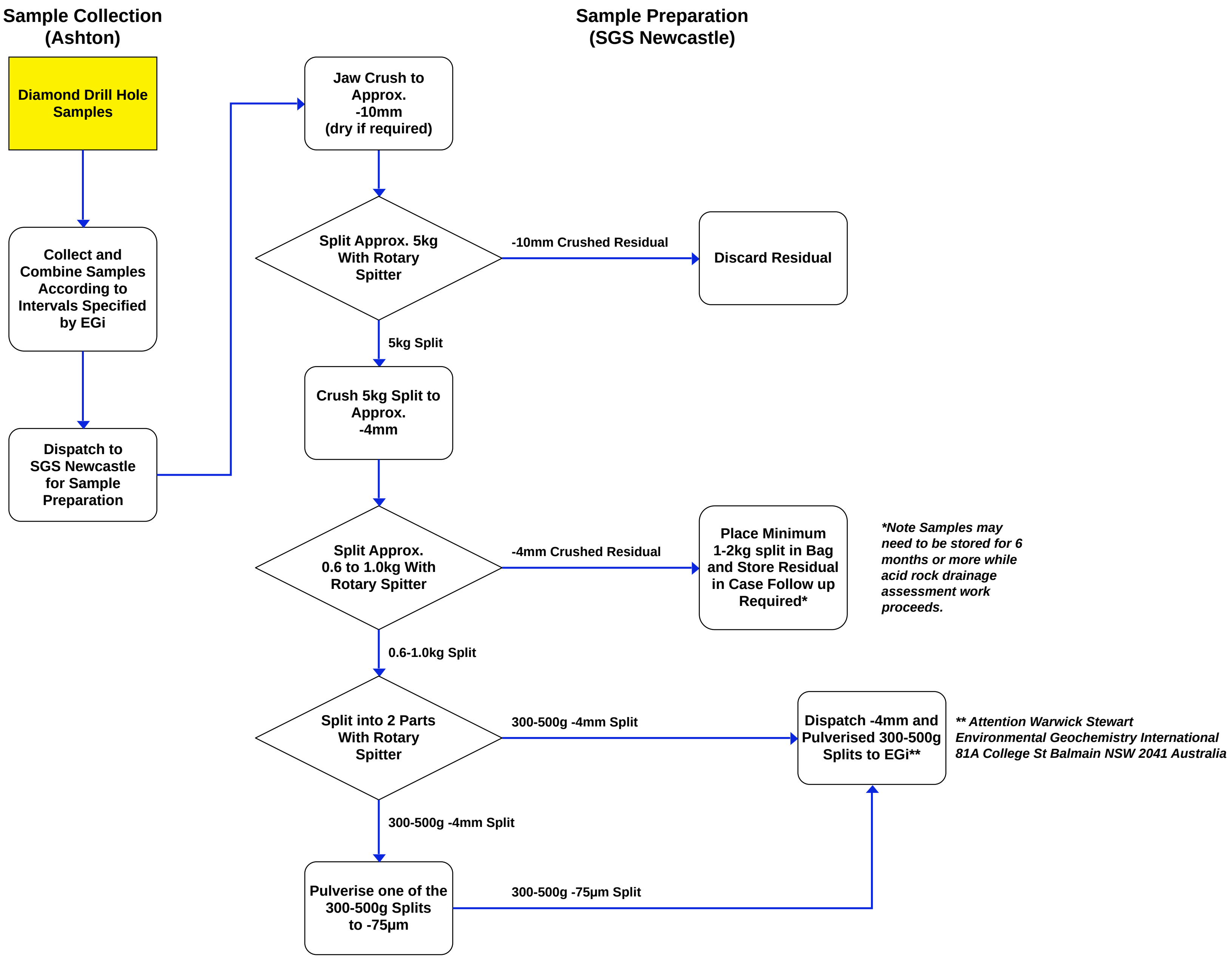


Figure 1: Flow chart showing sample preparation carried out for Ashton diamond hole core samples.

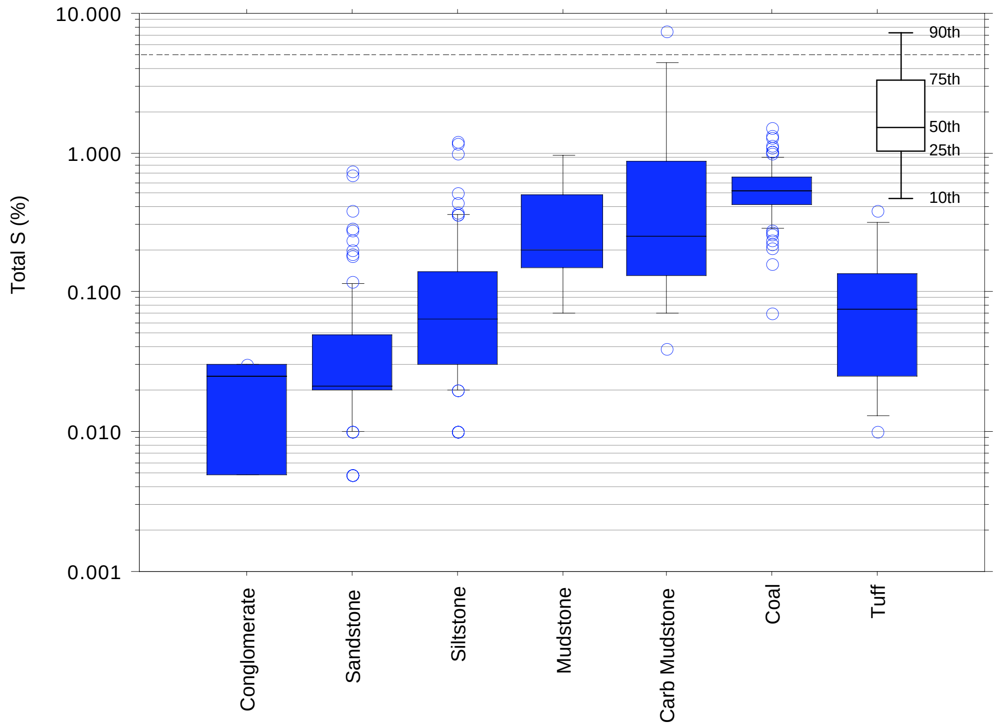


Figure 2: Box plot showing the distribution of S split by rock unit. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

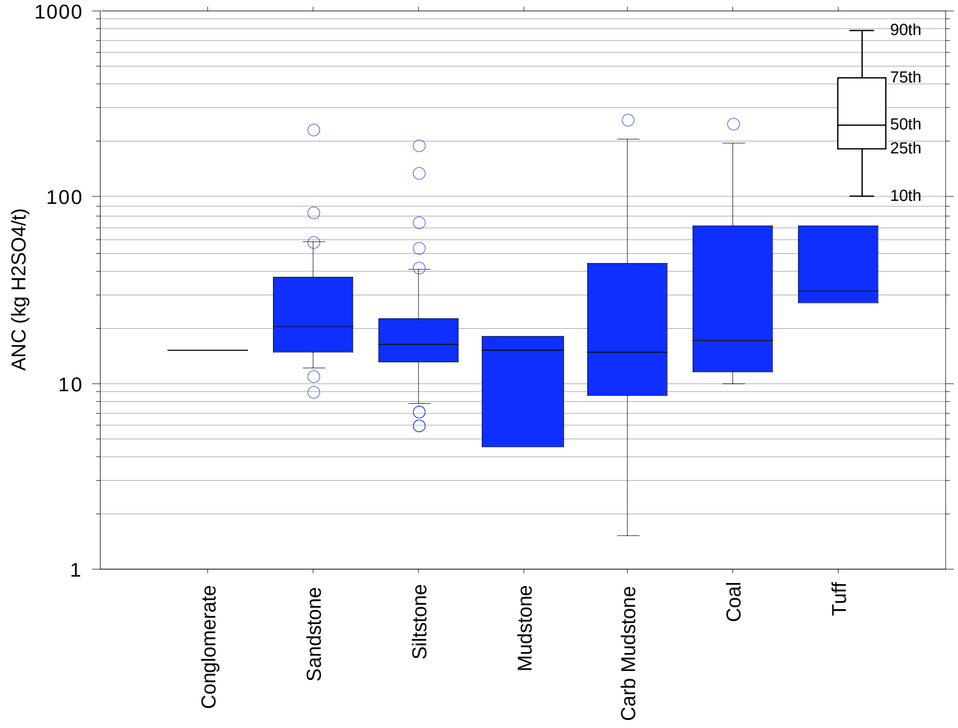


Figure 3: Box plot showing the distribution of ANC split by rock unit. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

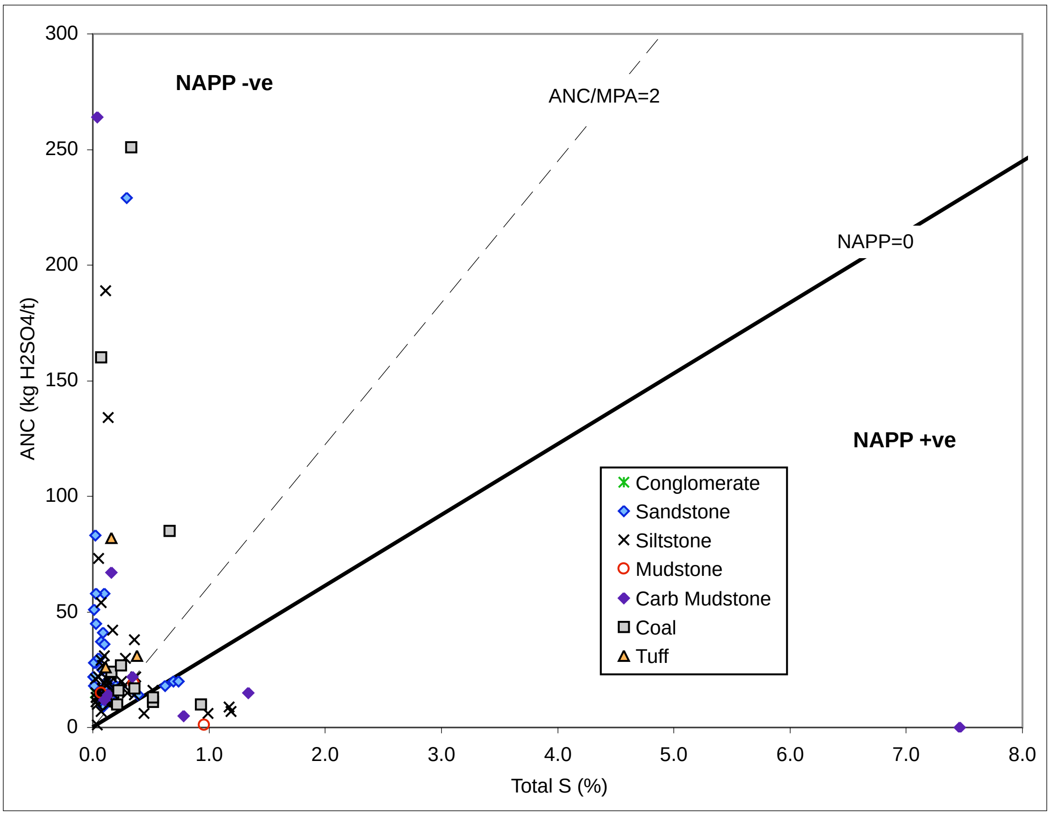


Figure 4: Acid-base account (ABA) plot showing ANC versus total S, split by lithology.

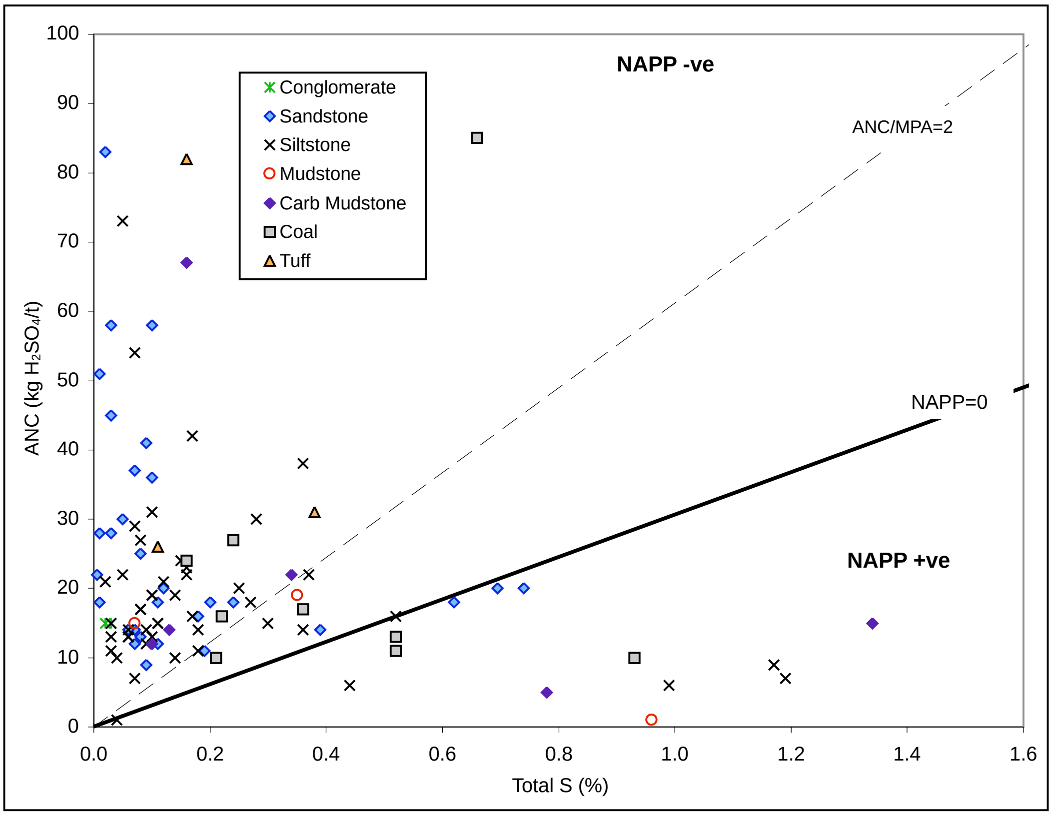


Figure 5: As for Figure 4 but rescaled.

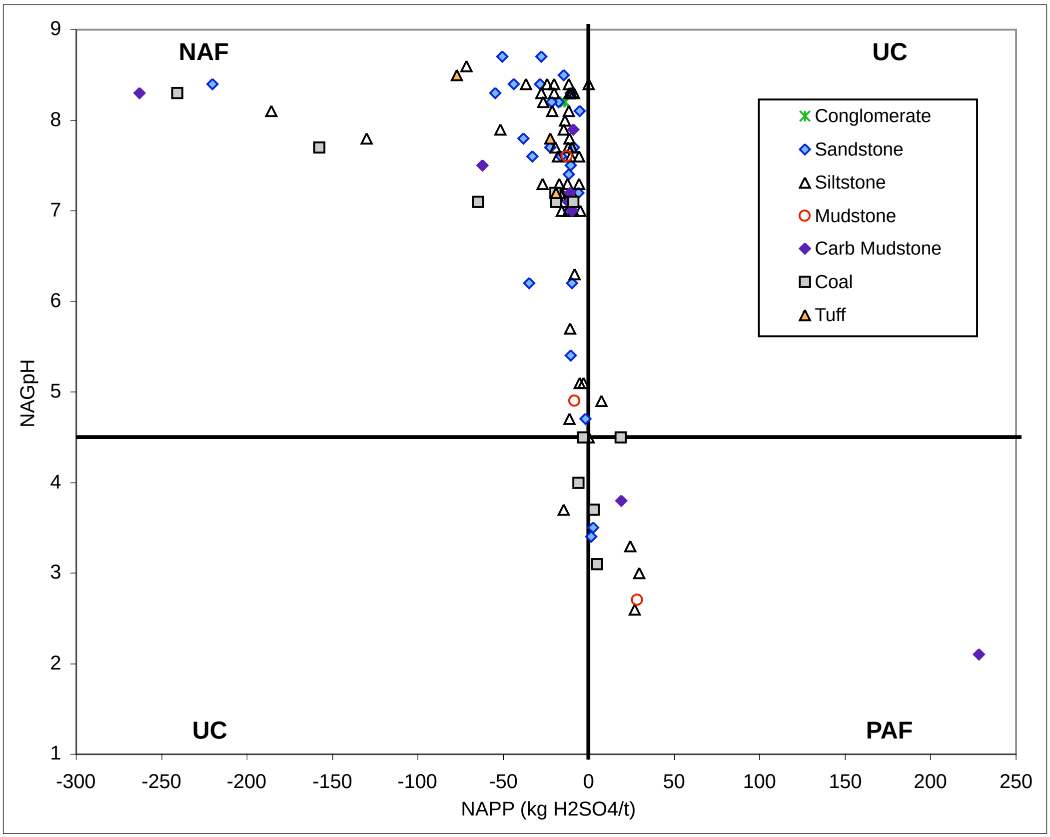


Figure 6: ARD classification plot showing NAGpH versus NAPP, split by lithology, with ARD classification domains indicated.

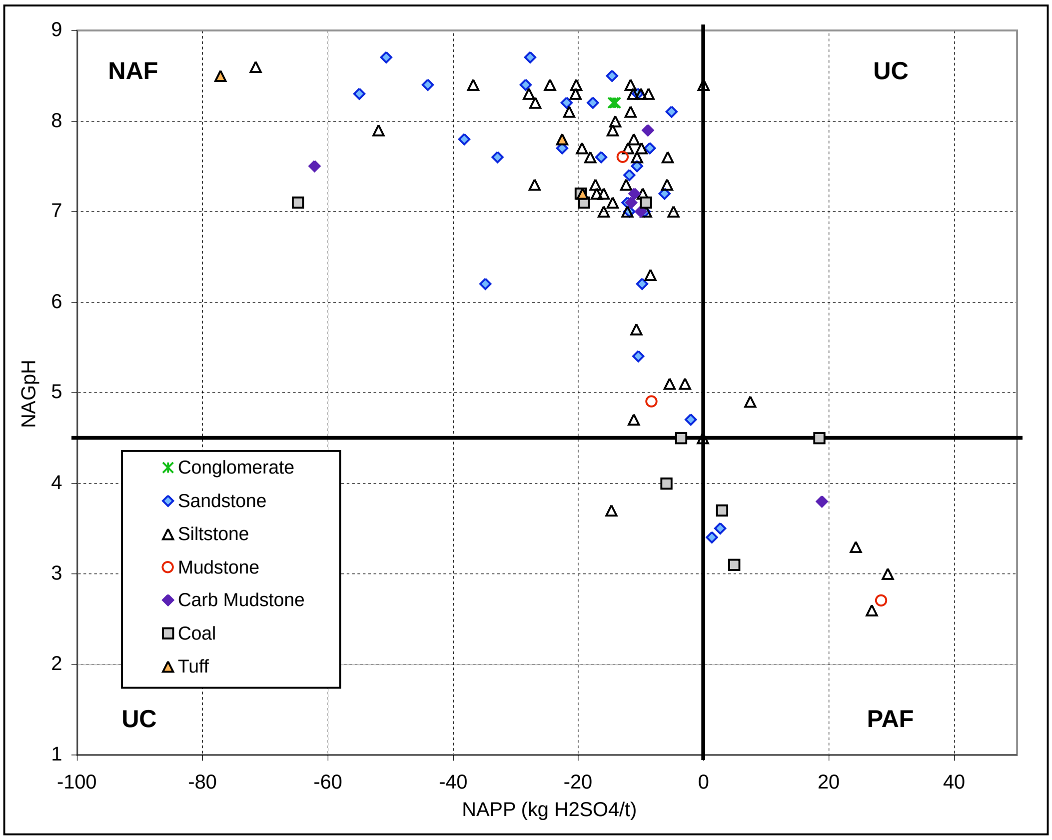


Figure 7: As for Figure 6 but rescaled.

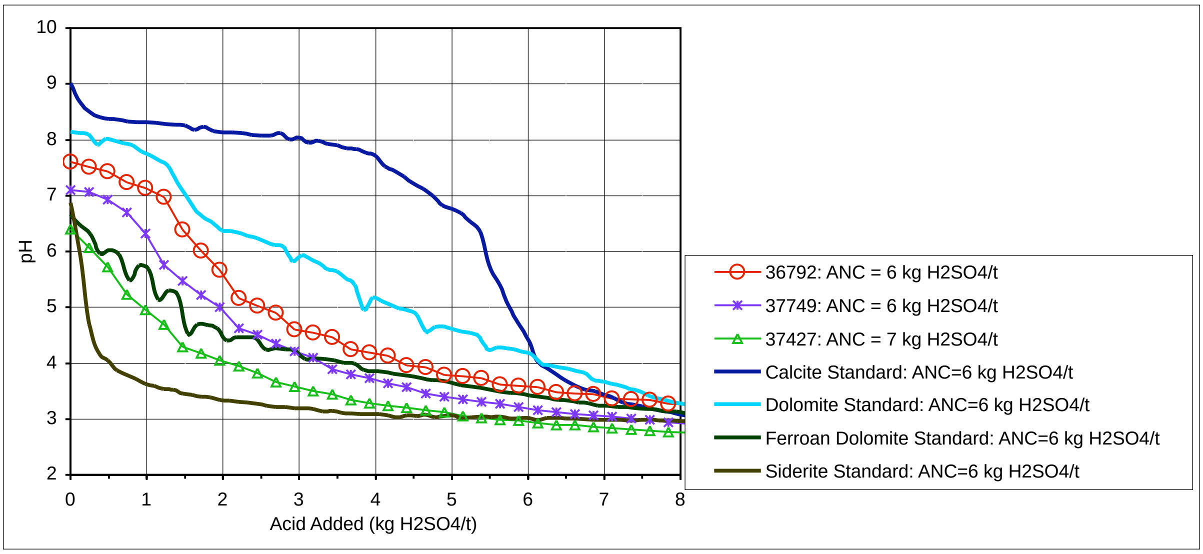


Figure 8: ABCC profile for samples with an ANC value close to 6 kg H_2SO_4/t. Carbonate standard curves are included for reference.

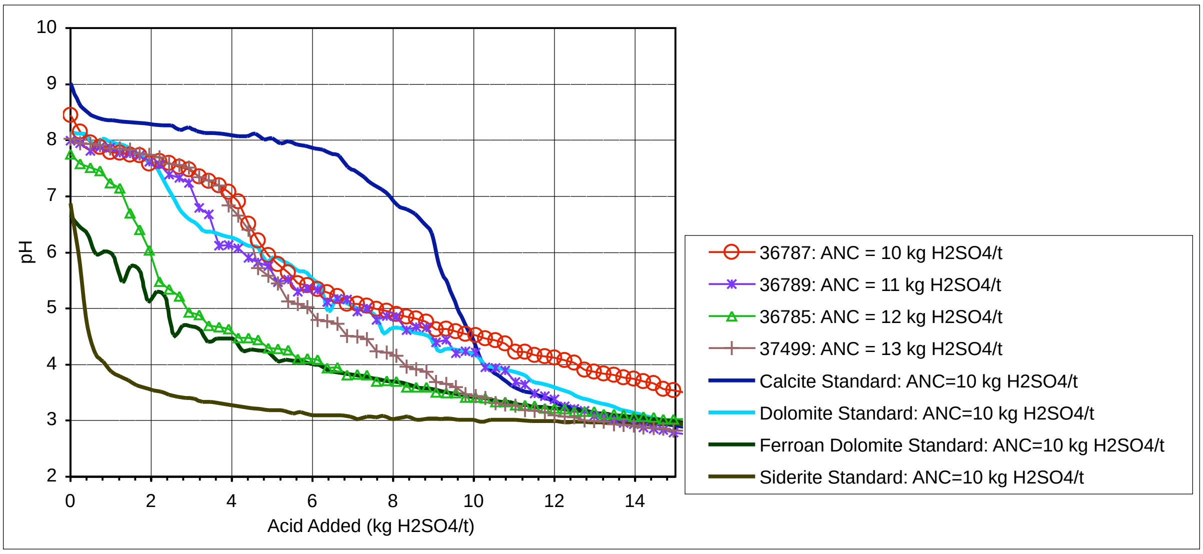


Figure 9: ABCC profile for samples with an ANC value close to 10 kg H_2SO_4/t. Carbonate standard curves are included for reference.

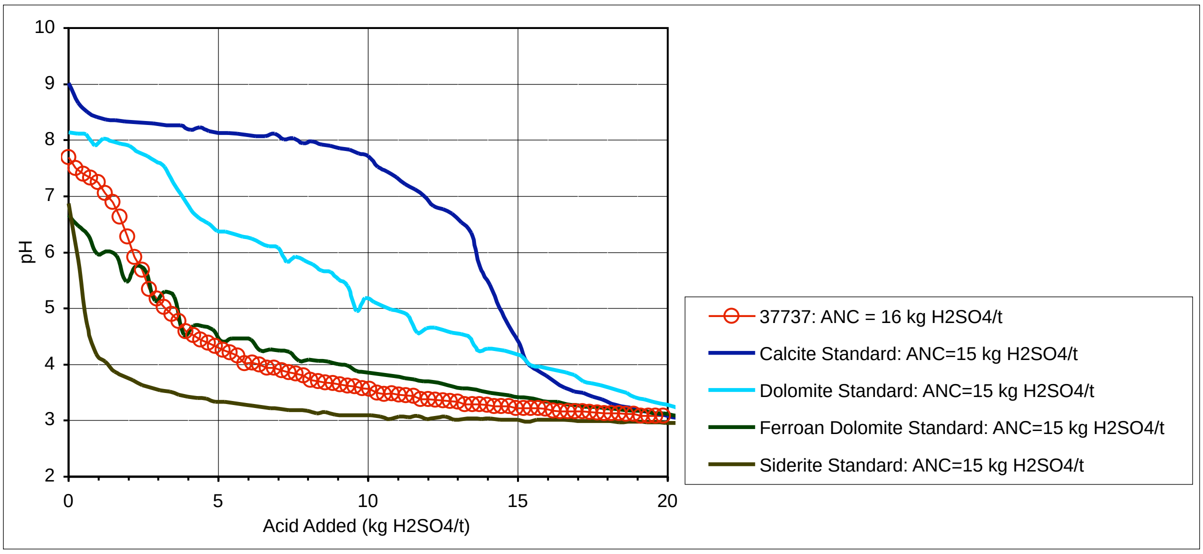


Figure 10: ABCC profile for sample 37737 with an ANC value close to 15 kg H_2SO_4/t. Carbonate standard curves are included for reference.

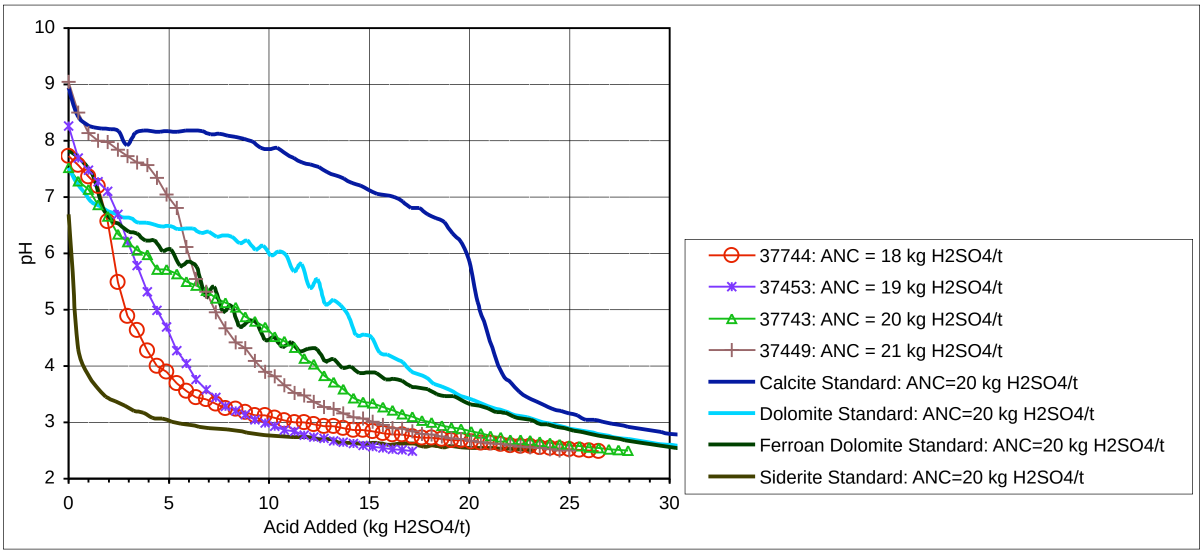


Figure 11: ABCC profile for samples with an ANC value close to 20 kg H_2SO_4/t. Carbonate standard curves are included for reference.

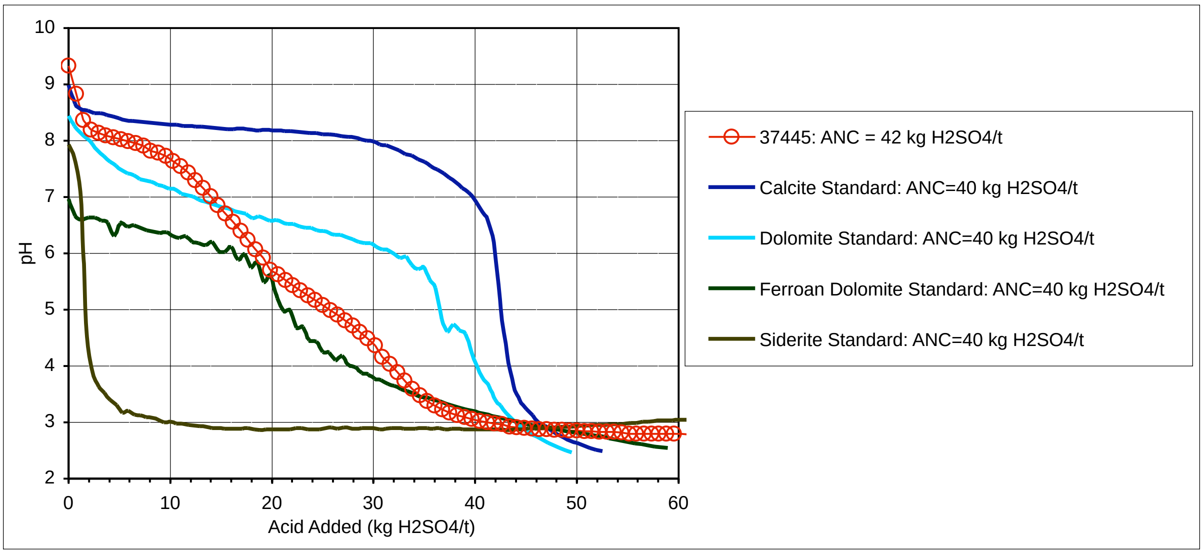


Figure 12: ABCC profile for sample 37445 with an ANC value close to 40 kg H_2SO_4/t. Carbonate standard curves are included for reference.

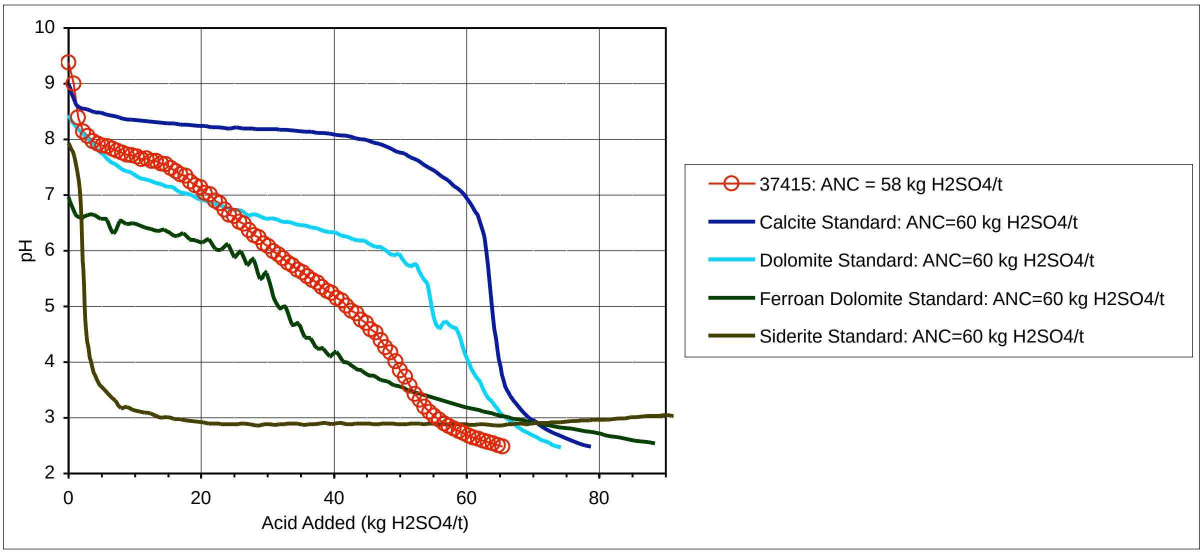


Figure 13: ABCC profile for sample 37415 with an ANC value close to 60 kg H_2SO_4/t. Carbonate standard curves are included for reference.

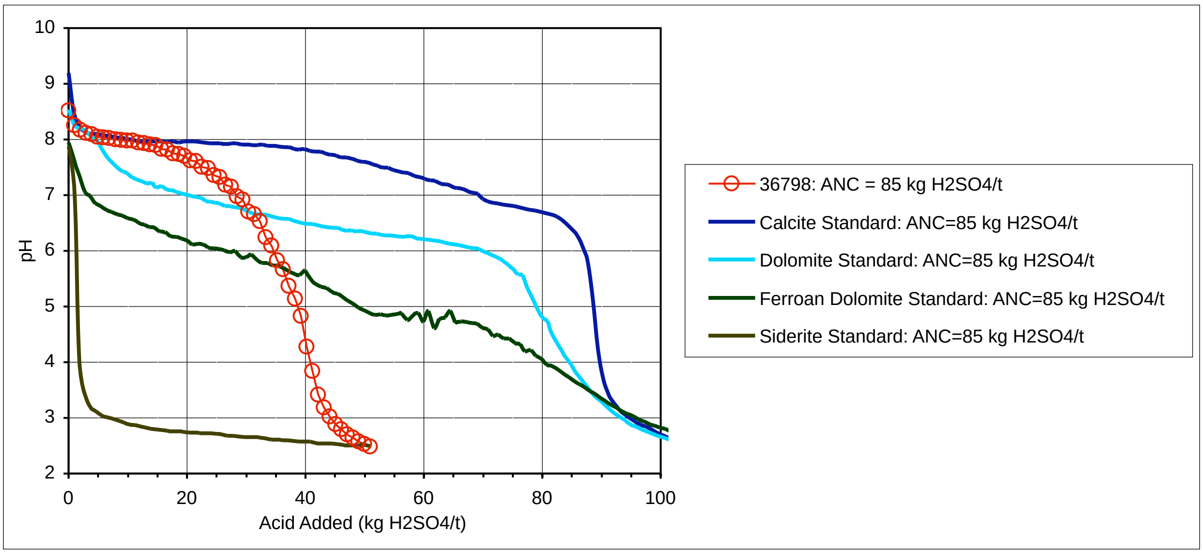


Figure 14: ABCC profile for sample 36798 with an ANC value of 85 kg H_2SO_4/t. Carbonate standard curves are included for reference.

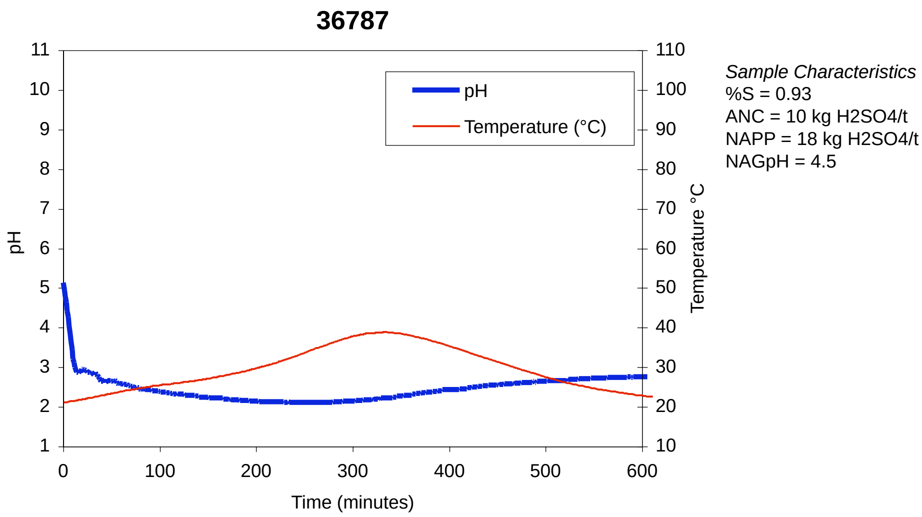


Figure 15: Kinetic NAG graph for sample 36787.

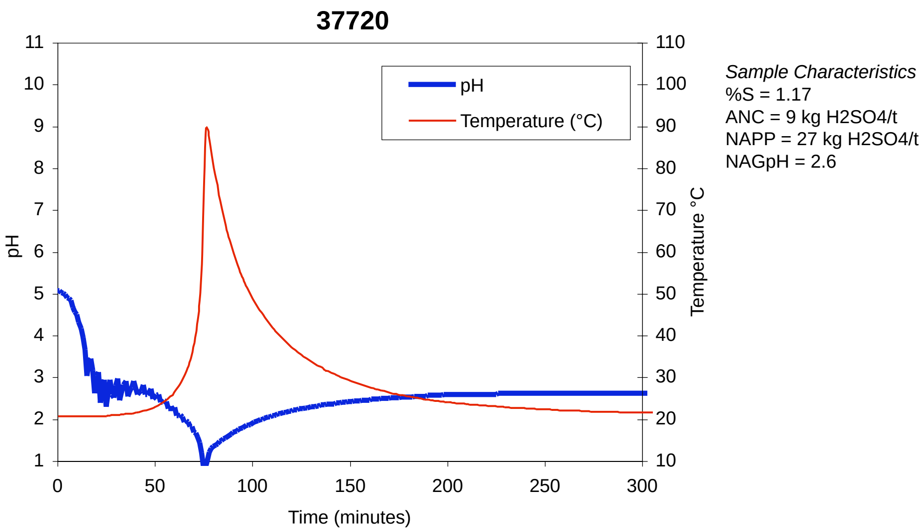


Figure 16: Kinetic NAG graph for sample 37720.

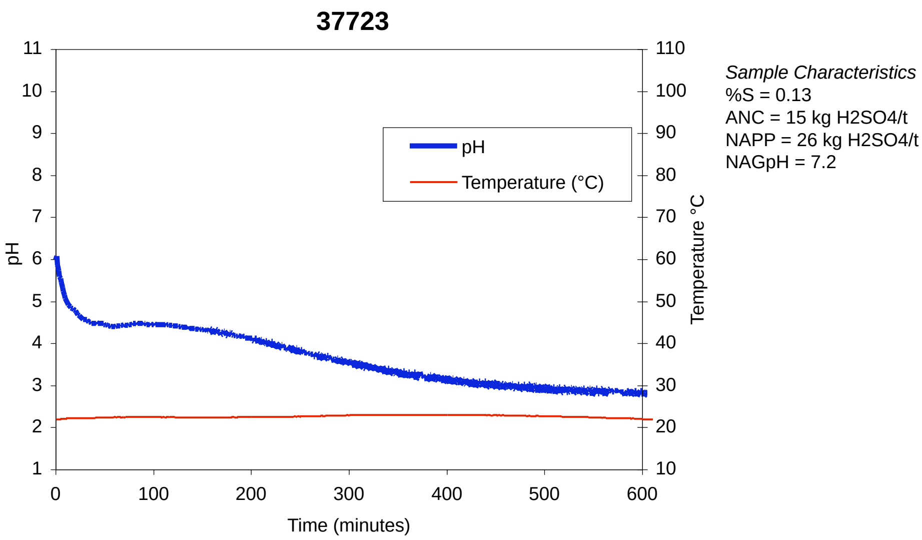
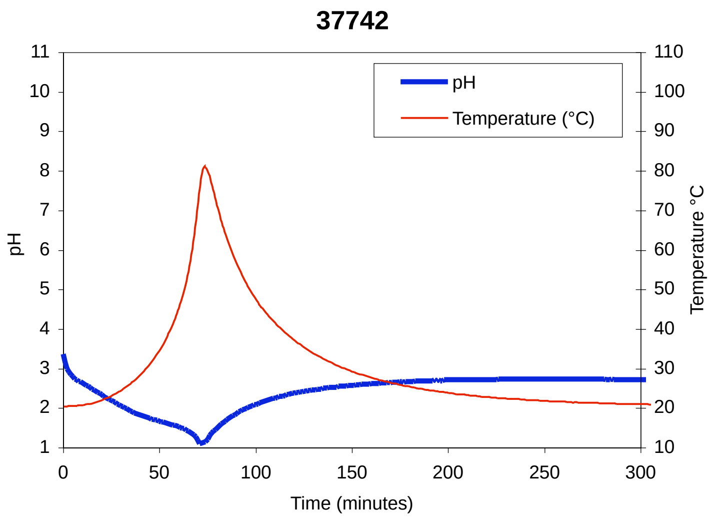
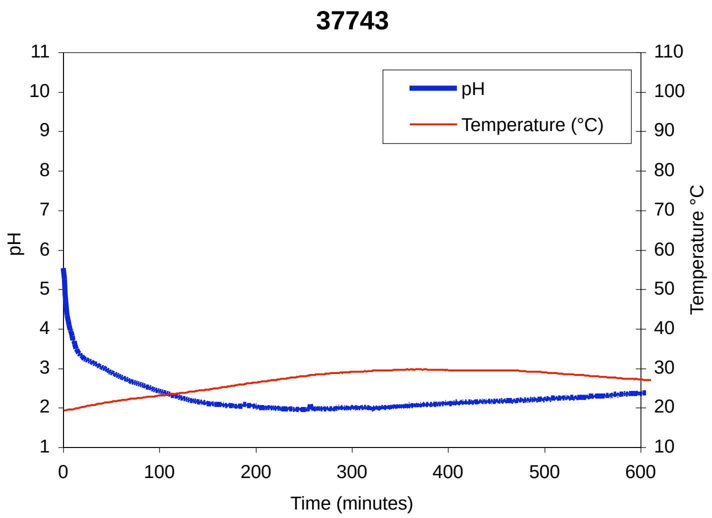


Figure 17: Kinetic NAG graph for sample 37723.



Sample Characteristics
%S = 0.96
ANC = 1 kg H2SO4/t
NAPP = 28 kg H2SO4/t
NAGpH = 2.7

Figure 18: Kinetic NAG graph for sample 37742.



Sample Characteristics
%S = 0.74
ANC = 20 kg H2SO4/t
NAPP = 3 kg H2SO4/t
NAGpH = 3.5

Figure 19: Kinetic NAG graph for sample 37743.

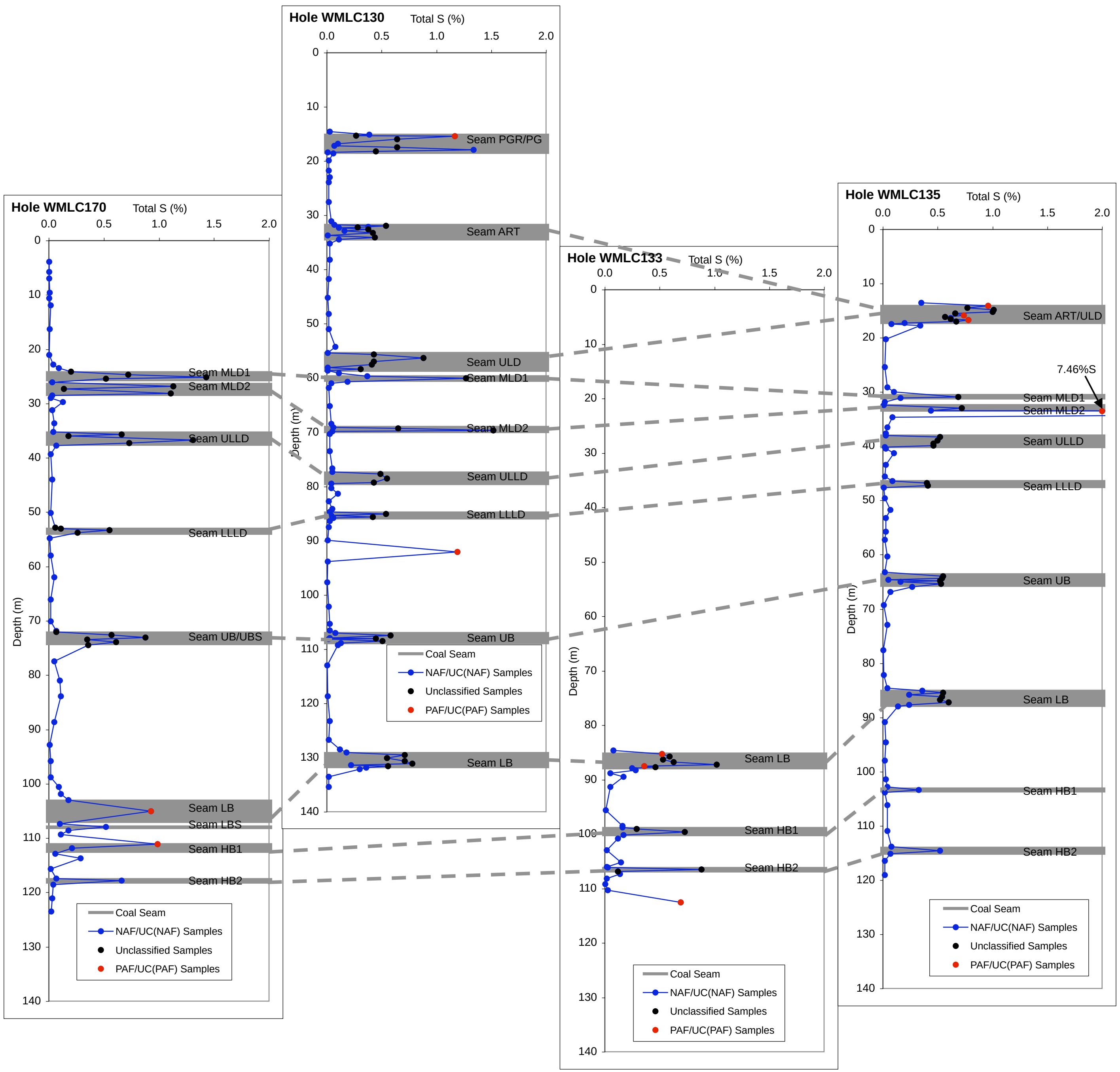


Figure 20: Downhole profiles of total S for Ashton drillholes. Approximate seam correlations are shown as dashed lines and sample ARD classification is indicated.

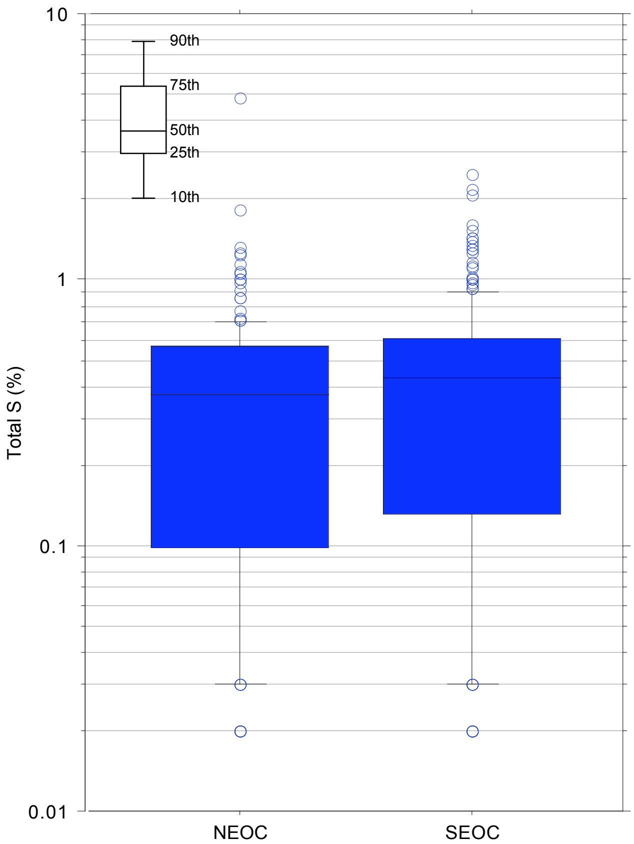


Figure 21: Box plot comparing the distribution of total S in coal seam, roof and floor samples for the South East Open Cut (SEOC) and North East Open Cut (NEOC). Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

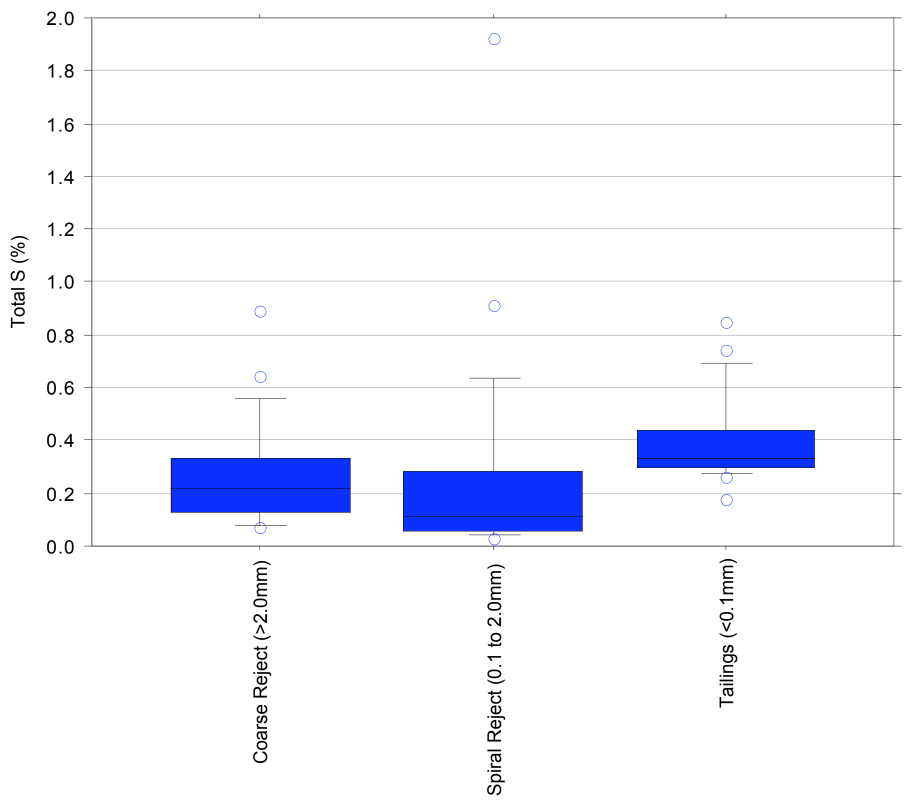


Figure 22: Box plot comparing the distribution of total S in various washery waste streams from processing at the NEOC and underground operations. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

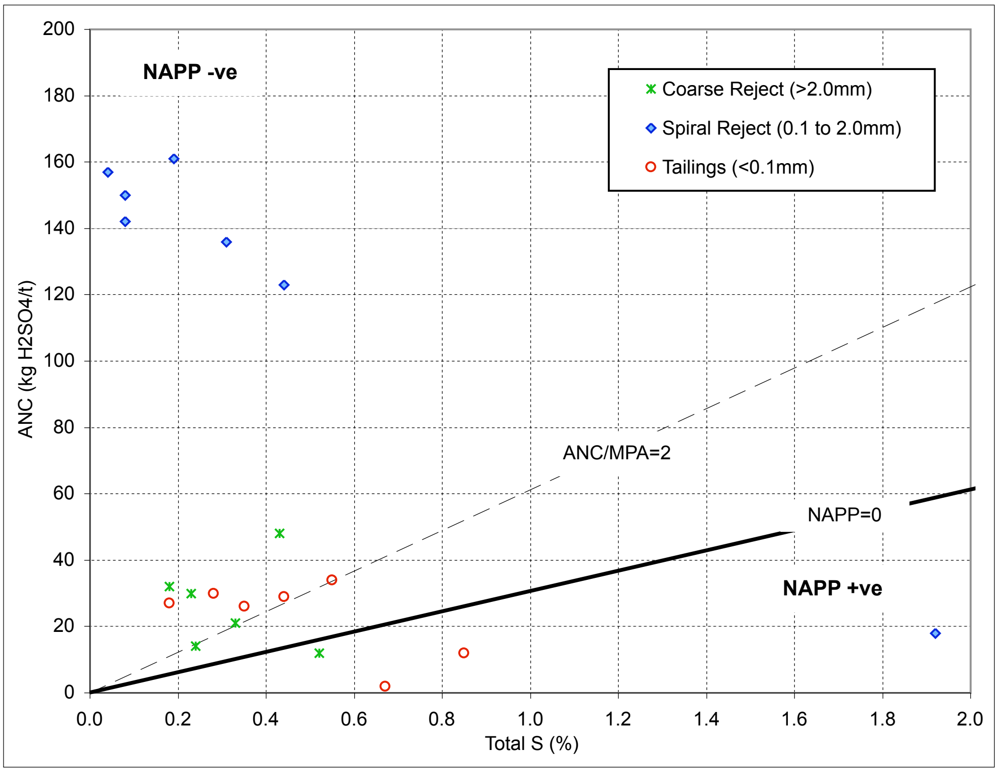


Figure 23: Acid-base account (ABA) plot for washery wastes from NEOC and underground operations showing ANC versus total S, split by washery waste type.

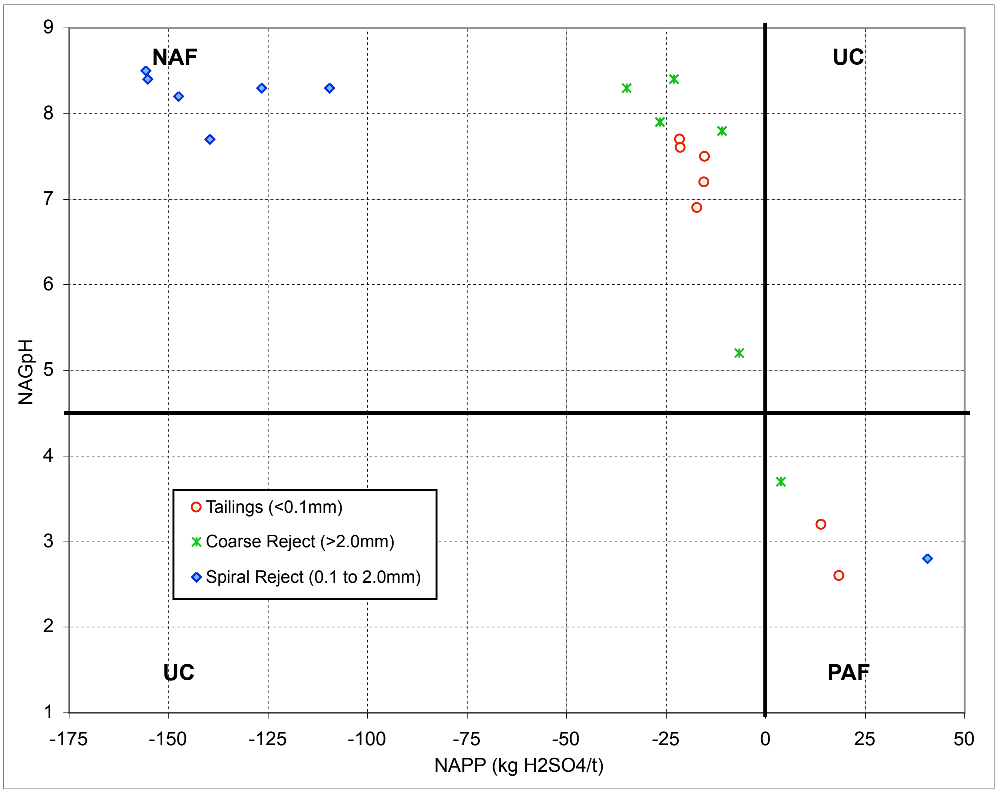


Figure 24: ARD classification plot for washery wastes showing NAGpH versus NAPP, split by lithology, with ARD classification domains indicated.

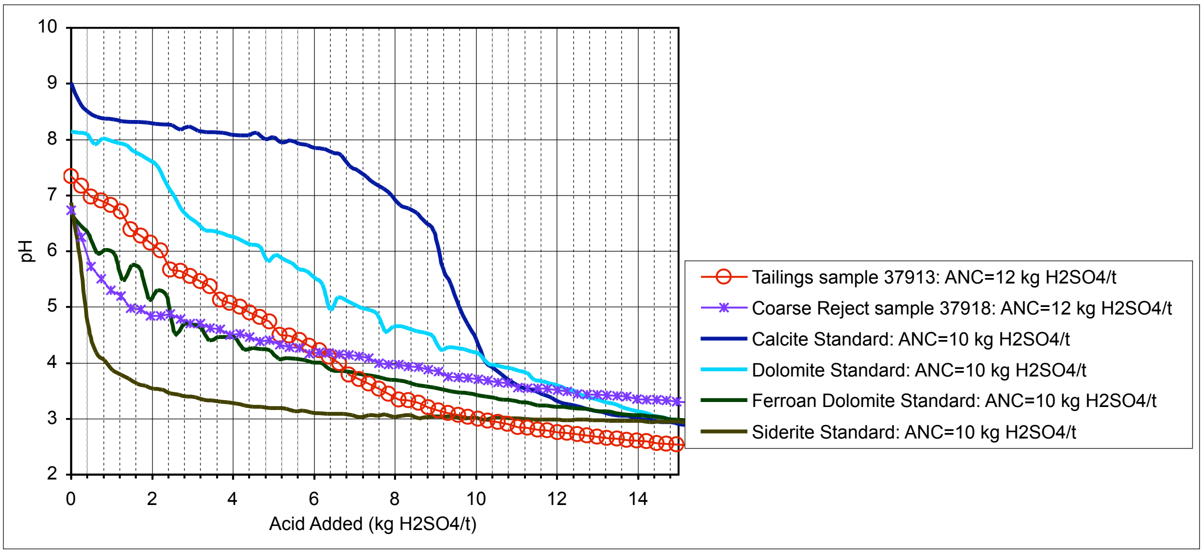


Figure 25: ABCC profile for washery waste samples with an ANC value close to 10 kg H_2SO_4/t. Carbonate standard curves are included for reference.

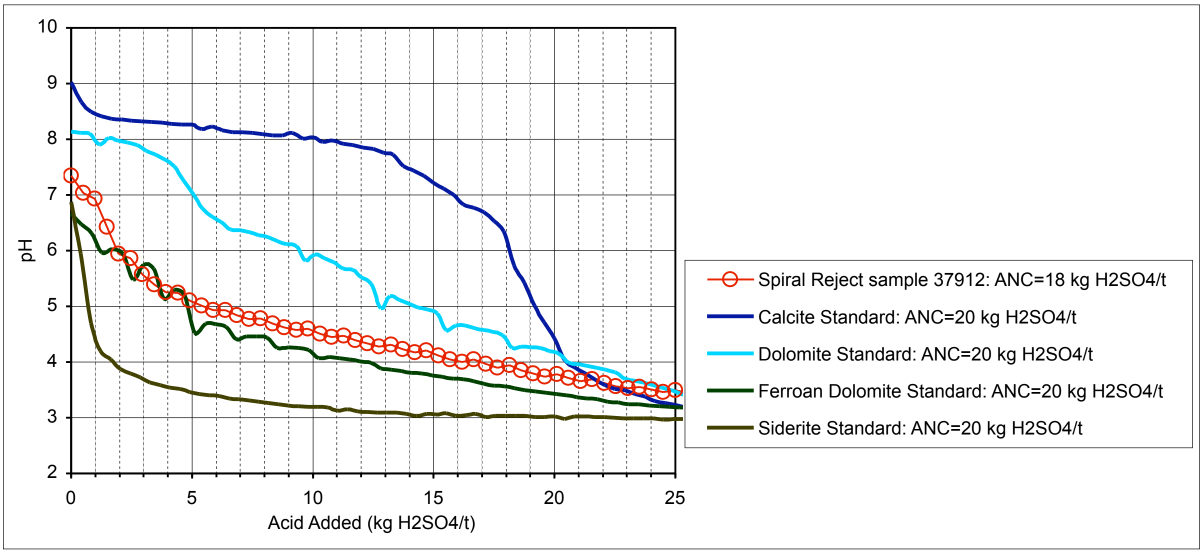


Figure 26: ABCC profile for washery waste sample 37912 with an ANC value close to 20 kg H_2SO_4/t. Carbonate standard curves are included for reference.

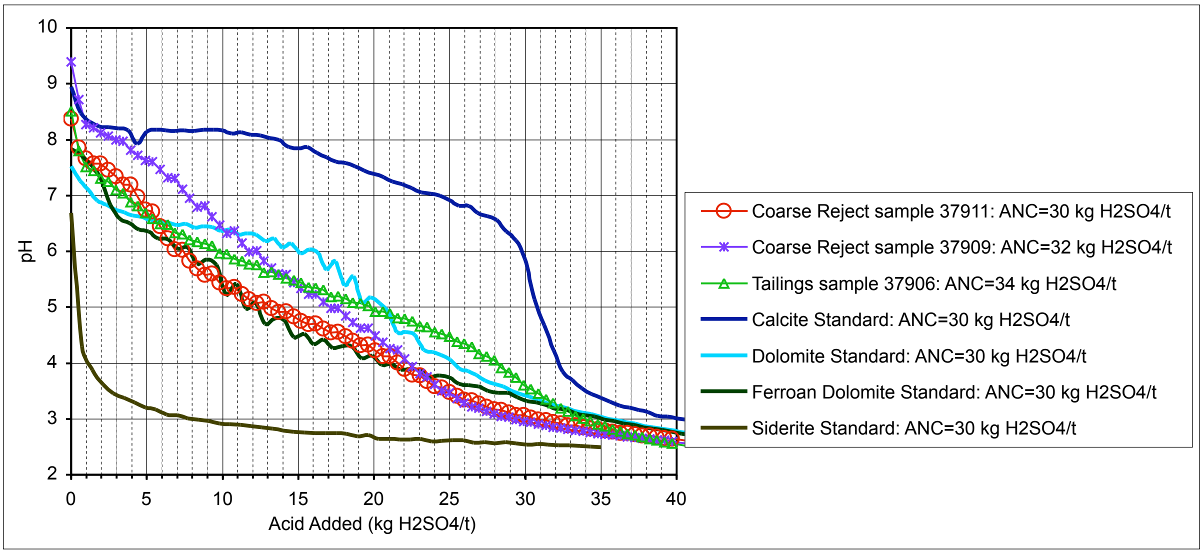


Figure 27: ABCC profile for washery waste samples with an ANC value close to 30 kg H_2SO_4/t. Carbonate standard curves are included for reference.

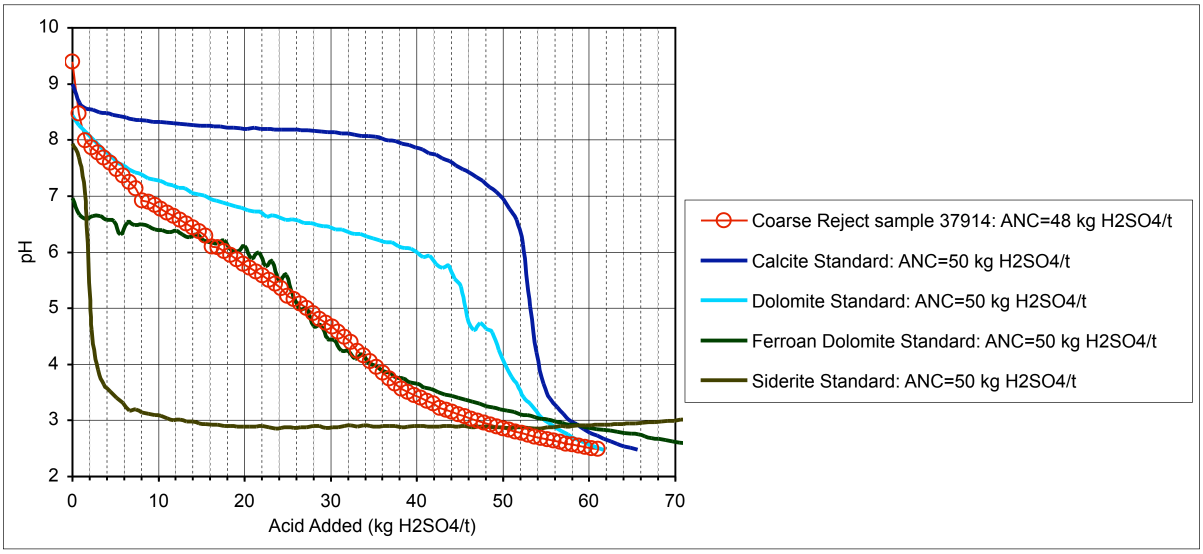


Figure 28: ABCC profile for washery waste sample 37914 with an ANC value close to 50 kg H_2SO_4/t. Carbonate standard curves are included for reference.

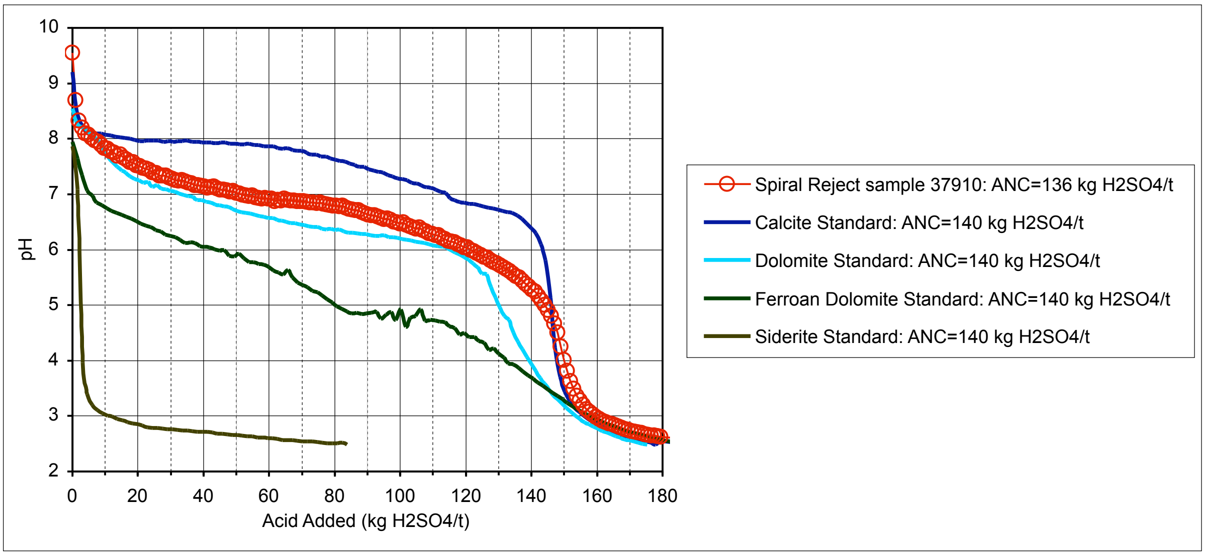


Figure 29: ABCC profile for washery waste sample 37910 with an ANC value close to 140 kg H_2SO_4/t. Carbonate standard curves are included for reference.

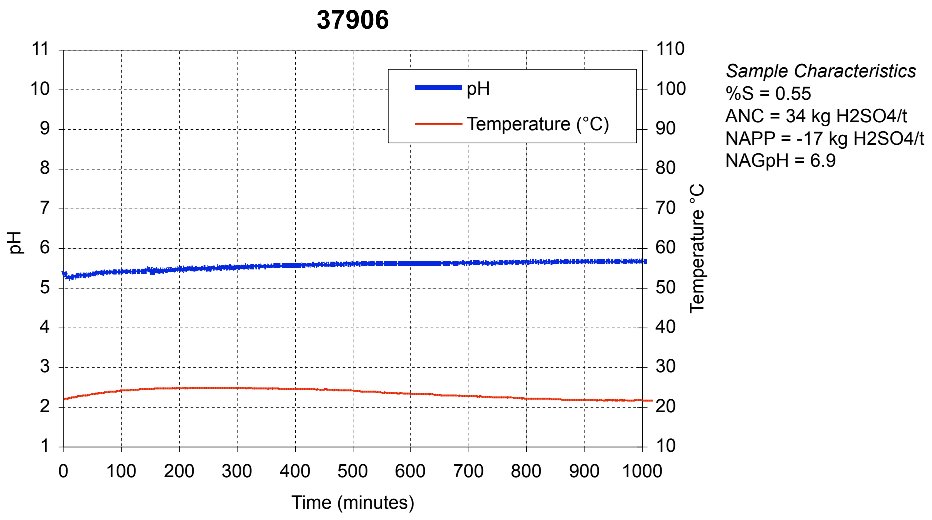


Figure 30: Kinetic NAG graph for tailings sample 37906.

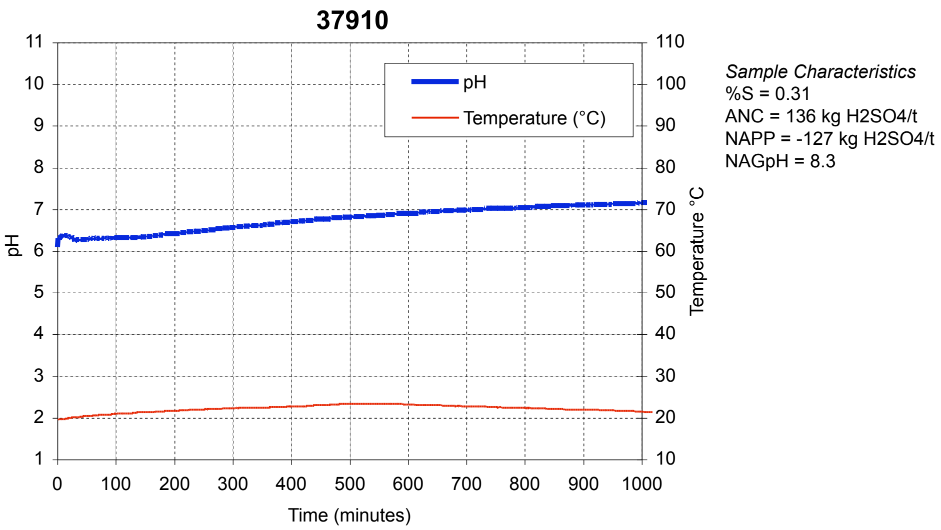


Figure 31: Kinetic NAG graph for spiral reject sample 37910.

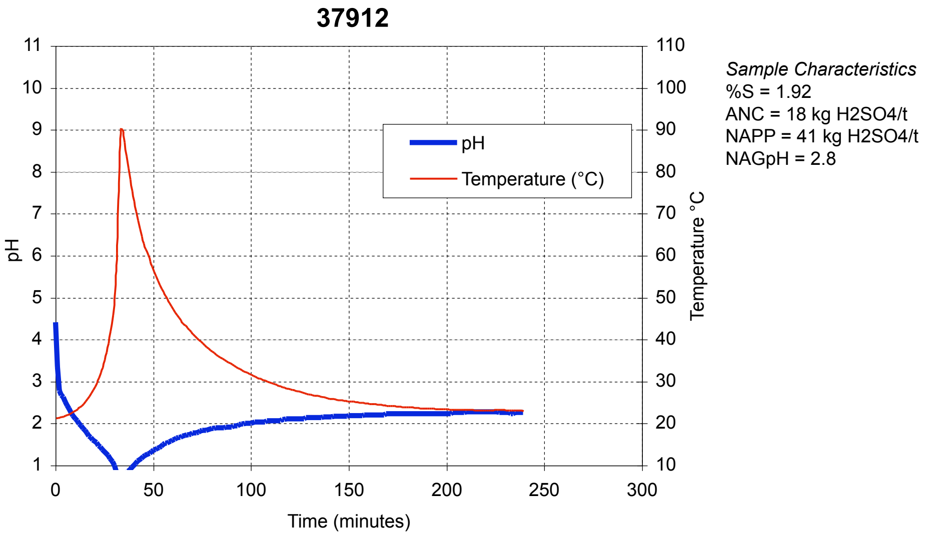


Figure 32: Kinetic NAG graph for spiral reject sample 37912.

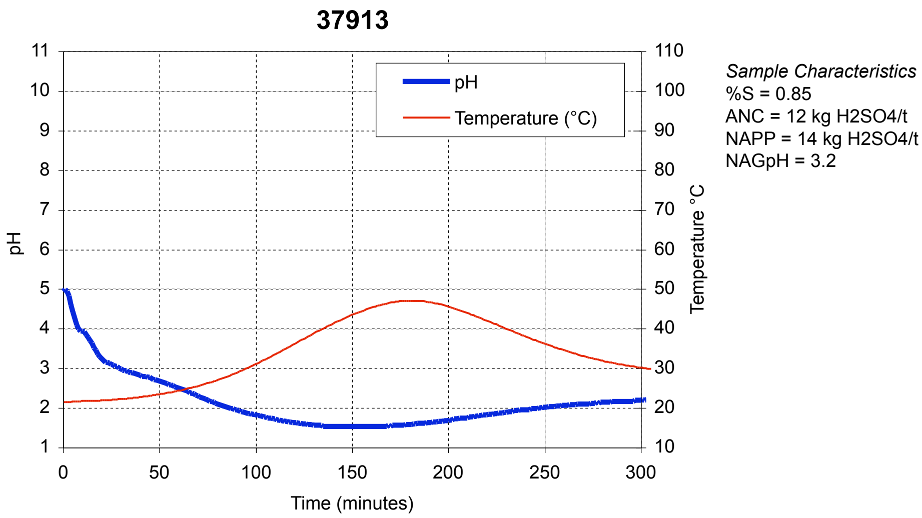


Figure 33: Kinetic NAG graph for tailings sample 37913.

APPENDIX A

Assessment of Acid Forming Characteristics

Assessment of Acid Forming Characteristics

Introduction

Acid rock drainage (ARD) is produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. The ability to identify in advance any mine materials that could potentially produce ARD is essential for timely implementation of mine waste management strategies.

A number of procedures have been developed to assess the acid forming characteristics of mine waste materials. The most widely used methods are the Acid-Base Account (ABA) and the Net Acid Generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates).

The values arising from the acid-base account are referred to as the potential acidity and the acid neutralising capacity, respectively. The difference between the potential acidity and the acid neutralising capacity value is referred to as the net acid producing potential (NAPP).

The chemical and theoretical basis of the ABA are discussed below.

Potential Acidity

The potential acidity that can be generated by a sample is calculated from an estimate of the pyrite (FeS_2) content and assumes that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

Based on the above reaction, the potential acidity 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). The pyrite content estimate can be based on total S and the potential acidity determined from total S is referred to as the maximum potential acidity (MPA), and is calculated as follows:

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

The use of an MPA calculated from total sulphur is a conservative approach because some sulphur may occur in forms other than pyrite. Sulphate-sulphur, organic sulphur and native sulphur, for example, are non-acid generating sulphur forms. Also, some sulphur may occur as other metal sulphides (e.g. covellite, chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating. The total sulphur content is commonly used to assess potential acidity because of the difficulty, costs and uncertainty involved in routinely determining the speciation of sulphur forms within samples, and determining reactive sulphide-sulphur contents. However, if the sulphide mineral forms are known then allowance can be made for non- and lesser acid generating forms to provide a better estimate of the potential acidity.

Acid Neutralising Capacity (ANC)

The acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid buffering is quantified in terms of the ANC.

The ANC is commonly determined by 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 and expressed in the same units as the MPA (kg H_2SO_4/t).

Net Acid Producing Potential (NAPP)

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

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

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

ANC/MPA Ratio

The ANC/MPA ratio is frequently used as a means of assessing the risk of acid generation from mine waste materials. The ANC/MPA ratio is another way of looking at the acid base account. 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. A NAPP of zero is equivalent to an ANC/MPA ratio of 1.

The purpose of the ANC/MPA ratio is to provide an indication of the relative margin of safety (or lack thereof) within a material. Various ANC/MPA values are reported in the literature for indicating safe values for prevention of acid generation. These values typically range from 1 to 3. As a general rule, an ANC/MPA ratio of 2 or more signifies that there is a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to acid rock drainage.

Acid-Base Account Plot

Sulphur and ANC data are often presented graphically in a format similar to that shown in Figure A-1. This figure includes a line indicating the division between NAPP positive samples from NAPP negative samples. Also shown are lines corresponding to ANC/MPA ratios of 2 and 3.

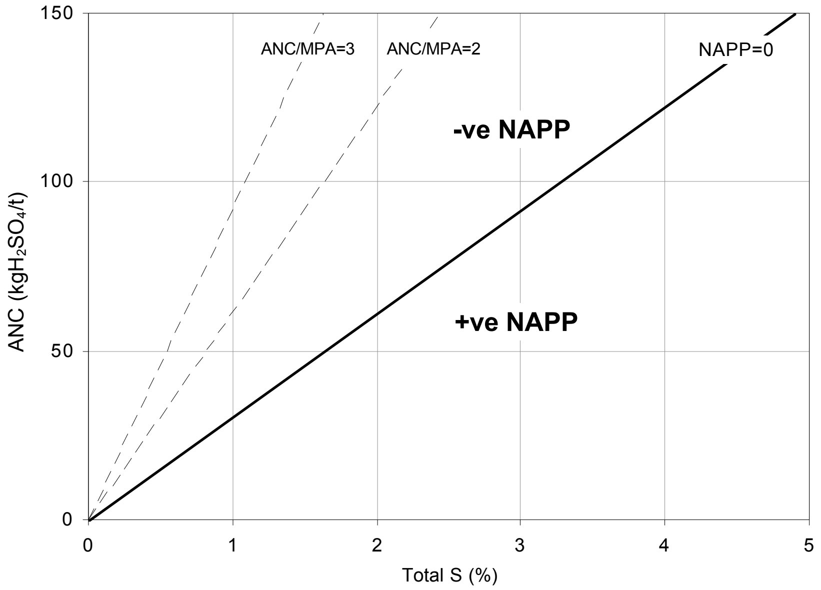


Figure A-1: Acid-base account (ABA) plot

Net Acid Generation (NAG) Test

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. The end result represents a direct measurement of the net amount of acid generated by the sample. The final pH is referred to as the NAGpH and the amount of acid produced is commonly referred to as the NAG capacity, and is expressed in the same units as the NAPP (kg H_2SO_4/t).

Several variations of the NAG test have been developed to accommodate the wide geochemical variability of mine waste materials. The four main NAG test procedures currently used by EGi are the single addition NAG test, the sequential NAG test, the kinetic NAG test, and the extended boil and calculated NAG test.

Single Addition NAG Test

The single addition NAG test involves the addition of 250 ml of 15% hydrogen peroxide to 2.5 g of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulphides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the NAGpH and NAG capacity are measured.

An indication of the form of the acidity is provided by initially titrating the NAG liquor to pH 4.5, then continuing the titration up to pH 7. The titration value at pH 4.5 includes acidity due to free acid (i.e. H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides at between pH 4.5 and 7.

Sequential NAG Test

When testing samples with high sulphide contents it is not uncommon for oxidation to be incomplete in the single addition NAG test. This can sometimes occur when there is catalytic breakdown of the hydrogen peroxide before it has had a chance to oxidise all of the sulphides in a sample. To overcome this limitation, a sequential NAG test is often carried out. This test may also be used to assess the relative geochemical lag of PAF samples with high ANC.

The sequential NAG test is a multi-stage procedure involving a series of single addition NAG tests on the one sample (i.e. 2.5 g of sample is reacted two or more times with 250 ml aliquots of 15% hydrogen peroxide). At the end of each stage, the sample is filtered and the solution is used for measurement of NAGpH and NAG capacity. The NAG test is then repeated on the solid residue. The cycle is repeated until such time that there is no further catalytic decomposition of the peroxide, or when the NAGpH is greater than pH 4.5. The overall NAG capacity of the sample is then determined by summing the individual acid capacities from each stage.

Kinetic NAG Test

The kinetic NAG test is the same as the single addition NAG test except that the temperature and pH of the liquor are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulphide oxidation and acid generation. 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, sulphidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulphide surfaces and/or oxidation products.

Extended Boil and Calculated NAG Test

Organic acids may be generated in NAG tests due to partial oxidation of carbonaceous materials[1] such as coal washery wastes. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulphides. Organic acid effects can therefore result in misleading NAG values and misclassification of the acid forming potential of a sample.

The extended boil and calculated NAG tests can be used to account for the relative proportions of pyrite derived acidity and organic acidity in a given NAG solution, thus providing a more reliable measure of the acid forming potential of a sample. The procedure involves two steps to differentiating pyritic acid from organic derived acid:

Extended Boil NAG	decompose the organic acids and hence remove the influence of non-pyritic acidity on the NAG solution.
Calculated NAG	calculate the net acid potential based on the balance of cations and anions in the NAG solution, which will not be affected by organic acid.

The extended boiling test is carried out on the filtered liquor of a standard NAG test, and involves vigorous boiling of the solution on a hot plate for 3-4 hours. After the boiling step the solution is cooled and the pH measured. An extended boil NAGpH less than 4.5 confirms the sample is potentially acid forming (PAF), but a pH value greater than 4.5 does not necessarily mean that the sample is non acid forming (NAF), due to some loss of free acid during the extended boiling procedure. To address this issue, a split of the same filtered NAG solution is assayed for concentrations of S, Ca, Mg, Na, K and Cl, from which a calculated NAG value is determined[2].

The concentration of dissolved S is used to calculate the amount of acid (as H_2SO_4) generated by the sample and the concentrations of Ca, Mg, Na and K are used to estimate the amount of acid neutralised (as H_2SO_4). The concentration of Cl is used to correct for soluble cations associated with Cl salts, which may be present in the sample and unrelated to acid generating and acid neutralising reactions.

The calculated NAG value is the amount of acid neutralised subtracted from the amount of acid generated. A positive value indicates that the sample has excess acid generation and is likely to be PAF, and a zero or negative value indicates that the sample has excess neutralising capacity and is likely to be NAF.

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[1] Stewart, W., Miller, S., Thomas, J.E., and Smart R. (2003), 'Evaluation of the Effects of Organic Matter on the Net Acid Generation (NAG) Test', in *Proceedings of the Sixth International Conference on Acid Rock drainage (ICARD), Cairns, 12-18th July 2003*, 211-222.

[2] Environmental Geochemistry International, Levay and Co. and ACeSSS, 2008. *ACARP Project C15034: Development of ARD Assessment for Coal Process Wastes*, EGi Document No. 3207/817, July 2008.

Sample Classification

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

- Barren;
- Non-acid forming (NAF);
- Potentially acid forming (PAF); and
- 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 for hard rock mines it generally applies to materials with a total sulphur content ≤ 0.1 %S and an ANC ≤ 5 kg H_2SO_4/t.

Non-acid forming (NAF)

A sample classified as NAF may, or may not, have a significant sulphur 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 sulphide 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 the final NAG pH ≥ 4.5.

Potentially acid forming (PAF)

A sample classified as PAF always has a significant sulphur 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.

Uncertain (UC)

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH ≤ 4.5). Uncertain samples are generally given a tentative classification that is shown in brackets e.g. UC(NAF).

Figure A-2 shows the format of the classification plot that is typically used for presentation of NAPP and NAG data. Marked on this plot are the quadrats representing the NAF, PAF and UC classifications.

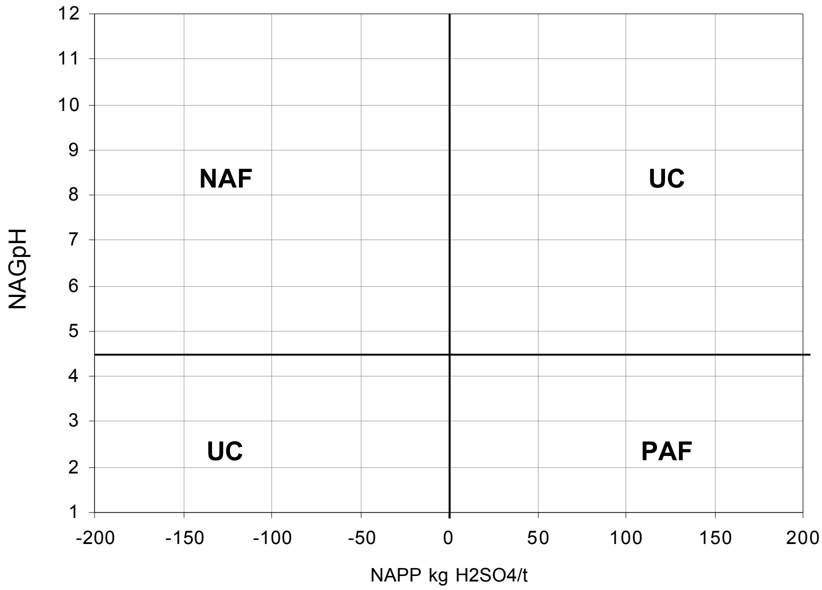

Figure A-2 ARD classification plot

Other Methods

Other test procedures may be used to define the acid forming characteristics of a sample.

pH and Electrical Conductivity

The pH and electrical conductivity (EC) of a sample is determined by equilibrating the sample in deionised water for a minimum of 12 hours (or overnight), typically at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Acid Buffering Characteristic Curve (ABCC) Test

The ABCC test involves slow titration of a sample with acid while continuously monitoring pH. These data provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.