

Taroborah Coal Project

Appendix 12 – Overburden Waste Characterisation

Sampling Methodology

Static Geochemical Assessment

Leach Column Test Results

TO:	AustralAsian Resource Consultants (AARC)
ATTENTION:	Alison Pearce (AARC) and Dave Thomas (IMC Mining Group Pty Ltd)
FROM:	Warwick Stewart
DATE:	6 March 2014
SUBJECT:	Discussion on the Sampling Approach for Geochemical Assessment of Overburden/Interburden from the Taroborah Coal Project

This memorandum outlines the approach to the overburden/interburden sampling programme carried out for geochemical assessment of the Taroborah Coal Project.

The sampling approach used was consistent with the sampling section of the Assessment and Management of Acid Drainage guideline of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland series (DME, 1995). The samples collected represented individual depth intervals and rock units, and the sampling programme was designed to take into account the geological variability, complexity and controls in relation to acid rock drainage potential.

In the case of sedimentary deposits such as Taroborah, the geological controls allow for more confident prediction of the distribution of ARD than say a typical metalliferous deposit, since the geochemical zones occur in sedimentary layers which can be related back to the well defined coal horizons or weathering boundaries. The total number of samples is less important than capturing the key geochemical horizons over a broad spatial area and confirming the continuity of these horizons by correlating between holes.

Two sampling programmes were carried out. The first in 2011 was arranged by IMC Mining Group Pty Ltd (IMC) and comprised geochemical testing of 172 samples from 6 open holes drilled across the site. The holes sampled were TAR002_OB, TAR024_OB, TAR027_OB, TAR028_OB, TAR030_OB and TAR034_OB. Sampling involved scooping of small sub-samples during drilling and compositing in the field, sufficient to provide an overall indication of the relative ARD potential of overburden and floor materials for the deposit.

The second programme was organised by EGi with IMC in 2012, and comprised collection of 108 samples from 3 cored drill holes spread across the deposit. The samples comprised entire core collected continuously throughout each core hole to provide more representative samples of overburden, interburden and coal, and obtain a better understanding of geological controls on the distribution of ARD rock types. The holes sampled were TAR020GT, TAR022GT and TAR027GT.

Figure 1 is a collar location plan for drill holes sampled for geochemical assessment, showing the combined sampling programmes cover a broad spatial distribution across the proposed opencut pit area.

The distribution and abundance of pyrite in coal bearing sedimentary sequences are largely controlled by the original depositional environment, with influences such as seawater incursions and presence of organic matter key to pyrite formation. As a result of these controls, pyrite is usually preferentially distributed in particular lithologies (such as carbonaceous mudstones) and stratigraphic horizons. Coal sequences usually have high lithological variation in the vertical sense but tend to show lateral continuity, and hence sampling for ARD assessment needs to take this into account by obtaining detailed continuous samples in individual holes spaced at wide intervals. The core sampling strategy carried out in 2012 aimed to screen the entire mine stratigraphy for acid potential, identify horizons of concern and look for correlations between holes that indicate continuity, and rely on geological controls to help predict the distribution of potentially acid forming (PAF) and non-acid forming (NAF) rock types. This approach results in better representation of mine materials in coal deposits, compared with a purely lithological approach to sampling.

Results of both programmes were used in the geochemical assessment, and when compared between holes on a stratigraphic basis there were a number of clear correlatable geochemical zones identified:

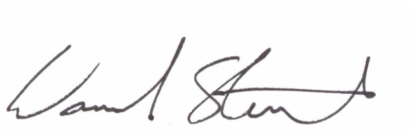
- NAF zone to the base of moderate weathering;
- High ANC zone 5m to 60m thick within the weathered NAF, particularly associated with and below basalt intercepts;
- Mixed NAF and PAF-LC zone from the base of moderate weathering to 5 to 10m above A Seam;
- PAF zone generally within 5 m of the A Seam roof but can be up to 10m;
- PAF A Seam;
- PAF/PAF-LC interburden between A Seam and B Seam;
- PAF B Seam;
- PAF-LC B Seam floor with PAF portions.

The estimated volumes of the main overburden/interburden units and number of samples tested for each is provided below:

Waste Rock Unit	Estimated Volume (bcm)	No. of Samples
Weathered NAF - Low ANC	40,700,000	43
Weathered NAF - High ANC	9,400,000	38
Mixed NAF and PAF-LC	36,800,000	52
PAF A Seam Roof	22,400,000	26
PAF/PAF-LC Interburden	17,600,000	70
PAF-LC/PAF B Seam floor	100,000	9

The density and approach to sampling at Taroborah is deemed sufficient at this stage of the project to estimate the relative proportion of geochemical material types for the purposes of planning. As stated above, the stratigraphic controls on pyrite occurrence increase the predictive power of the results, so that fewer samples with intervals linked to geology and correlation of results between holes can be used to define the distribution and continuity of geochemical horizons. The horizons defined so far are conservative in that the proportion of PAF materials may be overstated. It is expected that follow up testing during the detailed operational design stage would be able to better delineate PAF horizons and reduce the volume of materials requiring special handling.

Regards,



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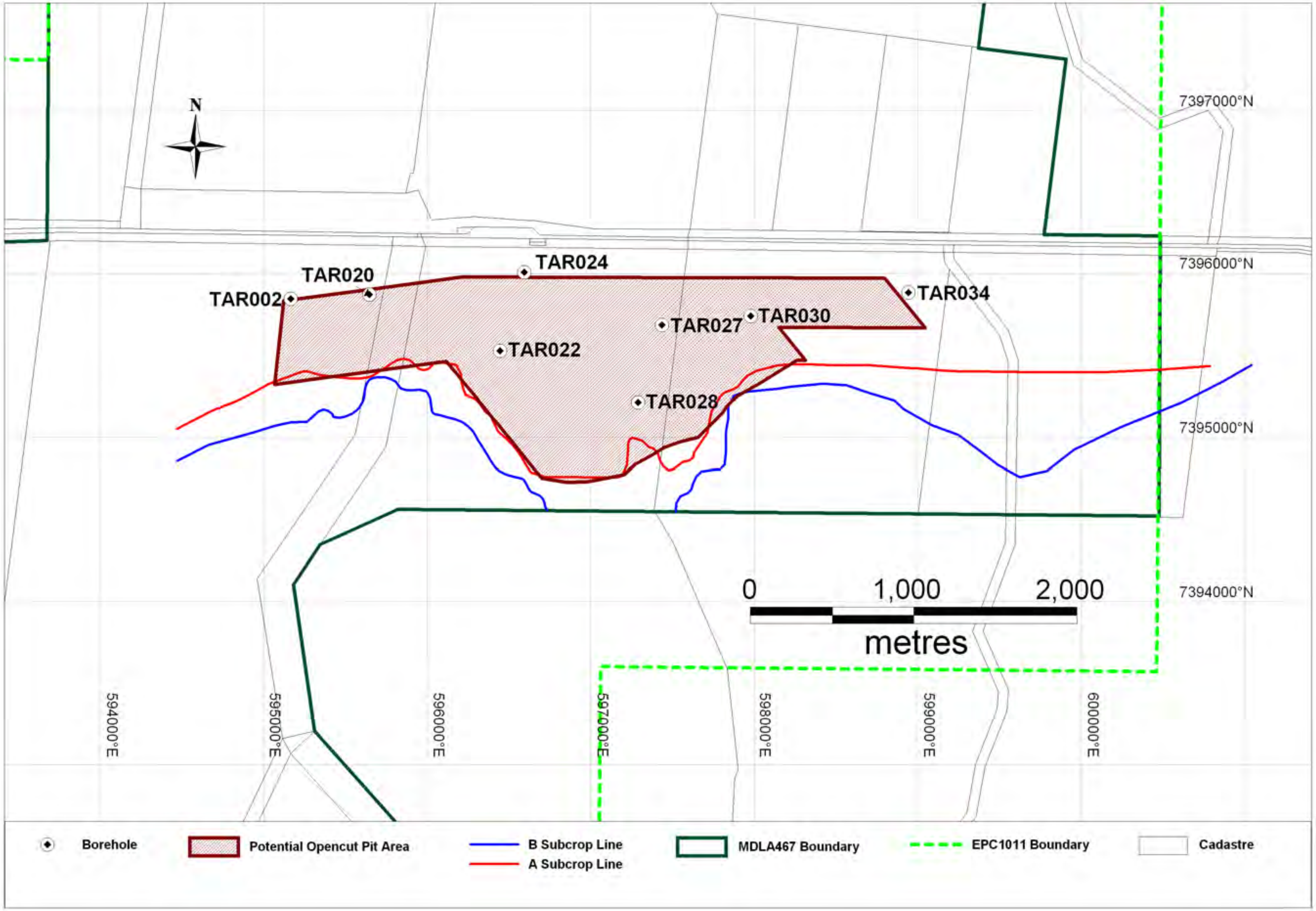

Figure 1: Location of drillholes sampled for geochemical testing.

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Static Geochemical Assessment of the Taroborah Coal Project

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List of Abbreviations

ARD	Acid Rock Drainage
ABA	Acid Base Account
$pH_{1:2}$	pH of a sample slurry with a solid to water ratio of 1:2 (w/w)
$EC_{1:2}$	EC of a sample slurry with a solid to water ratio of 1:2 (w/w)
ANC	Acid Neutralising Capacity in kg H_2SO_4/t
CNV	Carbonate Neutralising Value
MPA	Maximum Potential Acidity, calculated from total S in kg H_2SO_4/t
NAPP	Net Acid Producing Potential, calculated from ANC and total S (or MPA) in kg H_2SO_4/t.
NAG	Net Acid Generation (test)
NAGpH	pH of NAG solution before titration
$NAG_{(pH4.5)}$	NAG acidity titrated to pH 4.5 in kg H_2SO_4/t
$NAG_{(pH7.0)}$	NAG acidity titrated to pH 7.0 in kg H_2SO_4/t
ABCC	Acid Buffering Characteristic Curve
GAI	Geochemical Abundance Index based on multi-elements of solids
PAF	Potentially Acid Forming
PAF-LC	Potentially Acid Forming - Low Capacity
NAF	Non Acid Forming
UC	Uncertain

Executive Summary

Environmental Geochemistry International Pty Ltd (EGi) was commissioned by AustralAsian Resource Consultants Pty Ltd (AARC) on behalf of Shenhuo International Group Pty Ltd to carry out a geochemical assessment of the Taroborah Coal Project, a Permian aged thermal coal deposit located approximately 22 km west of Emerald in Central Queensland. The objectives of the work were to:

- assess the acid rock drainage (ARD), salinity and elemental solubility (including neutral mine drainage and alkaline mine drainage) potential of the proposed mine materials;
- identify any geochemical issues; and
- provide recommendations for materials management and any follow up test work which may be required.

Note that this report focuses on results of static geochemical testing. Leach column testing is in progress to provide more information on reaction kinetics.

A Seam and B Seam are the main target seams, which were deposited under marine influenced conditions. The deposit would be developed by open cut methods initially, with longwall underground methods used once high wall access is available. There would be a coal handling and preparation plant (CHPP) constructed on the Project site.

A total of 108 overburden/interburden samples and 27 laboratory generated washery waste samples were geochemically tested and assessed. Results from previous work carried out by SGS on 172 samples in 2011 were also assessed.

Results indicate that approximately two thirds of the overburden and interburden tested to date at Taroborah is likely to be non acid forming (NAF), and one third potentially acid forming (PAF) or PAF low capacity (PAF-LC). However, washery wastes and ROM coal are likely to be mainly PAF. Coarse and fine rejects from A Seam and B Seam tops would make up the bulk of the washery waste produced and are considered to have a high ARD risk, with the potential to rapidly release high acid and metal/metalloid loads. The ROM coal from A Seam and B Seam tops also have high ARD capacities and may also be fast reacting.

Total S and NAGpH could be potentially used as screening classification criteria for future testing of overburden/interburden samples. A conservative total S cut off of 0.1%S can be used alone as a guide to identify NAF and PAF, but more discriminating classification can be achieved with inclusion of the NAG test. Both tests could also be used in field checks and reconciliation of the predicted distribution of ARD rock types for overburden/interburden materials. Washery rejects would require more comprehensive testing due to inferences from organic S forms and organic acid generation in the NAG test.

Kinetic NAG testing indicates that PAF overburden/interburden and coal will rapidly generate ARD within weeks after exposure to atmospheric oxidation conditions. Constituents associated with ARD from these materials are likely to include Al, Co, Cr, Cu, Fe, Mn, Ni,

SO_4 and Zn, possibly slightly elevated B, and As, U and Th at pH values of around 3 or less. Constituents associated with ARD from rejects are similar, and likely to include Al, As, Co, Cr, Cu, Fe, Mn, Ni, SO_4 and Zn. Pyrite oxidation appears to be the main source of salinity in overburden/interburden, coal and washery waste materials.

Water extracts from NAF overburden/interburden indicated that neutral mine drainage was unlikely to contain significant metal/metalloid concentrations. Results did not indicate potential for alkaline mine drainage.

Results of exchangeable cation testing indicate most overburden/interburden materials are unlikely to be sodic. However, clay and soil within 12m or so of the surface may be partly sodic and subject to surface crusting and high erosion rates if placed on the surface of dumps and exposed directly to rainfall. Materials with sodic potential should be treated (with gypsum or lime) if exposed on dump surfaces or used in engineered structures.

The results of this static geochemical assessment of Taroborah mine waste and ROM coal have indicated potential implications for the management of mine materials as follows:

- Most of the overburden and interburden is expected to be NAF and will not require special handling for ARD control.
- Basalt and some underlying weathered sedimentary materials are a potential source of high acid neutralising capacity (ANC) material, which could be used to help mitigate or delay the onset of ARD from PAF and PAF-LC materials.
- A geological model predicting the distribution of PAF and NAF overburden/interburden horizons will be required for materials scheduling.
- The following management strategies should be considered for overburden and interburden materials placed in ex-pit and in-pit dumps:
  - out of pit dumps should be constructed with NAF material where possible;
  - PAF materials should be preferentially placed in-pit below the recovery groundwater table level to allow inundation at mine closure and prevent long term exposure to atmospheric oxidation. This requires oxidation and acid generation control measures to ensure PAF materials do not mobilise significant acid and dissolved metals/metalloids during inundation;
  - paddock dumping and traffic compacting PAF materials in lifts of 5 m or less should be considered to minimise the risk of accelerated oxidation through convection;
  - interim lifts/faces of placed PAF waste rock may need to be treated with crushed limestone for operational control of ARD before inundation can take place;
  - long term ARD control of any PAF materials placed above the final recovery groundwater table level should include a thick (5 to 20m) outer zone of NAF materials (preferably high ANC), and may require an engineered cover or

internal seal system to limit oxygen transfer and fluctuating moisture conditions in PAF materials;

- blending of PAF and acid neutralising materials (limestone, high ANC basalt and/or high ANC weathered sedimentary materials) could be used to increase lag times before onset of acid conditions within the PAF material;
- if placement of PAF in ex-pit dumps is required, other measures would be required in addition to the thick outer zone and cover/seal system described for in-pit dumps. Designs should prevent convective/advective transport of oxygen through the dump, which can reduce ARD loadings by a factor of at least 4. This can be achieved by setting back PAF materials from the face of the dump and adopting dumping strategies that avoid formation of continuous coarse layers and open chimney structures that act as air pathways. The immediate base of the dump should comprise a layer of NAF material (1m or more) to help isolate overlying PAF materials from any water flow along the interface between the dump and natural ground. Blending of PAF materials with limestone and/or higher ANC NAF should also be carried out to increase lag times and provide a factor of safety for the dumps. Kinetic testing of PAF and NAF blends will be required to determine optimum blending ratios;
- the mixed NAF/PAF-LC zone 10m above the A Seam and below the base of moderate weathering may generate low rates of ARD, and should be excluded from the outer slopes of spoil dumps unless blended with limestone and/or high ANC overburden to prevent ARD generation. Operational mixing during normal mining operations may be sufficient to negate any significant ARD risk from this horizon, but this would need to be confirmed with leach column testing, trials, field checks and monitoring.

- Coarse and fine rejects will be mainly produced from washing of A Seam and B Seam tops and are likely to have a high ARD risk (sulphur grade generally >4%S). In addition to considerations noted above, additional management efforts are likely to be required to prevent ARD, including:
  - blending with limestone to increase lag times and reduce oxidation rates;
  - placement below water in a dedicated facility or in-pit to control oxidation, and including designs to prevent significant seepage into groundwater;
  - possible use of low permeability encapsulation cells where immediate underwater disposal is not possible;
  - permanent and secure inundation where possible;
  - progressive installation of a robust cover/seal system where permanent inundation is not feasible.
- Design of a cover system for in-pit and ex-pit dumps, as well as offset distances of PAF material from the outer edges of ex-pit dumps, will require assessment of the hydraulic and physical properties of the various mine materials in conjunction with local climate conditions to determine the type of cover system and offset distance that is appropriate.

- The final Pit floor appears to be mainly PAF-LC with PAF portions, and provision should be made for monitoring runoff/leachate, limestone spreading on pit floor surfaces and water capture and treatment if required. Long term ARD control strategies for the pit floor should be incorporated into management of in-pit dumps, and may require a combination of groundwater inundation and a cover/seal system.
- ROM coal stockpiles, and in particular coal from A Seam and B Seam tops, are likely to at least partly generate ARD depending on residence times, reaction rates and lag times. Capture and treatment of runoff/leachate from ROM coal stockpiles is likely to be required.
- No direct testing of product coal was carried out, but wash trials indicate pyrite would preferentially report to the rejects stream, and hence the product coal should have a lower risk of ARD relative to ROM coal. Runoff/leachate from product coal stockpiles should be monitored, and provision should be made for capture and treatment if required.

In addition to the above, routine monitoring across the site should be carried out to provide checks on materials management actions and effects of ARD as follows:

- A programme of routine sampling and geochemical testing of overburden/interburden and washery waste materials is recommended during operations to monitor variation in acid potential and to reconcile the predicted distribution of ARD rock types in overburden. Combined total S and NAG testing could be used for screening of overburden/interburden ARD rock types.
- Water quality monitoring of seepage and runoff from pit walls and floors, waste rock dumps, ROM stockpiles and washery waste disposal areas should be carried out to check for ARD generation, assess the performance of management strategies, and determine and/or refine NAF/PAF blending ratios and lime and limestone treatment requirements.
- Site water quality monitoring programmes should include pH, EC, acidity/alkalinity, Ca, Mg, SO_4, Al, As, B, Co, Cr, Cu, Fe, Mn, Ni, Th, U and Zn, to monitor for effects of pyrite oxidation and acid, neutral and alkaline mine drainage.

It is recommended that additional investigations be carried out to better define ARD potential and refine and optimise management strategies, including:

- Continued testing of overburden/interburden and coal to further define the continuity and variation of PAF and NAF materials.
- Further geochemical characterisation of representative washery waste materials when available.
- Leach column testing of representative PAF overburden/interburden and washery wastes to determine lag times before onset of acid conditions and short and long term ARD potential to refine operational and long term management strategies.

- Leach column testing of PAF, PAF-LC and NAF materials in various ratios to help assess the effectiveness of operational blending of ROM overburden/interburden and washery waste materials for ARD control.
- Leach column testing of NAF materials to better evaluate neutral and alkaline mine drainage chemistry.

Note that leach column testing of individual PAF, PAF-LC and NAF rock types has commenced.

1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) was commissioned by AustralAsian Resource Consultants Pty Ltd (AARC) on behalf of Shenhuo International Group Pty Ltd to carry out a geochemical assessment of the Taroborah Coal Project, a thermal coal deposit located approximately 22 km west of Emerald in Central Queensland. The objectives of the work were to:

- assess the acid rock drainage (ARD), salinity and elemental solubility (including neutral mine drainage and alkaline mine drainage) potential of the proposed mine materials;
- identify any geochemical issues; and
- provide recommendations for materials management and any follow up test work which may be required.

Note that this report focuses on results of static geochemical testing[1]. Leach column testing is in progress to provide more information on reaction kinetics. It is understood that this report will contribute to an Environmental Impact Statement (EIS) being prepared by AARC.

The scope of work comprised the following:

- an initial scoping phase involving liaison with relevant project personnel, compilation of background project data, and a site visit in April 2012 to assess the suitability and availability of representative core through the proposed mine stratigraphic sequence, check for evidence of pyrite and neutralising carbonate occurrence, and obtain a better understanding of the continuity and variation of the major rock types;
- preparation of an overburden and interburden core sampling programme in conjunction with site geologists to represent the mine stratigraphy and expected geochemical variation of overburden;
- review and selection of appropriate washery waste materials for geochemical testing in consultation with relevant project personnel;
- collection of samples and arrangement of sample preparation by site personnel with advice from EGi;
- laboratory testing of samples; and
- assessment of results and reporting.

Tables and Figures referred to in this report are collated after the main text.

[1] Static tests measure geochemical characteristics of a sample at a point in time, such as capacities of a sample to produce or consume acid. Kinetic tests measure changes in geochemical characteristics over time, such as rates of acid generation.

2.0 Background and Geology

The Taroborah coal deposit is Permian in age and occurs within the Bowen Basin. There are two main target seams labelled A Seam and B Seam, which were deposited under marine influenced conditions. The deposit is covered by 1 to 2m of soils and 40 to 80m of weathered Tertiary and weathered Permian material. Permian overburden and interburden is dominated by sandstone and siltstone. The coal is classified as low rank and low ash thermal coal.

The deposit would be developed by open cut methods initially, with longwall underground methods used once high wall access is available after approximately 5 years of operation. Open cut mining would target A and B Seams, and underground mining would target the thicker B Seam only. Coal quality and washability investigations show that A Seam and the upper 0.5m of B Seam (B Seam tops) have high sulphur (most of which is pyritic), with A Seam averaging 10%S and B Seam tops averaging around 4%S, but also showing considerable variability. A Seam and B Seam tops would be washed at a coal handling and preparation plant (CHPP) constructed on the Project site to reduce the overall S content of the open cut product to less than 1%S. The lower part of B Seam does not require washing, with S contents averaging 0.9%S, and underground operations would generally focus on selectively mining the B Seam bottoms to minimise the need for washing. Product coal would be transported by an upgraded railway line to Emerald, and then sent to the port of Gladstone via the Central West and Blackwater Rail Systems.

The overburden and interburden initially mined would be placed in ex-pit dumps, with in-pit dumping carried out once space is available. Washery wastes may be disposed with overburden and interburden or placed in dedicated facilities.

Overburden, interburden and coal from holes TAR020GT and TAR027GT were examined during the site visit to check for evidence of pyrite and neutralising carbonate occurrence, and obtain a better understanding of the continuity and variation of the major rock types through the planned mine stratigraphic sequence. The holes were drilled in 2010, and it was expected that any significant pyritic zones would be readily apparent due to partial oxidation of pyrite and formation of iron oxides and distinctive yellow sulphate and jarosite salts.

Pyrite commonly occurred in minor amounts throughout the stratigraphy as scattered fine disseminations (Plate 1) and thin veinlets (Plate 2). Occasional stronger pyritic zones were evident, associated with carbonaceous mudstone layers (Plate 3), bioturbated and partly carbonaceous sandstone (Plate 4), sandstone/conglomerate just above A Seam (Plate 5), and within A Seam and B Seam Top coal (Plate 6, note that B Seam Bottom does not show strong jarosite/sulphate coatings).

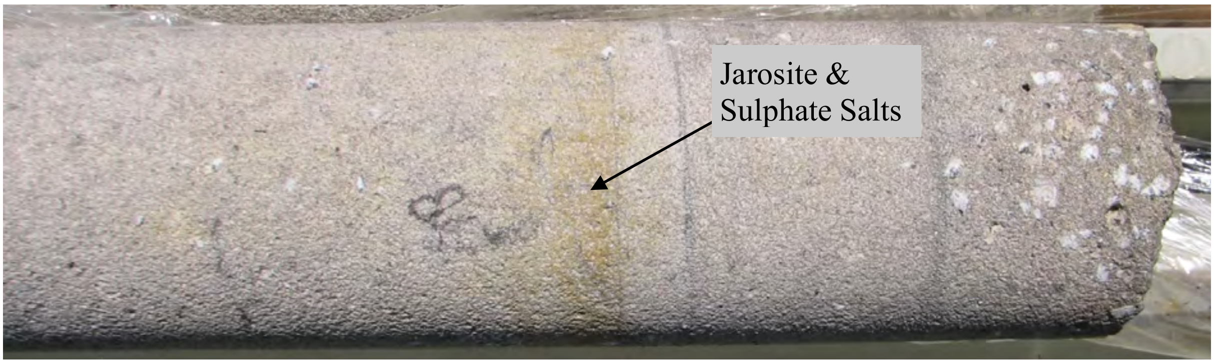

Plate 1: Jarosite and sulphate salts after fine disseminated pyrite in sandstone. Hole TAR027GT, depth 71.4m.

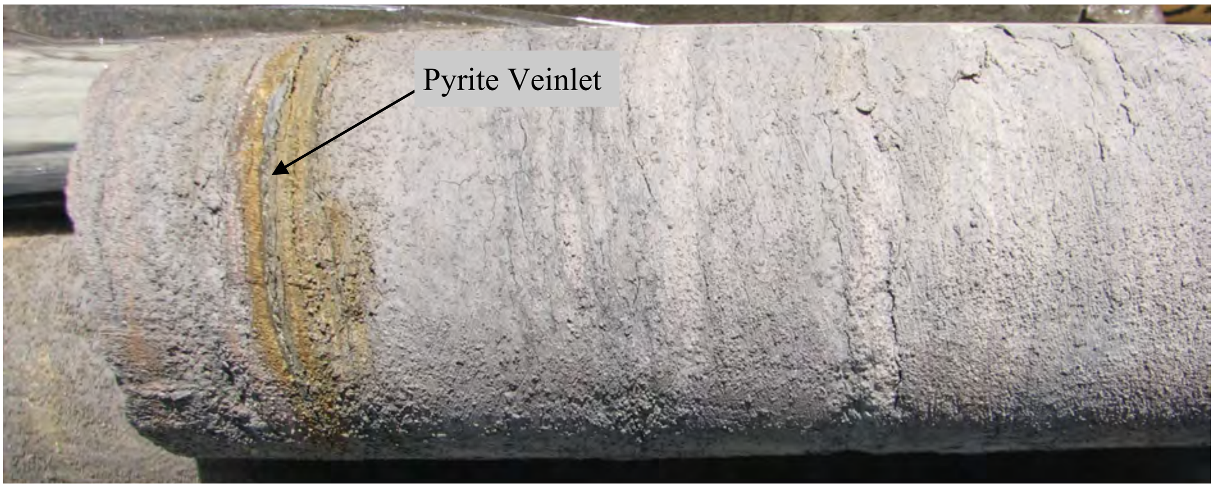

Plate 2: Thin pyrite veinlet with iron staining, jarosite and sulphate salts in sandstone. Hole TAR027GT, depth 54.5m.

Plate 3: Jarosite and sulphate salts after fine pyrite in carbonaceous mudstone. Hole TAR027GT, depth 77m.

Plate 4: Dusting of jarosite and sulphate salts after fine pyrite in bioturbated and partly carbonaceous sandstone. Hole TAR027GT, depth 62.25m.

Plate 5: Jarosite and sulphate salts after strongly pyritic zones in sandstone/conglomerate just above A Seam. Hole TAR020GT, depths 45.0-45.7m and 47.35-47.70m.

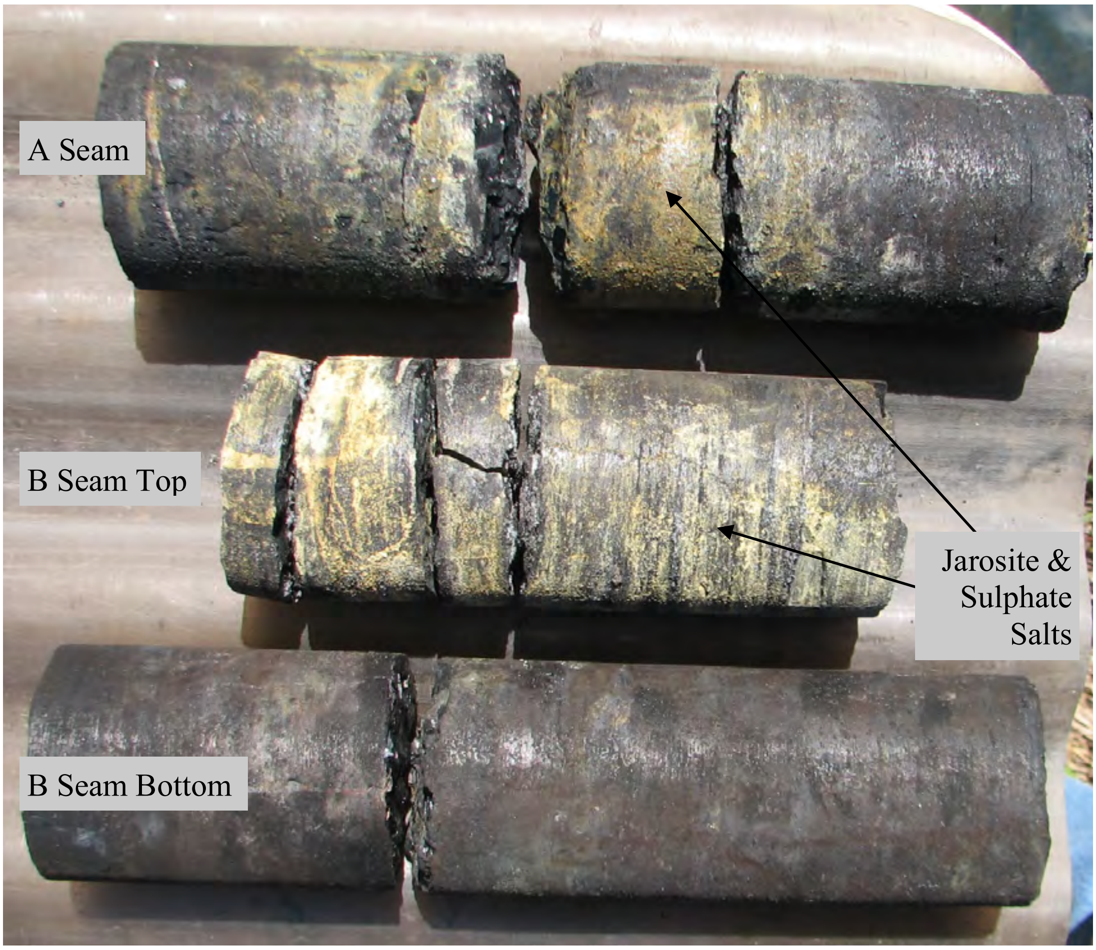

Plate 6: Jarosite and sulphate salts coating coal examples from A Seam and B Seam Top. Hole TAR027GT.

Application of 10% HCl to rock containing significant amounts of reactive acid neutralising carbonates (such as calcite and dolomite) results in vigorous fizzing. Materials with high contents of reactive carbonate can be used to help mitigate ARD. During inspection of the core, 10% HCl was applied intermittently to provide an indication of the presence of reactive carbonate. Most of the overburden/interburden showed no fizzing or only weak fizzing. However, there were zones of strong fizzing in basalt that continued into underlying weathered partly consolidated sedimentary material in the top 7m in TAR020GT and 18m in TAR027GT, indicating the presence of reactive carbonate. The reactive carbonate occurred in veins and matrix within the basalt (Plate 7) and throughout the weathered partly sedimentary material (Plate 8). The strongly fizzing sedimentary material was distinct from the more competent sedimentary rocks below, but was not obviously distinguished in the geological logs. It is common for basalt to contain reactive carbonate, and the basalt may have influenced the reactive carbonate content of the underlying sediments.

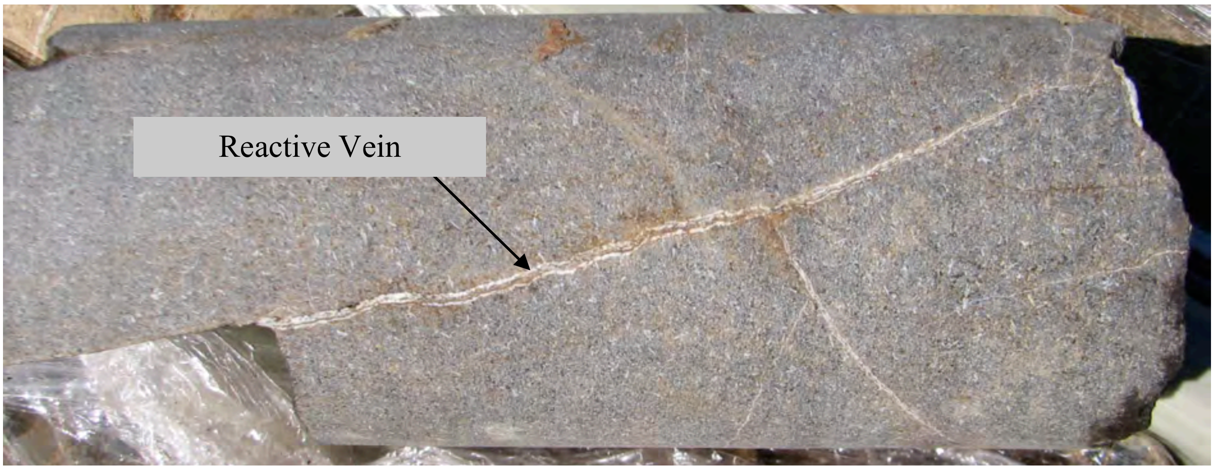

Plate 7: Basalt with reactive carbonate in the matrix and veins. Hole TAR027GT, 4.6m depth.

Plate 8: Weathered and partly consolidated sedimentary material containing reactive carbonate. Hole TAR027GT.

In summary, examination of the core shows that pyrite mainly occurs in low abundances in overburden and interburden, but there are significant zones of pyritic material with low reactive carbonate content that are likely to require management to prevent ARD. Most of the overburden/interburden is likely to have low buffering potential, but there appears to be a zone of high reactive carbonate content associated with basalt and the underlying weathered

sediments. The thickness of the reactive carbonate zone varied from 7m to 18m in the core examined, and these materials may be useful in helping to mitigate or delay the onset of ARD.

3.0 Sample Collection and Preparation

In 2011, IMC Mining Group Pty Ltd (IMC) arranged geochemical testing of 172 samples from 7 open holes drilled across the site. The test work was carried out by SGS (Mackay and Perth) and included standard static ARD testing, water extracts, and cation exchange capacity. The sampling method used (scooping of small sub-samples during drilling and compositing in the field) and poor chip returns meant that many of the samples collected were unlikely to be fully representative of the sample interval drilled. However, testing of the samples collected was expected to provide an overall indication of the relative ARD potential of overburden and floor materials for the deposit.

A follow up core sampling programme was carried out in 2012 to provide more representative samples of overburden, interburden and coal, and obtain a better understanding of geological controls on the distribution of ARD rock types. Results of the more representative 2012 sampling programme were used to assist with the assessment and interpretation of the 2011 open hole sample results.

The distribution and abundance of pyrite in coal bearing sedimentary sequences are largely controlled by the original depositional environment, with influences such as seawater incursions and presence of organic matter key to pyrite formation. As a result of these controls, pyrite is usually preferentially distributed in particular lithologies (such as carbonaceous mudstones) and stratigraphic horizons. Coal sequences usually have high lithological variation in the vertical sense, but tend to show lateral continuity, and hence sampling for ARD assessment needs to take this into account by obtaining detailed continuous samples in individual holes spaced at wide intervals. The core sampling strategy carried out in 2012 aimed to screen the entire mine stratigraphy for acid potential, identify horizons of concern and look for correlations between holes that indicate continuity, and rely on geological controls to help predict the distribution of potentially acid forming (PAF) and non-acid forming (NAF) rock types. This approach results in better representation of mine materials in coal deposits, compared with a purely lithological approach to sampling.

Three holes, TAR020GT, TAR022GT and TAR027GT were selected to cover the mine stratigraphy across the proposed open pit. Hole locations are shown in Figure 1.

Sampling involved collection of detailed continuous samples in all three holes. Intervals were selected by IMC geologists in conjunction with EGi to match geological boundaries, with intervals ranging from less than 0.5m to over 5m. A total of 108 samples encompassing overburden, coal and interburden horizons were collected. This programme was designed to highlight the presence of any problematic materials such as PAF horizons and the overall relative distribution of geochemical rock types, but was not sufficient to model exact distributions. More widespread testing of drillholes would be required during construction/operations to define the continuity and variation of geochemical rock types.

Sample preparation of core was arranged by IMC with advice from EGi, and carried out by ALS Laboratory Group (Brisbane), which involved drying (as required), crushing to a nominal -4mm, splitting, pulverising a 300g to 500g split to -212µm, and dispatch of 300g to 500g of -212µm pulverised samples and -4mm crushed samples to EGi.

In addition to the overburden/interburden and coal samples described above, samples were selected of laboratory wash trial sinks to represent coarse and fine rejects from A Seam, B Seam tops and B Seam bottoms. Only one coarse and fine sample was available from the A Seam. Preparation of wash trial samples was carried out by SGS Mackay and coordinated by IMC. The A Seam coarse rejects equivalent was prepared from the +0.25mm sink material (combined +2mm and -2mm to +0.25mm individual size fractions) washed at a specific gravity of 1.6. The B Seam coarse rejects equivalents were prepared from the same size fraction but washed at specific gravity of 1.8. Fine rejects for A and B seams were represented by the -0.25mm size fraction. EGi were provided with a total of 27 pulverised (-212µm) samples.

4.0 Methodology

The following tests were carried out on all 108 core and 27 laboratory rejects samples:

- Leco or Leco equivalent total S;
- pH and electrical conductivity (EC) of deionised water extracts at a ratio of 1 part solid to 2 parts water ($pH_{1:2}$ and $EC_{1:2}$) (except rejects sample 4446 due to insufficient sample);
- acid neutralising capacity (ANC);
- net acid producing potential (NAPP), calculated from total S and ANC; and
- standard single addition net acid generation (NAG) test.

Further 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.

In addition, selected samples were assayed for the following to identify any potential elemental concerns and to provide initial elemental solubility data:

- multi-element scans of solids; and
- multi-element scans of single stage deionised water batch extracts (ratio of 1 part solid to 2 parts water).

Water extractions for $pH_{1:2}$ and $EC_{1:2}$ and multi-element testing were carried out on -4mm crushed overburden/interburden samples. Pulverised samples were used for all other tests.

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

Standard multi-acid digest for elemental analysis could not be carried out directly on washery waste and coal samples due to the high carbon content, which can cause explosions during digestion. To overcome this issue, the samples were ashed to remove the organic component and ICP-AES and ICP-MS analysis performed on the ash, with concentrations calculated relative to the original sample weight. However, due to the potential loss of some volatile elements during ashing, element specific coal analysis methods were carried out on splits of the original solid to provide a more reliable measure of As, B, F, Hg, Sb and Se as follows:

- As, Sb, Se by Eschka hydride ICP-OES;
- B by Eschka ICP-OES;
- F by Pyrohydrolysis/ISE; and
- Hg by Leco direct combustion.

Total sulphur assays were arranged by IMC and carried out by ALS Laboratory Group (Brisbane) for overburden/interburden and coal samples from the three selected cored holes, and SGS (Mackay) for wash trial washery waste samples. Multi-element analyses of solids from lower organic carbon samples and ash from high organic carbon samples were carried out by ALS Laboratory Group (Brisbane). Coal specific elemental analyses of solids for high organic carbon samples were carried out by ALS Laboratory Group (Maitland). CRS analyses of sample solids were carried out by ALS Laboratory Group (Brisbane). Multi-element analyses of water extracts were carried out by ALS Laboratory Group (Sydney). Analyses of NAG solutions and S analysis of KCl digest solutions were carried out by Levay & Co. Environmental Services (Adelaide). All other analyses were carried out by EGi.

5.0 Overburden/Interburden Results

Acid forming characteristics of the 108 overburden/interburden and coal samples tested by EGi are presented in Table 1, comprising pH and EC of water extracts, total S, maximum potential acidity (MPA), ANC, NAPP, ANC/MPA ratio and single addition NAG.

Acid forming characteristics of 172 overburden/interburden samples tested in 2011 by SGS were provided by IMC and are shown in Table 2.

5.1 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 water extracts carried out by SGS were determined at a higher solid to water ratio of 1:5.

The combined EGi $pH_{1:2}$ and SGS $pH_{1:5}$ values ranged from 2.1 to 9.5, with most samples (60%) showing no inherent acidity with a pH of 6 or greater. Seventy samples had a slightly acidic pH of 4 to 6, and 36 of the samples tested had an acidic pH of less than 4.0.

The $EC_{1:2}$ and $EC_{1:5}$ values ranged from 0.03 to 16.21 dS/m with the majority of samples (80%) falling within the non-saline to slightly saline range with an EC of 0.8 dS/m or less. Eighty samples had a moderately saline EC of 0.8 to 1.6 dS/m, and 35 samples were saline with an EC of greater than 1.6 dS/m.

Figure 2 is a plot of combined $pH_{1:2}$ and $pH_{1:5}$ and combined $EC_{1:2}$ and $EC_{1:5}$ versus total S, which shows that the lower pH values (< pH 4) and the higher EC values (>1 dS/m) are generally associated with higher S (>0.5%S) samples. This indicates that lower pH and higher EC values are primarily the result of partial pyrite oxidation (and generation of soluble salts) occurring between sample collection and sample testing.

Results indicate low immediately available acidity and salinity in the samples except where pyrite is present and has partially oxidised.

5.2 Acid Base (NAPP) Results

Total S ranges from below detection to 18.1%S, with most samples (70%) having relatively low S values of less than 0.5%S. Figure 3 is a box plot of the distribution of S split by lithology for overburden/interburden and coal horizons. The plot shows that total S values for the basalt, soil, and sand are low, with most samples having total S of less than 0.1%S, and medians of 0.03%S or less. The clay samples show some higher S values of up to 1.5%S, but these higher S samples are highly weathered, and it is likely the S is in non acid generating sulphate forms. The carbonaceous shale and coal samples have distinctly elevated S relative to other lithologies, with medians of 0.7%S and 1.0%S, respectively. Although the sandstone samples have lower median S than the coal and carbonaceous shale samples at 0.3%S, the

sandstone samples cover a similar range and include samples with S of greater than 1%S. The median S for the siltstone is between the carbonaceous shale and sandstone at 0.6%S, with a maximum of just under 1%S.

ANC ranges up to 440 kg H_2SO_4/t, but the median ANC is insignificant at 1 kg H_2SO_4/t. Figure 4 is a box plot of the distribution of ANC split by lithology for overburden/interburden and coal horizons. The basalt samples have distinctly higher ANC than other lithologies, which is typical of this material. The clay samples have a low median ANC of 17 kg H_2SO_4/t, but a number of samples have moderate to high ANC greater than 40 kg H_2SO_4/t, mainly in close proximity to basalt and possibly either derived from basalt or affected by the basalt. Three of the sand samples have high ANC of greater than 100 kg H_2SO_4/t, but the remainder have low ANC values of 12 kg H_2SO_4/t or less. The sandstone, siltstone, carbonaceous shale and coal samples generally have low ANC values with medians of 5 kg H_2SO_4/t or less.

The NAPP value is an acid-base account calculation using measured total S and ANC values. It represents the balance between the 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 5 is an acid-base account plot of ANC versus total S. Figure 6 is the same as Figure 5, but re-scaled to better represent S values below 2%S and ANC values 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 value of 2 is also plotted. Note that the NAPP = 0 line is equivalent to an ANC/MPA of l. The ANC/MPA value 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.

The plots show that in general high S samples tend to have low ANC and vice versa, reflecting trends in S and ANC distribution shown in Figures 3 and 4. Results indicate that 35% of the samples tested are NAPP negative and 65% NAPP positive.

5.3 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.

Figure 7 is a box plot of the distribution of NAGpH, split by lithology. The figure shows that all of the carbonaceous shale and coal samples have low NAGpH values below 4.5, but these results are inconclusive in isolation due to potential organic acid effects. Most sandstone and siltstone samples (65% and 55% respectively) have NAGpH values of less than 4.5. All samples from the remaining lithologies have NAGpH values of greater than 4.5.

NAG test results are used in conjunction with NAPP values to classify samples according to acid forming potential. Figure 8 is an ARD classification plot showing NAGpH versus NAPP value. Figure 9 is the same as Figure 8, but with an expanded NAPP axis to better represent the range -50 to 50 kg H_2SO_4/t. Potentially acid forming (PAF), 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 plots show that most samples have consistent NAPP and NAGpH results, plotting in either the PAF or NAF domain, with 50 samples showing conflicting NAPP and NAGpH results.

A total of 87 samples (30%) plot in the NAF domain, of which 85 samples have relatively low total S of less than 0.5%S with a median of 0.02%S, indicating a low risk of ARD from materials represented by these samples.

There are 141 samples that plot in the PAF domain, with low ANC values of 15 kg H_2SO_4/t or less indicating an overall lack of significant buffering. Fifty seven of these samples have low NAG values to pH 4.5 of 5 kg H_2SO_4/t or less and are expected to be PAF but with a lower capacity to generate acid (PAF-LC). A number of PAF domain samples show evidence of organic acid effects, indicated by a large difference between the $NAG_{(pH4.5)}$ and $NAG_{(pH7.0)}$ values, and $NAG_{(pH4.5)}$ values that exceed the MPA. In these samples the NAG results overestimate the acid potential. Standard NAG test results affected by organic acids are highlighted in yellow in Table 1 and 2. Some samples have a NAPP value of 5 or less and are likely to be PAF-LC.

A total of 26 samples plot in the upper right uncertain domain. Most of these have total S values of around 1 %S or less and relatively low ANC values of less than 20 kg H_2SO_4/t, and the NAG test would normally account for all pyritic S in the sample. Two samples have moderate S values of 1.5%S (3609 and 3610), but these are highly weathered and it is unlikely that there is any significant residual pyrite. All 26 of these samples are expected to be NAF in accordance with the NAG results, and it is likely that the total S value includes non acid generating S forms, and hence the NAPP value may overestimate the acid generating potential in some cases.

Seven samples plot in the lower left uncertain domain. Three of these have low total S of less than 0.05%S, and are classified NAF since they are unlikely to result in low pH. SGS samples 023 and 024 from hole TAR024_OB show evidence of organic acid effects, have high ANC/MPA ratios of greater than 2 indicating a high factor of safety, and are assumed to be NAF in accordance with NAPP results. The 2 remaining samples (020 from hole TAR002_OB and 008 from hole TAR024_OB) have ANC/MPA ratios of less than 2 and are conservatively assumed to be PAF.

5.4 Extended Boil and Calculated NAG Results

Extended boil and calculated NAG testing was carried out on 15 selected samples to help resolve uncertainties in ARD classification based on standard NAG test results, as discussed in the previous section. Results are shown in Table 3.

The extended boil NAGpH for 10 of the samples remained less than 4.5, indicating these samples are likely to be acid producing. Results for the remaining samples show some increase in the NAGpH value of 1 to 3 pH units after the extended boiling step. The increased NAGpH confirms there are organic acid effects.

Note that the extended boil NAGpH value can be used to confirm samples are PAF, but an extended boil NAGpH value greater than 4.5 does not necessarily mean that samples 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 all of the samples are positive indicating these samples are likely to be acid producing. Samples 3598, 3634 and 3682 had acid potentials of less than 5 kg H_2SO_4/t, and are classified as potentially acid forming with a low capacity (PAF-LC).

5.5 Acid Buffering Characteristic Curve (ABCC) Testing

Acid buffering characteristic curve (ABCC) testing was carried out on 11 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 10 to 15, 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 7 of the samples (3576, 3577, 3579, 3610, 3641, 3643 and 3648) show strong buffering with profiles plotting close to those of calcite and dolomite standard curves, and generally indicating 100% of the ANC is readily available. Basalt sample 3643 is an exception, with only half the total ANC readily available (Figure 13). All these samples are in the weathered zone, comprising basalt, soil, sediments and semi-consolidated sedimentary rock, and have ANC values ranging from 16 kg H_2SO_4/t to 100 kg H_2SO_4/t.

Clay/claystone sample 3646 is also from the weathered zone and has a high ANC of 262 kg H_2SO_4/t. The ABCC profile for this sample plots close to the ferroan dolomite standard curve (Figure 15), and indicates that although 100% of the ANC is likely to be available, reaction rates are likely to be slower relative to dolomite.

The remaining samples are fresh sedimentary sandstone and siltstone, which have low to moderate ANC of 16 to 20 kg H_2SO_4/t. The ABCC profiles for these samples (Figures 10 and 11) plot close to the ferroan dolomite and between the siderite and ferroan dolomite standard curves, indicating slow reactivity and with only 40% to 50% likely to be effective.

Overall, ABCC results suggest that the acid buffering minerals in higher ANC weathered materials is likely to be mainly strongly reacting and readily available. This is consistent with observed zones of high fizzing in basalt and weathered sedimentary materials during core inspection (see Section 2). Fresh (unweathered) materials generally have low ANC and ABCC results indicate this is likely to be only partly available and slower reacting.

5.6 Kinetic NAG Testing

Kinetic NAG tests provide an indication of the kinetics of sulphide oxidation and acid generation for a sample. Kinetic NAG testing was carried out on 7 selected samples. Results are presented in Figures 16 to 22.

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 0.5%S. Only sample 3595 showed a distinct temperature peak (Figure 17), but this is significantly lower than would be expected if all of the 1.49%S in the sample was in pyritic form. Samples 3589, 3604, 3605, 3666 and 3669 all have subdued temperature peaks despite having total S values of greater than 0.8%S, indicating that these samples have pyritic S contents of 0.5%S or less and a significant proportion of non acid generating S forms.

The original S value provided by ALS Laboratory Group (Brisbane) for sample 3630 was 3.17%S, but this appeared unusually high compared to single addition NAG results. Kinetic NAG testing was carried out to check for a temperature peak, and the lack of any peak confirmed the potential for laboratory error in the S analysis. Re-testing by ALS indicated a sample mix up, and the S value was confirmed to be low at 0.11%S.

All 7 samples had low ANC of 7 kg H_2SO_4/t or less and most pH profiles show a rapid drop with time, reaching pH 4 in 3 minutes or less, and indicating lag times of less than 4 weeks before onset of acid conditions after exposure to atmospheric oxidation. Sample 3589 has a slightly longer lag of 13 minutes, indicating a lag of 1 to 2 months. Note that the pH profile for sample 3630 is not valid as the S content is too low.

Results indicate that PAF materials with low ANC represented by these samples are likely to rapidly generate ARD within a month after exposure to atmospheric oxidation conditions.

5.7 Sulphur Speciation

Sulphur speciation testing was carried out on 17 selected samples. Results are shown in Table 4. Note that the pyritic S value should only be treated as a guide to the pyrite content in the sample due to issues with repeatability in the chromium reducible sulphur (CRS) method[2]. Partial oxidation of pyrite was expected to occur in these samples prior to testing, and some of the S originally present as pyrite was likely to be in the form of acid sulphate salts. Hence the total acid generating S proportion of the sample is the sum of the pyritic S (from CRS) and the acid sulphate S.

Results for the A Seam coal samples (3628 and 3670) indicate that most of the S measured (75% to 90%) is in acid generating forms. Three B Seam tops samples were tested, of which sample 3677 had the highest total S of 4.16%S and is most typical, with the average S expected for B Seam tops at around 4%S (see Section 2). Sample 3677 shows a high proportion of acid generating S of 67%. The other two B Seam tops samples 3604 and 3635 are less typical, with lower S of 0.70% to 0.79%S, and show a significant but smaller acid generating proportion of 27% to 44%. The three B Seam bottoms samples have S values ranging from 0.62 to 0.82%S, and results indicate that most of the S measured (60% to 75%) is in non acid sulphate and low risk forms (most likely organic S). Results are consistent with findings of coal quality and washability investigations.

The proportion of acid generating S in the remaining 9 non-coal samples ranges from 35% to 84%, with an average of 60%. CRS testing carried out by SGS in 2011 (Table 2) was consistent, with pyritic S ranging from 1% to 100%, but also averaging around 60% of the total S. Results indicate that although most of the S in the overburden/interburden materials is likely to be pyritic, a significant proportion is likely to be in non acid generating forms. These results are consistent with findings from kinetic NAG temperature profiles (Section 5.6).

5.8 Multi-Element Analysis of Solids

Results of multi-element scans of solids from 20 selected samples were compared to the median soil abundance (from Bowen, 1979[3]) to highlight enriched elements. The extent of enrichment is reported as the Geochemical Abundance Index (GAI), which relates the actual concentration with an average or median abundance on a log 2 scale. The GAI is expressed in integer increments where a GAI of 0 indicates the element is present at a concentration similar to, or less than, median soil abundance; and a GAI of 6 indicates approximately a 100-fold enrichment above median soil abundance. As a general rule, a GAI of 3 or greater signifies enrichment that warrants further examination.

Results of multi-element analysis of solids are presented in Table 5, and the corresponding GAI values are presented in Table 6.

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[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. www.acarp.com.au.

[3] Bowen, H.J.M. (1979) Environmental Chemistry of the Elements. Academic Press, New York, p 36-37.

Results show that in addition to S (which was discussed earlier in relation to acid forming potential), many of the samples are slightly enriched to enriched in Be relative to median soils and a single sample shows enrichment of Tl. However, the Be and Tl contents are within normal ranges for sedimentary rock and are unlikely to be a concern.

5.9 Composition of Water Extracts

The same 20 sample solids were subjected to water extraction at a solids:liquor ratio of 1:2. Results are shown in Table 7, with total S of the sample solids also included for reference.

Thirteen of the samples produced acidic to slightly acidic water extract pH values of 2.2 to 4.4, due to partial oxidation of pyrite between sampling and testing. The acidic pH is associated with elevated Al, Co, Cu, Fe, Mn, Ni, SO_4 and Zn, and slightly elevated Cr. Samples with pH values of 3.1 or less also had elevated As of 0.5 to 2.3 mg/L, and slightly elevated Th and U of 0.1 to 1.0 mg/L. Four of the lower pH samples (3597, 3605, 3677 and 3678) also had slightly elevated B of 1.4 to 3.3 mg/L.

The remaining 7 samples had circum-neutral pH extracts and showed no significant concentrations of metals or metalloids.

Results indicate that significant metal/metalloid release will be associated with generation of ARD. The solubility of metals/metalloids will largely be determined by pH and therefore control of acid generation will effectively control metal leaching. Water extracts from NAF materials indicated that neutral mine drainage was unlikely to contain significant metal/metalloid concentrations. Results did not indicate potential for alkaline mine drainage. Extracts show that initial metal/metalloid release associated with any ARD generated from pyritic materials will include elevated Al, Co, Cr, Cu, Fe, Mn, Ni, SO_4 and Zn, possibly slightly elevated B, and elevated As, U and Th at pH values of around 3 or less.

5.10 Sodicity

SGS carried out exchangeable cations testing on 170 overburden/interburden samples as part of the IMC 2011 programme to provide an indication of any sodicity issues. Results are presented in Table 8.

Sodic materials tend to form low permeability soil horizons, accelerating erosion and inhibiting plant growth. Sodic soils are also dispersive and should not be used as construction materials since they are prone to tunnelling and collapse. The exchangeable sodium percentage (ESP) is a measure of exchangeable Na as a percentage of the total effective cation exchange capacity (ECEC).

The ESP can be used to classify samples according to sodicity as follows:

- ESP < 6% - Non-Sodic
- ESP 6-15% - Sodic
- ESP 15-30% - Strongly Sodic
- ESP >30% - Very Strongly Sodic

A number of samples have ESP values of greater than 6%, but most of these are associated with sand and sandstone with low ECEC values of less than 12 meq%, and would not result in significant dispersion or other sodic effects. Five samples were classified sodic, with ESP values of greater than 6% and high ECEC values of greater than 25 meq%. These sodic samples were associated with clay and soil materials in the upper 7m of hole TAR002_OB and the upper 12m of hole TAR028_OB.

Results indicate that most overburden/interburden materials are unlikely to be sodic. However, clay and soil within 12m of the surface may be partly sodic and subject to surface crusting and high erosion rates if placed on the surface of dumps and exposed directly to rainfall. Materials with sodic potential should be treated (with gypsum or lime) if exposed on dump surfaces or used in engineered structures.

More detailed testing would be required to accurately define the distribution and extent of sodic/dispersive materials.

5.11 Sample Classification and Distribution of ARD Rock Types

The results and discussions presented above were used to classify samples as NAF, PAF, PAF low capacity (PAF-LC) or UC in Tables 1 and 2. PAF-LC samples are defined as having an acid capacity of 5 kg H_2SO_4/t or less. 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.

The following table shows the approximate breakdown of geochemical rock types based on the combined EGi and SGS sample intervals tested to date (not taking spatial distribution or mining blocks into account) for overburden/interburden and coal (including partings):

Material Type	NAF inc. UC(NAF)	PAF-LC inc. UC(PAF-LC)	PAF
Overburden/Interburden	65%	21%	14%
ROM Coal	0%	0%	100%

The estimated proportions of ARD classes for overburden/interburden demonstrate that NAF materials are likely to dominate, but that PAF-LC and PAF materials would represent a significant proportion of materials mined in the open cut.

Coal seam intercepts were available from the 3 geotechnical holes tested by EGi (TAR020GT, TAR022GT and TAR027GT), and all 9 samples tested were classified PAF

indicating all ROM coal should be assumed to be PAF. A Seam would be most strongly acid forming with coal quality testing indicating an average of 10%S, followed by B Seam tops with an average of 4%S, and then B Seam bottoms with a lower average S of 0.9%S.

Figure 23 is a plot of total S profiles for the combined EGi and SGS drillholes geochemically tested. In addition to total S, the hole profiles also show coal seam intercepts, basalt intercepts, the base of moderate weathering and sample ARD classification, with NAF (including UC(NAF)) samples represented as blue symbols, PAF-LC (including UC(PAF-LC)) samples as orange symbols, and PAF (including UC(PAF)) samples as red symbols. The holes are approximately aligned according to coal seam stratigraphy, and are arranged by collar location from west on the left to east on the right. The S profiles show that PAF samples with higher total S are mainly associated with the coal seams and roof and floor. There are also some PAF-LC samples within fresh overburden above A Seam.

Figure 24 shows ANC profiles with the same information as Figure 23. The ANC profiles show that fresh overburden/interburden and coal generally has low or no ANC, but there are zones of high ANC in the weathered overburden associated with basalt and sedimentary materials. The weathered sedimentary materials only appear to have high ANC when basalt is present in the hole, with holes TAR020GT, TAR027GT, TAR027_OB, TAR030_OB and TAR034_OB all having basalt intercepts and showing broad zones of high ANC sedimentary materials below the basalt. There are no basalt intercepts in holes TAR002_OB, TAR022_OB and TAR028_OB and ANC is generally low. Hole TAR024_OB is an exception, with high ANC close to surface and no basalt. Overall, results indicate the basalt may influence the ANC of underlying sedimentary materials, possibly as a result of weathering processes. Further work would be required to understand the geological controls, and determine the continuity and variability of this high ANC zone.

More detailed sampling and testing would be required to accurately define the distribution, variation and continuity of NAF and PAF horizons, but the following specific geochemical zones are apparent:

- NAF zone to the base of moderate weathering;
- High ANC zone 5m to 60m thick within the weathered NAF, particularly associated with and below basalt intercepts;
- Mixed NAF and PAF-LC zone from the base of moderate weathering to 5 to 10m above A Seam;
- PAF zone generally within 5 m of the A Seam roof but can be up to 10m;
- PAF A Seam;
- PAF/PAF-LC interburden between A Seam and B Seam;
- PAF B Seam;
- PAF-LC B Seam floor with PAF portions.

For mine planning purposes, it should be assumed that materials from 10m above A Seam to the B Seam floor are PAF and will need to be managed to prevent ARD. The overall ARD potential of the mixed NAF/PAF-LC zone 10m above the A Seam and below the base of moderate weathering is uncertain, but given the general low ANC in these materials, it should be assumed for now (pending further investigation into the effects of operational mixing and leaching characteristics of these materials) that these materials have potential to generate ARD at low rates, and need to be excluded from the outer zones of spoil dumps unless treated with limestone or mixed with higher ANC material. The remaining materials are likely to be NAF, including a zone of high ANC basalt and sedimentary materials in the weathered zone that is potential source of buffering to assist management of PAF and PAF-LC materials.

It is understood the pit floor would mainly comprise the base of the B Seam, and testing to date indicates this is likely to be mainly PAF-LC but with PAF portions.

Figure 25 is a box plot showing the distribution of total S for overburden/interburden samples split into ARD classification classes. The plot shows that total S alone could potentially be used for routine classification by applying a cut off of 0.1%S, which segregates all PAF and all but 6 of the PAF-LC samples, but overestimates the proportion of PAF as 35% of the NAF samples have total S greater than 0.1%S. This 0.1%S cut off is conservative, and increasing the cut off to 0.2%S and include more PAF-LC materials as NAF may be possible after investigations into the effectiveness of operational mixing in controlling significant ARD from combined NAF and PAF-LC materials.

Figure 26 is a box plot showing the distribution of NAGpH split into ARD classification classes. The NAGpH is more discriminating than total S, with a very clear separation of NAF from PAF and PAF-LC materials at a cut off of pH 4.5. The plot also indicates that a NAGpH of 3.0 could be used to approximately segregate PAF and PAF-LC samples.

Total S and NAGpH combined could be potentially used as screening classification criteria for future testing of overburden/interburden samples. Both tests could also be used in field checks and reconciliation of the predicted distribution of ARD rock types for overburden and interburden materials. The NAG test in particular is adaptable for site use, and could be simplified to ensure ease of use and quick turn around.

Total S and NAGpH are less suited for screening classification of coal and washery wastes due to inferences from organic S forms and organic acid generation in the NAG test.

6.0 Washery Wastes Results

The acid forming characteristics of laboratory generated coarse and fine rejects samples are shown in Table 9. The samples represent equivalent rejects from individual samples of A Seam, B Seam tops and B Seam bottoms. Only one coarse and fine rejects sample was available from A Seam.

The $pH_{1:2}$ values were strongly to slightly acidic, ranging from 1.6 to 4.5. $EC_{1:2}$ values ranged from 0.55 to 20.9 dS/m, with 18 samples having saline $EC_{1:2}$ values greater than 1.6 dS/m. The lower pH and higher EC values are associated with higher S, and are related to partial oxidation of pyrite in these samples prior to testing.

Total S values are moderate to very high and range from 0.66 to 32.2%S. Coarse rejects generally have higher S than the fine rejects, and the A Seam rejects samples have the highest total S, followed by B Seam tops and then B Seam bottoms, which is consistent with the total S distribution of ROM coal.

ANC values are low for all samples, ranging from 0 to 7 kg H_2SO_4/t, and all samples were NAPP positive.

All NAGpH values were less than 4.5, but many of the fine rejects samples show evidence of organic acid effects (shaded yellow in Table 9), with NAG acidity values significantly greater than MPA values and NAG values likely to overestimate the acid potential.

Extended boil and calculated NAG testing was carried out on 17 selected rejects samples, and results are shown in Table 9. The calculated NAG values of all samples were positive, indicating these samples are likely to be PAF. The calculated NAG values are generally similar to the NAPP values, indicating most of the total S in these samples is pyritic.

Sulphur speciation test results for 17 selected rejects samples are shown in Table 10. Results indicate that most of the total S in the rejects is likely to be pyritic, with the acid generating S component in most (12) of the samples accounting for over 50% of the total S. Two of the B Seam bottoms samples (4448 and 4451) have relatively low acid generating S proportions of around 30%, indicating a significant portion of low risk S forms that are most likely organic S.

All samples were classified PAF based on results discussed above. Note that coarse and fine rejects from A Seam and B Seam tops have a high ARD risk, and are also likely to make up the vast bulk of the washery wastes produced. The B Seam bottoms coal will generally by-pass the wash plant.

Multi-element scans were carried out on 10 selected rejects samples solids. Results of multi-element analysis of solids are presented in Table 11 and the corresponding GAI values are presented in Table 12. All samples showed enrichment in S (already discussed above in regards to acid forming potential). The coarse rejects, the A Seam fine rejects and B Seam Tops rejects samples are particularly enriched in S, and have associated enrichment in Tl. The coarse rejects samples are enriched in Se. Individual samples show enrichment in Ag, As, Be, Hg and Mo. The enrichment of metals in these samples is typical of materials with high pyrite content.

The same samples were subjected to water extraction at a solids:liquor ratio of 1:2. Results are shown in Table 13. All extracts have an acidic pH of 1.7 to 4.3 due to partial oxidation of

pyrite, with the higher S samples (coarse rejects, A Seam fine rejects and B Seam Tops rejects) having values of less than pH 3. The acidic pH is associated with elevated concentrations of Al, Co, Cu, Fe, Mn, Ni, SO_4 and Zn, and slightly elevated Cr. Five of the higher S extracts also have elevated As of 0.84 to 2.36 mg/L. Note that although the Ag, Be, Hg, Mo and Se were elevated in some of the solids, these elements were not significantly mobilised in the water extracts.

7.0 Conclusions and Recommendations

Results indicate that the majority of the overburden and interburden tested to date at Taroborah is likely to be NAF. However, washery wastes and ROM coal are likely to be mainly PAF. Coarse and fine rejects from A Seam and B Seam tops would make up the bulk of the washery waste produced and are considered to have a high ARD risk, with the potential to rapidly release high acid and metal/metalloid loads. The ROM coal from A Seam and B Seam tops also have high ARD capacities and may also be fast reacting.

A guide to the relative proportion of NAF and PAF/PAF-LC overburden/interburden was calculated based on sample interval weightings, and NAF materials were estimated to make up approximately two thirds of overburden/interburden, with the remaining one third PAF or PAF-LC. Overall, results suggest the presence of distinct horizons of NAF and PAF material in overburden and interburden that should be amenable to selective mining. The following specific geochemical zones are apparent:

- NAF zone to the base of moderate weathering;
- High ANC zone 5m to 60m thick within the weathered NAF, particularly associated with and below basalt intercepts;
- Mixed NAF and PAF-LC zone from the base of moderate weathering to 5-10 above A Seam;
- PAF zone generally within 5 m of the A Seam roof but can be up to 10m;
- PAF A Seam;
- PAF/PAF-LC interburden between A Seam and B Seam;
- PAF B Seam;
- PAF-LC B Seam floor with PAF portions.

For mine planning purposes, it should be assumed that materials from 10m above A Seam to the B Seam floor are PAF.

It is understood the pit floor would mainly comprise the base of the B Seam, and results indicate this is likely to be mainly PAF-LC with PAF portions.

Total S and NAGpH could be potentially used as screening classification criteria for future testing of overburden/interburden samples. A conservative total S cut off of 0.1%S can be

used alone as a guide to identify NAF and PAF, but more discriminating classification can be achieved with inclusion of the NAG test. Both tests could also be used in field checks and reconciliation of the predicted distribution of ARD rock types for overburden/interburden materials. Washery rejects would require more comprehensive testing due to inferences from organic S forms and organic acid generation in the NAG test.

Kinetic NAG testing indicates that PAF overburden/interburden and coal will rapidly generate ARD within weeks after exposure to atmospheric oxidation conditions. Constituents associated with ARD from these materials are likely to include Al, Co, Cr, Cu, Fe, Mn, Ni, SO_4 and Zn, possibly slightly elevated B, and As, U and Th at pH values of around 3 or less. Constituents associated with ARD from rejects are similar, and likely to include Al, As, Co, Cr, Cu, Fe, Mn, Ni, SO_4 and Zn. Pyrite oxidation appears to be the main source of salinity in overburden/interburden, coal and washery waste materials.

Water extracts from NAF overburden/interburden indicated that neutral mine drainage was unlikely to contain significant metal/metalloid concentrations. Results did not indicate potential for alkaline mine drainage.

Results of exchangeable cation testing indicate most overburden/interburden materials are unlikely to be sodic. However, clay and soil within 12m or so of the surface may be partly sodic and subject to surface crusting and high erosion rates if placed on the surface of dumps and exposed directly to rainfall. Materials with sodic potential should be treated (with gypsum or lime) if exposed on dump surfaces or used in engineered structures.

The results of this static geochemical assessment of Taroborah mine waste and ROM coal have indicated potential implications for the management of mine materials as follows:

- Most of the overburden and interburden is expected to be NAF and will not require special handling for ARD control.
- Basalt and some underlying weathered sedimentary materials are a potential source of high ANC material, which could be used to help mitigate or delay the onset of ARD from PAF and PAF-LC materials.
- A geological model predicting the distribution of PAF and NAF overburden/interburden horizons will be required for materials scheduling.
- The following management strategies should be considered for overburden and interburden materials placed in ex-pit and in-pit dumps:
    - out of pit dumps should be constructed with NAF material where possible;
    - PAF materials should be preferentially placed in-pit below the recovery groundwater table level to allow inundation at mine closure and prevent long term exposure to atmospheric oxidation. This requires oxidation and acid generation control measures to ensure PAF materials do not mobilise acid and dissolved metals/metalloids during inundation;

- paddock dumping and traffic compacting PAF materials in lifts of 5 m or less should be considered to minimise the risk of accelerated oxidation through convection;
- interim lifts/faces of placed PAF waste rock may need to be treated with crushed limestone for operational control of ARD before inundation can take place;
- long term ARD control of any PAF materials placed above the final recovery groundwater table level should include a thick (5 to 20m) outer zone of NAF materials (preferably high ANC), and may require an engineered cover or internal seal system to limit oxygen transfer and fluctuating moisture conditions in PAF materials;
- blending of PAF and acid neutralising materials (limestone, high ANC basalt and/or high ANC weathered sedimentary materials) could be used to increase lag times before onset of acid conditions within the PAF material;
- if placement of PAF in ex-pit dumps is required, other measures would be required in addition to the thick outer zone and cover/seal system described for in-pit dumps. Designs should prevent convective/advective transport of oxygen through the dump, which can reduce ARD loadings by a factor of at least 4. This can be achieved by setting back PAF materials from the face of the dump and adopting dumping strategies that avoid formation of continuous coarse layers and open chimney structures that act as air pathways. The immediate base of the dump should comprise a layer of NAF material (1m or more) to help isolate overlying PAF materials from any water flow along the interface between the dump and natural ground. Blending of PAF materials with limestone and/or higher ANC NAF should also be carried out to increase lag times and provide a factor of safety for the dumps. Kinetic testing of PAF and NAF blends will be required to determine optimum blending ratios;
- the mixed NAF/PAF-LC zone 10m above the A Seam and below the base of moderate weathering may generate low rates of ARD, and should be excluded from the outer slopes of spoil dumps unless blended with limestone and/or high ANC overburden to prevent ARD generation. Operational mixing during normal mining operations may be sufficient to negate any significant ARD risk from this horizon, but this would need to be confirmed with leach column testing, trials, field checks and monitoring.

• Coarse and fine rejects will be mainly produced from washing of A Seam and B Seam tops and are likely to have a high ARD risk (sulphur grade generally >4%S). In addition to considerations noted above, additional management efforts are likely to be required to prevent ARD, including:
  - blending with limestone to increase lag times and reduce oxidation rates;
  - placement below water in a dedicated facility or in-pit to control oxidation, and including designs to prevent significant seepage into groundwater;

  - possible use of low permeability encapsulation cells where immediate underwater disposal is not possible;
  - permanent and secure inundation where possible;
  - progressive installation of a robust cover/seal system where permanent inundation is not feasible.

- Design of a cover system for in-pit and ex-pit dumps, as well as offset distances of PAF material from the outer edges of ex-pit dumps, will require assessment of the hydraulic and physical properties of the various mine materials in conjunction with local climate conditions to determine the type of cover system and offset distance that is appropriate.
- The final Pit floor appears to be mainly PAF-LC with PAF portions, and provision should be made for monitoring runoff/leachate, limestone spreading on pit floor surfaces and water capture and treatment if required. Long term ARD control strategies for the pit floor should be incorporated into management of in-pit dumps, and may require a combination of groundwater inundation and a cover/seal system.
- ROM coal stockpiles, and in particular coal from A Seam and B Seam tops, are likely to at least partly generate ARD depending on residence times, reaction rates and lag times. Capture and treatment of runoff/leachate from ROM coal stockpiles is likely to be required.
- No direct testing of product coal was carried out, but wash trials indicate pyrite would preferentially report to the rejects stream, and hence the product coal should have a lower risk of ARD relative to ROM coal. Runoff/leachate from product coal stockpiles should be monitored, and provision should be made for capture and treatment if required.

In addition to the above, routine monitoring across the site should be carried out to provide checks on materials management actions and effects of ARD as follows:

- A programme of routine sampling and geochemical testing of overburden/interburden and washery waste materials is recommended during operations to monitor variation in acid potential and to reconcile the predicted distribution of ARD rock types in overburden. Combined total S and NAG testing could be used for screening of overburden/interburden ARD rock types.
- Water quality monitoring of seepage and runoff from pit walls and floors, waste rock dumps, ROM stockpiles and washery waste disposal areas should be carried out to check for ARD generation, assess the performance of management strategies, and determine and/or refine NAF/PAF blending ratios and lime and limestone treatment requirements.
- Site water quality monitoring programmes should include pH, EC, acidity/alkalinity, Ca, Mg, SO_4, Al, As, B, Co, Cr, Cu, Fe, Mn, Ni, Th, U and Zn, to monitor for effects of pyrite oxidation and acid, neutral and alkaline mine drainage.

It is recommended that additional investigations be carried out to better define ARD potential and refine and optimise management strategies, including:

- Continued testing of overburden/interburden and coal to further define the continuity and variation of PAF and NAF materials.
- Further geochemical characterisation of representative washery waste materials when available.
- Leach column testing of representative PAF overburden/interburden and washery wastes to determine lag times before onset of acid conditions and short and long term ARD potential to refine operational and long term management strategies.
- Leach column testing of PAF, PAF-LC and NAF materials in various ratios to help assess the effectiveness of operational blending of ROM overburden/interburden and washery waste materials for ARD control.
- Leach column testing of NAF materials to better evaluate neutral and alkaline mine drainage chemistry.

Note that leach column testing of individual PAF, PAF-LC and NAF rock types has commenced.

Table 1: Acid forming characteristics of overburden/interburden and coal samples tested by EGi.

Hole Name	Depth (m)			Lithology	Seam	Weathering	Comments	Site Sample ID	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					SINGLE ADDITION NAG			ARD Classification
	From	To	Interval									Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
TAR020GT	0.00	1.00	1.00	Soil		Decomposed		1	3576	7.9	0.31	0.03	1	51	-50	55.98	8.4	0		NAF
TAR020GT	1.00	3.90	2.90	Basalt		High		2	3577	7.5	0.28	0.01	0	100	-100	327.48	8.3	0		NAF
TAR020GT	3.90	5.00	1.10	Sandstone		High		3	3578	7.3	0.33	<0.01	0	146	-146	952.28	8.1	0		NAF
TAR020GT	5.00	7.00	2.00	Sandstone/Sand		High		4	3579	7.4	0.43	0.03	1	69	-68	75.05	8.3	0		NAF
TAR020GT	7.00	8.70	1.70	Sandstone/Sand		High		5	3580	7.2	0.36	0.02	1	12	-11	18.94	7.1	0		NAF
TAR020GT	8.70	11.00	2.30	Sandstone		High		6	3581	7.6	0.28	<0.01	0	6	-6	38.16	6.4	0		NAF
TAR020GT	11.00	13.10	2.10	Sandstone		High		7	3582	7.7	0.21	<0.01	0	7	-7	44.83	6.3	0		NAF
TAR020GT	13.10	15.40	2.30	Siltstone		Mod		8	3583	7.3	0.25	0.04	1	5	-4	4.09	6.0	0		NAF
TAR020GT	15.40	18.00	2.60	Sandstone/Siltstone		Mod		9	3584	7.6	0.29	0.06	2	5	-3	2.62	7.1	0		NAF
TAR020GT	18.00	20.15	2.15	Sandstone		Slight		10	3585	6.9	0.24	0.13	4	11	-7	2.82	7.2	0		NAF
TAR020GT	20.15	21.70	1.55	Sandstone/Siltstone		Fresh		11	3586	6.8	0.23	0.12	4	9	-6	2.56	6.9	0		NAF
TAR020GT	21.70	23.60	1.90	Sandstone/Siltstone		Fresh		12	3587	7.1	0.23	0.24	7	10	-3	1.42	6.2	0		NAF
TAR020GT	23.60	29.05	5.45	Sandstone		Fresh	Lesser siltstone	13	3588	4.2	2.26	0.57	17	13	4	0.77	4.7	0		UC(NAF)
TAR020GT	29.05	31.10	2.05	Sandstone/Siltstone/Clay		Fresh		14	3589	4.4	2.02	0.92	28	4	24	0.15	4.1	3	20	PAF-LC
TAR020GT	31.10	33.50	2.40	Sandstone/Siltstone		Fresh	Minor weath clay	15	3590	7.3	0.35	0.26	8	20	-12	2.55	6.2	0		NAF
TAR020GT	33.50	37.00	3.50	Sandstone		Fresh	Lesser siltstone	16	3591	3.5	3.11	0.55	17	7	10	0.39	4.4	0.5	10	UC(PAF-LC)
TAR020GT	37.00	40.65	3.65	Sandstone		Fresh	Lesser siltstone	17	3592	4.5	1.76	0.74	23	0	23	0.00	3.4	9	18	PAF
TAR020GT	40.65	43.00	2.35	Sandstone		Mod		18	3593	6.9	0.33	0.02	1	1	0	1.50	5.4	0		NAF
TAR020GT	43.00	45.25	2.25	Sandstone/Clay		High		19	3594	6.8	0.23	0.83	25	0	25	0.00	3.8	12	21	PAF
TAR020GT	45.25	47.25	2.00	Sandstone/Clay		Fresh	Pyritic	20	3595	3.0	4.41	1.49	46	0	46	0.00	2.6	31	41	PAF
TAR020GT	47.25	47.47	0.22	Conglomerate		Slight	Pyritic	21	3596	2.2	16.21	18.10	554	0	554	0.00	2.1	312	355	PAF
TAR020GT	47.47	48.36	0.89	Coal	A	Fresh		22	3597	2.5	5.45	5.21	159	0	159	0.00	2.0	105	149	PAF
TAR020GT	48.36	49.30	0.94	Sandstone/Siltstone		Fresh	Coaly wisps	23	3598	5.2	1.76	0.18	6	1	5	0.16	4.3	2	25	PAF-LC
TAR020GT	49.30	50.25	0.95	Sandstone/Siltstone		Fresh	Coaly wisps	24	3599	6.2	0.23	0.06	2	1	1	0.67	4.7	0		NAF
TAR020GT	50.25	53.00	2.75	Sandstone		Fresh		25	3600	6.6	0.38	0.02	1	1	-1	2.15	4.9	0		NAF
TAR020GT	53.00	56.00	3.00	Sandstone		Fresh		26	3601	6.3	0.34	0.02	1	0	1	0.00	5.4	0		NAF
TAR020GT	56.00	57.30	1.30	Sandstone		Fresh		27	3602	3.7	0.33	0.04	1	1	0	0.61	4.7	0		NAF
TAR020GT	57.30	58.30	1.00	Sandstone		Fresh		28	3603	7.2	0.18	0.11	3	3	0	0.99	5.1	0		UC(NAF)
TAR020GT	58.30	58.80	0.50	Coal	B Tops	Fresh		29	3604			0.96	29	0	29	0.00	2.1	209	269	PAF
TAR020GT	58.80	61.36	2.56	Coal	B Bottoms	Fresh		30	3605	3.4	0.94	0.82	25	7	18	0.29	2.1	241	300	PAF
TAR020GT	61.36	61.80	0.44	Sandstone/Siltstone		Fresh		31	3606	7.4	0.20	0.07	2	4	-2	1.86	6.1	0		NAF
TAR020GT	61.80	62.70	0.90	Sandstone/Siltstone		Fresh		32	3607	7.5	0.24	0.47	14	0	14	0.00	3.9	3	15	PAF-LC
TAR022GT	0.00	2.84	2.84	Soil		Decomposed	Very Poor recovery	33	3608			0.03	1	1	0	0.66	4.8	0		NAF
TAR022GT	2.84	4.50	1.66	Clay		High		35	3609	6.3	1.04	1.50	46	4	42	0.09	5.7	0		UC(NAF)
TAR022GT	4.50	6.50	2.00	Clay/Sand		High		36	3610	6.8	1.87	1.50	46	16	30	0.35	7.3	0		UC(NAF)
TAR022GT	6.50	10.50	4.00	Clay/Sand		High		37	3611	6.5	1.11	0.99	30	2	29	0.06	5.9	0		UC(NAF)
TAR022GT	10.50	14.50	4.00	Clay/Sand		High		38	3612	7.2	0.33	0.54	17	3	14	0.16	6.1	0		UC(NAF)
TAR022GT	14.50	17.80	3.30	Clay/Sand		High		39	3613	7.3	0.31	0.05	2	1	0	0.96	5.9	0		NAF
TAR022GT	17.80	19.80	2.00	Clay/Sand		High		40	3614	7.4	0.26	0.01	0	3	-3	9.98	5.8	0		NAF
TAR022GT	19.80	20.00	0.20	Sandstone/Siltstone		Mod		41	3615			0.01	0	2	-1	5.00	6.2	0		NAF
TAR022GT	20.00	23.84	3.84	Sandstone/Siltstone		Slight		42	3616	4.4	2.14	0.32	10	2	8	0.19	4.8	0		UC(NAF)
TAR022GT	23.84	24.30	0.46	Clay/Sand		Mod		43	3617	7.5	0.23	0.38	12	8	4	0.67	5.1	0		UC(NAF)
TAR022GT	24.30	27.50	3.20	Siltstone/Sandstone		Fresh		44	3618	7.7	0.23	0.64	20	8	12	0.39	4.4	1	17	PAF-LC
TAR022GT	27.50	31.00	3.50	Siltstone/Sandstone		Fresh		45	3619	7.2	0.26	0.68	21	9	12	0.43	4.6	0		UC(NAF)
TAR022GT	31.00	34.00	3.00	Siltstone/Sandstone		Fresh		46	3620	6.8	0.25	0.70	21	16	6	0.72	4.9	0		UC(NAF)
TAR022GT	34.00	38.00	4.00	Siltstone/Sandstone		Fresh		47	3621	6.7	0.22	0.46	14	11	3	0.79	5.9	0		UC(NAF)
TAR022GT	38.00	41.20	3.20	Siltstone/Sandstone		Fresh		48	3622	3.0	5.11	0.95	29	0	29	0.00	3.3	12	20	PAF
TAR022GT	41.20	41.85	0.65	Sandstone		High		49	3623	7.3	0.61	0.04	1	7	-6	5.56	5.2	0		NAF
TAR022GT	41.85	44.50	2.65	Sandstone		Slight		50	3624	7.2	0.72	<0.01	0	1	-1	4.29	5.6	0		NAF
TAR022GT	44.50	47.25	2.75	Sandstone		Slight		51	3625	6.9	0.40	0.01	0	1	0	1.94	5.4	0		NAF
TAR022GT	47.25	49.00	1.75	Sandstone		High		52	3626	6.8	0.43	0.02	1	1	0	1.32	5.5	0		NAF
TAR022GT	49.00	49.37	0.37	Sandstone		Fresh		53	3627	2.7	3.26	0.54	17	0	17	0.00	3.0	9	13	PAF
TAR022GT	49.37	50.84	1.47	Coal	A	Fresh		54	3628	2.1	15.29	10.10	309	0	309	0.00	1.9	463	493	PAF
TAR022GT	50.84	51.76	0.92	Carb Siltstone/Sandstone		Fresh		55	3629	5.5	0.43	0.01	0	1	-1	2.67	4.2	0.4	18	NAF
TAR022GT	51.76	52.80	1.04	Sandstone		Fresh		56	3630	5.1	1.46	0.11	3	0	3	0.00	4.1	1	15	PAF-LC
TAR022GT	52.80	55.80	3.00	Sandstone		Fresh		57	3631	6.9	0.22	0.11	3	0	3	0.06	4.2	1	15	PAF-LC
TAR022GT	55.80	58.50	2.70	Sandstone		Fresh		58	3632	7.2	0.20	0.02	1	1	0	0.96	5.1	0		NAF
TAR022GT	58.50	59.70	1.20	Sandstone		Fresh		59	3633	7.3	0.20	0.05	2	1	1	0.44	4.8	0		NAF
TAR022GT	59.70	60.70	1.00	Sandstone		Fresh		60	3634	7.4	0.19	0.09	3	0	3	0.06	4.1	1	11	PAF-LC
TAR022GT	60.70	61.20	0.50	Coal	B Tops	Fresh		61	3635	2.9	1.11	0.65	20	1	19	0.03	2.0	215	273	PAF
TAR022GT	61.20	63.62	2.42	Coal	B Bottoms	Fresh		62	3636	3.7	0.74	0.70	21	5	16	0.25	1.9	255	318	PAF
TAR022GT	63.62	66.65	3.03	Sandstone		Fresh	Coaly wisps	63	3637	7.2	0.35	0.28	9	0	9	0.00	3.8	1	12	PAF-LC

Table 1: Acid forming characteristics of overburden/interburden and coal samples tested by EGi.

Hole Name	Depth (m)			Lithology	Seam	Weathering	Comments	Site Sample ID	EGi Sample Number	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					SINGLE ADDITION NAG			ARD Classification
	From	To	Interval									Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
TAR022GT	66.65	67.10	0.45	Sandstone/Siltstone		Fresh		64	3638	2.6	3.39	0.67	21	0	21	0.00	3.2	7	13	PAF
TAR022GT	67.10	67.47	0.37	Sandstone/Siltstone		Fresh		65	3639	6.7	0.88	0.32	10	5	5	0.47	4.2	2	24	PAF-LC
TAR022GT	67.47	67.84	0.37	Sandstone		Fresh		66	3640	6.8	0.63	0.09	3	0	3	0.04	4.9	0		UC(NAF)
TAR027GT	0.00	0.50	0.50	Soil		Decomposed		67	3641	6.6	0.59	0.01	0	22	-21	71.10	7.7	0		NAF
TAR027GT	0.50	2.50	2.00	Soil/Clay/Basalt		High		68	3642			0.02	1	89	-89	145.78	7.5	0		NAF
TAR027GT	2.50	4.50	2.00	Basalt		High		69	3643	7.3	0.15	0.01	0	73	-73	239.18	7.8	0		NAF
TAR027GT	4.50	6.50	2.00	Basalt		High		70	3644	7.2	0.23	<0.01	0	134	-134	874.72	8.2	0		NAF
TAR027GT	6.50	10.50	4.00	Clay/Claystone		High		71	3645	7.5	0.19	<0.01	0	28	-27	180.35	7.4	0		NAF
TAR027GT	10.50	14.50	4.00	Clay/Claystone		High		72	3646	7.6	0.18	<0.01	0	262	-262	1712.42	7.5	0		NAF
TAR027GT	14.50	17.80	3.30	Clay/Claystone		High		73	3647	7.7	0.19	<0.01	0	343	-342	2239.01	8.1	0		NAF
TAR027GT	17.80	19.80	2.00	Clay/Claystone/Sandstone		High		74	3648	7.8	0.17	0.01	0	96	-96	313.60	8.1	0		NAF
TAR027GT	19.80	22.00	2.20	Sandstone		High		75	3649	7.6	0.16	0.01	0	4	-4	13.24	5.9	0		NAF
TAR027GT	22.00	25.00	3.00	Sandstone		High		76	3650	7.7	0.11	0.01	0	1	0	2.36	5.8	0		NAF
TAR027GT	25.00	27.50	2.50	Sandstone		High		77	3651	7.5	0.11	0.02	1	1	0	1.21	5.6	0		NAF
TAR027GT	27.50	30.00	2.50	Clay/Sand		High		78	3652	7.8	0.17	0.01	0	1	0	2.59	5.6	0		NAF
TAR027GT	30.00	34.00	4.00	Clay/Sand		High		79	3653	7.6	0.22	0.41	13	1	12	0.05	5.5	0		UC(NAF)
TAR027GT	34.00	37.00	3.00	Clay/Sand		High		80	3654	7.4	0.23	0.35	11	1	10	0.05	5.8	0		UC(NAF)
TAR027GT	37.00	41.00	4.00	Sand/Clay		High		81	3655	7.5	0.19	0.01	0	1	-1	3.55	5.7	0		NAF
TAR027GT	41.00	45.60	4.60	Sand/Clay		High		82	3656	7.3	0.20	<0.01	0	3	-3	21.50	6.5	0		NAF
TAR027GT	45.60	47.85	2.25	Sand/Clay		High	patches of residual fresh material	83	3657	6.8	0.43	<0.01	0	9	-9	61.60	7.1	0		NAF
TAR027GT	47.85	50.00	2.15	Siltstone/Sandstone		Mod		84	3658	6.7	0.31	0.38	12	0	12	0.00	4.1	2	13	PAF-LC
TAR027GT	50.00	50.80	0.80	Sandstone/Siltstone		Slight		85	3659	4.6	1.75	0.56	17	5	13	0.27	4.3	1	16	PAF-LC
TAR027GT	50.80	53.50	2.70	Siltstone/Sandstone		Fresh		86	3660	4.3	2.36	0.63	19	6	14	0.29	4.2	1	8	PAF-LC
TAR027GT	53.50	54.66	1.16	Siltstone/Sandstone/Clay		Fresh		87	3661	4.5	1.26	0.55	17	6	11	0.36	4.4	0.2	10	PAF-LC
TAR027GT	54.66	58.00	3.34	Siltstone/Sandstone		Fresh		88	3662	4.7	1.07	0.59	18	16	2	0.88	5.7	0		NAF
TAR027GT	58.00	61.20	3.20	Siltstone/Sandstone		Fresh		89	3663	7.2	0.38	0.30	9	16	-6	1.70	6.9	0		NAF
TAR027GT	61.20	61.90	0.70	Siltstone/Sandstone		Fresh		90	3664	5.1	1.99	0.59	18	0	18	0.00	3.6	3	10	PAF-LC
TAR027GT	61.90	64.23	2.33	Siltstone/Sandstone		Fresh		91	3665	5.0	1.87	0.83	25	0	25	0.00	3.6	8	19	PAF
TAR027GT	64.23	65.40	1.17	Siltstone/Sandstone		Fresh	Minor highly weathered clay	92	3666	2.8	4.91	0.95	29	0	29	0.00	2.8	15	23	PAF
TAR027GT	65.40	68.50	3.10	Sandstone		Fresh		93	3667	5.3	1.87	0.42	13	0	13	0.00	2.7	14	18	PAF
TAR027GT	68.50	70.00	1.50	Sandstone		Fresh		94	3668	5.2	1.69	0.24	7	3	4	0.45	3.2	4	8	PAF-LC
TAR027GT	70.00	71.37	1.37	Sandstone		Fresh		95	3669	2.6	3.35	0.81	25	0	25	0.00	2.7	18	22	PAF
TAR027GT	71.37	72.55	1.18	Coal	A	Fresh	Pyritic at top	96	3670	2.1	14.21	13.20	404	0	404	0.00	1.8	247	305	PAF
TAR027GT	72.55	73.75	1.20	Sandstone		Fresh		97	3671	4.2	2.29	0.19	6	0	6	0.03	3.8	1	14	PAF-LC
TAR027GT	73.75	75.90	2.15	Sandstone/Carb Siltstone		Fresh		98	3672	6.8	0.72	0.12	4	2	2	0.56	4.6	0		UC(NAF)
TAR027GT	75.90	77.05	1.15	Sandstone/Carb Siltstone		Fresh		99	3673	2.8	1.91	0.37	11	0	11	0.00	3.3	5	10	PAF-LC
TAR027GT	77.05	79.00	1.95	Carb Sandstone		Fresh		100	3674	6.7	0.32	0.13	4	0	4	0.00	3.6	3	11	PAF-LC
TAR027GT	79.00	81.76	2.76	Carb Sandstone		Fresh		101	3675	4.2	0.43	0.09	3	1	2	0.23	3.9	1	14	PAF-LC
TAR027GT	81.76	83.01	1.25	Sandstone/Gravel		Fresh		102	3676	7.2	0.23	0.17	5	0	5	0.00	4.0	1	11	PAF-LC
TAR027GT	83.01	83.51	0.50	Coal	B Tops	Fresh	Pyritic in part towards top	103	3677	2.3	6.21	4.29	131	0	131	0.00	2.0	86	123	PAF
TAR027GT	83.51	86.07	2.56	Coal	B Bottoms	Fresh	Pyritic in part towards top	104	3678	3.7	0.83	0.74	23	4	19	0.17	1.9	247	299	PAF
TAR027GT	86.07	86.50	0.43	Sandstone/Siltstone		Fresh		105	3679	2.6	2.76	0.44	13	0	13	0.00	4.1	2	14	PAF-LC
TAR027GT	86.50	87.50	1.00	Sandstone/Siltstone		Fresh		106	3680	7.3	0.15	0.21	6	0	6	0.00	4.0	2	15	PAF-LC
TAR027GT	87.50	88.45	0.95	Sandstone/Siltstone		Fresh		107	3681	7.2	0.24	0.16	5	0	5	0.01	4.5	0		UC(NAF)
TAR027GT	88.45	89.23	0.78	Siltstone/Sandstone		Fresh		108	3682	3.9	2.22	0.22	7	0	7	0.00	2.9	12	38	PAF-LC
TAR027GT	89.23	90.48	1.25	Carb Sandstone/Siltstone		Fresh		109	3683	2.6	3.35	0.77	24	0	24	0.00	3.2	8	14	PAF

KEY

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

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

MPA = Maximum Potential Acidity (kgH_2SO_4/t)

ANC = Acid Neutralising Capacity (kgH_2SO_4/t)

NAPP = Net Acid Producing Potential (kgH_2SO_4/t)

NAGpH = pH of NAG liquor

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

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

NAF = Non-Acid Forming

PAF = Potentially Acid Forming

PAF-LC = PAF Low Capacity

UC = Uncertain Classification

(expected classification in brackets)

Coal seam interval

Missing interval or sample not available

Standard NAG results overestimate acid potential due to organic acid effects

Table 2: Acid forming characteristics of overburden/interburden and coal samples tested by SGS in 2011.

Hole Name	Depth (m) From	Depth (m) To	Depth (m) Interval	Lithology	Seam	Weathering	Comments	Site Sample ID	$pH_{1:5}$	$EC_{1:5}$	ACID-BASE ANALYSIS Total %S	CRS (%)	Total C (%)	MPA	ANC	NAPP	ANC/MPA	SINGLE ADDITION NAG NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	ARD Classification
TAR002_OB	0.00	1.00	1.00	Soil		Decomposed		001	8.3	0.46	0.06	0.01	0.63	2	10	-8	5.32	7.6			NAF
TAR002_OB	1.00	7.00	6.00	Clay		High		002	8.5	0.56	0.02	0.01	0.27	1	16	-15	24.90	8.7			NAF
TAR002_OB	7.00	12.00	5.00	Sand		Mod		003	8.2	0.08	0.03	0.01	0.04	1	0	1	0.11	5.6			NAF
TAR002_OB	12.00	22.00	10.00	Clay		Mod		004	8.4	0.06	0.04	0.01	0.05	1	1	0	1.04	6.2			NAF
TAR002_OB	22.00	32.00	10.00	Siltstone/Sandstone		Slight		005	8.2	0.06	0.34	0.01	0.07	10	3	8	0.24	6.1			UC(NAF)
TAR002_OB	32.00	36.00	4.00	Sandstone		Slight		006	8.4	0.03	0.03	0.01	0.15	1	1	0	1.42	6.4			NAF
TAR002_OB	36.00	46.00	10.00	Sandstone		Slight		007	5.9	1.00	0.43	0.27	2.18	13	9	4	0.71	4.2			PAF-LC
TAR002_OB	46.00	56.00	10.00	Sandstone		Slight		008	5.0	0.81	0.59	0.36	2.52	18	12	6	0.66	3.8			PAF-LC
TAR002_OB	56.00	59.00	3.00	Sandstone/Gravel		Fresh		009	4.2	0.47	0.47	0.33	0.43	14	0	14	0.01	2.8			PAF
TAR002_OB	59.00	61.00	2.00	Sandstone		Fresh		010	6.4	0.18	0.04	0.02	0.13	1	1	0	1.01	4.9			NAF
TAR002_OB	61.00	62.00	1.00	Sandstone		Fresh		011	6.2	0.16	0.05	0.02	0.22	2	3	-2	2.22	5.6			NAF
TAR002_OB	62.00	63.00	1.00	Sandstone		Fresh		012	5.2	0.35	0.12	0.08	0.25	4	1	3	0.32	4.0			PAF-LC
TAR002_OB	63.00	64.00	1.00	Sandstone		Fresh		013	5.6	0.38	0.20	0.02	0.39	6	3	4	0.41	3.5			PAF-LC
TAR002_OB	64.00	65.00	1.00	Coal	Seam A	Fresh															
TAR002_OB	65.00	65.50	0.50	Sandstone/Siltstone		Fresh		014	3.7	0.70	0.70	0.42	4.87	21	1	20	0.06	2.8			PAF
TAR002_OB	65.50	66.00	0.50	Sandstone/Siltstone		Fresh		015	4.0	0.56	0.60	0.33	4.53	18	3	16	0.14	2.8			PAF
TAR002_OB	66.00	66.50	0.50	Sandstone/Siltstone		Fresh		016	4.5	0.73	0.49	0.30	1.94	15	1	14	0.08	2.9			PAF
TAR002_OB	66.50	67.00	0.50	Sandstone/Siltstone		Fresh		017	4.5	0.54	0.35	0.25	1.57	11	0	11	0.01	3.1			UC(PAF-LC)
TAR002_OB	67.00	69.00	2.00	Sandstone		Fresh		018	5.1	0.25	0.10	0.06	0.42	3	0	3	0.03	4.2			PAF-LC
TAR002_OB	69.00	71.00	2.00	Sandstone		Fresh		019	4.8	0.31	0.37	0.27	0.26	11	5	6	0.43	2.9			PAF
TAR002_OB	71.00	72.00	1.00	Sandstone		Fresh		020	5.5	0.46	1.14	0.90	1.61	35	60	-25	1.72	4.1			UC(PAF-LC)
TAR002_OB	72.00	73.00	1.00	Sandstone		Fresh		021	4.5	1.00	1.28	1.10		39	1	38	0.03	2.4			PAF
TAR002_OB	73.00	74.00	1.00	Sandstone		Fresh		022	5.4	0.35	0.39	0.25	0.14	12	3	10	0.21	2.9			PAF
TAR002_OB	74.00	77.00	3.00	Coal	Seam B	Fresh															
TAR002_OB	77.00	77.50	0.50	Carb Shale/Sandstone		Fresh		023	3.9	1.00	1.09	0.75	3.85	33	0	33	0.00	2.5			PAF
TAR002_OB	77.50	78.00	0.50	Carb Shale/Sandstone		Fresh		024	4.0	0.77	0.98	0.68	5.98	30	0	30	0.00	2.6			PAF
TAR002_OB	78.00	78.50	0.50	Carb Shale/Sandstone		Fresh		025	2.9	1.50	0.48	0.15	3.72	15	1	13	0.08	3.0			UC(PAF-LC)
TAR002_OB	78.50	79.00	0.50	Carb Shale/Sandstone		Fresh		026	4.1	0.72	0.41	0.25	3.44	13	0	13	0.01	3.1			UC(PAF-LC)
TAR002_OB	79.00	84.00	5.00	Carb Shale/Sandstone		Fresh		027	3.9	0.86	0.41	0.22	1.67	13	0	12	0.01	2.9			PAF
TAR024_OB	0.00	1.00	1.00	Soil		Decomposed		001	7.9	0.86	0.05	<0.01	0.37	1	10	-8	6.67	9.0		0	NAF
TAR024_OB	1.00	4.00	3.00	Sand		High		002	9.0	0.33	0.22	<0.01	2.24	7	170	-163	25.25	8.6		0	NAF
TAR024_OB	4.00	8.00	4.00	Sand		Mod		003	8.9	0.15	0.06	<0.01	0.06	2	1	1	0.62	6.8			UC(NAF)
TAR024_OB	8.00	18.00	10.00	Sand/Clay		Mod		004	8.7	0.11	0.11	<0.01	0.05	3	0	3	0.03	6.0			UC(NAF)
TAR024_OB	18.00	21.00	3.00	Sandstone		Mod		005	8.3	0.06	0.03	<0.01	0.16	1	0	1	0.12	9.3		0	NAF
TAR024_OB	21.00	31.00	10.00	Sandstone/Siltstone		Slight		006	5.9	0.60	0.26	0.13	2.13	8	4	4	0.49	4.7			UC(NAF)
TAR024_OB	31.00	41.00	10.00	Sandstone/Siltstone		Slight		007	5.2	1.10	0.50	0.26	2.27	15	9	6	0.59	3.3			UC(PAF-LC)
TAR024_OB	41.00	51.00	10.00	Sandstone/Siltstone		Slight		008	4.8	0.97	0.59	0.36	2.31	18	29	-11	1.60	3.8			UC(PAF-LC)
TAR024_OB	51.00	53.00	2.00	Sandstone		Slight		009	3.9	0.79	0.45	0.22		14	0	14	0.01	2.7			PAF
TAR024_OB	53.00	56.00	3.00	Sandstone		Fresh		010	5.2	0.87	0.31	0.18	0.16	9	0	9	0.01	3.1			UC(PAF-LC)
TAR024_OB	56.00	58.00	2.00	Sandstone		Fresh		011	4.5	0.70	0.23	0.12	0.12	7	0	7	0.01	3.5			UC(PAF-LC)
TAR024_OB	58.00	59.00	1.00	Sandstone		Fresh		012	6.0	0.11	0.24	0.02		7							UC(PAF)
TAR024_OB	59.00	60.00	1.00	Sandstone		Fresh		013	7.8	0.07	0.03	0.02	0.07	1	0	1	0.11	5.6			NAF
TAR024_OB	60.00	61.00	1.00	Sandstone		Fresh		014	7.7	0.04	0.29	0.04		9	0	9	0.01				UC(PAF)
TAR024_OB	61.00	62.00	1.00	Coal	Seam A	Fresh															
TAR024_OB	62.00	62.50	0.50	Carb Shale		Fresh		015	2.8	1.70	2.24	1.60	11.00	69				2.2	56	73	PAF
TAR024_OB	62.50	63.00	0.50	Carb Shale		Fresh		016	2.7	1.80	2.66	1.70	13.10	81	0	81	0.00	2.1	67	90	PAF
TAR024_OB	63.00	63.50	0.50	Carb Shale		Fresh		017	3.0	1.40	3.15	2.40	3.50	96	0	96	0.00	2.0	80	87	PAF
TAR024_OB	63.50	64.00	0.50	Carb Shale		Fresh		018	3.0	1.40	2.75	2.30	3.69	84	0	84	0.00	2.1	50	82	PAF
TAR024_OB	64.00	66.00	2.00	Sandstone		Fresh		019	4.0	0.54	0.80	0.47	1.55	25	0	24	0.00	2.5	20	25	PAF
TAR024_OB	66.00	67.00	1.00	Sandstone		Fresh		020	5.4	0.17	0.08	0.06	0.17	3	0	2	0.04	4.8	0	3	UC(NAF)
TAR024_OB	67.00	68.00	1.00	Sandstone		Fresh		021	5.4	0.26	0.20	0.14	0.13	6	0	6	0.02	3.5	2	6	PAF-LC
TAR024_OB	68.00	69.00	1.00	Sandstone		Fresh		022	6.0	0.13	0.31	0.12		9	1	9	0.06	3.3	2	4	PAF-LC
TAR024_OB	69.00	72.00	3.00	Coal	Seam B	Fresh															
TAR024_OB	72.00	72.50	0.50	Carb Shale/Sandstone		Fresh		023	5.6	0.66	0.67	0.36	13.90	20	49	-29	2.40	3.5	10	41	UC(NAF)
TAR024_OB	72.50	73.00	0.50	Carb Shale/Sandstone		Fresh		024	5.3	0.67	0.77	0.38	19.00	23	52	-29	2.22	3.1	13	46	UC(NAF)
TAR024_OB	73.00	73.50	0.50	Carb Shale/Sandstone		Fresh		025	4.1	0.70	0.66	0.39	2.10	20	0	20	0.00	2.7	12	19	PAF
TAR024_OB	73.50	74.00	0.50	Carb Shale/Sandstone		Fresh		026	4.2	0.63	0.31	0.13	4.08	10	0	9	0.01	3.3	4	8	PAF-LC
TAR024_OB	74.00	78.00	4.00	Carb Shale/Sandstone		Fresh		027	4.1	0.81	0.52	0.27	1.82	16	0	16	0.01	2.8	9	13	PAF

Table 2: Acid forming characteristics of overburden/interburden and coal samples tested by SGS in 2011.

Hole Name	Depth (m)			Lithology	Seam	Weathering	Comments	Site Sample ID	$pH_{1:5}$	$EC_{1:5}$	ACID-BASE ANALYSIS							SINGLE ADDITION NAG			ARD Classification
	From	To	Interval								Total %S	CRS (%)	Total C (%)	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
TAR027_OB	0.00	1.00	1.00	Soil		Decomposed		001	8.2	0.21	0.09	<0.01	1.02	3	23	-20	8.17	8.2	0	0	NAF
TAR027_OB	1.00	2.00	1.00	Clay		High		002	8.4	0.15	0.15	<0.01	0.42	4	43	-39	9.69	8.7	0	0	NAF
TAR027_OB	2.00	7.00	5.00	Basalt		Mod		003	8.8	0.13	0.11	<0.01	1.35	3	130	-127	37.93	8.6	0	0	NAF
TAR027_OB	7.00	17.00	10.00	Clay		Mod		004	9.0	0.16	0.07	<0.01	1.89	2	150	-148	67.15	9.4	0	0	NAF
TAR027_OB	17.00	21.00	4.00	Clay		Mod		005	9.5	0.14	0.10	<0.01	2.74	3	220	-217	70.49	9.7	0	0	NAF
TAR027_OB	21.00	31.00	10.00	Sand		Mod		006	8.5	0.08	0.07	<0.01	0.09	2	0	2	0.05	8.7	0	0	UC(NAF)
TAR027_OB	31.00	41.00	10.00	Sand		Slight		007	8.3	0.07	0.42	<0.01	0.08	13	0	13	0.01	8.0	0	0	UC(NAF)
TAR027_OB	41.00	45.00	4.00	Sand		Fresh		008	8.1	0.10	0.04	<0.01	0.49	1	12	-11	9.12	7.9	0	0	NAF
TAR027_OB	45.00	55.00	10.00	Sandstone/Siltstone		Fresh		009	5.7	1.00	0.47	0.23	2.01	15	9	5	0.65	3.6	2	7	PAF-LC
TAR027_OB	55.00	65.00	10.00	Sandstone/Siltstone		Fresh		010	4.6	1.20	0.75	0.36	1.96	23	14	9	0.61	3.4	4	11	PAF-LC
TAR027_OB	65.00	66.00	1.00	Sandstone/Siltstone		Fresh		011	4.2	0.83	1.05	0.88	0.48	32	0	32	0.00	2.4	28	32	PAF
TAR027_OB	66.00	68.00	2.00	Sandstone		Fresh		012	4.7	0.46	0.20	0.14	0.19	6	1	5	0.19	3.3	3	6	PAF-LC
TAR027_OB	68.00	69.00	1.00	Sandstone		Fresh		013	4.9	0.38	0.11	0.06	0.10	3	0	3	0.03	3.8	1	3	PAF-LC
TAR027_OB	69.00	70.00	1.00	Sandstone		Fresh		014	4.5	0.69	0.27	0.18	0.12	8	0	8	0.01	3.0	6	8	UC(PAF-LC)
TAR027_OB	70.00	71.00	1.00	Sandstone		Fresh		015	2.3	8.20	10.70	6.90	8.04	327	0	327	0.00	1.9	260	290	PAF
TAR027_OB	71.00	72.00	1.00	Coal	Seam A	Fresh															
TAR027_OB	72.00	72.50	0.50	Sandstone/Carb Sandstone		Fresh		016	2.4	4.90	7.06	5.40	16.60	216	0	216	0.00	1.8	200	230	PAF
TAR027_OB	72.50	73.00	0.50	Sandstone/Carb Sandstone		Fresh		017	3.8	0.59	0.48	0.35	2.67	15	0	15	0.01	2.7	13	18	PAF
TAR027_OB	73.00	73.50	0.50	Sandstone/Carb Sandstone		Fresh		018	4.2	0.58	0.44	0.35	3.05	13	0	13	0.01	2.6	13	17	PAF
TAR027_OB	73.50	74.00	0.50	Sandstone/Carb Sandstone		Fresh		019	3.8	0.88	0.87	0.61	2.62	27	0	27	0.00	2.4	24	31	PAF
TAR027_OB	74.00	76.00	2.00	Sandstone/Carb Sandstone		Fresh		020	4.1	0.46	0.51	0.37	2.17	16	0	15	0.01	2.7	12	17	PAF
TAR027_OB	76.00	77.00	1.00	Sandstone		Fresh		021	5.1	0.15	0.10	0.08	0.22	3	0	3	0.03	3.6	2	3	PAF-LC
TAR027_OB	77.00	79.00	2.00	Sandstone		Fresh		022	4.1	1.10	1.93	1.60	1.29	59	0	59	0.00	2.1	51	58	PAF
TAR027_OB	79.00	80.00	1.00	Sandstone		Fresh		023	5.3	0.31	0.25	0.15	1.03	7	0	7	0.01	3.1	4	7	PAF-LC
TAR027_OB	80.00	81.00	1.00	Sandstone		Fresh		024	5.7	0.52	0.37	0.25	0.27	11	0	11	0.01	3.0	5	9	PAF-LC
TAR027_OB	81.00	82.00	1.00	Sandstone		Fresh		025	3.9	1.70	2.56	1.80	17.20	78	0	78	0.00	2.1	65	78	PAF
TAR027_OB	82.00	85.00	3.00		Seam B	Fresh															
TAR027_OB	85.00	85.50	0.50	Sandstone/Carb Sandstone		Fresh		026	3.9	0.67	0.36	0.21	6.28	11	0	11	0.01	3.1	4	9	PAF-LC
TAR027_OB	85.50	86.00	0.50	Sandstone/Carb Sandstone		Fresh		027	5.1	0.43	0.28	0.19		9	0	8	0.01	3.0	4	6	PAF-LC
TAR027_OB	86.00	86.50	0.50	Sandstone/Carb Sandstone		Fresh		028	5.3	0.28	0.12	0.07		4	2	2	0.54	4.3		1	PAF-LC
TAR027_OB	86.50	87.00	0.50	Sandstone/Carb Sandstone		Fresh		029	6.8	0.29	0.07	0.04	1.40	2	9	-7	4.05	7.0	0	0	NAF
TAR027_OB	87.00	90.00	3.00	Sandstone/Carb Sandstone		Fresh		030	3.8	0.79	0.57	0.37	4.99	17	0	17	0.01	2.7	10	16	PAF
TAR028_OB	0.00	1.00	1.00	Soil		Decomposed		001		0.52	0.04	0.03	0.96	1	34	-33	29.24	8.0	0	0	NAF
TAR028_OB	1.00	7.00	6.00	Clay		High		002		1.30	0.01	<0.01	0.18	0	14	-14	65.36	7.8	0	0	NAF
TAR028_OB	7.00	12.00	5.00	Clay/Sand		High		003		0.60	0.01	<0.01	0.36	0	32	-32	149.39	8.3	0	0	NAF
TAR028_OB	12.00	21.00	9.00	Sand		High		004		0.58	0.01	<0.01	0.09	0	1	-1	5.45	6.6		0	NAF
TAR028_OB	21.00	31.00	10.00	Sand		Mod		005		0.32	0.03	<0.01	0.09	1	0	1	0.13	6.0		0	NAF
TAR028_OB	31.00	40.00	9.00	Sand		Mod		006		0.23	0.02	0.01	0.29	1	5	-4	6.67	6.9		0	NAF
TAR028_OB	40.00	50.00	10.00	Siltstone/Sandstone		Slight		007		1.20	0.58	0.36	1.09	18	1	17	0.06	2.8	7	11	PAF
TAR028_OB	50.00	52.00	2.00	Sandstone		Fresh		008		0.27	0.15	0.11	0.10	5	1	4	0.22	3.2	3	4	PAF-LC
TAR028_OB	52.00	53.00	1.00	Sandstone		Fresh		009		0.49	0.38	0.26	0.08	12	0	12	0.01	2.8	6	7	PAF
TAR028_OB	53.00	54.00	1.00	Sandstone		Fresh		010		0.35	0.16	0.12	0.06	5	0	5	0.02	3.2	3	4	PAF-LC
TAR028_OB	54.00	55.00	1.00	Sandstone		Fresh		011		1.10	1.50	1.10	8.37	46	0	46	0.00	2.2	33	38	PAF
TAR028_OB	55.00	56.00	1.00	Coal	Seam A	Fresh															
TAR028_OB	56.00	56.50	0.50	Carb Sandstone/Sandstone		Fresh		012		1.30	1.60	1.20	24.10	49	0	49	0.00	2.1	57	84	PAF
TAR028_OB	56.50	57.00	0.50	Carb Sandstone/Sandstone		Fresh		013		0.45	0.43	0.15	4.21	13	0	13	0.01	2.9	7	13	PAF
TAR028_OB	57.00	57.50	0.50	Sandstone		Fresh		014		0.55	0.31	0.22		9	1	8	0.11	3.1	4	8	PAF-LC
TAR028_OB	57.50	58.00	0.50	Sandstone		Fresh		015		0.44	0.36	0.27	1.35	11	2	9	0.18	2.9	5	8	PAF-LC
TAR028_OB	58.00	61.00	3.00	Sandstone		Fresh		016		0.41	0.39	0.29	0.67	12	0	12	0.01	2.8	6	10	PAF
TAR028_OB	61.00	63.00	2.00	Sandstone		Fresh		017		0.12	0.04	0.04	0.21	1	2	-1	1.72	4.4	0	1	NAF
TAR028_OB	63.00	64.00	1.00	Sandstone		Fresh		018		0.13	0.07	0.07	0.07	2	1	1	0.47	3.7	1	3	PAF-LC
TAR028_OB	64.00	65.00	1.00	Sandstone		Fresh		019		0.09	0.02	0.02	0.11	1	1	0	1.72	4.2	0	2	NAF
TAR028_OB	65.00	66.00	1.00	Sandstone		Fresh		020		0.15	0.21	0.13	15.20	6	0	6	0.02	3.6	4	13	PAF-LC
TAR028_OB	66.00	69.00	3.00	Coal	Seam B	Fresh															
TAR028_OB	69.00	69.50	0.50	Carb Sandstone/Sandstone		Fresh		021		0.80	0.52	0.29		16	0	16	0.01	2.8	10	18	PAF
TAR028_OB	69.50	70.00	0.50	Carb Sandstone/Sandstone		Fresh		022		0.90	0.76	0.47	2.67	23	0	23	0.00	2.6	12	17	PAF
TAR028_OB	70.00	70.50	0.50	Carb Sandstone/Sandstone		Fresh		023		0.70	0.73	0.49		22	0	22	0.00	2.7	10	18	PAF
TAR028_OB	70.50	71.00	0.50	Carb Sandstone/Sandstone		Fresh		024		0.50	0.22	0.12		7	0	7	0.01	3.4	2		PAF-LC
TAR028_OB	71.00	73.00	2.00	Carb Sandstone/Sandstone		Fresh		025		0.84	0.65	0.42	2.74	20	0	20	0.01	2.6	10		PAF
TAR028_OB	73.00	78.00	5.00	Sandstone		Fresh		026		0.50	0.45	0.33	1.12	14	4	10	0.28	3.1	5		PAF-LC

Table 2: Acid forming characteristics of overburden/interburden and coal samples tested by SGS in 2011.

Hole Name	Depth (m)			Lithology	Seam	Weathering	Comments	Site Sample ID	$pH_{1:5}$	$EC_{1:5}$	ACID-BASE ANALYSIS							SINGLE ADDITION NAG			ARD Classification
	From	To	Interval								Total %S	CRS (%)	Total C (%)	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
TAR030_OB	0.00	1.00	1.00	Soil		Decomposed		001	7.9	0.31	0.02	0.01	0.92	1	21	-20	34.31	7.4	0	0	NAF
TAR030_OB	1.00	2.00	1.00	Clay		High		002	8.7	0.20	0.01	0.01	1.02	0	91	-91	424.84	8.2	0	0	NAF
TAR030_OB	2.00	7.00	5.00	Igneous Rock/Clay		Mod/High		003	8.7	0.20	<0.01	<0.01	1.08	0	98	-98	640.52	8.3	0	0	NAF
TAR030_OB	7.00	17.00	10.00	Clay		High		004	8.5	0.21	<0.01	<0.01	0.16	0	11	-11	71.90	7.8	0	0	NAF
TAR030_OB	17.00	27.00	10.00	Clay		High		005	8.9	0.18	<0.01	<0.01	2.08	0	170	-170	1111.11	8.5	0	0	NAF
TAR030_OB	27.00	37.00	10.00	Clay		High		006	9.0	0.16	<0.01	<0.01	0.22	0	18	-18	117.65	8.4	0	0	NAF
TAR030_OB	37.00	47.00	10.00	Sandstone/Clay		Mod/High		007	9.0	0.16	0.02	0.01	0.40	0	15	-15	32.68	8.0	0	0	NAF
TAR030_OB	47.00	52.00	5.00	Sandstone/Clay		Mod/High		008	9.0	0.12	<0.01	0.13		0	10	-10	64.05	8.2	0	0	NAF
TAR030_OB	52.00	62.00	10.00	Sandstone/Siltstone		Slightly/Mod		009	7.1	0.82	0.40	0.26		12	14	-2	1.14	5.1	0	2	NAF
TAR030_OB	62.00	66.00	4.00	Siltstone/Sandstone		Slightly/Mod		010	7.2	1.10	0.79	0.60		24	38	-14	1.57	4.9	0	5	NAF
TAR030_OB	66.00	71.00	5.00	Siltstone/Sandstone		Fresh		011	7.1	1.10	0.45	0.29		14	35	-21	2.54	6.7	0		NAF
TAR030_OB	71.00	73.00	2.00	Sandstone/Siltstone		Fresh		012	4.8	1.30	0.89	0.51		27	0	27	0.00	2.7	10	14	PAF
TAR030_OB	73.00	74.00	1.00	Sandstone		Fresh		013	6.3	1.50	0.92	0.57		28	7	21	0.25	2.8	8	13	PAF
TAR030_OB	74.00	76.00	2.00	Sandstone		Fresh		014	6.7	0.95	0.71	0.45	0.53	22	3	19	0.13	2.7	9	12	PAF
TAR030_OB	76.00	77.00	1.00	Sandstone		Fresh		015	7.2	0.52	0.43	0.33	0.31	13	5	8	0.37	3.3	3	7	PAF-LC
TAR030_OB	77.00	78.00	1.00	Sandstone		Fresh		016	7.3	0.49	0.27	0.20	0.27	8	6	2	0.71	3.8	1	2	PAF-LC
TAR030_OB	78.00	79.00	1.00	Sandstone		Fresh		017	4.8	2.40	5.60	4.10	3.99	171	0	171	0.00	1.9	92	100	PAF
TAR030_OB	79.00	81.00	2.00	Coal	Seam A	Fresh															
TAR030_OB	81.00	81.50	0.50	Carb Sandstone/Sandstone		Fresh		018	6.3	0.76	0.62	0.42	14.40	19	1	18	0.05	2.8	9	19	PAF
TAR030_OB	81.50	82.00	0.50	Carb Sandstone/Sandstone		Fresh		019	5.3	0.58	0.42	0.26	6.76	13	0	13	0.01	2.9	6	13	PAF
TAR030_OB	82.00	82.50	0.50	Sandstone/Carb Sandstone		Fresh		020	5.2	0.68	0.44	0.28	5.72	13	0	13	0.01	3.0	7	17	UC(PAF-LC)
TAR030_OB	82.50	83.00	0.50	Sandstone/Carb Sandstone		Fresh		021	7.1	0.56	0.29	0.19	1.84	9	0	9	0.01	3.8	2	5	PAF-LC
TAR030_OB	83.00	85.00	2.00	Sandstone/Carb Sandstone		Fresh		022	6.9	0.34	0.37	0.28	0.79	11	0	11	0.01	3.2	4	7	PAF-LC
TAR030_OB	85.00	86.00	1.00	Sandstone/Carb Sandstone		Fresh		023	6.7	0.77	0.99	0.67	1.04	30	14	16	0.46	3.1	5	9	PAF-LC
TAR030_OB	86.00	87.00	1.00	Sandstone/Carb Sandstone		Fresh		024	7.8	0.15	0.08	0.07	0.37	3	0	2	0.04	4.9	0	1	UC(NAF)
TAR030_OB	87.00	88.00	1.00	Sandstone/Carb Sandstone		Fresh		025	6.5	0.36	0.52	0.39	5.13	16	9	7	0.55	3.3	4	13	PAF-LC
TAR030_OB	88.00	91.00	3.00	Coal	Seam B	Fresh															
TAR030_OB	91.00	91.50	0.50	Sandstone/Carb Sandstone		Fresh		026	5.5	0.67	0.34	0.19	6.69	10	6	5	0.57	3.6	2	12	PAF-LC
TAR030_OB	91.50	92.00	0.50	Sandstone/Carb Sandstone		Fresh		027	5.9	0.71	0.36	0.22	3.56	11	4	7	0.35	3.6	2	7	PAF-LC
TAR030_OB	92.00	92.50	0.50	Sandstone/Carb Sandstone		Fresh		028	4.7	0.75	0.50	0.30	3.03	15	0	15	0.01	2.9	7	11	PAF
TAR030_OB	92.50	93.00	0.50	Sandstone/Carb Sandstone		Fresh		029	5.9	0.65	0.30	0.19	1.70	9	1	8	0.11	3.4	2	5	PAF-LC
TAR030_OB	93.00	97.00	4.00	Sandstone/Carb Sandstone		Fresh		030	5.7	0.67	0.55	0.40	2.13	17	2	15	0.12	2.9	7	10	PAF
TAR034_OB	0.00	1.00	1.00	Soil		Decomposed		001	8.7	0.17	0.01	0.01	1.37	0	88	-88	261.44	8.2	0	0	NAF
TAR034_OB	1.00	11.00	10.00	Basalt		Mod		002	8.8	0.13	<0.01	<0.01	1.16	0	160	-160	1045.75	8.4	0	0	NAF
TAR034_OB	11.00	12.00	1.00	Basalt		Mod		003	8.9	0.16	<0.01	<0.01	1.74	0	190	-190	1241.83	8.6	0	0	NAF
TAR034_OB	12.00	20.00	8.00	Clay		High		004	8.7	0.14	<0.01	<0.01	0.13	0	18	-18	117.65	8.3	0	0	NAF
TAR034_OB	20.00	30.00	10.00	Sand/Clay		Mod/High		005	9.1	0.14	<0.01	<0.01	1.33	0	110	-110	718.95	8.4	0	0	NAF
TAR034_OB	30.00	32.00	2.00	Sand/Clay		Mod/High		006	9.2	0.14	0.01	<0.01	2.76	0	240	-240	980.39	8.4	0	0	NAF
TAR034_OB	32.00	42.00	10.00	Clay		High		007	9.3	0.19	0.02	<0.01	0.24	1	27	-26	51.90	8.3	0	0	NAF
TAR034_OB	42.00	44.00	2.00	Clay		High		008	8.5	0.83	0.24	0.13	0.43	7	14	-7	1.91	6.7	0		NAF
TAR034_OB	44.00	47.00	3.00	Clay/Siltstone		High/Mod		009	7.0	1.80	1.50	1.10	6.38	46	49	-3	1.07	5.4	0	1	NAF
TAR034_OB	47.00	53.00	6.00	Clay/Sandstone		High/Mod		010	8.4	0.77	0.37	0.26	5.46	11	420	-409	37.10	8.7	0	0	NAF
TAR034_OB	53.00	60.00	7.00	Sandstone/Siltstone		Mod		011	8.8	0.36	0.14	0.10	5.42	4	440	-436	102.71	8.9	0	0	NAF
TAR034_OB	60.00	70.00	10.00	Sandstone/Siltstone		Slight		012	8.6	0.37	0.12	0.09	1.09	4	43	-39	11.71	8.8	0	0	NAF
TAR034_OB	70.00	72.00	2.00	Sandstone		High	Fe Staining	013	8.6	0.28	0.09	0.07	0.61	3	17	-14	6.39	8.7	0	0	NAF
TAR034_OB	72.00	75.00	3.00	Sandstone/Siltstone		Slight		014	7.9	0.76	0.34	0.24	1.77	10	30	-20	2.88	8.4	0	0	NAF
TAR034_OB	75.00	76.00	1.00	Sandstone/Siltstone		Mod	Fe Staining	015	8.0	0.63	0.15	0.10	0.60	5	12	-7	2.61	8.3	0	0	NAF
TAR034_OB	76.00	78.00	2.00	Sandstone/Siltstone		Mod	Fe Staining	016	7.9	8.70	0.17	0.10	0.65	5	19	-14	3.65	8.9	0	0	NAF
TAR034_OB	78.00	79.00	1.00	Sandstone/Siltstone		Mod	Fe Staining	017	7.5	0.76	1.10	0.74	0.32	34	8	26	0.23	2.8	10	13	PAF
TAR034_OB	79.00	80.00	1.00	Sandstone/Siltstone		Mod	Fe Staining	018	8.1	0.53	0.43	0.32		13	13	0	0.99	6.5	0		UC(NAF)
TAR034_OB	80.00	81.00	1.00	Sandstone/Siltstone		Mod	Fe Staining	019	8.3	0.45	0.29	0.21	0.19	9	8	1	0.88	5.1	0	1	UC(NAF)
TAR034_OB	81.00	84.00	3.00	Coal	Seam A	Fresh															
TAR034_OB	84.00	84.50	0.50	Sandstone/Carb Sandstone		Fresh		020	7.9	0.36	0.22	0.19	1.79	7	8	-1	1.16	6.0	0		NAF
TAR034_OB	84.50	85.00	0.50	Sandstone/Carb Sandstone		Fresh		021	7.7	0.43	0.21	0.14	1.56	6	4	3	0.61	5.1	0		UC(NAF)
TAR034_OB	85.00	85.50	0.50	Sandstone/Carb Sandstone		Fresh		022	7.6	0.63	0.46	0.30	1.20	14	12	2	0.85	5.7	0		UC(NAF)
TAR034_OB	85.50	86.00	0.50	Sandstone/Carb Sandstone		Fresh		023	8.2	0.27	0.10	0.08	1.77	3	1	2	0.33	7.0	0	0	UC(NAF)
TAR034_OB	86.00	87.00	1.00	Sandstone		Fresh		024	7.5	0.27	0.09	0.06	1.16	3	2	1	0.77	4.2	1	2	PAF-LC
TAR034_OB	87.00	88.00	1.00	Sandstone		Fresh		025	7.1	0.22	0.12	0.10	1.28	4	0	4	0.03	3.6	1	3	PAF-LC
TAR034_OB	88.00	89.00	1.00	Sandstone		Fresh		026	6.0	0.26	0.12	0.09	0.26	4	0	4	0.03	3.6	1	3	PAF-LC
TAR034_OB	89.00	90.00	1.00	Sandstone		Fresh		027	5.7	0.29	0.15	0.11	0.60	5	1	4	0.22	3.9	1	2	PAF-LC

Table 2: Acid forming characteristics of overburden/interburden and coal samples tested by SGS in 2011.

Hole Name	Depth (m)			Lithology	Seam	Weathering	Comments	Site Sample ID	$pH_{1:5}$	$EC_{1:5}$	ACID-BASE ANALYSIS							SINGLE ADDITION NAG			ARD Classification
	From	To	Interval								Total %S	CRS (%)	Total C (%)	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	
TAR034_OB	90.00	94.00	4.00	Coal	Seam B	Fresh															
TAR034_OB	94.00	94.50	0.50	Sandstone/Carb Sandstone		Fresh		028	5.2	0.40	0.16	0.09	5.46	5	1	4	0.20	3.4	2	8	PAF-LC
TAR034_OB	94.50	95.00	0.50	Sandstone/Carb Sandstone		Fresh		029	6.4	0.39	0.10	0.06	1.78	3	3	0	0.95	6.2	0		UC(NAF)
TAR034_OB	95.00	95.50	0.50	Sandstone/Carb Sandstone		Fresh		030	6.0	0.40	0.12	0.07	2.00	4	4	0	1.06	6.6	0		NAF
TAR034_OB	95.50	96.00	0.50	Sandstone/Carb Sandstone		Fresh		031	5.0	0.51	0.25	0.16	2.22	8	0	8	0.01	3.1	3	6	PAF-LC
TAR034_OB	96.00	103.00	7.00	Sandstone/Carb Sandstone		Fresh		032	4.3	0.64	0.89	0.65	1.13	27	0	27	0.00	2.5	15	18	PAF

KEY

$pH_{1:5}$ = pH of 1:5 extract

$EC_{1:5}$ = Electrical Conductivity of 1:5 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

PAF = Potentially Acid Forming

PAF-LC = PAF Low Capacity

UC = Uncertain Classification

(expected classification in brackets)

Coal seam interval

Missing interval or sample not available

Standard NAG results overestimate acid potential due to organic acid effects

Table 3: Extended boil and calculated NAG test results for selected overburden/interburden and coal samples.

EGi Sample Number	Site Sample Number	Summary Lithology	ACID-BASE ANALYSIS					STANDARD NAG TEST			Extended Boil NAGpH	Calculated NAG
			Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$		
3589	14	Sandstone	0.92	27	4	23	0.16	4.1	3	20	4.3	13
3592	17	Sandstone	0.74	22	0	22	0.00	3.4	9	18	3.7	15
3598	23	Sandstone	0.18	5	1	4	0.20	4.3	2	25	5.7	3
3604	29	Coal	0.96	28	0	28	0.00	2.1	209	269	3.7	24
3605	30	Coal	0.82	23	7	15	0.32	2.1	241	300	5.0	15
3618	44	Siltstone	0.64	14	8	6	0.55	4.4	1	17	4.3	10
3627	53	Sandstone	0.54	1	0	1	0.00	3.0	9	13	3.3	12
3634	60	Sandstone	0.09	3	0	3	0.05	4.1	1	11	4.3	2
3635	61	Coal	0.65	9	1	9	0.07	2.0	215	273	3.7	19
3636	62	Coal	0.70	14	5	9	0.39	1.9	255	318	4.3	19
3639	65	Sandstone	0.32	9	5	5	0.50	4.2	2	24	4.7	6
3664	90	Siltstone	0.59	18	0	18	0.00	3.6	3	10	3.6	7
3665	91	Siltstone	0.83	25	0	25	0.00	3.6	8	19	3.6	15
3678	104	Coal	0.74	19	4	15	0.21	1.9	247	299	4.7	16
3682	108	Siltstone	0.22	8	0	8	0.00	2.9	12	38	6.4	3

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)

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 4: Sulphur speciation results for selected overburden/interburden and coal samples.

EGi Sample Number	Summary Lithology	Seam	Total %S	Pyritic S (%)	Acid Sulphate %S	Total Acid Generating S (%)	Non-Acid Sulphate %S	Low Risk S Forms (%)	Proportion Total Acid Generating to Total S
3589	Sandstone		0.97	0.45	0.07	0.52	0.45	0.00	53%
3592	Sandstone		0.78	0.20	0.20	0.40	0.38	0.00	52%
3604	Coal	B Tops	0.79	0.21	0.14	0.35	0.18	0.26	44%
3605	Coal	B Bottoms	0.68	0.22	0.04	0.26	0.13	0.29	38%
3618	Siltstone		0.68	0.41	0.04	0.45	0.23	0.00	66%
3619	Siltstone		0.64	0.31	0.08	0.39	0.25	0.00	61%
3628	Coal	A	12.75	9.60	1.84	11.44	1.31	0.00	90%
3630	Sandstone		0.12	0.07	0.03	0.10	0.02	0.00	84%
3635	Coal	B Tops	0.70	0.12	0.07	0.19	0.10	0.41	27%
3636	Coal	B Bottoms	0.82	0.18	0.04	0.22	0.05	0.55	27%
3640	Sandstone		0.09	0.04	0.02	0.06	0.03	0.00	65%
3664	Siltstone		0.58	0.20	0.09	0.29	0.29	0.00	50%
3665	Siltstone		0.80	0.03	0.25	0.28	0.52	0.00	35%
3670	Coal	A	15.25	9.97	1.51	11.48	3.77	0.00	75%
3677	Coal	B Tops	4.16	2.32	0.47	2.79	1.37	0.00	67%
3678	Coal	B Bottoms	0.62	0.13	0.02	0.15	0.18	0.30	24%
3682	Siltstone		0.19	0.05	0.07	0.12	0.07	0.00	61%

Pyritic S (%) = CRS (%)

Acid Sulphate S = KCl Acid Sulphate S

Total Acid Generating S = Pyritic S + Acid Sulphate S

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

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

Table 5: Multi-element composition of selected overburden/interburden and coal sample solids (mg/kg except where shown).

Element	Detection Limit	Lithology/Sample Number																			
		Soil	Sandstone	Sandstone	Sandstone	Sandstone	Coal - A Seam	Coal - B Seam Bottoms	Clay	Clay	Sandstone	Siltstone	Soil	Basalt	Siltstone	Siltstone	Sandstone	Sandstone	Sandstone	Coal - B Seam Tops	Coal - B Seam Bottoms
		3576	3586	3588	3591	3595	3597	3605	3609	3610	3616	3622	3641	3643	3663	3665	3669	3671	3675	3677	3678
Ag	0.01	0.13	0.08	0.1	0.16	0.05	0.06	0.03	0.07	0.04	0.09	0.14	0.07	0.09	0.17	0.14	0.05	0.07	0.05	0.03	0.03
Al	0.01%	6.19%	7.15%	7.53%	6.75%	2.47%	1.17%	0.69%	4.88%	6.32%	6.95%	6.45%	6.59%	7.75%	8.55%	5.87%	2.25%	6.27%	3.17%	1.08%	0.91%
As	0.2	2.5	6.6	12.1	14.8	6.6	19.5	1.7	14.8	5.6	14.9	15.4	2.3	0.4	14.7	13	6.1	2	1	16.5	0.7
Ba	10	240	410	400	400	270	50	60	420	460	340	190	480	410	440	250	330	340	270	50	200
Be	0.05	1.11	2.19	2.33	1.83	0.69	7.08	1.02	1.61	1.23	2.86	1.7	0.81	0.66	2.35	1.6	0.77	1.96	0.73	3.29	1.7
Bi	0.01	0.12	0.28	0.49	0.47	0.07	0.24	0.14	0.32	0.22	0.34	0.33	0.08	0.02	0.62	0.31	0.09	0.29	0.08	0.16	0.24
Ca	0.01%	1.95%	0.16%	0.18%	0.19%	0.02%	0.12%	0.15%	0.06%	0.40%	0.12%	0.06%	1.26%	4.93%	0.32%	0.08%	0.02%	0.04%	0.01%	0.06%	0.19%
Cd	0.02	0.03	0.28	0.13	0.15	0.22	0.1	0.03	<0.02	<0.02	0.18	0.26	0.04	0.04	0.15	0.14	0.04	0.06	<0.02	0.06	0.03
Ce	0.01	59.9	70	86	64.7	22.6	31.3	7.81	44.6	77.5	89.1	56.1	51	27.4	82.1	51.2	24.5	62.6	21.5	23.5	17.35
Co	0.1	37.6	8.1	8.8	6.9	4.1	16	2.1	15.8	4.7	15.8	9.4	48.5	38.3	8.9	5.9	3.1	2	1.8	7.7	2.9
Cr	1	163	36	49	41	17	34	4	79	62	38	41	230	214	48	36	21	35	13	10	7
Cs	0.05	0.49	6.98	9.32	8.51	1.62	0.25	<0.05	3.95	3.66	8.69	6.58	0.99	0.68	11.4	6.72	1.3	10.45	2.15	0.21	0.08
Cu	0.2	35.4	13.4	20	24.2	3.9	10.1	5.8	22.8	13.5	16.6	17.2	43.3	51.6	34.8	14.8	3.3	12.8	3.5	8.5	9.7
Fe	0.01%	5.17%	2.75%	3.56%	4.34%	2.55%	3.28%	1.28%	8.74%	4.29%	2.62%	1.75%	6.19%	7.16%	4.47%	1.70%	1.93%	1.32%	0.96%	2.03%	0.70%
Ga	0.05	17.25	19.05	20.4	18.15	6.31	9.84	2.77	17.5	15.2	18.15	16.1	18.35	19.8	22.9	15.35	7.89	18.05	7.4	5.62	4.63
Ge	0.05	0.19	0.16	0.22	0.2	0.13	1.54	0.2	0.23	0.16	0.24	0.16	0.24	0.29	0.27	0.18	0.16	0.2	0.16	0.24	0.3
Hf	0.1	3.1	4.1	4.7	4	1.6	2	0.9	4.5	4.6	4.4	4.1	3	2.5	4.8	3.5	1.4	4.3	1.5	1.3	1.6
Hg	0.005	0.007	0.032	0.04	0.024	0.018	0.044	0.009	0.027	0.014	0.051	0.026	0.012	0.157	0.051	0.03	0.006	0.04	0.008	0.416	0.006
In	0.005	0.053	0.061	0.071	0.07	0.015	0.034	0.015	0.085	0.072	0.059	0.055	0.06	0.061	0.087	0.049	0.013	0.059	0.017	0.021	0.029
K	0.01%	0.07%	2.20%	2.05%	1.33%	0.83%	0.04%	0.01%	1.16%	1.25%	1.78%	0.93%	0.11%	0.23%	1.83%	1.07%	0.76%	1.68%	1.25%	0.03%	0.02%
La	1	28.8	34.4	39.9	28.5	11.1	17.6	3.7	23	44.3	39.9	25	20.5	12.8	36.9	23	12.1	32.3	11.1	10.9	8
Li	0.2	12.1	47.9	44.7	37.1	14.8	9.8	10	10.1	15.5	51.2	35.8	12.3	6	40.2	35.5	20.3	43.5	15.2	9.7	18.1
Mg	0.01%	1.12%	0.34%	0.42%	0.31%	0.03%	0.05%	0.04%	0.25%	0.36%	0.35%	0.14%	1.16%	3.98%	0.66%	0.17%	0.03%	0.19%	0.05%	0.02%	0.04%
Mn	5	997	416	362	501	128	43	212	349	183	371	94	1460	950	380	83	139	106	96	14	76
Mo	0.05	0.64	0.53	1.1	3.43	3.21	6.61	0.8	2.88	1.32	1.03	4.36	0.43	0.67	2.14	3.94	2.13	0.57	0.53	2.2	0.59
Na	0.01%	0.06%	0.06%	0.06%	0.05%	0.03%	0.03%	0.01%	0.14%	0.14%	0.08%	0.04%	0.06%	1.59%	0.06%	0.05%	0.03%	0.05%	0.05%	0.01%	0.01%
Nb	0.1	22.3	13.9	13.9	8.6	3.4	4.2	2.3	12.1	10.5	13.2	8.1	17.9	15	11.2	7.7	3	14.4	5.1	3.8	3.6
Ni	0.2	110.5	17.3	23.5	17	12.1	38	2.3	41.6	13.4	39.8	20.9	137	167.5	19.6	17.5	7.9	10.7	5	17	2.5
P	10	160	410	390	430	170	120	490	510	480	290	200	160	1010	660	230	290	110	70	120	650
Pb	0.5	9.4	24.7	24.7	19.7	10.5	6.8	3.3	19.3	26.1	22.5	17.1	7.3	1.6	25.7	16.1	10	23.8	13.7	5.6	5.6
Rb	0.1	3.6	133.5	135	91.3	47	2.6	0.1	32.4	38.9	118	66.4	7.9	5.5	125	73.1	41.4	117	67.8	1.7	0.5
Re	0.002	<0.002	<0.002	0.003	0.006	0.036	0.003	0.006	<0.002	<0.002	0.005	0.014	<0.002	<0.002	0.005	0.007	0.011	<0.002	<0.002	<0.002	0.002
S	0.01%	0.03%	0.12%	0.57%	0.55%	1.49%	5.21%	0.82%	1.50%	1.50%	0.32%	0.95%	0.01%	0.01%	0.30%	0.83%	0.81%	0.19%	0.09%	4.29%	0.74%
Sb	0.05	0.29	0.66	0.76	0.64	0.52	1.04	0.13	1.87	0.75	0.67	0.67	0.25	0.05	0.78	0.62	0.33	0.54	0.31	0.54	0.28
Sc	0.1	14.2	9.4	11.3	11.3	2.1	4.3	1.7	16.6	15.1	9.7	9.1	16.2	18.4	14.8	8.4	1.8	8.5	2.6	3.5	3.1
Se	1	1	1	2	3	2	<1	<1	2	1	3	2	1	1	3	2	1	1	<1	<1	<1
Sn	0.2	1.9	4	4.2	3.2	1.4	1.5	0.8	3.3	3	4	2.8	1.5	1.1	3.8	2.7	1.3	4.2	1.7	1	1.1
Sr	0.2	240	57.3	108.5	108.5	72.5	97.8	68.9	213	261	82.9	71.6	90.3	356	138	53.5	147	47.6	33.5	53.1	83.8
Ta	0.05	1.32	1.16	1.16	0.71	0.33	0.19	0.18	0.96	0.92	1.15	0.71	1.12	0.94	0.93	0.64	0.31	1.29	0.5	0.26	0.27
Te	0.05	<0.05	<0.05	0.06	0.07	<0.05	0.05	<0.05	0.11	0.05	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	0.07
Th	0.2	4.9	12.6	15.1	10.7	3.9	4.8	2.3	15.6	15.8	13.9	9.8	3.8	1.3	14.2	8.9	4.1	14	4.6	4.6	4.7
Ti	0.005%	0.74%	0.34%	0.35%	0.30%	0.09%	0.05%	0.04%	0.29%	0.26%	0.32%	0.29%	0.84%	0.81%	0.38%	0.26%	0.09%	0.33%	0.10%	0.11%	0.06%
Tl	0.02	0.08	0.66	0.75	0.44	0.7	2.34	0.23	0.24	0.24	1.11	0.81	0.1	0.05	0.46	0.41	0.39	0.59	0.45	1.18	0.16
U	0.10	0.6	2.6	2.9	2.8	3.7	6	0.6	3.7	2	4.7	4.4	0.6	0.4	3.1	2.7	2	3.4	1	1.1	1.2
V	1	114	69	105	132	33	80	9	187	108	76	118	122	116	173	92	38	50	14	25	18
W	0.1	1.2	2.9	2.7	2	0.8	0.4	0.6	3.1	2.1	2.5	2.4	0.9	0.3	2.5	1.6	0.5	2.6	0.8	0.7	1
Y	0.1	18.2	17.8	23.5	25.8	6.6	15.5	2.5	14	10.7	28.7	23.1	18.9	15.9	31	19.4	7.3	12.8	5.8	10	6.2
Zn	2	55	68	69	81	11	450	2	30	28	100	116	64	100	99	66	12	56	30	22	6
Zr	0.5	133.5	154.5	174	152	53.1	101.5	35.7	181	161	158	145	125	107	179.5	129.5	48.5	150	48.2	48	52.3

< element at or below analytical detection limit.

Table 6: Geochemical abundance indices (GAI) of selected overburden/interburden and coal sample solids. Values 3 and over are highlighted in yellow.

Element	Median Soil Abundance*	Sample Number																			
		Soil	Sandstone	Sandstone	Sandstone	Sandstone	Coal - A Seam	Coal - B Seam Bottoms	Clay	Clay	Sandstone	Siltstone	Soil	Basalt	Siltstone	Siltstone	Sandstone	Sandstone	Sandstone	Coal - B Seam Tops	Coal - B Seam Bottoms
		3576	3586	3588	3591	3595	3597	3605	3609	3610	3616	3622	3641	3643	3663	3665	3669	3671	3675	3677	3678
Ag	0.05	1	-	-	1	-	-	-	-	-	-	1	-	-	1	1	-	-	-	-	-
Al	7.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	6	-	-	-	1	-	1	-	1	-	1	1	-	-	1	1	-	-	-	1	-
Ba	500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Be	0.3	1	2	2	2	1	4	1	2	1	3	2	1	1	2	2	1	2	1	3	2
Bi	0.2	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Ca	1.5%	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Cd	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ce	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	8	2	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-
Cr	70	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Cs	4	-	-	1	1	-	-	-	-	-	1	-	-	-	1	-	-	1	-	-	-
Cu	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe	4.0%	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Ga	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ge	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hf	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hg	0.06	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	-
In	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	1.4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
La	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Li	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	0.5%	1	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-
Mn	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mo	1.2	-	-	-	1	1	2	-	1	-	-	1	-	-	-	1	-	-	-	-	-
Na	0.5%	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Nb	10	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	50	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
P	800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pb	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rb	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Re																					
S	0.07%	-	-	2	2	4	6	3	4	4	2	3	-	-	2	3	3	1	-	5	3
Sb	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sc	7	-	-	-	-	-	-	-	1	1	-	-	1	1	-	-	-	-	-	-	-
Se	0.4	1	1	2	2	2	1	1	2	1	2	2	1	1	2	2	1	1	1	1	1
Sn	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sr	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ta	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Te																					
Th	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ti	0.50%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tl	0.2	-	1	1	1	1	3	-	-	-	2	1	-	-	1	-	-	1	1	2	-
U	2	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	-	-	-	-	-
V	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W	1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	90	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zr	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

Table 7: Chemical composition of water extracts for selected overburden/interburden and coal samples.

Parameter		Detection Limit	Lithology/Sample Number																			
			Soil	Sandstone	Sandstone	Sandstone	Sandstone	Coal - A Seam	Coal - B Seam Bottoms	Clay	Clay	Sandstone	Siltstone	Soil	Basalt	Siltstone	Siltstone	Sandstone	Sandstone	Sandstone	Coal - B Seam Tops	Coal - B Seam Bottoms
			0.03%S	0.12%S	0.57%S	0.55%S	1.49%S	5.21%S	0.82%S	1.50%S	1.50%S	0.32%S	0.95%S	0.01%S	0.01%S	0.30%S	0.83%S	0.81%S	0.19%S	0.09%S	4.29%S	0.74%S
			3576	3586	3588	3591	3595	3597	3605	3609	3610	3616	3622	3641	3643	3663	3665	3669	3671	3675	3677	3678
pH		0.1	8.2	6.9	4.3	3.5	2.8	2.4	3.3	6.4	6.5	4.4	2.6	6.5	7.6	6.1	3.1	2.6	3.8	4.2	2.2	3.4
EC	dS/m	0.001	0.32	0.88	3.21	3.11	5.36	9.35	1.85	2.21	2.96	2.14	6.34	0.53	0.22	1.96	5.29	3.72	1.97	0.43	10.24	1.22
Alkalinity	mg/l	1	79	15						12	34			63	97							
Acidity	mg/l	1			110	423	5228	9283	431			117	6097			15	7049	2893	206	132	7102	168
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	0.02	<0.01	6.95	18.4	251	68.5	4.72	0.06	<0.01	6.52	275	0.03	0.04	0.11	344	142	3.74	7.69	23.9	1.06
As	mg/l	0.001	<0.001	<0.001	0.004	0.008	1.14	1.62	0.002	<0.001	<0.001	0.003	2.31	<0.001	<0.001	<0.001	1.79	0.526	0.001	<0.001	1.07	0.001
B	mg/l	0.05	0.08	0.06	0.12	0.12	0.06	3.25	2.07	0.16	0.12	0.19	<0.05	0.07	<0.05	0.12	<0.05	0.08	0.15	0.09	2.06	1.4
Ba	mg/l	0.001	0.428	0.057	0.031	0.031	0.057	0.016	0.069	0.149	0.253	0.04	0.07	0.459	0.284	0.04	0.108	0.049	0.073	0.094	0.02	0.097
Be	mg/l	0.001	<0.001	<0.001	0.022	0.054	0.028	0.284	0.021	<0.001	<0.001	0.042	0.165	<0.001	<0.001	<0.001	0.162	0.041	0.042	0.022	0.147	0.004
Ca	mg/l	1	13	68	183	180	22	116	98	21	23	99	114	32	15	176	176	22	57	24	104	75
Cd	mg/l	0.0001	<0.0001	0.0005	0.0068	0.0183	0.0609	0.0089	0.0025	<0.0001	<0.0001	0.0114	0.0903	0.0005	<0.0001	0.0024	0.0506	0.0088	0.0041	0.0018	0.0123	0.0006
Cl	mg/l	1	20	14	4	6	<1	<1	5	670	808	202	4	20	11	9	2	3	8	9	<1	5
Co	mg/l	0.001	<0.001	0.016	0.119	0.32	1.43	1.54	0.078	0.004	0.001	1.49	3.2	0.022	<0.001	0.103	2.43	1.06	0.131	0.337	2.11	0.042
Cr	mg/l	0.001	<0.001	<0.001	0.006	0.036	0.529	0.293	0.008	<0.001	<0.001	0.003	0.673	<0.001	<0.001	<0.001	0.574	0.454	0.028	0.008	0.063	0.001
Cu	mg/l	0.001	0.009	0.008	0.068	0.453	0.374	0.323	0.036	0.008	0.002	0.032	3.58	0.01	0.006	0.011	3.01	0.403	0.154	0.112	0.655	0.023
F	mg/l	0.1	2.2	0.3	0.8	0.8	<0.1	<0.1	0.4	0.1	0.6	1.4	<0.1	0.3	0.2	0.2	<0.1	<0.1	0.3	0.3	<0.1	0.3
Fe	mg/l	0.05	<0.05	<0.05	21	61	1520	4260	144	1.31	<0.05	7.07	1350	0.09	<0.05	<0.05	1380	893	56.3	15.2	2980	41.7
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	<1	13	16	13	3	2	3	2	2	9	2	1	1	33	3	1	17	4	1	3
Mg	mg/l	1	10	82	386	311	20	71	69	90	114	224	156	18	8	248	232	22	58	22	54	53
Mn	mg/l	0.001	<0.001	1.86	13.4	27.4	6.62	6.17	1.48	0.133	0.033	9.37	8.49	0.072	0.004	2.95	7.33	8.37	1.37	2.52	1.7	1.21
Mo	mg/l	0.001	<0.001	<0.001	0.001	0.002	0.147	0.016	<0.001	<0.001	<0.001	<0.001	0.033	<0.001	<0.001	<0.001	0.022	0.043	<0.001	<0.001	0.008	<0.001
Na	mg/l	1	26	15	10	10	4	28	25	310	364	131	5	17	13	29	3	4	14	6	8	20
Ni	mg/l	0.001	<0.001	0.021	0.662	1.26	3.48	6.42	0.281	0.006	0.002	3.05	5.01	0.05	0.002	0.236	3.9	2.16	0.515	0.641	4.6	0.083
P	mg/l	1	<1	<1	<1	<1	7	<1	<1	<1	<1	<1	14	<1	<1	<1	21	4	<1	<1	3	<1
Pb	mg/l	0.001	<0.001	<0.001	0.002	0.004	0.012	0.034	0.003	<0.001	<0.001	0.002	0.011	<0.001	<0.001	<0.001	0.004	<0.001	0.031	0.012	0.022	0.002
Sb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
Se	mg/l	0.01	<0.01	0.02	0.06	0.14	0.1	0.06	<0.01	<0.01	<0.01	0.09	0.41	<0.01	<0.01	0.12	0.43	0.09	0.02	<0.01	0.12	0.01
Si	mg/l	0.1	2.21	2.58	5.15	6.8	0.54	1.25	1.25	2.74	1.9	2.63	2.7	3.63	7.55	5.69	4.41	0.94	4.97	1.02	1.88	0.99
Sn	mg/l	0.001	0.03	<0.001	0.001	0.004	0.01	0.017	<0.001	0.003	<0.001	<0.001	0.004	0.001	0.004	<0.001	0.008	0.003	<0.001	<0.001	0.002	<0.001
SO4	mg/l	1	21	480	2100	1910	5310	10300	909	192	188	1210	6260	72	8	1520	6680	3000	552	230	8000	543
Sr	mg/l	0.001	0.319	0.375	0.882	<0.001	0.787	1.91	1.1	0.542	0.57	0.941	1.14	0.228	0.127	1.37	0.724	1.17	0.704	0.006	1.06	0.749
Th	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	0.307	0.071	0.002	<0.001	<0.001	<0.001	1.05	<0.001	<0.001	<0.001	0.796	0.308	0.004	<0.001	0.21	0.003
U	mg/l	0.001	<0.001	<0.001	0.002	<0.001	0.94	0.169	0.003	<0.001	<0.001	0.003	0.875	<0.001	<0.001	<0.001	0.202	0.316	0.01	<0.001	0.027	<0.001
Zn	mg/l	0.005	0.01	0.09	1.47	4.06	3.70	7.70	0.47	0.11	0.03	8.32	32.10	0.17	0.01	0.77	23.80	3.87	3.70	4.27	3.55	0.30

Table 8: Exchangeable cations for overburden/interburden samples tested by SGS in 2011.

Hole ID	Depth (m)			Lithology	Weathering	Sample Code	ex Na	ex K	ex Ca	ex Mg	ECEC	% ECEC Na (ESP)	% ECEC K	% ECEC Ca	% ECEC Mg	Classification
	From	To	Interval				(meq%)	(meq%)	(meq%)	(meq%)	(meq%)					
TAR002_OB	0.00	1.00	1.00	Soil	Decomposed	001	3.0	0.1	19.0	15.0	37.1	8.1	0.4	51.2	40.4	Sodic
TAR002_OB	1.00	7.00	6.00	Clay	High	002	2.7	0.1	17.0	9.0	28.8	9.4	0.2	59.1	31.3	Sodic
TAR002_OB	7.00	12.00	5.00	Sand	Mod	003	0.3	0.0	1.1	1.4	2.9	11.2	1.1	38.6	49.1	
TAR002_OB	12.00	22.00	10.00	Clay	Mod	004	0.3	0.0	1.5	1.6	3.4	7.4	1.2	44.2	47.2	
TAR002_OB	22.00	32.00	10.00	Siltstone/Sandstone	Slight	005	0.2	0.1	1.3	1.2	2.8	5.4	4.3	46.9	43.3	
TAR002_OB	32.00	36.00	4.00	Sandstone	Slight	006	0.1	0.2	1.5	1.5	3.3	2.7	7.2	45.0	45.0	
TAR002_OB	36.00	46.00	10.00	Sandstone	Slight	007	0.1	0.3	2.9	5.2	8.6	1.5	3.9	33.9	60.7	
TAR002_OB	46.00	56.00	10.00	Sandstone	Slight	008	0.2	0.3	1.9	2.6	5.0	3.2	6.0	38.3	52.4	
TAR002_OB	56.00	59.00	3.00	Sandstone/Gravel	Fresh	009	0.0	0.0	0.6	0.9	1.6	0.6	0.6	40.0	58.7	
TAR002_OB	59.00	61.00	2.00	Sandstone		010	0.1	0.1	0.7	0.6	1.5	7.5	6.8	44.5	41.1	
TAR002_OB	61.00	62.00	1.00	Sandstone		011	0.1	0.1	0.4	0.5	1.1	8.3	9.3	40.7	41.7	
TAR002_OB	62.00	63.00	1.00	Sandstone		012	0.1	0.1	0.9	1.2	2.3	5.2	4.3	38.5	51.9	
TAR002_OB	63.00	64.00	1.00	Sandstone	Fresh	013	0.1	0.2	0.9	1.2	2.4	5.4	6.3	38.1	50.2	
TAR002_OB	65.00	65.50	0.50	Sandstone/Siltstone		014	0.2	0.2	1.8	2.5	4.6	3.9	3.2	38.9	54.0	
TAR002_OB	65.50	66.00	0.50	Sandstone/Siltstone		015	0.2	0.2	1.4	1.9	3.6	5.2	4.1	38.5	52.2	
TAR002_OB	66.00	66.50	0.50	Sandstone/Siltstone		016	0.2	0.2	1.9	2.8	5.1	3.4	3.8	37.5	55.3	
TAR002_OB	66.50	67.00	0.50	Sandstone/Siltstone	Fresh	017	0.2	0.2	1.4	2.1	3.9	4.2	4.9	36.4	54.5	
TAR002_OB	67.00	69.00	2.00	Sandstone		018	0.1	0.2	0.6	0.7	1.7	7.9	10.9	36.4	44.8	
TAR002_OB	69.00	71.00	2.00	Sandstone		019	0.1	0.1	0.5	0.5	1.3	9.5	11.1	36.5	42.9	
TAR002_OB	71.00	72.00	1.00	Sandstone		020	0.0	0.0	0.5	0.7	1.2	0.8	0.8	38.5	59.8	
TAR002_OB	72.00	73.00	1.00	Sandstone		021	0.0	0.0	0.3	0.4	0.7	1.4	1.4	47.2	50.0	
TAR002_OB	73.00	74.00	1.00	Sandstone	Fresh	022	0.0	0.0	0.2	0.2	0.4	4.9	2.4	46.3	46.3	
TAR002_OB	77.00	77.50	0.50	Carb Shale/Sandstone		023	0.1	0.1	1.7	4.1	6.0	2.0	0.8	28.5	68.7	
TAR002_OB	77.50	78.00	0.50	Carb Shale/Sandstone		024	0.2	0.1	1.1	3.2	4.6	4.5	2.4	23.8	69.3	
TAR002_OB	78.00	78.50	0.50	Carb Shale/Sandstone		025	0.0	0.0	1.7	3.5	5.2	0.2	0.2	32.6	67.0	
TAR002_OB	78.50	79.00	0.50	Carb Shale/Sandstone		026	0.2	0.1	2.1	2.8	5.2	3.4	2.7	40.2	53.6	
TAR002_OB	79.00	84.00	5.00	Carb Shale/Sandstone	Fresh	027	0.0	0.0	1.1	3.5	4.7	0.9	0.6	23.6	74.9	
TAR024_OB	0.00	1.00	1.00	Soil	Decomposed	001	0.3	0.1	16.0	4.7	21.1	1.2	0.7	75.8	22.3	
TAR024_OB	1.00	4.00	3.00	Sand	High	002	1.0	0.1	16.0	6.5	23.6	4.2	0.5	67.8	27.5	
TAR024_OB	4.00	8.00	4.00	Sand	Mod	003	0.5	0.1	1.8	1.1	3.5	14.5	1.4	52.2	31.9	
TAR024_OB	8.00	18.00	10.00	Sand/Clay		004	0.7	0.2	1.5	1.9	4.3	16.4	5.3	34.6	43.8	
TAR024_OB	18.00	21.00	3.00	Sandstone	Mod	005	0.3	0.2	2.0	1.5	4.0	6.8	5.5	50.1	37.6	
TAR024_OB	21.00	31.00	10.00	Sandstone/Siltstone		006	0.2	0.3	2.1	2.7	5.4	3.9	6.4	39.3	50.5	
TAR024_OB	31.00	41.00	10.00	Sandstone/Siltstone		007	0.2	0.3	3.4	6.2	10.1	2.1	3.3	33.5	61.1	
TAR024_OB	41.00	51.00	10.00	Sandstone/Siltstone		008	0.4	0.4	3.5	6.7	11.0	3.5	3.8	31.8	60.9	
TAR024_OB	51.00	53.00	2.00	Sandstone	Slight	009	0.0	0.0	1.1	1.9	3.0	0.3	0.7	36.3	62.7	
TAR024_OB	53.00	56.00	3.00	Sandstone		010	0.0	0.0	0.6	1.3	2.0	0.5	0.5	32.3	66.7	
TAR024_OB	56.00	58.00	2.00	Sandstone		011	0.0	0.0	0.3	0.6	1.0	1.1	1.1	35.8	62.1	
TAR024_OB	58.00	59.00	1.00	Sandstone		012										
TAR024_OB	59.00	60.00	1.00	Sandstone		013	0.1	0.1	0.3	0.2	0.7	19.1	10.3	41.2	29.4	

Table 8: Exchangeable cations for overburden/interburden samples tested by SGS in 2011.

Hole ID	Depth (m)			Lithology	Weathering	Sample Code	ex Na	ex K	ex Ca	ex Mg	ECEC	% ECEC Na (ESP)	% ECEC K	% ECEC Ca	% ECEC Mg	Classification
	From	To	Interval				(meq%)	(meq%)	(meq%)	(meq%)	(meq%)					
TAR024_OB	60.00	61.00	1.00	Sandstone	Fresh	014										
TAR024_OB	62.00	62.50	0.50	Carb Shale		015	0.0	0.0	1.6	1.9	3.5	0.3	0.3	45.5	54.0	
TAR024_OB	62.50	63.00	0.50	Carb Shale		016	0.0	0.0	1.7	2.4	4.1	0.5	0.5	41.1	58.0	
TAR024_OB	63.00	63.50	0.50	Carb Shale		017	0.0	0.0	1.5	2.1	3.6	0.3	0.6	41.3	57.9	
TAR024_OB	63.50	64.00	0.50	Carb Shale	Fresh	018	0.0	0.0	1.6	2.2	3.8	0.3	0.5	41.8	57.4	
TAR024_OB	64.00	66.00	2.00	Sandstone		019	0.0	0.0	0.8	1.1	2.0	1.5	1.0	41.6	55.8	
TAR024_OB	66.00	67.00	1.00	Sandstone		020	0.1	0.1	0.3	0.4	1.0	13.5	12.5	33.3	40.6	
TAR024_OB	67.00	68.00	1.00	Sandstone		021	0.2	0.1	0.6	0.5	1.4	10.9	8.8	40.9	39.4	
TAR024_OB	68.00	69.00	1.00	Sandstone	Fresh	022	0.1	0.1	0.2	0.3	0.7	16.9	11.3	33.8	38.0	
TAR024_OB	72.00	72.50	0.50	Carb Shale/Sandstone		023	0.2	0.2	1.2	3.4	5.0	4.6	3.0	24.1	68.3	
TAR024_OB	72.50	73.00	0.50	Carb Shale/Sandstone		024	0.3	0.1	1.3	3.5	5.2	5.7	2.3	24.9	67.0	
TAR024_OB	73.00	73.50	0.50	Carb Shale/Sandstone		025	0.1	0.1	1.3	3.1	4.6	2.2	1.5	28.4	67.8	
TAR024_OB	73.50	74.00	0.50	Carb Shale/Sandstone		026	0.2	0.2	1.3	3.3	5.0	4.0	4.8	25.8	65.5	
TAR024_OB	74.00	78.00	4.00	Carb Shale/Sandstone	Fresh	027	0.1	0.1	1.2	3.4	4.8	2.7	1.3	25.1	71.0	
TAR027_OB	0.00	1.00	1.00	Soil	Decomposed	001	0.6	0.3	33.0	25.0	58.9	1.1	0.4	56.0	42.5	
TAR027_OB	1.00	2.00	1.00	Clay	High	002	1.0	0.1	36.0	33.0	70.1	1.4	0.1	51.4	47.1	
TAR027_OB	2.00	7.00	5.00	Basalt	Mod	003	1.0	0.0	33.0	26.0	60.0	1.6	0.1	55.0	43.3	
TAR027_OB	7.00	17.00	10.00	Clay		004	1.0	0.1	15.0	22.0	38.1	2.6	0.2	39.4	57.8	
TAR027_OB	17.00	21.00	4.00	Clay	Mod	005	1.3	0.1	14.0	24.0	39.4	3.3	0.3	35.5	60.9	
TAR027_OB	21.00	31.00	10.00	Sand	Mod	006	0.2	0.0	1.3	2.0	3.5	5.1	1.1	36.9	56.8	
TAR027_OB	31.00	41.00	10.00	Sand		007	0.2	0.2	0.9	1.5	2.7	5.9	7.0	31.7	55.4	
TAR027_OB	41.00	45.00	4.00	Sand	Slight	008	0.2	0.3	1.8	2.8	5.1	4.1	5.7	35.3	54.9	
TAR027_OB	45.00	55.00	10.00	Sandstone/Siltstone		009	0.2	0.3	3.7	5.5	9.8	2.5	3.4	37.9	56.3	
TAR027_OB	55.00	65.00	10.00	Sandstone/Siltstone		010	0.4	0.4	4.4	7.2	12.4	3.4	2.9	35.5	58.2	
TAR027_OB	65.00	66.00	1.00	Sandstone/Siltstone	Fresh	011	0.0	0.0	1.4	1.6	3.0	0.3	0.3	46.4	53.0	
TAR027_OB	66.00	68.00	2.00	Sandstone		012	0.0	0.0	0.5	0.7	1.2	1.6	0.8	41.1	56.5	
TAR027_OB	68.00	69.00	1.00	Sandstone		013	0.0	0.0	0.3	0.4	0.8	1.3	1.3	44.2	53.2	
TAR027_OB	69.00	70.00	1.00	Sandstone		014	0.0	0.0	0.5	0.6	1.1	1.0	1.0	45.7	52.4	
TAR027_OB	70.00	71.00	1.00	Sandstone	Fresh	015	0.2	0.1	0.7	0.8	1.7	8.6	6.3	39.1	46.0	
TAR027_OB	72.00	72.50	0.50	Sandstone/Carb Sandstone		016	0.0	0.0	1.9	2.5	4.5	0.9	0.7	42.5	55.9	
TAR027_OB	72.50	73.00	0.50	Sandstone/Carb Sandstone		017	0.2	0.2	1.5	2.3	4.1	4.6	3.6	36.2	55.6	
TAR027_OB	73.00	73.50	0.50	Sandstone/Carb Sandstone		018	0.2	0.2	1.4	2.5	4.3	5.3	4.2	32.5	58.0	
TAR027_OB	73.50	74.00	0.50	Sandstone/Carb Sandstone		019	0.0	0.0	0.8	1.4	2.3	0.9	0.9	36.6	61.7	
TAR027_OB	74.00	76.00	2.00	Sandstone/Carb Sandstone	Fresh	020	0.2	0.1	1.0	1.9	3.2	5.6	4.3	31.1	59.0	
TAR027_OB	76.00	77.00	1.00	Sandstone		021	0.1	0.1	0.4	0.6	1.2	10.7	9.0	32.8	47.5	
TAR027_OB	77.00	79.00	2.00	Sandstone		022	0.0	0.0	0.5	0.7	1.3	1.6	0.8	40.3	57.4	
TAR027_OB	79.00	80.00	1.00	Sandstone		023	0.0	0.0	0.4	0.6	1.1	3.5	1.8	38.6	56.1	
TAR027_OB	80.00	81.00	1.00	Sandstone		024	0.0	0.0	0.4	0.6	1.0	2.1	1.0	40.2	56.7	
TAR027_OB	81.00	82.00	1.00	Sandstone	Fresh	025	0.0	0.0	0.5	0.6	1.2	3.4	0.9	41.9	53.8	
TAR027_OB	85.00	85.50	0.50	Sandstone/Carb Sandstone		026	0.2	0.2	1.7	4.3	6.5	3.3	3.7	26.4	66.7	

Table 8: Exchangeable cations for overburden/interburden samples tested by SGS in 2011.

Hole ID	Depth (m)			Lithology	Weathering	Sample Code	ex Na	ex K	ex Ca	ex Mg	ECEC	% ECEC Na (ESP)	% ECEC K	% ECEC Ca	% ECEC Mg	Classification
	From	To	Interval				(meq%)	(meq%)	(meq%)	(meq%)	(meq%)					
TAR027_OB	85.50	86.00	0.50	Sandstone/Carb Sandstone		027	0.1	0.2	1.0	2.4	3.6	3.0	4.4	26.2	66.3	
TAR027_OB	86.00	86.50	0.50	Sandstone/Carb Sandstone		028	0.1	0.3	1.0	2.5	3.9	3.6	7.9	24.4	64.1	
TAR027_OB	86.50	87.00	0.50	Sandstone/Carb Sandstone		029	0.2	0.3	2.1	3.1	5.7	2.7	5.5	37.1	54.8	
TAR027_OB	87.00	90.00	3.00	Sandstone/Carb Sandstone	Fresh	030	0.1	0.1	2.1	5.8	8.1	1.7	1.0	25.9	71.4	
TAR028_OB	0.00	1.00	1.00	Soil	Decomposed	001	4.8	0.5	14.0	15.0	34.3	14.0	1.3	40.9	43.8	Sodic
TAR028_OB	1.00	7.00	6.00	Clay	High	002	13.0	0.6	12.0	61.0	86.6	15.0	0.7	13.9	70.4	Sodic
TAR028_OB	7.00	12.00	5.00	Clay/Sand	High	003	4.8	0.1	13.0	15.0	32.9	14.6	0.3	39.5	45.6	Sodic
TAR028_OB	12.00	21.00	9.00	Sand	High	004	1.7	0.1	2.0	3.9	7.7	22.2	0.8	26.1	50.9	
TAR028_OB	21.00	31.00	10.00	Sand		005	1.3	0.3	0.8	2.6	4.9	26.4	5.7	15.2	52.7	
TAR028_OB	31.00	40.00	9.00	Sand	Mod	006	0.8	0.6	2.3	5.8	9.5	8.7	6.2	24.2	60.9	
TAR028_OB	40.00	50.00	10.00	Siltstone/Sandstone	Slight	007	0.3	0.1	3.4	9.0	12.9	2.6	0.9	26.5	70.0	
TAR028_OB	50.00	52.00	2.00	Sandstone		008	0.0	0.0	0.4	0.9	1.3	0.8	1.5	29.0	68.7	
TAR028_OB	52.00	53.00	1.00	Sandstone		009	0.0	0.0	0.6	0.8	1.4	0.7	1.5	40.4	57.4	
TAR028_OB	53.00	54.00	1.00	Sandstone		010	0.0	0.0	0.3	0.9	1.2	1.6	1.6	23.0	73.8	
TAR028_OB	54.00	55.00	1.00	Sandstone	Fresh	011	0.1	0.0	0.6	1.1	1.8	5.0	0.6	33.3	61.1	
TAR028_OB	56.00	56.50	0.50	Carb Sandstone/Sandstone		012	0.2	0.0	2.1	2.9	5.2	2.9	0.8	40.5	55.9	
TAR028_OB	56.50	57.00	0.50	Carb Sandstone/Sandstone	Fresh	013	0.3	0.4	2.1	3.2	6.0	5.0	6.8	34.9	53.2	
TAR028_OB	57.00	57.50	0.50	Sandstone		014	0.3	0.3	1.1	2.4	4.1	6.6	8.0	26.8	58.5	
TAR028_OB	57.50	58.00	0.50	Sandstone		015	0.2	0.3	1.1	2.5	4.1	5.8	6.8	26.7	60.7	
TAR028_OB	58.00	61.00	3.00	Sandstone	Fresh	016	0.4	0.2	1.1	2.6	4.3	9.0	5.1	25.5	60.3	
TAR028_OB	61.00	63.00	2.00	Sandstone		017	0.2	0.3	0.6	1.6	2.7	8.9	9.6	22.2	59.3	
TAR028_OB	63.00	64.00	1.00	Sandstone		018	0.2	0.2	0.3	1.0	1.7	12.8	10.5	19.8	57.0	
TAR028_OB	64.00	65.00	1.00	Sandstone		019	0.2	0.2	0.3	0.7	1.4	12.5	16.2	22.8	48.5	
TAR028_OB	65.00	66.00	1.00	Sandstone	Fresh	020	0.3	0.1	1.1	1.3	2.9	11.2	4.6	38.6	45.6	
TAR028_OB	69.00	69.50	0.50	Carb Sandstone/Sandstone		021	0.2	0.2	1.2	3.8	5.4	4.1	2.8	22.3	70.8	
TAR028_OB	69.50	70.00	0.50	Carb Sandstone/Sandstone		022	0.0	0.0	1.4	3.8	5.2	0.2	0.4	26.8	72.7	
TAR028_OB	70.00	70.50	0.50	Carb Sandstone/Sandstone		023	0.3	0.2	2.0	4.9	7.4	3.6	3.1	27.0	66.2	
TAR028_OB	70.50	71.00	0.50	Carb Sandstone/Sandstone		024	0.3	0.6	2.2	4.7	7.8	4.2	7.2	28.2	60.3	
TAR028_OB	71.00	73.00	2.00	Carb Sandstone/Sandstone	Fresh	025	0.1	0.1	1.7	5.0	6.9	1.7	0.7	24.7	72.8	
TAR028_OB	73.00	78.00	5.00	Sandstone	Fresh	026	0.2	0.1	0.9	3.0	4.2	3.6	2.4	21.7	72.3	
TAR030_OB	0.00	1.00	1.00	Soil	Decomposed	001	0.5	0.7	15.0	15.0	31.2	1.5	2.4	48.0	48.0	
TAR030_OB	1.00	2.00	1.00	Clay	High	002	1.2	0.2	16.0	16.0	33.4	3.6	0.7	47.9	47.9	
TAR030_OB	2.00	7.00	5.00	Igneous Rock/Clay	Mod/High	003	1.3	0.1	15.0	16.0	32.4	4.0	0.3	46.3	49.4	
TAR030_OB	7.00	17.00	10.00	Clay		004	1.6	0.3	14.0	15.0	30.9	5.2	0.9	45.3	48.6	
TAR030_OB	17.00	27.00	10.00	Clay		005	1.6	0.2	14.0	15.0	30.8	5.2	0.5	45.5	48.8	
TAR030_OB	27.00	37.00	10.00	Clay	Mod	006	0.9	0.3	12.0	15.0	28.2	3.2	1.2	42.5	53.1	
TAR030_OB	37.00	47.00	10.00	Sandstone/Clay		007	0.4	0.5	3.2	5.8	9.9	3.8	5.2	32.4	58.6	
TAR030_OB	47.00	52.00	5.00	Sandstone/Clay	Mod/High	008	0.4	0.5	6.0	6.7	13.6	2.8	3.8	44.2	49.3	
TAR030_OB	52.00	62.00	10.00	Sandstone/Siltstone	Slightly/Mod	009	0.3	0.5	5.5	7.2	13.5	2.2	3.8	40.7	53.3	
TAR030_OB	62.00	66.00	4.00	Siltstone/Sandstone	Slightly/Mod	010	0.7	0.9	11.0	15.0	27.5	2.4	3.2	40.0	54.5	

Table 8: Exchangeable cations for overburden/interburden samples tested by SGS in 2011.

Hole ID	Depth (m)			Lithology	Weathering	Sample Code	ex Na	ex K	ex Ca	ex Mg	ECEC	% ECEC Na (ESP)	% ECEC K	% ECEC Ca	% ECEC Mg	Classification
	From	To	Interval				(meq%)	(meq%)	(meq%)	(meq%)	(meq%)					
TAR030_OB	66.00	71.00	5.00	Siltstone/Sandstone	Fresh	011	0.7	0.9	9.0	15.0	25.6	2.5	3.5	35.2	58.7	
TAR030_OB	71.00	73.00	2.00	Sandstone/Siltstone		012	0.5	0.3	7.5	14.0	22.3	2.3	1.3	33.6	62.8	
TAR030_OB	73.00	74.00	1.00	Sandstone		013	0.4	0.3	9.5	14.0	24.2	1.5	1.3	39.3	57.9	
TAR030_OB	74.00	76.00	2.00	Sandstone		014	0.3	0.2	6.0	5.4	11.9	2.1	1.7	50.6	45.6	
TAR030_OB	76.00	77.00	1.00	Sandstone		015	0.2	0.2	3.6	3.7	7.7	2.4	2.2	47.1	48.4	
TAR030_OB	77.00	78.00	1.00	Sandstone		016	0.1	0.1	3.4	3.1	6.8	1.9	1.9	50.3	45.9	
TAR030_OB	78.00	79.00	1.00	Sandstone		017	0.2	0.2	4.9	7.6	12.9	1.8	1.5	37.9	58.8	
TAR030_OB	81.00	81.50	0.50	XA/Sandstone		018	0.4	0.3	4.8	4.6	10.1	3.6	3.1	47.7	45.7	
TAR030_OB	81.50	82.00	0.50	XA/Sandstone		019	0.3	0.3	2.5	3.7	6.8	4.1	4.6	36.8	54.5	
TAR030_OB	82.00	82.50	0.50	Sandstone(XA)		020	0.3	0.3	2.3	3.9	6.8	4.8	4.1	33.8	57.3	
TAR030_OB	82.50	83.00	0.50	Sandstone(XA)		021	0.2	0.3	4.2	4.4	9.1	2.3	3.1	46.2	48.4	
TAR030_OB	83.00	85.00	2.00	Sandstone(XA)		022	0.1	0.2	2.2	2.5	5.0	2.6	3.6	43.9	49.9	
TAR030_OB	85.00	86.00	1.00	Sandstone(XA)		023	0.2	0.2	9.0	9.8	19.2	0.9	1.1	46.9	51.1	
TAR030_OB	86.00	87.00	1.00	Sandstone(XA)		024	0.1	0.2	1.4	2.5	4.3	3.3	5.4	32.8	58.5	
TAR030_OB	87.00	88.00	1.00	Sandstone(XA)		025	0.2	0.1	1.3	2.2	3.8	4.7	3.4	34.1	57.7	
TAR030_OB	91.00	91.50	0.50	Sandstone(XA)		026	0.2	0.3	2.2	4.3	7.1	3.3	4.7	31.2	60.9	
TAR030_OB	91.50	92.00	0.50	Sandstone(XA)		027	0.2	0.4	2.4	4.3	7.3	2.7	5.2	33.0	59.1	
TAR030_OB	92.00	92.50	0.50	Sandstone(XA)		028	0.2	0.3	1.8	4.4	6.7	3.6	4.2	26.8	65.5	
TAR030_OB	92.50	93.00	0.50	Sandstone(XA)		029	0.2	0.4	1.6	4.0	6.2	3.6	5.8	25.9	64.7	
TAR030_OB	93.00	97.00	4.00	Sandstone(XA)		030	0.2	0.2	1.5	3.9	5.7	3.1	2.8	26.1	67.9	
TAR034_OB	0.00	1.00	1.00	Soil	Decomposed	001	0.5	0.5	16.0	16.0	33.1	1.6	1.6	48.4	48.4	
TAR034_OB	1.00	11.00	10.00	Basalt	Mod	002	0.9	0.4	16.0	16.0	33.3	2.6	1.1	48.1	48.1	
TAR034_OB	11.00	12.00	1.00	Basalt	Mod	003	1.6	0.5	15.0	16.0	33.1	4.8	1.5	45.3	48.4	
TAR034_OB	12.00	20.00	8.00	Clay	High	004	0.9	0.5	15.0	15.0	31.4	2.9	1.6	47.7	47.7	
TAR034_OB	20.00	30.00	10.00	Sand/Clay	Mod/High	005	1.1	0.7	15.0	15.0	31.8	3.5	2.1	47.2	47.2	
TAR034_OB	30.00	32.00	2.00	Sand/Clay	Mod/High	006	1.2	0.7	15.0	15.0	31.9	3.8	2.3	47.0	47.0	
TAR034_OB	32.00	42.00	10.00	Clay	High	007	1.5	1.5	14.0	48.0	65.0	2.3	2.3	21.5	73.8	
TAR034_OB	42.00	44.00	2.00	Clay	High	008	1.1	2.0	15.0	15.0	33.1	3.3	6.0	45.3	45.3	
TAR034_OB	44.00	47.00	3.00	Clay/Siltstone	High/Mod	009	0.9	1.2	15.0	15.0	32.1	2.7	3.7	46.8	46.8	
TAR034_OB	47.00	53.00	6.00	Clay/Sandstone	High/Mod	010	0.5	2.1	15.0	14.0	31.6	1.5	6.6	47.5	44.3	
TAR034_OB	53.00	60.00	7.00	Sandstone/Siltstone	Mod	011	0.4	1.7	13.0	9.0	24.1	1.6	7.1	54.0	37.4	
TAR034_OB	60.00	70.00	10.00	Sandstone/Siltstone	Slight	012	0.4	1.1	13.0	14.0	28.5	1.4	3.9	45.6	49.1	
TAR034_OB	70.00	72.00	2.00	Sandstone	High	013	0.3	0.6	14.0	15.0	29.9	1.1	1.9	46.8	50.2	
TAR034_OB	72.00	75.00	3.00	Sandstone/Siltstone	Slight	014	0.6	0.9	14.0	15.0	30.5	1.9	3.0	45.9	49.2	
TAR034_OB	75.00	76.00	1.00	Sandstone/Siltstone		015	0.4	0.7	14.0	15.0	30.2	1.4	2.5	46.4	49.7	
TAR034_OB	76.00	78.00	2.00	Sandstone/Siltstone		016	0.4	0.7	15.0	15.0	31.0	1.2	2.1	48.3	48.3	
TAR034_OB	78.00	79.00	1.00	Sandstone/Siltstone		017	0.2	0.4	9.5	12.0	22.2	1.1	1.9	42.9	54.2	
TAR034_OB	79.00	80.00	1.00	Sandstone/Siltstone		018	0.4	0.6	13.0	15.0	29.0	1.5	2.1	44.8	51.7	
TAR034_OB	80.00	81.00	1.00	Sandstone/Siltstone	Mod	019	0.3	0.4	12.0	11.0	23.7	1.4	1.5	50.6	46.4	
TAR034_OB	84.00	84.50	0.50	Sandstone/XA		020	0.2	0.5	7.0	7.5	15.2	1.6	3.2	46.0	49.2	

Table 8: Exchangeable cations for overburden/interburden samples tested by SGS in 2011.

Hole ID	Depth (m)			Lithology	Weathering	Sample Code	ex Na	ex K	ex Ca	ex Mg	ECEC	% ECEC Na (ESP)	% ECEC K	% ECEC Ca	% ECEC Mg	Classification
	From	To	Interval				(meq%)	(meq%)	(meq%)	(meq%)	(meq%)					
TAR034_OB	84.50	85.00	0.50	Sandstone/XA		021	0.3	0.5	8.0	9.0	17.8	1.6	2.8	45.0	50.6	
TAR034_OB	85.00	85.50	0.50	Sandstone/XA		022	0.2	0.4	13.0	8.2	21.9	1.1	2.0	59.5	37.5	
TAR034_OB	85.50	86.00	0.50	Sandstone/XA	Fresh	023	0.1	0.4	5.0	2.6	8.1	1.7	4.4	61.7	32.1	
TAR034_OB	86.00	87.00	1.00	Sandstone		024	0.2	0.3	2.1	2.4	5.0	3.2	6.2	42.3	48.3	
TAR034_OB	87.00	88.00	1.00	Sandstone		025	0.1	0.2	1.6	2.1	4.1	3.4	5.4	39.4	51.7	
TAR034_OB	88.00	89.00	1.00	Sandstone		026	0.1	0.2	1.1	1.8	3.2	3.4	6.5	34.2	55.9	
TAR034_OB	89.00	90.00	1.00	Sandstone	Fresh	027	0.1	0.3	1.0	1.7	3.0	4.3	8.3	31.4	56.1	
TAR034_OB	94.00	94.50	0.50	Sandstone/(XA)		028	0.2	0.4	2.1	3.1	5.7	2.6	6.6	36.6	54.1	
TAR034_OB	94.50	95.00	0.50	Sandstone/(XA)		029	0.2	0.4	1.9	2.7	5.1	3.3	7.0	37.0	52.6	
TAR034_OB	95.00	95.50	0.50	Sandstone/(XA)		030	0.2	0.3	1.7	2.6	4.8	3.1	6.9	35.6	54.4	
TAR034_OB	95.50	96.00	0.50	Sandstone/(XA)		031	0.2	0.4	1.5	3.4	5.5	3.3	7.0	27.5	62.3	
TAR034_OB	96.00	103.00	7.00	Sandstone/(XA)	Fresh	032	0.1	0.1	2.1	2.9	5.1	1.8	1.0	40.9	56.4	

Table 9: Acid forming characteristics of laboratory generated coarse and fine rejects samples.

Hole Name	Coal Quality Sample No	Sample Type	Seam	Raw Coal Total S (%)	EGi Sample No	$pH_{1:2}$	$EC_{1:2}$	ACID-BASE ANALYSIS					STANDARD NAG TEST			Extended Boil NAGpH	Calculated NAG	ARD Classification
								Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$			
TAR 025	TAR 025 CQ001 A SEAM	Coarse Rejects	A	7.66	4428	1.6	20.94	32.30	988	0	988	0.00	1.9	456	476	2.4	907	PAF
TAR 025	TAR 025 CQ002 B TOP	Coarse Rejects	B Tops	0.96	4429	2.0	18.21	16.85	516	0	516	0.00	1.9	306	339	2.3	505	PAF
TAR 025	TAR 025 CQ003 B SEAM	Coarse Rejects	B Bottoms	0.88	4430	1.9	19.45	14.65	448	0	448	0.00	2.0	255	308	2.3	350	PAF
TAR 216	TAR 216 CQ002	Coarse Rejects	B Bottoms	0.79	4431	2.5	2.39	4.20	129	4	125	0.03	2.3	43	76			PAF
TAR 218	TAR 218 CQ002	Coarse Rejects	B Bottoms	0.62	4432	2.3	4.26	2.63	80	0	80	0.00	2.2	73	94			PAF
TAR 227	TAR 227 CQ001	Coarse Rejects	B Tops	15.15	4433	1.7	19.21	18.79	575	0	575	0.00	2.0	320	361			PAF
TAR 239	TAR 239 CQ002	Coarse Rejects	B Bottoms	0.95	4434	2.0	10.29	8.16	250	0	250	0.00	2.1	164	214			PAF
TAR 242	TAR 242 CQ001	Coarse Rejects	B Tops	5.18	4435	2.1	18.66	17.29	529	0	529	0.00	1.9	314	355			PAF
TAR 243	TAR 243 CQ002	Coarse Rejects	B Bottoms	0.84	4436	2.2	11.76	10.13	310	0	310	0.00	2.0	193	270			PAF
TAR 255	TAR 255 CQ002	Coarse Rejects	B Bottoms	1.08	4437	3.0	6.05	15.00	459	0	459	0.00	2.0	298	360	2.3	458	PAF
TAR 260	TAR 260 CQ002	Coarse Rejects	B Bottoms	0.7	4438	2.5	3.11	2.76	84	0	84	0.00	2.1	55	97	2.5	114	PAF
TAR 278	TAR 278 CQ001	Coarse Rejects	B Tops	3.86	4439	2.1	10.35	13.55	415	0	415	0.00	1.9	264	301	2.3	356	PAF
TAR 289	TAR 289 CQ002	Coarse Rejects	B Bottoms	1.98	4440	2.0	16.88	17.49	535	0	535	0.00	1.9	304	359			PAF
TAR 025	TAR 025 CQ001 A SEAM	Fine Rejects	A	7.66	4441	2.0	15.54	17.65	540	0	540	0.00	1.8	270	319	2.3	430	PAF
TAR 025	TAR 025 CQ002 B TOP	Fine Rejects	B Tops	0.96	4442	4.1	0.98	0.88	27	0	27	0.00	1.9	238	287	3.1	27	PAF
TAR 025	TAR 025 CQ003 B SEAM	Fine Rejects	B Bottoms	0.88	4443	3.9	1.24	0.94	29	3	26	0.10	1.9	198	268	3.3	19	PAF
TAR 216	TAR 216 CQ002	Fine Rejects	B Bottoms	0.79	4444	4.0	1.14	1.19	36	3	33	0.08	2.0	178	257	3.7	16	PAF
TAR 217	TAR 217 CQ001	Fine Rejects	B Tops	0.76	4445	4.1	0.81	0.86	26	0	26	0.00	2.0	219	280	4.4	14	PAF
TAR 280	TAR 280 CQ001	Fine Rejects	B Bottoms	1.84	4446			2.78	85	0	85	0.00	2.0	122	171			PAF
TAR 227	TAR 227 CQ001	Fine Rejects	B Tops	15.15	4447	2.1	8.45	15.73	481	0	481	0.00	1.9	345	412			PAF
TAR 239	TAR 239 CQ002	Fine Rejects	B Bottoms	0.95	4448	3.8	0.93	0.88	27	5	22	0.19	1.9	236	293	4.8	13	PAF
TAR 242	TAR 242 CQ001	Fine Rejects	B Tops	5.18	4449	2.4	3.45	4.97	152	0	152	0.00	2.1	113	149			PAF
TAR 243	TAR 243 CQ002	Fine Rejects	B Bottoms	0.84	4450	4.2	0.72	0.83	25	4	21	0.16	1.9	246	314	4.4	18	PAF
TAR 255	TAR 255 CQ002	Fine Rejects	B Bottoms	1.08	4451	4.1	0.69	1.41	43	5	38	0.12	1.9	211	278	4.9	15	PAF
TAR 260	TAR 260 CQ002	Fine Rejects	B Bottoms	0.7	4452	4.5	0.55	0.66	20	7	13	0.35	2.0	214	282	4.8	12	PAF
TAR 278	TAR 278 CQ001	Fine Rejects	B Tops	3.86	4453	2.1	2.98	4.82	147	0	147	0.00	2.0	136	186	2.5	103	PAF
TAR 289	TAR 289 CQ002	Fine Rejects	B Bottoms	1.98	4454	2.2	2.75	1.74	53	2	51	0.04	2.0	244	317	3.2	24	PAF

KEY

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

Standard NAG results overestimate acid potential due to organic acid effects

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
PAF-LC = PAF - lower capacity
UC = Uncertain Classification
(expected classification in brackets)

Table 10: Sulphur speciation results for selected laboratory generated coarse and fine rejects samples.

EGi Sample Number	Hole Name	Sample Type	Seam	Total %S	Pyritic S (%)	Acid Sulphate %S	Total Acid Generating S (%)	Non-Acid Sulphate %S	Low Risk S Forms (%)	Proportion Total Acid Generating to Total S
4428	TAR 025	Coarse Rejects	A	32.30	21.60	3.71	25.31	6.99	0.00	78%
4429	TAR 025	Coarse Rejects	B Tops	16.85	12.40	1.00	13.40	3.45	0.00	80%
4430	TAR 025	Coarse Rejects	B Bottoms	14.65	11.10	0.48	11.58	2.44	0.63	79%
4437	TAR 255	Coarse Rejects	B Bottoms	15.00	11.50	0.32	11.82	1.54	1.64	79%
4438	TAR 260	Coarse Rejects	B Bottoms	2.76	2.17	0.15	2.32	0.37	0.07	84%
4439	TAR 278	Coarse Rejects	B Tops	13.55	9.12	1.59	10.71	2.84	0.00	79%
4441	TAR 025	Fine Rejects	A	17.65	14.40	1.31	15.71	1.94	0.00	89%
4442	TAR 025	Fine Rejects	B Tops	0.88	0.40	0.10	0.50	0.38	0.00	56%
4443	TAR 025	Fine Rejects	B Bottoms	0.94	0.67	0.04	0.71	0.17	0.06	75%
4444	TAR 216	Fine Rejects	B Bottoms	1.19	0.64	0.03	0.67	0.21	0.32	56%
4445	TAR 217	Fine Rejects	B Tops	0.86	0.33	0.06	0.39	0.15	0.31	46%
4448	TAR 239	Fine Rejects	B Bottoms	0.88	0.29	0.02	0.31	0.10	0.47	36%
4450	TAR 243	Fine Rejects	B Bottoms	0.83	0.38	0.04	0.42	0.10	0.31	51%
4451	TAR 255	Fine Rejects	B Bottoms	1.41	0.36	0.02	0.38	0.09	0.94	27%
4452	TAR 260	Fine Rejects	B Bottoms	0.66	0.27	0.02	0.29	0.07	0.30	44%
4453	TAR 278	Fine Rejects	B Tops	4.82	2.93	0.47	3.40	1.25	0.17	71%
4454	TAR 289	Fine Rejects	B Bottoms	1.74	0.78	0.07	0.85	0.49	0.40	49%

Pyritic S (%) = CRS (%)

Acid Sulphate S = KCl Acid Sulphate S

Total Acid Generating S = Pyritic S + Acid Sulphate S

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

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

Table 11: Multi-element composition of selected rejects sample solids (mg/kg except where shown).

Element	Detection Limit	Sample Description/Sample Number									
		Coarse Rejects					Fine Rejects				
		A	B Tops	B Bottoms	B Bottoms	B Tops	A	B Tops	B Bottoms	B Bottoms	B Tops
		4428	4429	4430	4437	4439	4441	4442	4443	4451	4453
Ag	0.01	0.14	0.32	1.67	0.31	1.00	0.76	0.31	0.23	0.04	0.07
Al	0.01%	0.79%	4.60%	3.16%	5.81%	5.13%	1.05%	1.06%	0.67%	0.87%	1.32%
As	0.2	24.3	83.9	28.7	35.7	49.6	22.2	5.1	1.8	1.5	22.7
B	10	10	28	25	32	27	62	67	104	110	70
Ba	10	83	148	64	142	698	217	110	91	98	500
Be	0.05	0.1	2	0.3	0.2	1.6	0.9	6.9	0.9	1	3.5
Bi	0.01	0.16	0.77	0.26	0.46	0.48	0.24	0.28	0.13	0.16	0.21
Ca	0.01%	0.01%	0.05%	0.25%	0.20%	0.02%	0.05%	0.08%	0.15%	0.25%	0.05%
Cd	0.02	0.09	0.25	0.54	0.67	0.18	0.08	0.08	0.05	0.09	0.47
Ce	0.01	2.4	41	12	10	35	16	31	7.8	8.9	43
Co	0.1	5.1	32	2.6	2.1	7.7	3.8	9.3	2.2	1.9	4.7
Cr	1	1.8	14	5.4	5.7	15	10	21	6.3	6	21
Cs	0.05	0.24	1.49	0.09	0.21	0.73	0.48	0.27	0.01	0.01	0.13
Cu	0.2	187	47	20	65	38	32	27	15	27	31
F	20	<20	145	280	268	235	63	60	105	190	61
Fe	0.01%	19.00%	11.00%	16.00%	14.00%	8.00%	13.00%	0.60%	2.00%	1.00%	3.60%
Ga	0.05	1.2	16	3.3	9.2	20	2.8	8.2	2.3	2.8	7.6
Ge	0.05	0.37	0.35	0.31	0.31	0.29	0.69	0.65	0.54	0.32	1.3
Hf	0.01	0.32	2.2	0.6	1.4	2.6	0.8	1.9	0.72	1	2.6
Hg	0.005	0.62	0.04	0.07	0.45	0.62	0.43	0.02	0.02	0.02	0.27
In	0.005	0.01	0.06	0.01	0.03	0.07	0.01	0.03	0.01	0.02	0.03
K	0.01%	0.02%	0.16%	0.02%	0.05%	0.08%	0.05%	0.04%	0.01%	0.01%	0.02%
La	0.5	1.24	17.7	5.39	4.7	14	8.97	13.8	3.51	4.05	16.2
Li	0.2	4.3	27	30	55	38	6.2	12	8.3	14	15
Mg	0.01%	<0.01%	0.04%	0.13%	0.18%	0.02%	0.01%	0.03%	0.05%	0.04%	0.01%
Mn	5	55	25	1542	546	70	50	13	374	59	31
Mo	0.05	3.1	20	4.8	17	4.8	3.7	2.7	0.9	0.9	2.6
Na	0.01%	<0.01%	0.01%	<0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
Nb	0.1	0.9	13	2.2	7.4	18	1.8	6	1.4	2.2	7.5
Ni	0.2	16	179	8.3	5.7	65	12	21	4.1	3.1	26
P	10	46	291	736	669	895	214	254	343	715	500
Pb	0.5	5.6	69	19	29	31	13	20	5.6	4	14
Rb	0.1	1.1	10	0.44	1.6	4.7	3	1.6	0.06	0.07	0.83
Re	0.002	0.001	0.006	0.001	0.002	0.002	0.002	0.002	0.001	0.001	0.002
S	0.01%	32.30%	16.85%	14.65%	15.00%	13.55%	17.65%	0.88%	0.94%	1.41%	4.82%
Sb	0.05	<0.2	2	<0.2	<0.2	1.1	0.2	0.7	<0.2	<0.2	0.5
Sc	0.1	0.4	4.8	1.6	2.3	3.3	1.2	4	1	1.4	3
Se	1	1.7	6.7	6.7	8.8	4.1	1.1	2.6	1.2	1.3	0.3
Sn	0.2	5	19	2.8	5.7	4.8	5.4	4.4	1.7	1.4	3.3
Sr	0.2	15	116	38	59	290	84	133	54	76	197
Ta	0.05	0.07	1.54	0.24	0.81	1.54	0.12	0.49	0.1	0.14	0.44
Te	0.05	0.07	0.56	0.16	0.16	0.08	0.06	0.1	0.05	0.06	0.08
Th	0.2	0.9	13	2.5	6.5	11	1.9	6.6	1.2	1.8	5.9
Ti	0.005%	0.03%	0.73%	0.06%	0.23%	0.78%	0.04%	0.24%	0.03%	0.04%	0.18%
Tl	0.02	4.6	23.0	6.1	3.7	22.0	2.2	0.9	0.2	0.2	10.0
U	0.1	0.37	4	0.64	1.8	5.1	0.71	1.8	0.49	0.73	2.2
V	1	4	21	5	11	31	15	48	8	15	66
W	0.1	11	8.2	11	6.5	9.9	12	4.1	3.4	2	1.9
Y	0.1	0.9	14	2.5	2	11	4.4	11	2.7	2.8	18
Zn	2	77	52	20	22	62	56	117	22	31	436
Zr	0.5	11	64	15	37	83	35	>40	27	>40	>40

< element at or below analytical detection limit.

Table 12: Geochemical abundance indices (GAI) of selected rejects sample solids. Values 3 and over are highlighted in yellow.

Element	Median Soil Abundance*	Sample Description/Sample Number									
		Coarse Rejects					Fine Rejects				
		A	B Tops	B Bottoms	B Bottoms	B Tops	A	B Tops	B Bottoms	B Bottoms	B Tops
		4428	4429	4430	4437	4439	4441	4442	4443	4451	4453
Ag	0.05	1	2	4	2	4	3	2	2	-	-
Al	7.1%	-	-	-	-	-	-	-	-	-	-
As	6	1	3	2	2	2	1	-	-	-	1
B	20	-	-	-	-	-	1	1	2	2	1
Ba	500	-	-	-	-	-	-	-	-	-	-
Be	0.3	-	2	-	-	2	1	4	1	1	3
Bi	0.2	-	1	-	1	1	-	-	-	-	-
Ca	1.5%	-	-	-	-	-	-	-	-	-	-
Cd	0.35	-	-	-	-	-	-	-	-	-	-
Ce	50	-	-	-	-	-	-	-	-	-	-
Co	8	-	1	-	-	-	-	-	-	-	-
Cr	70	-	-	-	-	-	-	-	-	-	-
Cs	4	-	-	-	-	-	-	-	-	-	-
Cu	30	2	-	-	1	-	-	-	-	-	-
F	200	-	-	-	-	-	-	-	-	-	-
Fe	4.0%	2	1	1	1	-	1	-	-	-	-
Ga	20	-	-	-	-	-	-	-	-	-	-
Ge	1	-	-	-	-	-	-	-	-	-	-
Hf	6	-	-	-	-	-	-	-	-	-	-
Hg	0.06	3	-	-	2	3	2	-	-	-	2
In	1	-	-	-	-	-	-	-	-	-	-
K	1.4%	-	-	-	-	-	-	-	-	-	-
La	40	-	-	-	-	-	-	-	-	-	-
Li	25	-	-	-	1	-	-	-	-	-	-
Mg	0.5%	-	-	-	-	-	-	-	-	-	-
Mn	1000	-	-	-	-	-	-	-	-	-	-
Mo	1.2	1	3	1	3	1	1	1	-	-	1
Na	0.5%	-	-	-	-	-	-	-	-	-	-
Nb	10	-	-	-	-	-	-	-	-	-	-
Ni	50	-	1	-	-	-	-	-	-	-	-
P	800	-	-	-	-	-	-	-	-	-	-
Pb	35	-	-	-	-	-	-	-	-	-	-
Rb	150	-	-	-	-	-	-	-	-	-	-
Re	0										
S	0.07%	8	7	7	7	7	7	3	3	4	6
Sb	1	-	-	-	-	-	-	-	-	-	-
Sc	7	-	-	-	-	-	-	-	-	-	-
Se	0.4	2	3	3	4	3	1	2	1	1	-
Sn	4	-	2	-	-	-	-	-	-	-	-
Sr	250	-	-	-	-	-	-	-	-	-	-
Ta	2	-	-	-	-	-	-	-	-	-	-
Te	0										
Th	9	-	-	-	-	-	-	-	-	-	-
Ti	0.50%	-	-	-	-	-	-	-	-	-	-
Tl	0.2	4	6	4	4	6	3	2	-	-	5
U	2	-	-	-	-	1	-	-	-	-	-
V	90	-	-	-	-	-	-	-	-	-	-
W	1.5	2	2	2	2	2	2	1	1	-	-
Y	40	-	-	-	-	-	-	-	-	-	-
Zn	90	-	-	-	-	-	-	-	-	-	2
Zr	400	-	-	-	-	-	-	-	-	-	-

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

Table 13: Chemical composition of water extracts for selected rejects samples.

Parameter		Detection Limit	Sample Description/Sample Number									
			Coarse Rejects					Fine Rejects				
			A	B Tops	B Bottoms	B Bottoms	B Tops	A	B Tops	B Bottoms	B Bottoms	B Tops
			4428	4429	4430	4437	4439	4441	4442	4443	4451	4453
pH		0.1	1.7	2.0	2.1	2.7	2.1	1.9	3.8	4.0	4.3	2.1
EC	dS/m	0.001	20.96	17.25	10.21	8.11	12.39	16.95	1.21	1.11	0.681	3.89
Ag	mg/l	0.001	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.001	<0.001	<0.001	<0.010
Al	mg/l	0.01	623	348	62.8	128	674	78.6	5.15	2.22	0.64	31.4
As	mg/l	0.001	1.31	0.84	0.04	0.14	2.36	0.85	0.02	<0.001	<0.001	0.99
B	mg/l	0.05	<0.50	<0.50	<0.50	<0.50	<0.50	0.77	0.68	0.94	1.16	0.72
Ba	mg/l	0.001	0.056	0.018	0.032	0.017	0.022	0.022	0.063	0.088	0.105	0.015
Be	mg/l	0.001	0.014	0.079	<0.010	<0.010	0.086	0.03	0.05	0.004	<0.001	0.072
Ca	mg/l	1	17	71	117	94	34	22	76	62	46	30
Cd	mg/l	0.0001	0.0087	0.0085	0.009	0.0104	0.019	0.0043	0.0017	0.0007	0.0003	0.0255
Cl	mg/l	1	20	176	441	319	112	<1	4	5	6	2
Co	mg/l	0.001	1.35	1.48	0.366	0.398	1.7	0.443	0.318	0.129	0.024	0.422
Cr	mg/l	0.001	0.416	0.258	0.052	0.096	0.308	0.258	0.014	0.002	<0.001	0.047
Cu	mg/l	0.001	13.8	4.34	0.179	1.13	1.45	0.73	0.131	0.036	0.03	2.16
F	mg/l	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.1	<0.1
Fe	mg/l	0.05	9930	5040	2670	3050	4880	3730	132	34.6	3.03	1270
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	8	5	1	2	2	2	2	2	2	1
Mg	mg/l	1	6	49	102	84	31	6	33	33	29	11
Mn	mg/l	0.001	3.96	18.5	48.1	33.7	4.32	2.21	0.397	2.79	0.315	1.16
Mo	mg/l	0.001	0.058	0.027	<0.010	<0.010	0.019	<0.010	<0.001	<0.001	<0.001	<0.010
Na	mg/l	1	6	6	4	4	5	6	8	8	14	4
Ni	mg/l	0.001	2.38	4.22	0.579	0.607	14	1.02	0.591	0.071	0.014	2.54
P	mg/l	1	7	8	1	4	6	5	<1	<1	<1	<1
Pb	mg/l	0.001	0.057	0.1	0.026	0.033	0.013	0.015	0.001	<0.001	<0.001	<0.010
Sb	mg/l	0.001	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.001	<0.001	<0.001	<0.010
Se	mg/l	0.01	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.01	<0.01	<0.01	<0.10
Si	mg/l	0.1	<0.50	0.95	0.71	0.85	1.83	<0.50	0.18	0.1	0.13	0.86
Sn	mg/l	0.001	0.166	0.053	<0.010	0.014	<0.010	0.039	<0.001	<0.001	<0.001	<0.010
SO4	mg/l	1	29900	14700	5810	7550	16300	10300	68	38	21	3650
Sr	mg/l	0.001	0.804	1.27	0.751	0.753	0.733	1.05	0.767	0.642	0.382	0.254
Th	mg/l	0.001	0.086	0.512	0.039	0.042	0.472	0.068	0.002	<0.001	<0.001	0.146
U	mg/l	0.001	0.024	0.041	<0.010	<0.010	0.144	0.021	<0.001	<0.001	<0.001	0.019
Zn	mg/l	0.005	19.6	8.92	2.59	4.43	6.21	3.18	4.29	1.25	0.736	12.8

< element at or below analytical detection limit.

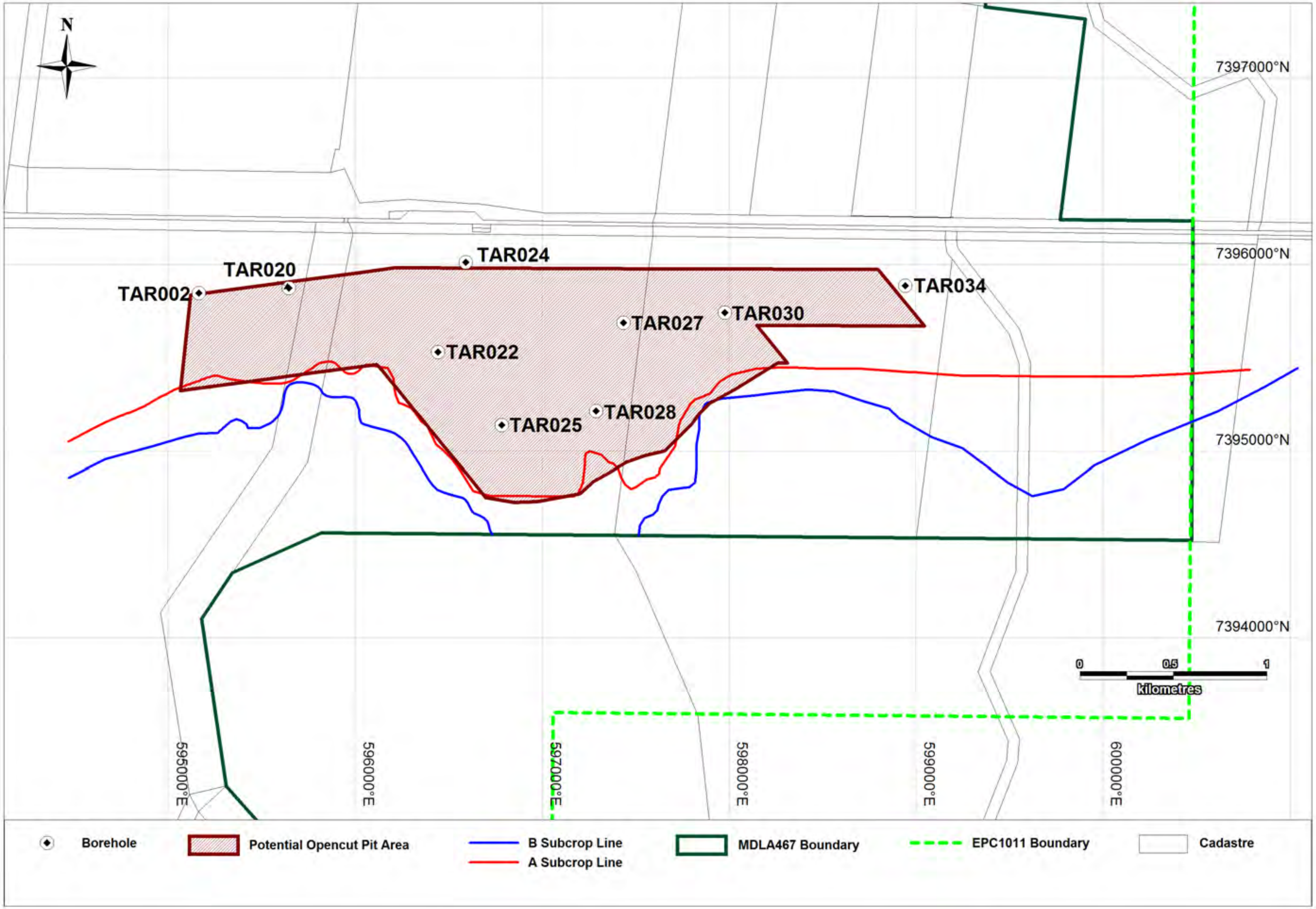

Figure 1: Location of drillholes sampled for geochemical testing.

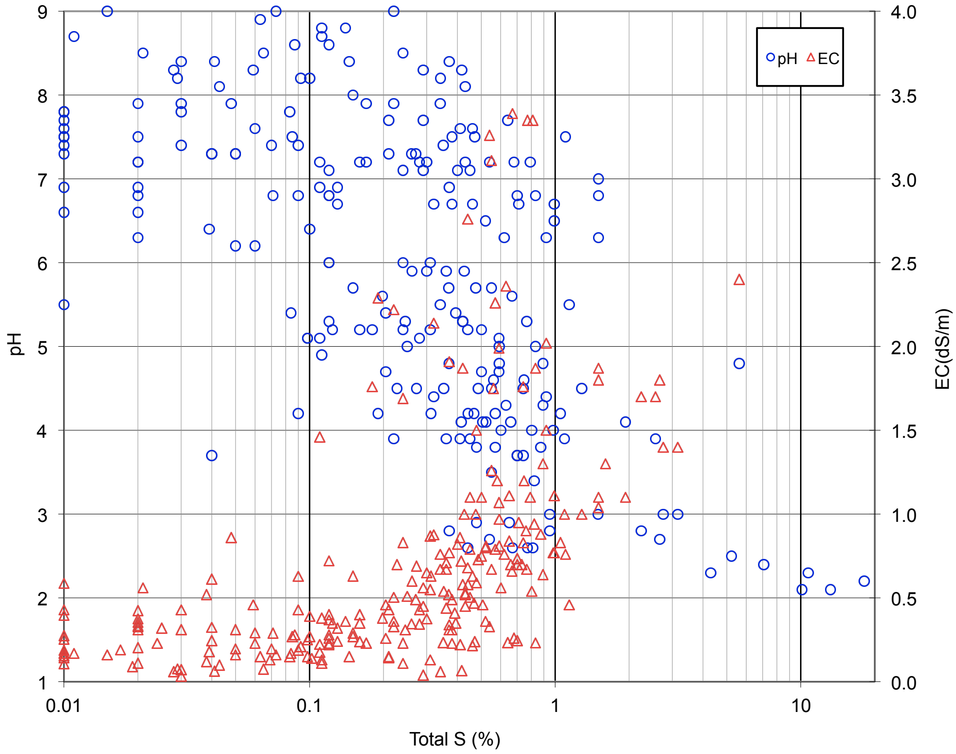

Figure 2: Plot showing combined $pH_{1:2}$ and $pH_{1:5}$ and combined $EC_{1:2}$ and $EC_{1:5}$ versus total S for overburden/interburden and coal samples.

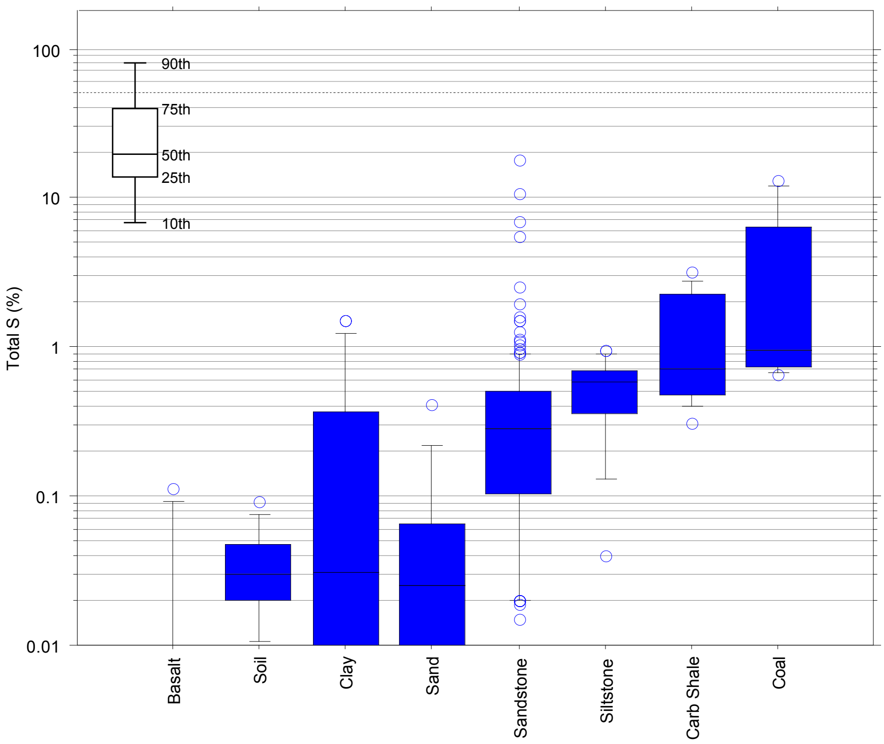

Figure 3: Box plot showing the distribution of S split by lithology for overburden/interburden and coal samples. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

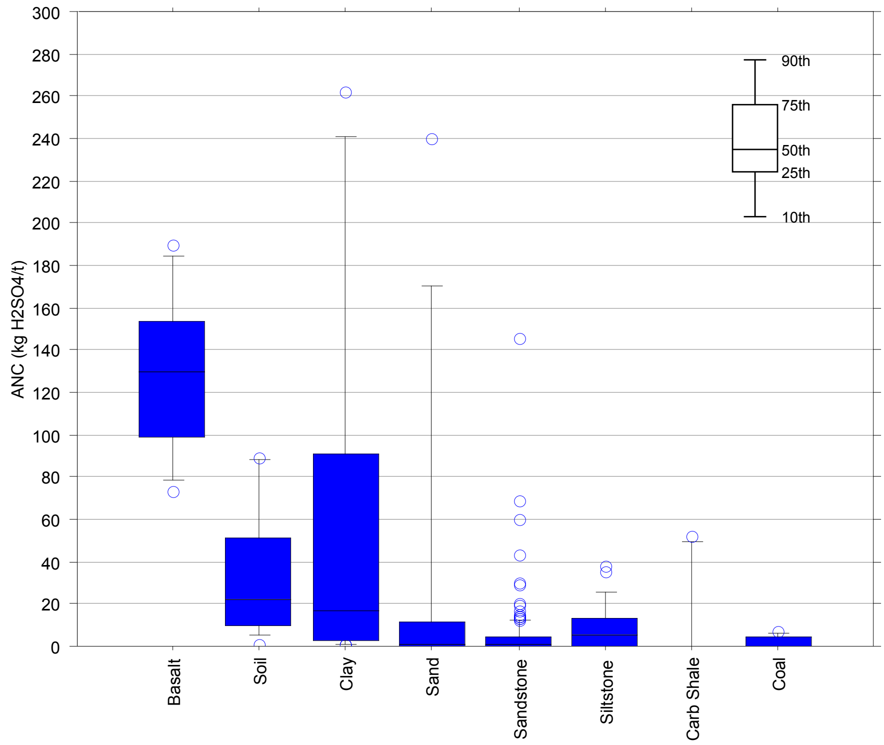

Figure 4: Box plot showing the distribution of ANC split by lithology for overburden/interburden and coal samples. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

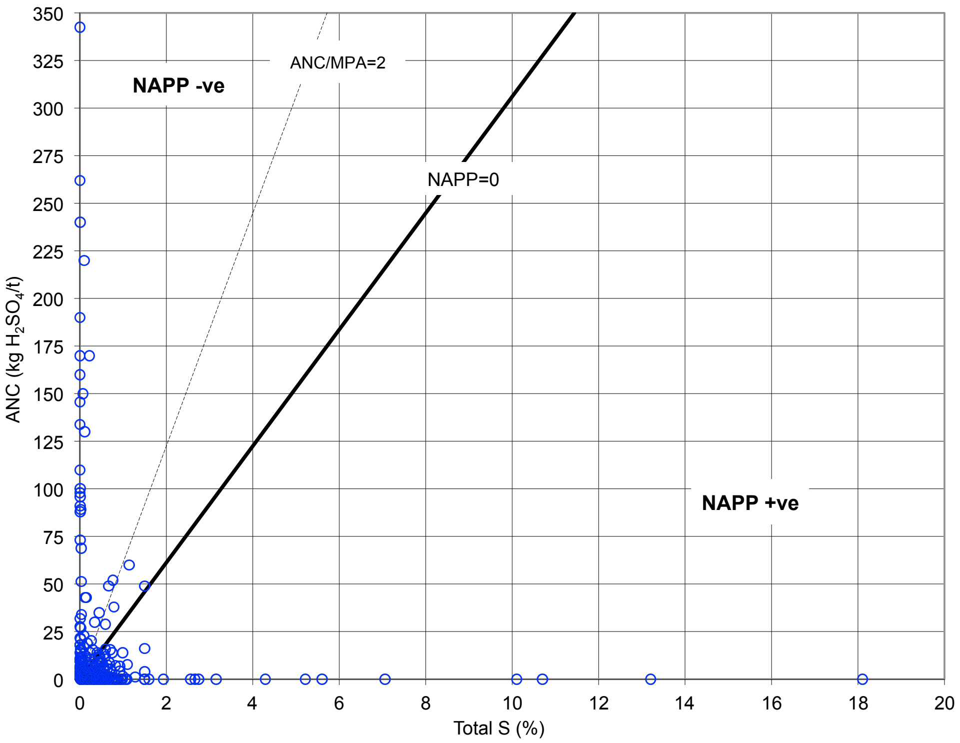

Figure 5: Acid-base account (ABA) plot showing ANC versus total S for overburden/interburden and coal samples.

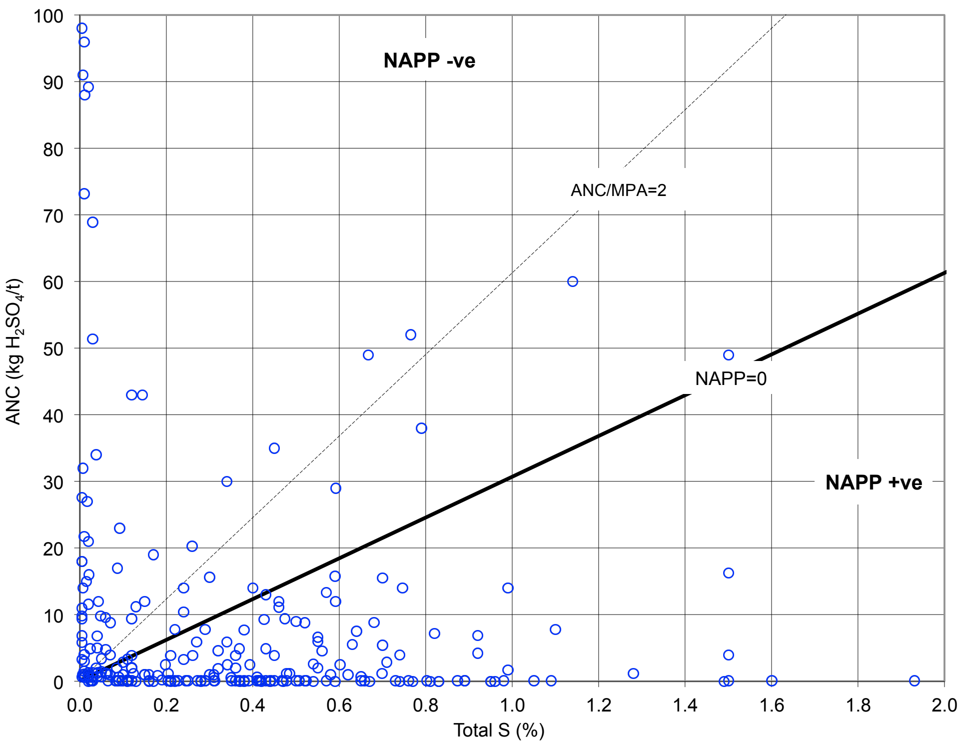

Figure 6: As for Figure 5 with an expanded scale.

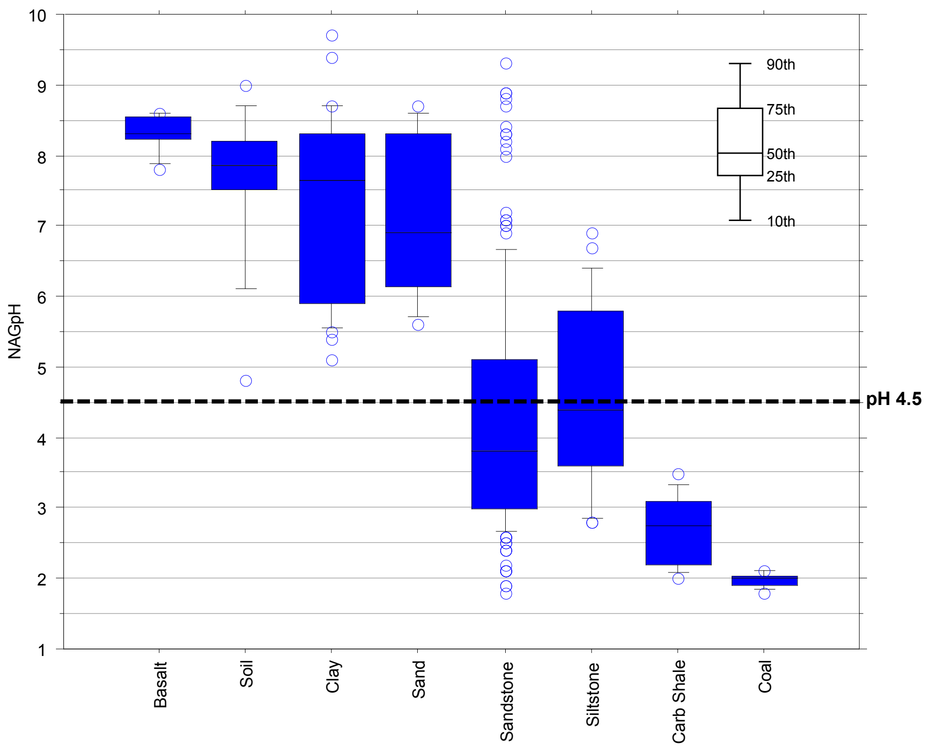

Figure 7: Box plot showing the distribution of NAGpH split by lithology for overburden/interburden and coal samples. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

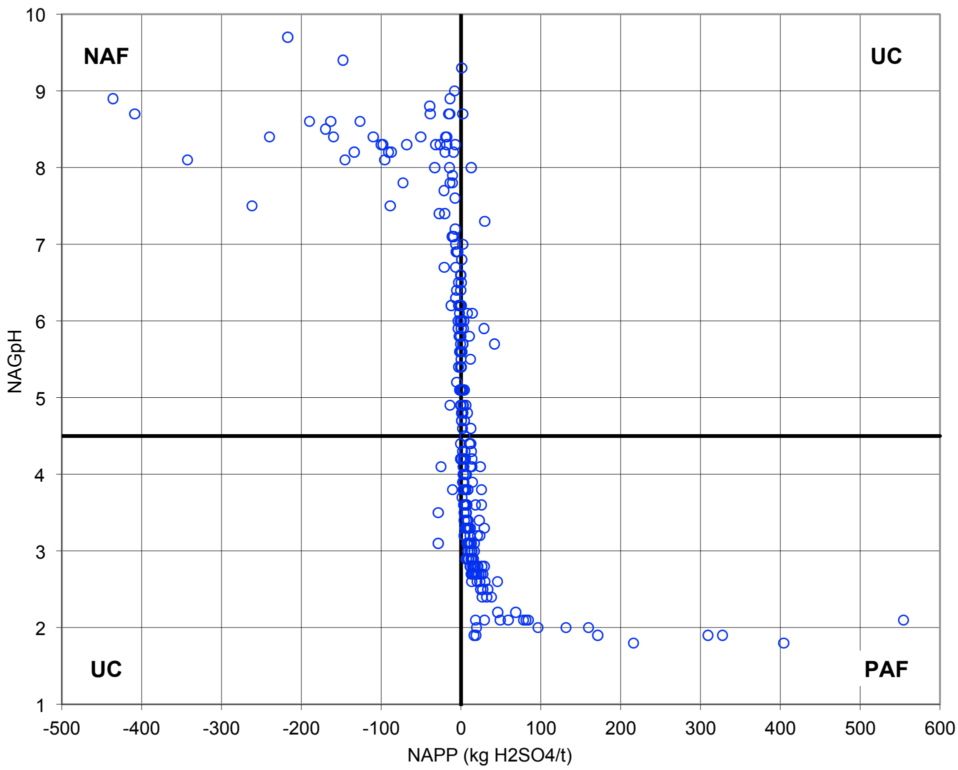

Figure 8: ARD classification plot showing NAGpH versus NAPP for overburden/interburden and coal samples, with ARD classification domains indicated.

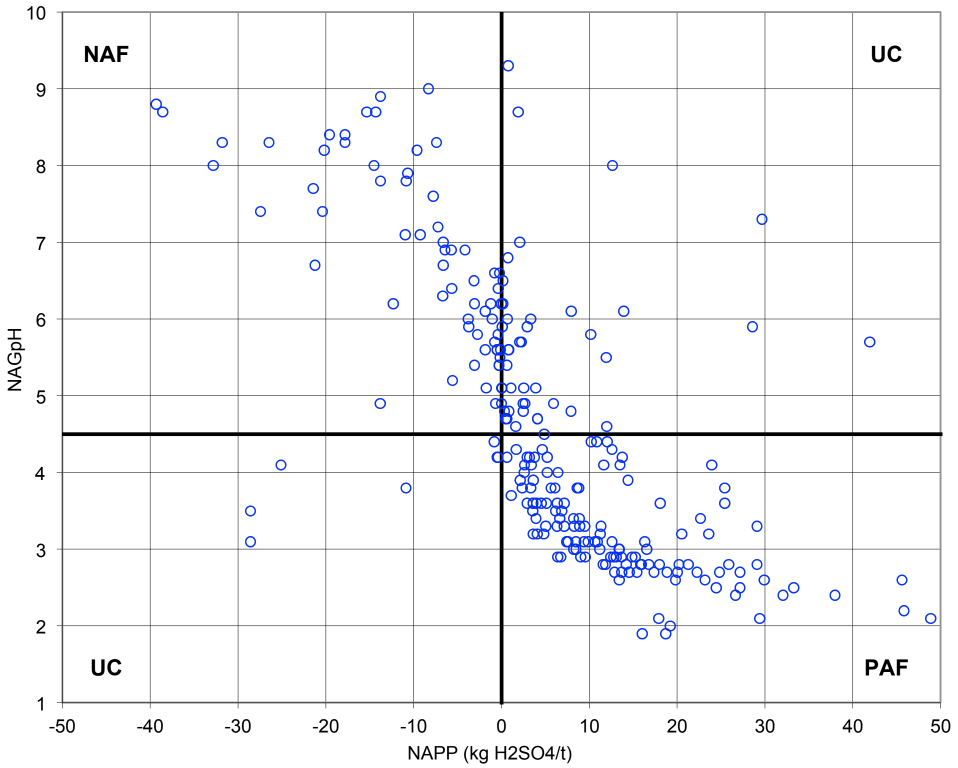

Figure 9: As for Figure 8 with an expanded NAPP axis.

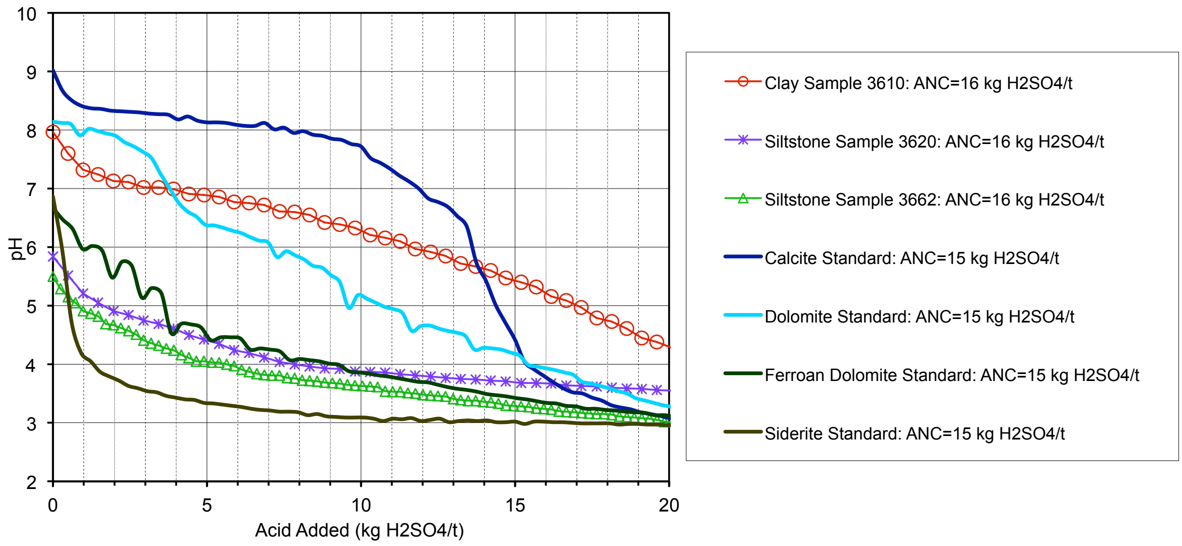

Figure 10: ABCC profile for samples with an ANC value close to 15 kg H_2SO_4/t. Carbonate standard curves are included for reference.

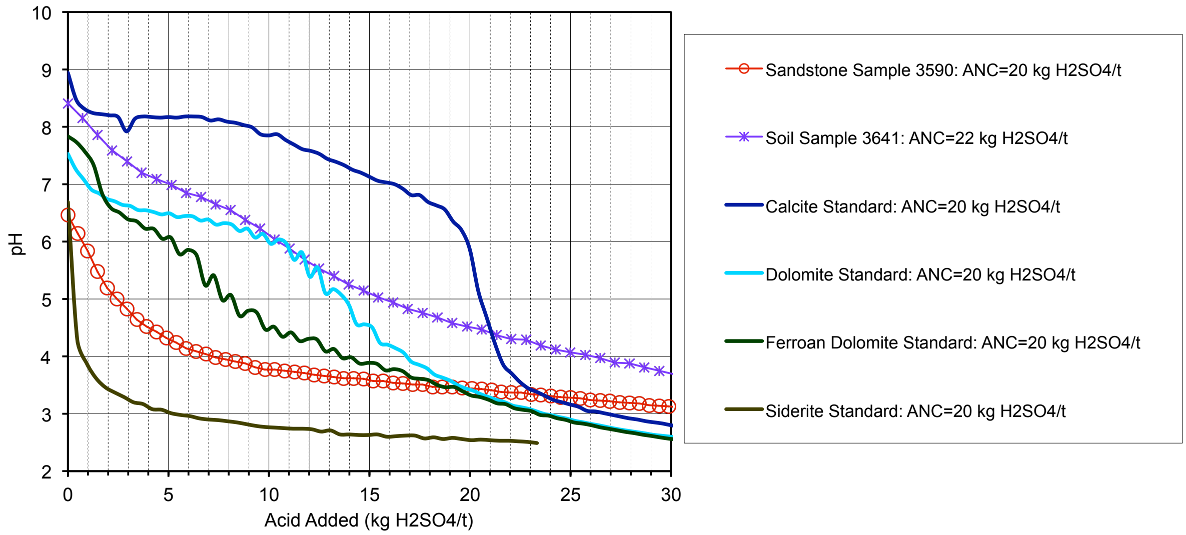

Figure 11: ABCC profile for samples with an ANC value close to 20 kg H_2SO_4/t. Carbonate standard curves are included for reference.

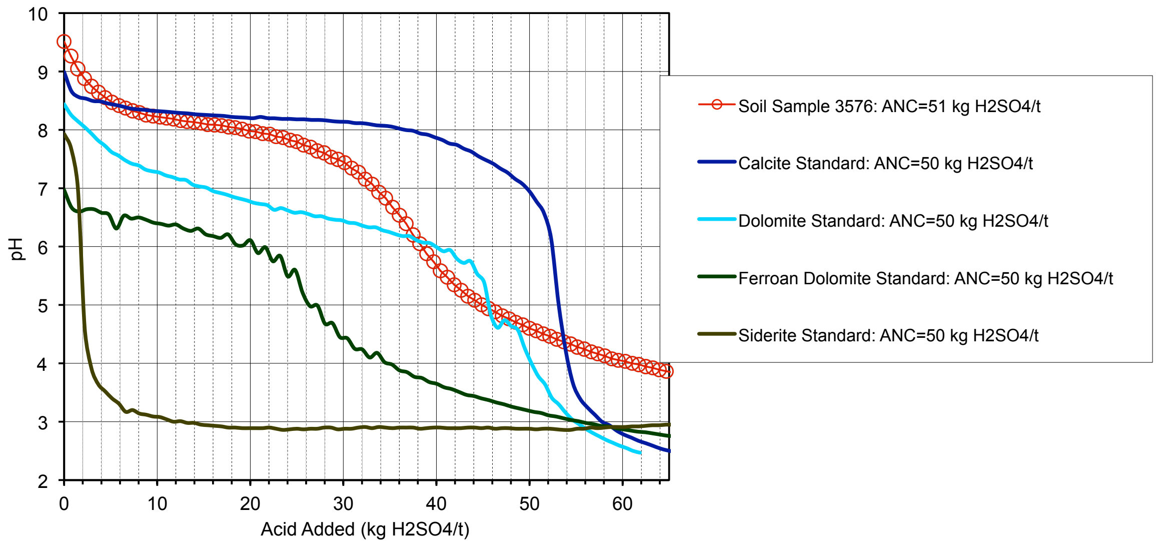

Figure 12: ABCC profile for sample 3576 with an ANC value close to 50 kg H_2SO_4/t. Carbonate standard curves are included for reference.

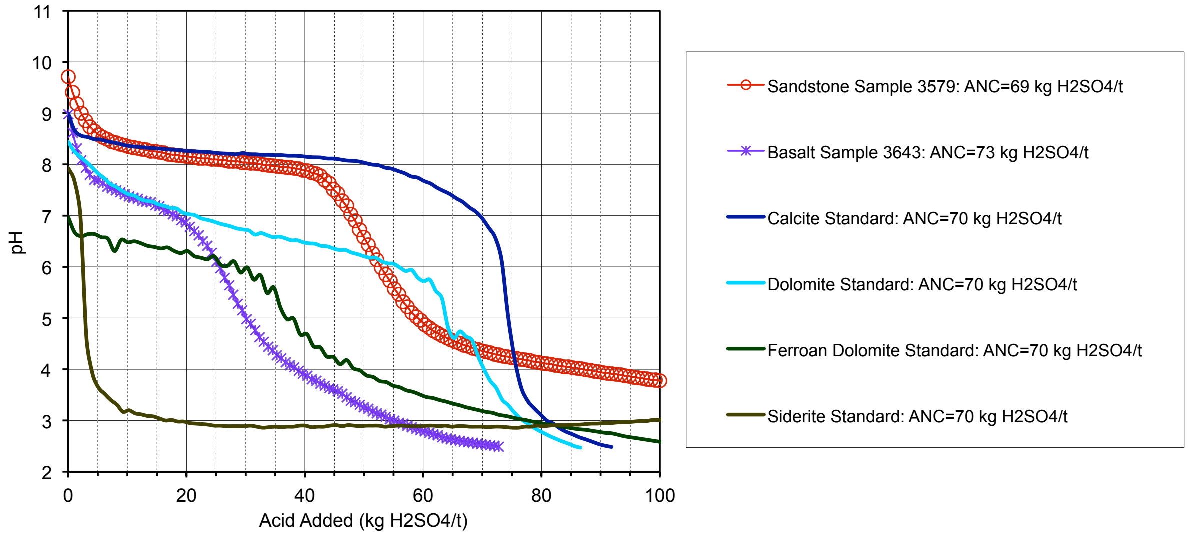

Figure 13: ABCC profile for samples with an ANC value close to 70 kg H_2SO_4/t. Carbonate standard curves are included for reference.

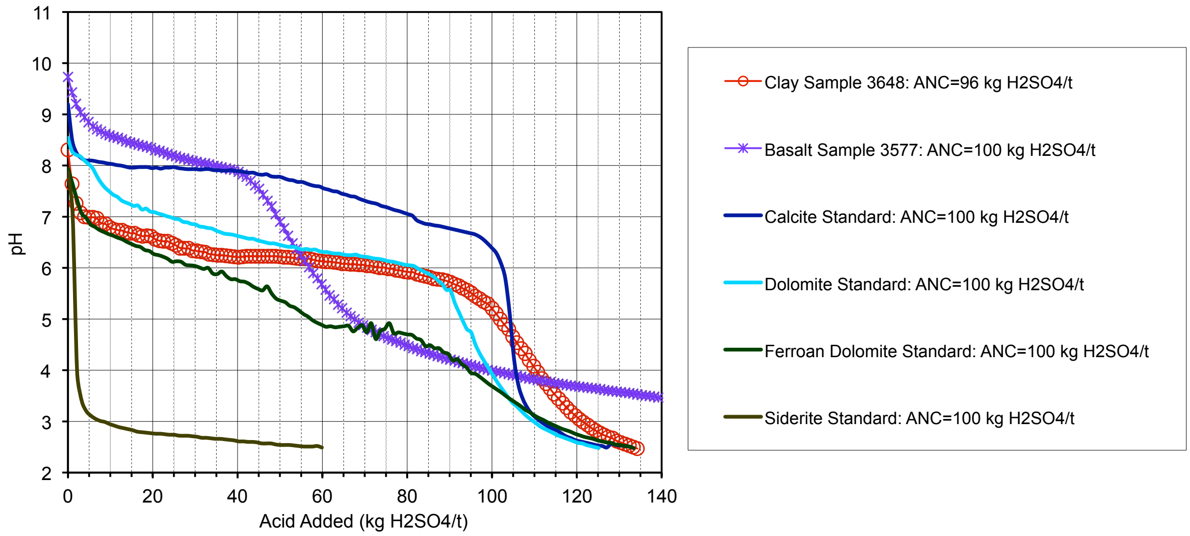

Figure 14: ABCC profile for samples with an ANC value close to 100 kg H_2SO_4/t. Carbonate standard curves are included for reference.

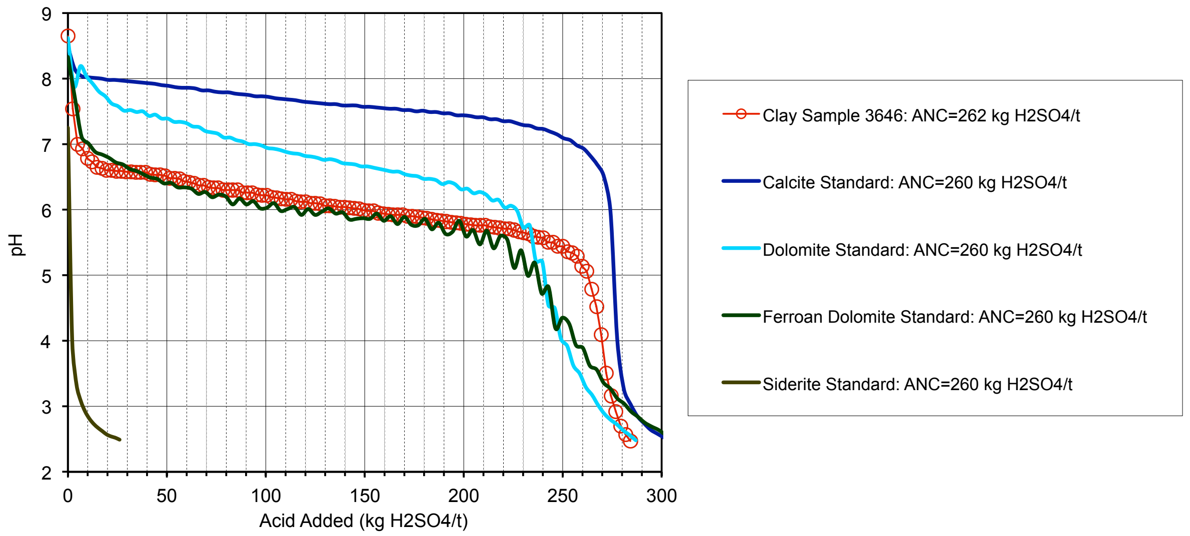

Figure 15: ABCC profile for sample 3646 with an ANC value close to 260 kg H_2SO_4/t. Carbonate standard curves are included for reference.

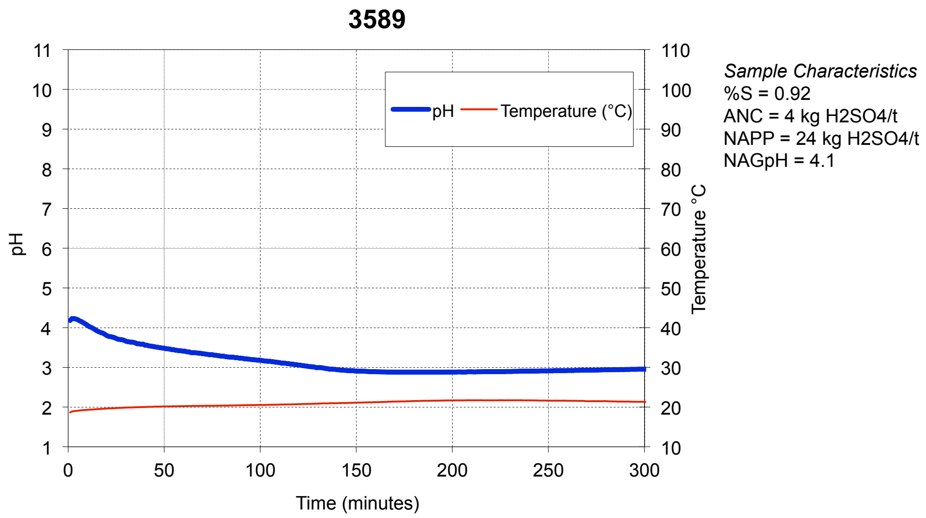

Figure 16: Kinetic NAG graph for sandstone sample 3589.

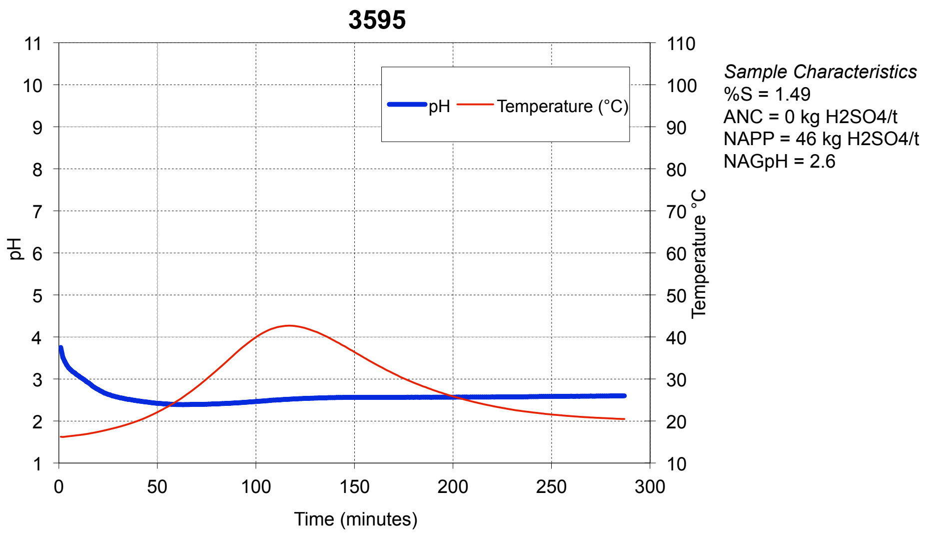

Figure 17: Kinetic NAG graph for sandstone sample 3595.

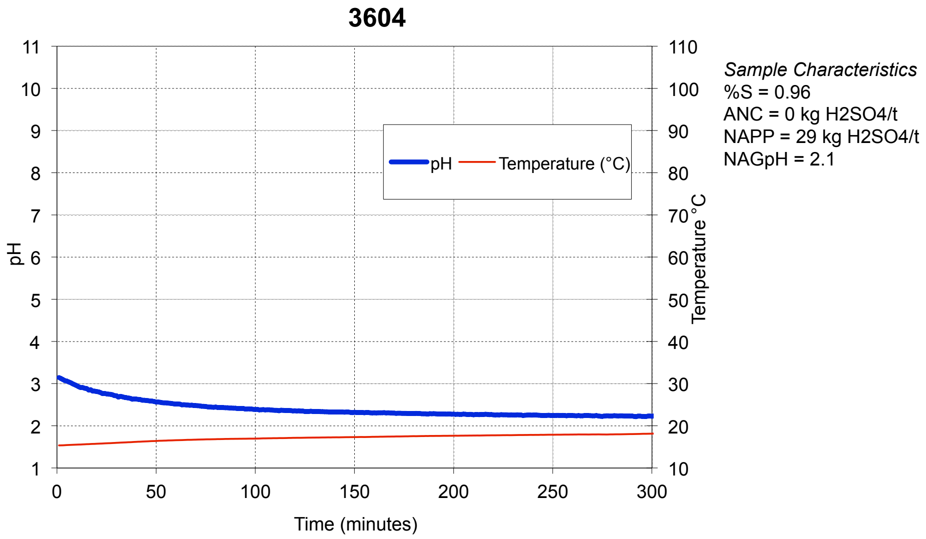

Figure 18: Kinetic NAG graph for coal sample 3604.

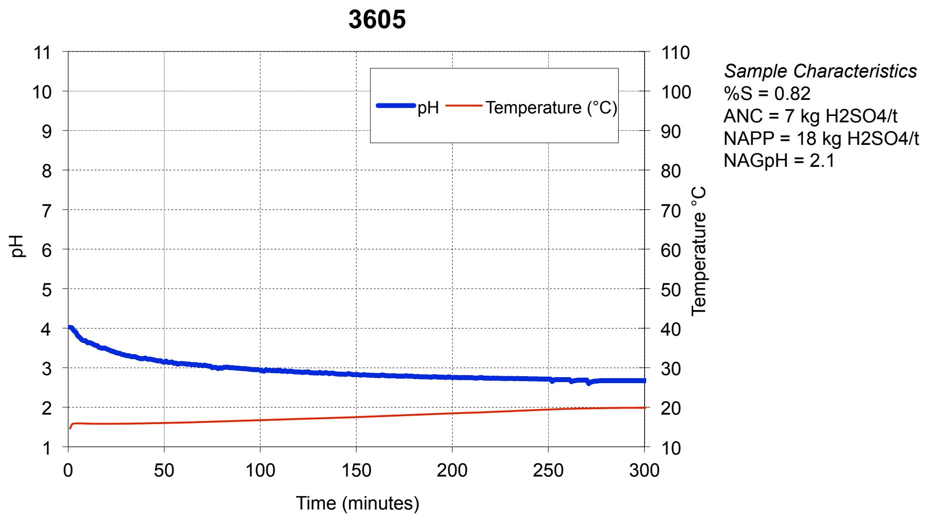

Figure 19: Kinetic NAG graph for coal sample 3605.

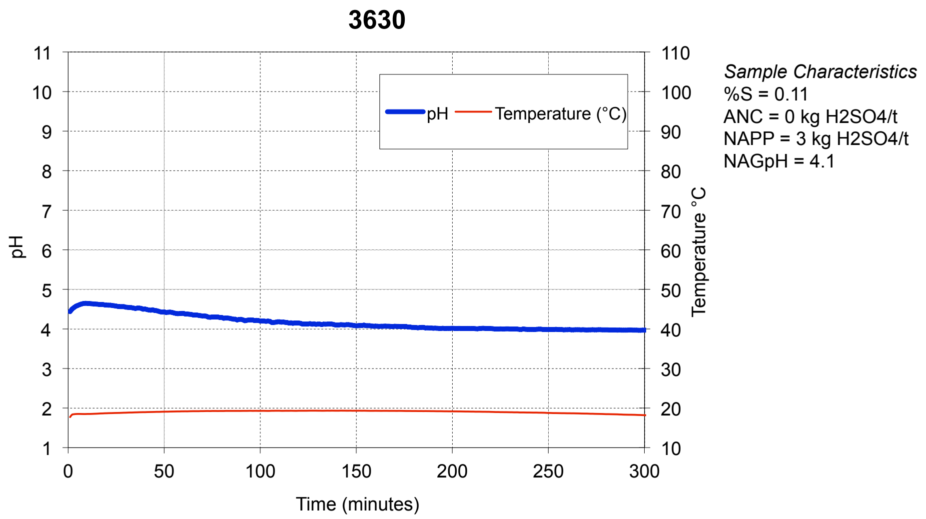

Figure 20: Kinetic NAG graph for sandstone sample 3630.

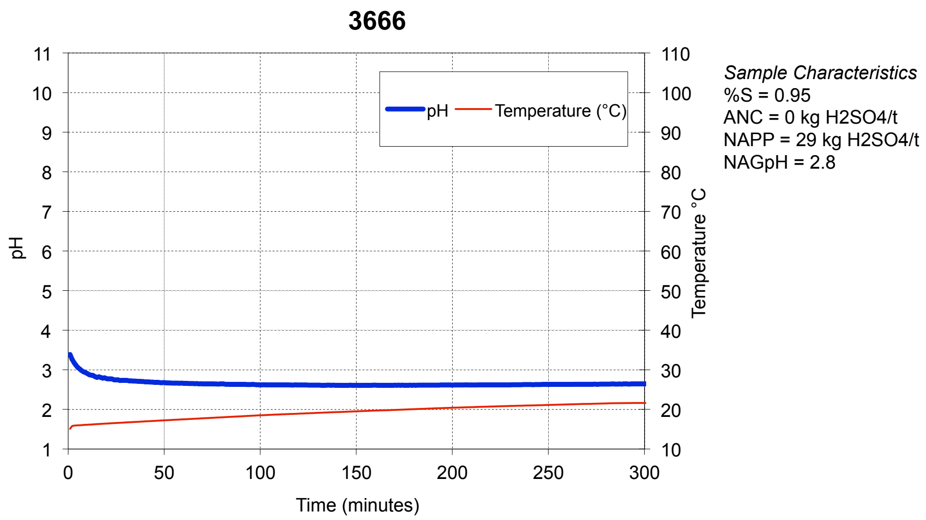

Figure 21: Kinetic NAG graph for siltstone sample 3666.

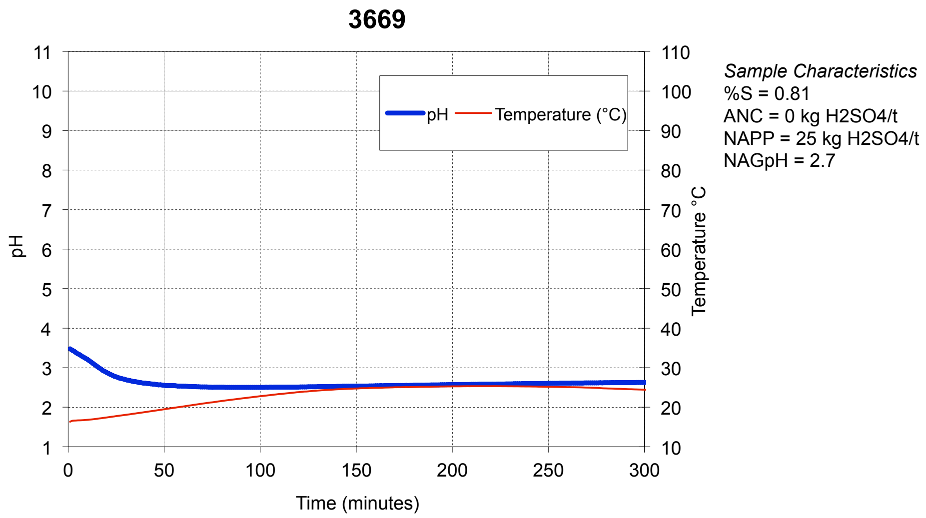

Figure 22: Kinetic NAG graph for sandstone sample 3669.

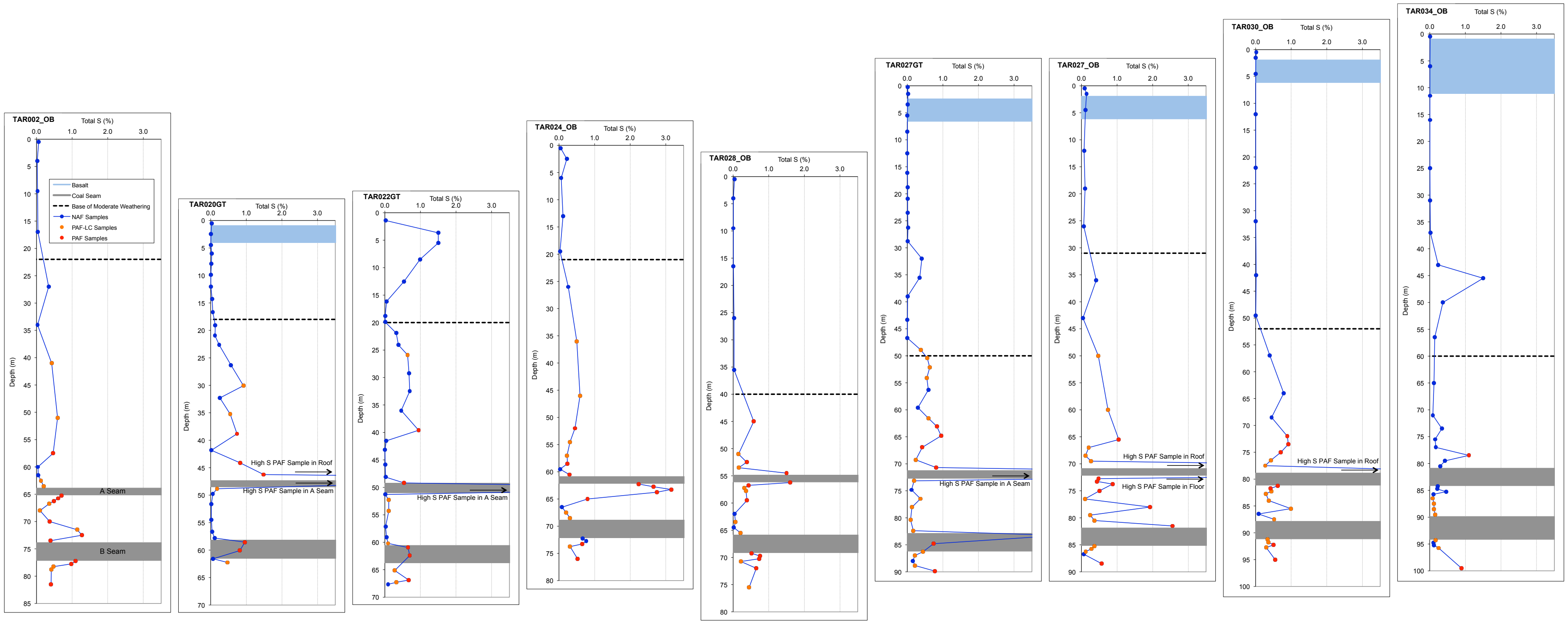

Figure 23: Plot of total S profiles for Taroborah drill holes. PAF samples are shown as red symbols, PAF-LC as orange symbols and NAF as blue symbols. Profiles are aligned by seam stratigraphy.

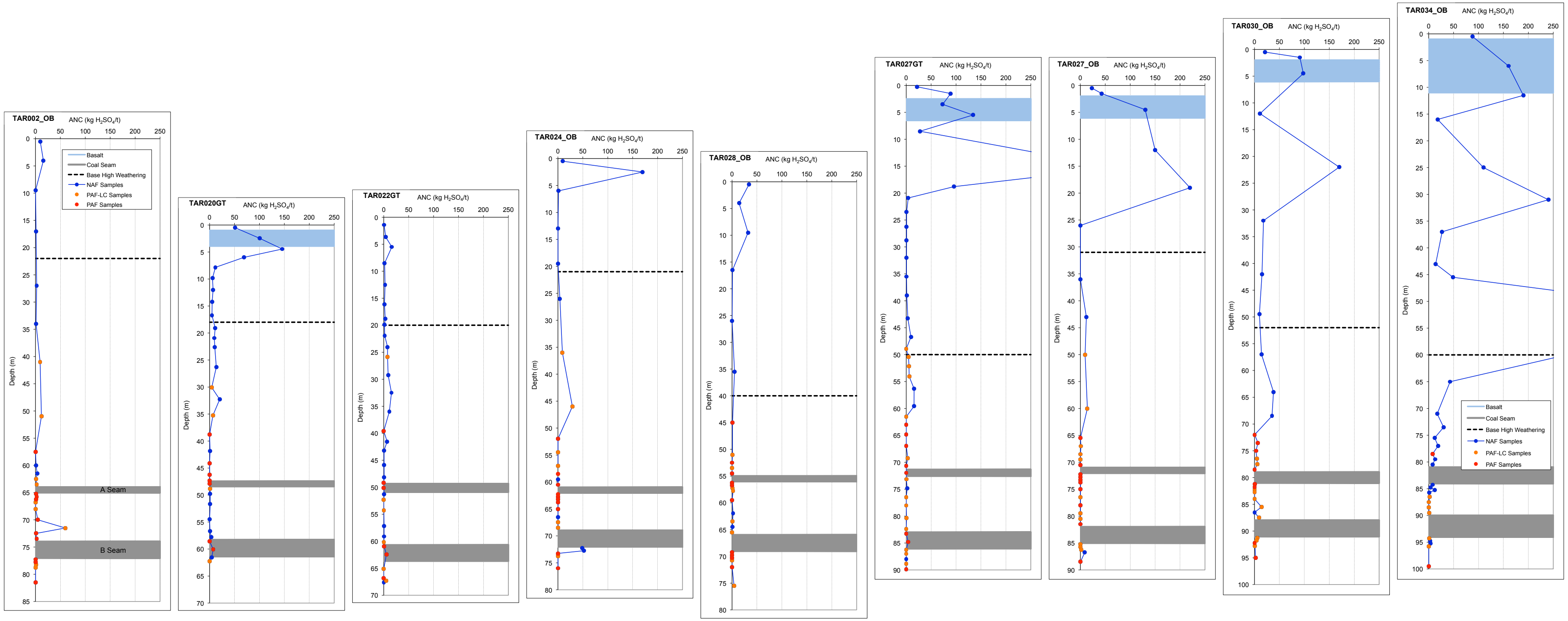

Figure 24: Plot of ANC profiles for Taroborah drill holes. PAF samples are shown as red symbols, PAF-LC as orange symbols and NAF as blue symbols. Profiles are aligned by seam stratigraphy.

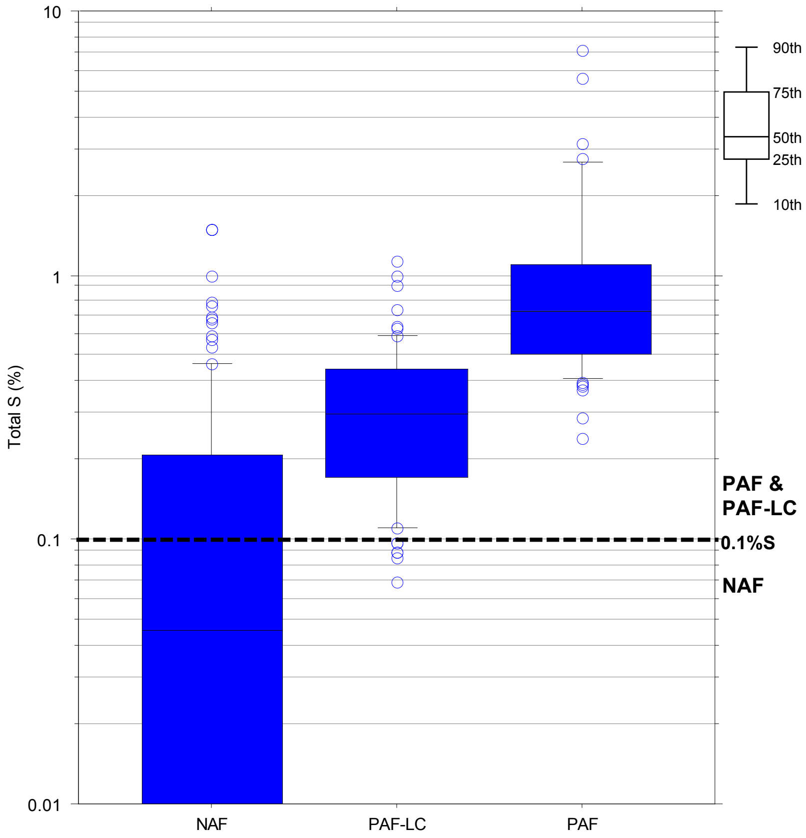

Figure 25: Box plot showing the distribution of total S for overburden/interburden only split by ARD classification. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

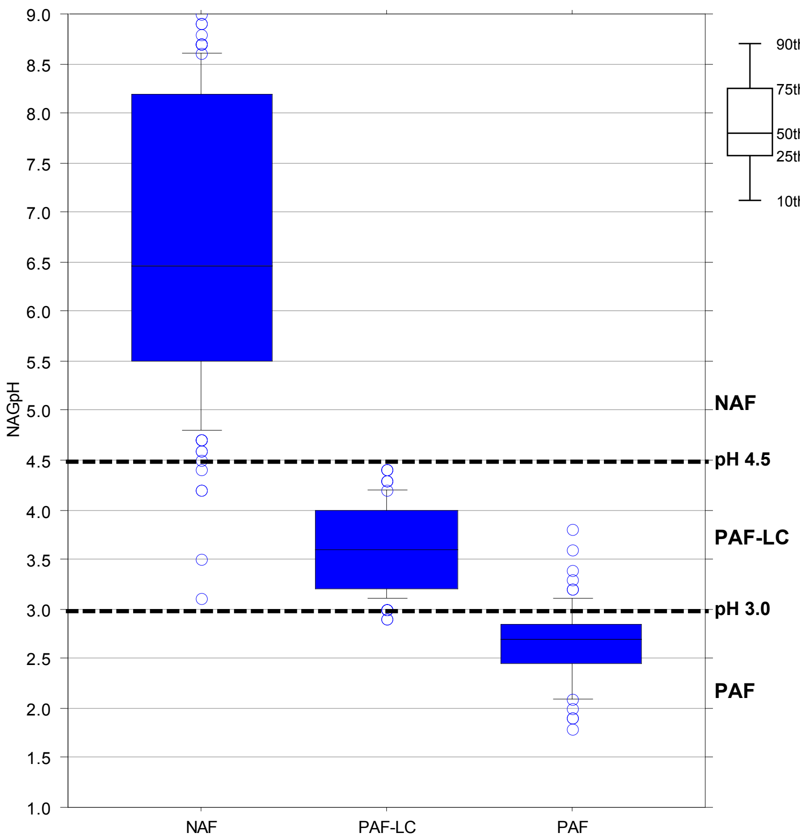

Figure 26: Box plot showing the distribution of NAGpH for overburden/interburden only split by ARD classification. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

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.

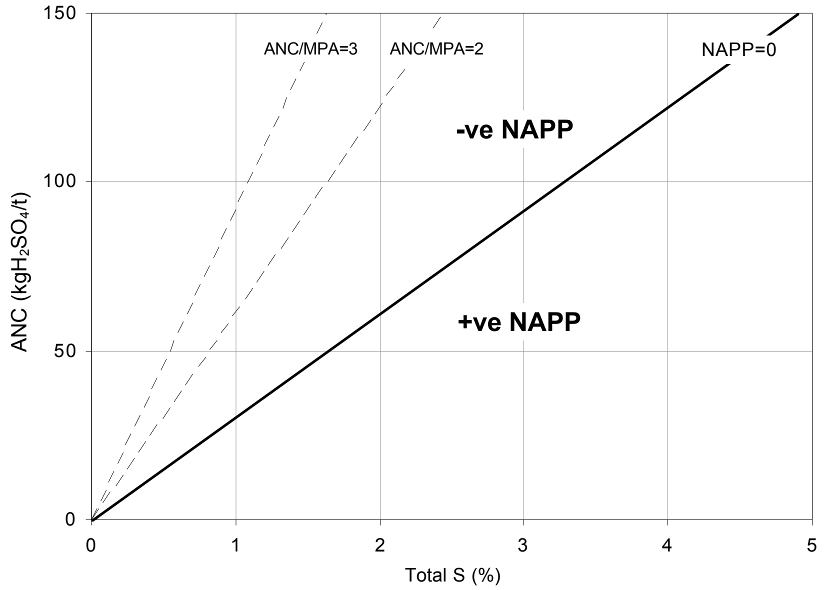

Figure A-1: Acid-base account (ABA) plot

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.

---

[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.

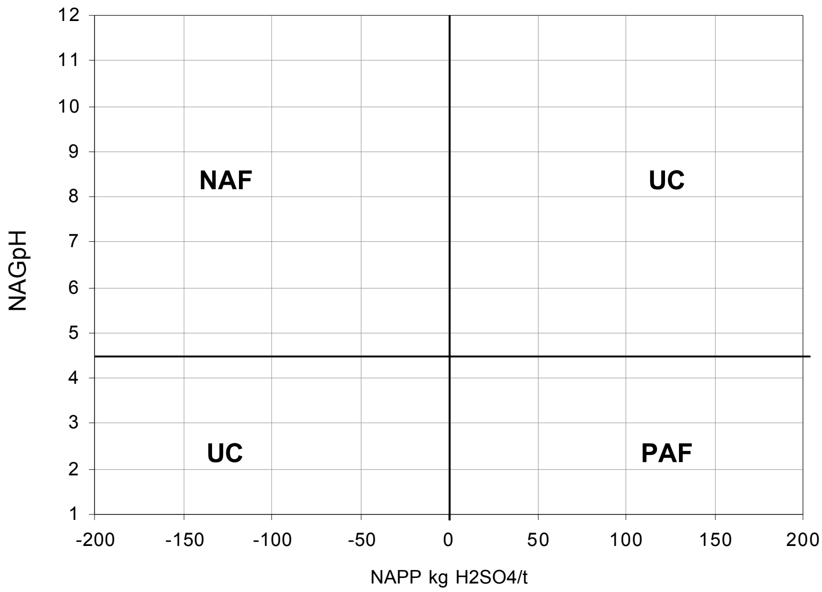

Figure A-2 ARD classification plot

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.

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Document No. 4208/1114

Leach Column Test Results for Overburden and Interburden from the Taroborah Coal Project

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List of Abbreviations

Abbreviations Used in Geochemical Assessment

ARD	Acid Rock Drainage
ABA	Acid Base Account
$pH_{1:2}$	pH of a sample slurry with a solid to water ratio of 1:2 (by weight)
$EC_{1:2}$	Electrical Conductivity of a sample slurry with a solid to water ratio of 1:2 (by weight)
S	Sulphur
CRS	Chromium Reducible Sulphur
H_2SO_4	Sulphuric Acid
SO_4	Sulphate
$CaCO_3$	Calcium Carbonate
ANC	Acid Neutralising Capacity in kg H_2SO_4/t
MPA	Maximum Potential Acidity, calculated from total S in kg H_2SO_4/t
NAPP	Net Acid Producing Potential, calculated from ANC and total S (or MPA) in kg H_2SO_4/t.
NAG	Net Acid Generation (test)
NAGpH	pH of NAG solution before titration
$NAG_{(pH4.5)}$	NAG acidity titrated to pH 4.5 in kg H_2SO_4/t
$NAG_{(pH7.0)}$	NAG acidity titrated to pH 7.0 in kg H_2SO_4/t
ABCC	Acid Buffering Characteristic Curve
GAI	Geochemical Abundance Index based on multi-elements of solids
PAF	Potentially Acid Forming
PAF-LC	Potentially Acid Forming - Low Capacity
NAF	Non Acid Forming
UC	Uncertain

Units of Measurement

%	Percentage
°C	Degrees Celsius
dS	Deci Siemen
m	Metre
kg	Kilogram
mg	Milligram
t	Tonne
L	Litre
ml	Millilitre

Other Abbreviations

AARC	AustralAsian Resource Consultants Pty Ltd
ALS	Australian Laboratory Services
EGi	Environmental Geochemistry International Pty Ltd
SESL	Sydney Environmental and Soil Laboratory

Executive Summary

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by Shenhuo International Group Pty Ltd (Shenhuo) to carry out leach column testing of overburden and interburden from the Taroborah Coal Project, a thermal coal deposit located approximately 22 km west of Emerald in Central Queensland. The objective of the work was to provide information on leaching characteristics and lag times of key waste rock types for use in water quality predictions and to help refine materials management options. Leach column testing followed on from the static geochemical assessment that was carried out by EGi in 2012/2013[1].

This report presents final results and findings of leach column testing after 76 weeks of operation.

Leach column testing was carried out on the following 7 material types to represent the main overburden/interburden geochemical zones identified in the static assessment:

- Weathered Low ANC NAF Sedimentary Rock
- Weathered High ANC NAF Sedimentary Rock
- Weathered High ANC NAF Basalt Rock
- Fresh NAF/PAF-LC A Seam Overburden
- Fresh PAF A Seam Roof
- Fresh PAF/PAF-LC A Seam/B Seam Interburden
- Fresh PAF-LC B Seam Floor (pit floor)

Leach column test results confirm that weathered NAF materials are unlikely to leach significant metals and metalloids, but the weathered low ANC NAF sedimentary rock may initially produce some salinity. This unit should be investigated further to better define the salinity leaching potential and whether it is likely to result in any significant impacts. Materials represented by the high ANC basalt and high ANC sedimentary rock appear to be suitable for use in mitigating or delaying the onset of ARD from PAF and PAF-LC materials.

The column leachates for the NAF/PAF-LC A Seam overburden sample generally have a circum-neutral pH, indicating operational mixing of NAF and PAF-LC materials in the A Seam overburden zone may be sufficient to control ARD. Note that some salinity can be expected due to pyrite oxidation reactions, and Mn concentrations may be elevated. Larger scale trials would need to be carried out to confirm these results.

[1] *Static Geochemical Assessment of the Taroborah Coal Project,* EGi Document No. 4208/1024, August 2013.

Results also show that PAF and PAF-LC materials are likely to generate significant ARD with short lag times, and will require selective handling and mitigation measures to prevent ARD during operations and at closure, as discussed in the 2013 EGi static geochemical assessment report[2]. Acid release is likely to be associated with elevated Al, As, Co, Cr, Cu, Fe, Mn, Ni and Zn, and slightly elevated Cd, Th and U.

ARD management strategies for the PAF A Seam roof and PAF/PAF-LC A Seam/B Seam interburden include selective handling and incorporation into a cover system to control oxygen and water flux, and blending with acid neutralising materials such as limestone and high ANC overburden materials to help control ARD generation. The following management strategies should be considered for overburden and interburden materials placed in ex-pit and in-pit dumps:

- out of pit dumps should be constructed with NAF material where possible;
- PAF overburden/interburden materials should be preferentially placed in-pit below the recovery groundwater table level to allow inundation at mine closure and prevent long term exposure to atmospheric oxidation. This requires oxidation and acid generation control measures to ensure PAF materials do not mobilise acid and dissolved metals/metalloids during inundation;
- paddock dumping and traffic compacting PAF overburden and interburden in lifts of 5 m or less should be considered to minimise the risk of accelerated oxidation through convection;
- interim lifts/faces of placed PAF waste rock may need to be treated with crushed limestone for operational control of ARD before inundation can take place;
- long term ARD control of any PAF materials placed above the final recovery groundwater table level should include a thick (5 to 20m) outer zone of NAF materials (preferably high ANC), and may require an engineered cover or internal seal system to limit oxygen transfer and fluctuating moisture conditions in PAF materials;
- it is understood that placement of PAF in ex-pit dumps will be required for the first year of operation, and other measures will be required in addition to the thick outer zone and cover/seal system described for in-pit dumps. Designs should prevent convective/advective transport of oxygen through the dump, which can reduce ARD loadings by a factor of at least 4. This can be achieved by setting back PAF materials from the face of the dump and adopting dumping strategies that avoid formation of continuous coarse layers and open chimney structures that act as air pathways. The immediate base of the dump should comprise a layer of NAF material (1m or more) to help isolate

[2] *Static Geochemical Assessment of the Taroborah Coal Project,* EGi Document No. 4208/1024, August 2013.

overlying PAF materials from any water flow along the interface between the dump and natural ground.

- blending of PAF and PAF-LC with acid neutralising materials (limestone, high ANC basalt and/or high ANC weathered sedimentary materials) could be used to increase lag times before onset of acid conditions within the PAF and PAF-LC material, and may even be sufficient for long term control of ARD but would require confirmation with trials and kinetic testing.

Column testing of the PAF-LC B Seam floor suggests that final pit floor materials represented by this sample may be fast reacting, and mitigation will be required to control ARD. Strategies could include placement of crushed limestone and/or high ANC NAF overburden on pit floor surfaces, and covering with compacted waste materials to increase lag times and reduce oxidation and water flux.

Note that leach column testing was not carried out on washery waste materials since there has not been sufficient representative material generated by washery trials to date. However, static geochemical assessment work[3] clearly shows that coarse and fine rejects are likely to have a high ARD risk (sulphur grade generally >4%S) and will require additional management efforts to prevent ARD, such as limestone blending, encapsulation and permanent inundation.

Further investigations are recommended to better define management requirements for Taroborah overburden and interburden:

- investigate the saline leaching potential of the low ANC weathered NAF sedimentary rock unit in more detail, with leach testing of fresh samples, assessment of groundwater quality and influence, and evaluation of potential impacts;
- carry out leach column testing on blends of PAF and PAF-LC overburden/interburden with high ANC NAF overburden to demonstrate the effectiveness of this approach and to help determine optimal blending ratios; and
- carry out leach column testing on PAF-LC final pit floor materials mixed with crushed limestone and high ANC NAF overburden to help determine optimal blending ratios for ARD control.

1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by Shenhuo International Group Pty Ltd (Shenhuo) to carry out leach column testing of overburden and interburden from the Taroborah Coal Project, a thermal coal deposit located approximately 22 km west of Emerald in Central Queensland. The objective of the work was to provide information on leaching characteristics and lag times of key waste rock types for use in water quality predictions and to help refine materials management options. Leach column testing followed on from the static geochemical assessment that was carried out by EGi in 2012/2013[3].

This report presents final results and findings of leach column testing after 76 weeks of operation.

2.0 Sample Selection and Preparation

The Taroborah coal deposit is Permian in age and occurs within the Bowen Basin. The two main target seams are A Seam and B Seam, which were deposited under marine influenced conditions. A Seam and the upper 0.5m of B Seam (B Seam tops) have high sulphur (most of which is pyritic), with A Seam averaging 10%S and B Seam tops averaging around 4%S, but also showing considerable variability. The upper surface of the project area comprises 1 to 2m of soils, followed by a 40 to 80m thick weathered zone comprising weathered Tertiary basalt, weathered Tertiary sedimentary material, and weathered Permian sedimentary material. The fresh Permian overburden and interburden below the weathered zone is dominated by sandstone and siltstone. The coal is classified as low rank and low ash thermal coal.

Static geochemical characterisation work indicated that non acid forming (NAF) materials would make up approximately two thirds of overburden/interburden, with the remaining one third potentially acid forming (PAF) or PAF with low acid capacity (PAF-LC). Results suggested the presence of distinct geochemical zones of NAF and PAF/PAF-LC overburden/interburden and coal as follows:

- NAF zone to the base of moderate weathering;
- High acid neutralising capacity (ANC) zone 5m to 60m thick within the weathered NAF, particularly associated with and below basalt intercepts;
- Mixed NAF and PAF-LC zone from the base of moderate weathering to 5-10 above A Seam;
- PAF zone generally within 5 m of the A Seam roof but up to 10m;
- PAF A Seam;

[3] *Static Geochemical Assessment of the Taroborah Coal Project,* EGi Document No. 4208/1024, August 2013.

- PAF/PAF-LC interburden between A Seam and B Seam;
- PAF B Seam;
- PAF-LC B Seam floor with PAF portions.

Leach column testing was carried out on the following 7 material types to represent the above overburden/interburden geochemical zones:

- Weathered Low ANC NAF Sedimentary Rock
- Weathered High ANC NAF Sedimentary Rock
- Weathered High ANC NAF Basalt Rock
- Fresh NAF/PAF-LC A Seam Overburden
- Fresh PAF A Seam Roof
- Fresh PAF/PAF-LC A Seam/B Seam Interburden
- Fresh PAF-LC B Seam Floor (pit floor)

Column samples were composited from individual samples tested by EGi as part of the static geochemical assessment to represent typical materials. Details of the samples used to make up the composites are shown in Table 1.

Individual crushed -4mm samples were combined and mixed at EGi. A representative 300 to 500g split was collected from each composite and dispatched to Sydney Environmental and Soil Laboratory (SESL) for pulverising to -75µm for geochemical characterisation.

3.0 Test Methodology

Pulverised splits of all 7 column composites were subjected to the following static geochemical characterisation tests:

- total S (Leco equivalent);
- ANC;
- net acid producing potential (NAPP), calculated from total S and ANC;
- single addition net acid generation (NAG) test; and
- multi-element testing of solids.

Further 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 testing to check pyrite reactivity and to indicate lag times; and
- acid buffering characteristic curve (ABCC) testing to define the relative availability of the ANC measured.

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

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

All 7 of the crushed -4mm composite samples were subjected to standard free draining column testing, which involved loading columns with approximately 2kg of sample and carrying out weekly wet-dry cycles and monthly leaching cycles. The samples were wetted by applying deionised water to the surface, and the resulting leachates were collected through the funnel at the base. An initial (week 0) leachate sample was collected from each column by flushing at a rate of 400 ml/kg. Thereafter, water was added to the columns once per week in four-weekly cycles. In the first three weeks of each cycle, water was added at a rate of 100 ml/kg. In the fourth week of each cycle, water was added at a rate of 400 ml/kg to flush the oxidation products into the leachate collection vessels. Heat lamps were used to dry the samples between water additions to promote oxidation throughout the samples.

Leachates were analysed for pH, electrical conductivity (EC), acidity/alkalinity and a suite of 32 elements as follows:

> Ag, Al, As, B, Ba, Be, Ca, Cd, Cl, Co, Cr, Cu, F, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, S (as SO_4), Sb, Se, Si, Sn, Sr, Th, U and Zn

Total S assays of column feed samples were carried out by SESL. Total S of the leached column solid sample 4583, and multi-element and CRS analyses of column feed sample solids were carried out by ALS Laboratory Group (Brisbane). Column leachates were analysed 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.

4.0 Geochemical Characterisation of Column Feed Samples

ARD characterisation results for the 7 column feed samples are presented in Table 2, comprising total S, maximum potential acidity (MPA), ANC, NAPP, ANC/MPA ratio and single addition NAG.

The NAPP value is an acid-base account calculation using measured total S and ANC values. It represents the balance between the 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. NAG test results are used in conjunction with NAPP values to classify samples according to acid forming potential. 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.

Samples 4582 and 4583 have positive NAPP values but NAGpH values greater than 4.5. The remaining samples have consistent NAPP and NAGpH results.

The weathered high ANC basalt and weathered high ANC NAF sedimentary rock (samples 4580 and 4581) have low S of 0.01%S and high ANC values of 85 and 128 kg H_2SO_4/t as expected. ABCC profiles for these samples are shown in Figures 1 and 2, respectively. 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. The figures include 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 profiles for both samples plot close to the dolomite standard curves. Results indicate 75% of the ANC in the weathered high ANC NAF basalt and 100% in the weathered high ANC NAF sedimentary rock is readily available. Results confirm these composites are NAF and acid consuming.

The weathered low ANC NAF sedimentary rock sample 4582 has low S of 0.17%S, low ANC of 2 kg H_2SO_4/t and the NAPP value is marginally positive at 3 kg H_2SO_4/t. The NAGpH is 7.2, and the NAG test would normally account for all pyritic S in low S and low ANC samples. This sample is classified NAF consistent with NAG test results.

Fresh NAF/PAF-LC A Seam overburden sample 4583 has moderate S of 0.44%S, an ANC of 6 kg H_2SO_4/t, a positive NAPP value of 7 kg H_2SO_4/t, but a NAGpH of 5.2, and further testing was carried out to confirm the classification of this sample.

S speciation testing was carried out on sample 4583 to provide an indication of the proportion of acid generating S forms. 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 repeatability in the chromium reducible sulphur (CRS) method[4]. Partial oxidation of

[4] 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. www.acarp.com.au.

pyrite was expected to occur prior to testing, and some of the S originally present as pyrite was likely to be in the form of acid sulphate salts. Hence the total acid generating S proportion of the sample is the sum of the pyritic S (from CRS) and the acid sulphate S. Results indicate the acid generating S makes up roughly half the total S at 0.22%S. Again the NAG test would normally account for all pyritic S in this low S sample, and it is classified NAF consistent with NAG test results.

The remaining 3 samples 4584, 4585 and 3637 were expected to be PAF and PAF-LC, and had positive NAPP values and NAGpH values less than 4.5, as expected. Sulphur speciation testing of these three samples (Table 3) confirms that most of the S is present in acid generating forms.

Extended boil and calculated NAG testing was carried out on samples 4584, 4585 and 3637 to account for possible organic acid effects on standard NAG test results. Results in Table 2 show that all 3 samples have an extended boil NAGpH of less than 4.5, confirming these samples are likely to be acid producing. The calculated NAG value is determined from assays of anions and cations released to the NAG solution. The calculated NAG values for all 3 of the samples are positive indicating these samples are likely to be acid producing. Sample 3637 had an acid potential of less than 5 kg H_2SO_4/t, and is classified as potentially acid forming with a low capacity (PAF-LC).

Kinetic NAG tests provide an indication of the kinetics of sulphide oxidation and acid generation for a sample. Kinetic NAG testing was carried out on the fresh PAF A Seam roof sample 4584, and results are presented in Figure 3. Results show that the sample was acid producing at the start of the test. It is likely that acid conditions developed in the sample prior to testing due to partial oxidation of pyrite during storage.

Multi-element testing was carried out on all 7 column samples and results were compared to the median soil abundance (from Bowen, 1979[5]) to highlight enriched elements. The extent of enrichment is reported as the Geochemical Abundance Index (GAI), which relates the actual concentration with an average abundance on a log 2 scale. The GAI is expressed in integer increments where a GAI of 0 indicates the element is present at a concentration similar to, or less than, average abundance; and a GAI of 6 indicates approximately a 100-fold enrichment above average abundance. As a general rule, a GAI of 3 or greater signifies enrichment that warrants further examination.

Results of multi-element analysis and corresponding GAI values are presented in Table 4. Results show slight enrichment in Be for most samples, but Be values are within normal ranges for soils. PAF A Seam roof sample 4584 is enriched in S, which is discussed above in the context of acid forming potential.

Overall, geochemical characterisation testing confirmed the expected characteristics of the composited column samples.

[5] Bowen, H.J.M. (1979) Environmental Chemistry of the Elements. Academic Press, New York, p 36-37.

5.0 Leach Column Test Results

Column leach test results are presented in Tables 5 to 11. Figures 4 to 39 show profiles of pH, EC, acidity (alkalinity plotted as negative acidity), SO_4, Cl, Al, As, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Th, U and Zn, with the results grouped into NAF samples (Figures 4 to 21), and PAF-LC and PAF samples (Figures 22 to 39).

The three weathered NAF column samples (4580, 4581 and 4582) were operated to week 28 and then terminated. These columns were operated for a short period as they contained low sulphide and hence solubility, rather than oxidation kinetics, was the main control on element release. The remaining 4 columns were operated for 76 weeks.

5.1 Weathered NAF Leach Column Results

The 3 weathered NAF overburden/interburden columns (weathered high ANC NAF basalt rock column 4580, weathered high ANC NAF sedimentary rock column 4581 and weathered low ANC NAF sedimentary rock column 4582) had low S of less than 0.2%, variable ANC, and were not expected to produce acid leachate. The objectives of these columns were to check for mobilisation of salts and metals/metalloids.

All three weathered NAF columns showed circum-neutral pH for the operation period and steady alkalinities of around 80 to 130 mg $CaCO_3$/L.

EC was elevated at 6.4 dS/m in the initial collection (week 0) in the low ANC sedimentary rock column 4582 due mainly to Cl (Na) and SO_4 (Mg and Ca) salts. The concentrations of these salts dropped in successive collections, with low SO_4 concentrations of less than 50 mg/L by week 8 and Cl concentrations of less than 50 mg/L by week 4. The EC was much lower in the high ANC basalt rock column 4580 and high ANC sedimentary rock column 4581, at 0.7 dS/m and 1.3 dS/m, respectively, and this dropped to non saline values (less than 0.4 dS/m) in the week 4 collection.

Concentrations of metals/metalloids were low for all 3 weathered NAF columns.

Results indicate that weathered NAF low ANC sedimentary overburden represented by the sample tested may initially produce some salinity due to the presence of Na, Cl and Mg-Ca SO_4 salts. None of the weathered NAF overburden materials are likely to leach significant metal/metalloid concentrations. The leachate trends in all 3 weathered NAF columns were stable by week 28 and they were terminated, since continuation would not provide significant additional information.

5.2 Fresh NAF/PAF-LC A Seam Overburden Leach Column Results

Fresh NAF/PAF-LC A seam overburden column 4583 sample had a moderate total S of 0.44%S, of which roughly half was expected to be pyritic (see Section 4), a low ANC of 6 kg H_2SO_4/t, and a NAGpH of 5.2. The sample was expected to be NAF overall, and the

purpose of the column was to assess the leaching characteristics of fresh materials from the zone of mixed NAF and PAF-LC above the A seam.

The pH of the initial collection was slightly acidic at 5.5, but column leachates had circum-neutral pH thereafter, with steady alkalinities of around 40 mg $CaCO_3$/L.

The slightly acidic initial pH is associated with elevated EC, due mainly to Mg-Ca SO_4 salts, and is most likely due to accumulation of pyrite oxidation products prior to leach column testing. The sulphate concentrations were high in the initial collection at close to 10,000 mg/L, dropped to just below 3000 mg/L in week 4, and showed a gradual decrease thereafter down to around 200 mg/L by week 76. The presence of significant dissolved Mg increased the sulphate solubility, resulting in higher salinities in these circum-neutral leachates than if Ca was the dominant cation and gypsum the main solubility control.

Some slightly elevated dissolved Na-K Cl salts were also present in the initial collection, with Cl concentrations dropping from 138 mg /L in the initial collection to 23 mg/L by week 4.

The EC dropped to slightly saline values of 0.48 dS/m by week 76.

The initial collection also had elevated concentrations of Al, Co, Cu, Fe, Mn, Ni and Zn due to the slightly acidic pH conditions. Concentrations of metals/metalloids were low in successive collections except for Mn. The Mn concentrations showed a gradual decrease in concentration with time, dropping below 1 mg/L in week 24. The Mn concentrations were most likely due to interaction of acid (generated by pyrite oxidation) with Mn containing carbonate.

Results confirm that rates of buffering in this sample were sufficient to account for acid generation to date. Results also indicate that although leachates from materials represented by this sample are likely to be circum neutral, some salinity can be expected due to pyrite oxidation reactions, along with elevated Mn concentrations. Peak oxidation rates were moderate at around 3×10^{-7} kg $O_2/m^3/s$.

The leachates show low salinity and metal/metalloid concentrations, with SO_4 release showing decreasing trend. The rates of buffering matched rates of acid generation for the 76 weeks of operation.

This column was terminated at week 76.

The leached column sample solid was geochemically characterised after it was terminated to check whether any acid was likely to be generated. Results are shown in Table 2, and show that the S dropped to 0.14%S, the ANC to 2 kg H_2SO_4/t, resulting in a marginally positive NAPP of 2 kg H_2SO_4/t. The NAG pH is just below 4.5, and the NAG capacity to pH 4.5 is marginal at 0.3 kg H_2SO_4/t. Sulphur speciation (Table 3) indicates that only

0.07%S is pyritic. Overall, results suggest that it is unlikely this column would have produced significant acid had it been continued.

5.3 Fresh PAF and PAF-LC Leach Column Results

Three columns were commissioned to represent the main acid forming overburden/interburden units identified at Taroborah, comprising PAF A Seam roof column 4584, PAF/PAF-LC A Seam/B Seam interburden column 4585, and PAF-LC B Seam floor column 3637.

All three columns produced acidic pH in the initial collection, at close to pH 2.5, due to the presence of ARD oxidation products accumulated in the sample prior to leach column testing. The pH dropped below pH 2.5 in week 4 for all columns. PAF-LC B Seam floor column 3637 showed a gradually increasing pH trend from week 8, as did the PAF/PAF-LC A Seam/B Seam interburden column 4585 from week 24. The PAF A Seam roof column 4584 showed a pH just above 2 for the operation period, with a slightly increasing trend from week 32, and a slight decreasing trend from week 52 and remaining under pH 2.5 for the operation period.

EC was controlled primarily by acidity and SO_4, with trends showing decreasing concentrations with time. It appears that peak reaction rates have already occurred, with the reduction in acidity and SO_4 concentrations due to depletion of fast reacting pyrite forms. The relative magnitude of acidity and sulphate concentration trends are consistent with the acid potential of each of the columns, with the PAF A Seam roof sample showing the highest acidities and SO_4 concentrations, and the PAF-LC B Seam floor sample showing the lowest. Peak oxidation rates were high for the PAF A Seam roof sample at 1×10^{-6} kg $O_2/m^3/s$, and moderate to high for the PAF/PAF-LC A Seam/B Seam interburden and PAF-LC B Seam floor samples at 5×10^{-7} kg $O_2/m^3/s$.

Chloride concentrations were relatively low at less than 50 mg/L.

Acid release in the columns is associated with elevated Al, As, Co, Cr, Cu, Fe, Mn, Ni and Zn, and slightly elevated Cd, Th and U.

Results confirm that PAF and PAF-LC materials represented by the samples tested will generate significant ARD, resulting in low pH, high acidity, high salinity and elevated concentrations of metals/metalloids. The core used for these samples was collected from holes drilled in 2010, and results show significant pyrite oxidation had taken place before leach columns were commenced. Hence the results do not provide an accurate measure of lag times before acid conditions develop in freshly excavated PAF and PAF-LC overburden/interburden. However, the high concentrations of stored acidity in the samples recovered in the initial collection indicates acid conditions are likely to occur in a short time frame of weeks to a few months.

Peak oxidation rates have passed, and by week 76 the concentrations of metals/metalloids had reduced considerably, with Al, and Fe still elevated, and Cu, Mn and Zn only slightly

elevated. Concentrations of acid, salinity and metals/metalloids in the leach columns would be expected to continue to slowly decline with time, but materials represented by these samples are likely to generate significant acid for many years. The PAF and PAF-LC columns were terminated at week 76.

6.0 Conclusions

Leach column test results confirm that weathered NAF materials are unlikely to leach significant metals and metalloids, but the weathered low ANC NAF sedimentary rock may initially produce some salinity. This unit should be investigated further to better define the salinity leaching potential and whether it is likely to result in any significant impacts. Materials represented by the high ANC basalt and high ANC sedimentary rock appear to be suitable for use in mitigating or delaying the onset of ARD from PAF and PAF-LC materials.

The column leachates for the NAF/PAF-LC A Seam overburden sample generally have a circum-neutral pH, indicating operational mixing of NAF and PAF-LC materials in the A Seam overburden zone may be sufficient to control ARD. Note that some salinity can be expected due to pyrite oxidation reactions, and Mn concentrations may be elevated. Larger scale trials would need to be carried out to confirm these results.

Results also show that PAF and PAF-LC materials are likely to generate significant ARD with short lag times, and will require selective handling and mitigation measures to prevent ARD during operations and at closure, as discussed in the 2013 EGi static geochemical assessment report[6]. Acid release is likely to be associated with elevated Al, As, Co, Cr, Cu, Fe, Mn, Ni and Zn, and slightly elevated Cd, Th and U.

ARD management strategies for the PAF A Seam roof and PAF/PAF-LC A Seam/B Seam interburden include selective handling and incorporation into a cover system to control oxygen and water flux, and blending with acid neutralising materials such as limestone and high ANC overburden materials to help control ARD generation. The following management strategies should be considered for overburden and interburden materials placed in ex-pit and in-pit dumps:

- out of pit dumps should be constructed with NAF material where possible;
- PAF overburden/interburden materials should be preferentially placed in-pit below the recovery groundwater table level to allow inundation at mine closure and prevent long term exposure to atmospheric oxidation. This requires oxidation and acid generation control measures to ensure PAF materials do not mobilise acid and dissolved metals/metalloids during inundation;

[6] *Static Geochemical Assessment of the Taroborah Coal Project,* EGi Document No. 4208/1024, August 2013.

- paddock dumping and traffic compacting PAF overburden and interburden in lifts of 5 m or less should be considered to minimise the risk of accelerated oxidation through convection;
- interim lifts/faces of placed PAF waste rock may need to be treated with crushed limestone for operational control of ARD before inundation can take place;
- long term ARD control of any PAF materials placed above the final recovery groundwater table level should include a thick (5 to 20m) outer zone of NAF materials (preferably high ANC), and may require an engineered cover or internal seal system to limit oxygen transfer and fluctuating moisture conditions in PAF materials;
- it is understood that placement of PAF in ex-pit dumps will be required for the first year of operation, and other measures will be required in addition to the thick outer zone and cover/seal system described for in-pit dumps. Designs should prevent convective/advective transport of oxygen through the dump, which can reduce ARD loadings by a factor of at least 4. This can be achieved by setting back PAF materials from the face of the dump and adopting dumping strategies that avoid formation of continuous coarse layers and open chimney structures that act as air pathways. The immediate base of the dump should comprise a layer of NAF material (1m or more) to help isolate overlying PAF materials from any water flow along the interface between the dump and natural ground.
- blending of PAF and PAF-LC with acid neutralising materials (limestone, high ANC basalt and/or high ANC weathered sedimentary materials) could be used to increase lag times before onset of acid conditions within the PAF and PAF-LC material, and may even be sufficient for long term control of ARD but would require confirmation with trials and kinetic testing.

Column testing of the PAF-LC B Seam floor suggests that final pit floor materials represented by this sample may be fast reacting, and mitigation will be required to control ARD. Strategies could include placement of crushed limestone and/or high ANC NAF overburden on pit floor surfaces, and covering with compacted waste materials to increase lag times and reduce oxidation and water flux.

Note that leach column testing was not carried out on washery waste materials since there has not been sufficient representative material generated by washery trials to date. However, static geochemical assessment work[3] clearly shows that coarse and fine rejects are likely to have a high ARD risk (sulphur grade generally >4%S) and will require additional management efforts to prevent ARD, such as limestone blending, encapsulation and permanent inundation.

Further investigations are recommended to better define management requirements for Taroborah overburden and interburden:

- investigate the saline leaching potential of the low ANC weathered NAF sedimentary rock unit in more detail, with leach testing of fresh samples, assessment of groundwater quality and influence, and evaluation of potential impacts;
- carry out leach column testing on blends of PAF and PAF-LC overburden/interburden with high ANC NAF overburden to demonstrate the effectiveness of this approach and to help determine optimal blending ratios; and
- carry out leach column testing on PAF-LC final pit floor materials mixed with crushed limestone and high ANC NAF overburden to help determine optimal blending ratios for ARD control.

Table 1: Composite list for leach column samples.

Individual Samples					Composite Samples	
EGi Sample No	Hole Name	Site Sample No	Lithology	Weight (kg)	EGI Column Composite Sample No	Column Composite Description
3577	TAR020GT	2	Basalt	2.0	4580	Weathered High ANC NAF Basalt Rock
3643	TAR027GT	69	Basalt	2.0		
3644	TAR027GT	70	Basalt	2.0		
3578	TAR020GT	3	Sandstone	1.0	4581	Weathered High ANC NAF Sedimentary Rock
3579	TAR020GT	4	Sandstone/Sand	1.0		
3645	TAR027GT	71	Clay/Claystone	1.0		
3646	TAR027GT	72	Clay/Claystone	1.0		
3647	TAR027GT	73	Clay/Claystone	1.0		
3648	TAR027GT	74	Clay/Claystone/Sandstone	1.0		
3580	TAR020GT	5	Sandstone/Sand	0.5	4582	Weathered Low ANC NAF Sedimentary Rock
3584	TAR020GT	9	Sandstone/Siltstone	0.5		
3611	TAR022GT	37	Clay/Sand	0.5		
3613	TAR022GT	39	Clay/Sand	0.5		
3614	TAR022GT	40	Clay/Sand	0.5		
3650	TAR027GT	76	Sandstone	0.5		
3651	TAR027GT	77	Sandstone	0.5		
3585	TAR020GT	10	Sandstone	1.0	4583	Fresh NAF/PAF-LC A Seam Overburden
3590	TAR020GT	15	Sandstone/Siltstone	1.0		
3591	TAR020GT	16	Sandstone	1.0		
3618	TAR022GT	44	Siltstone/Sandstone	1.0		
3623	TAR022GT	49	Sandstone	1.0		
3660	TAR027GT	86	Siltstone/Sandstone	1.0		
3662	TAR027GT	88	Siltstone/Sandstone	1.0		
3664	TAR027GT	90	Siltstone/Sandstone	1.0		
3594	TAR020GT	19	Sandstone/Clay	2.0	4584	Fresh PAF A Seam Roof
3595	TAR020GT	20	Sandstone/Clay	2.0		
3665	TAR027GT	91	Siltstone/Sandstone	2.0		
3666	TAR027GT	92	Siltstone/Sandstone	2.0		
3669	TAR027GT	95	Sandstone	2.0		
3671	TAR027GT	97	Sandstone	1.0	4585	Fresh PAF/PAF-LC A Seam/B Seam Interburden
3672	TAR027GT	98	Sandstone/Carb Siltstone	1.0		
3673	TAR027GT	99	Sandstone/Carb Siltstone	1.0		
3674	TAR027GT	100	Carb Sandstone	1.0		
3675	TAR027GT	101	Carb Sandstone	1.0		
3676	TAR027GT	102	Sandstone/Gravel	1.0		
4584			Fresh PAF A Seam Roof Composite	2.0		
3637	TAR022GT	63	Sandstone	4.0	3637	Fresh PAF-LC B Seam Floor

Table 2: Acid forming characteristics of leach column samples.

EGi Sample Number	Sample Description	ACID-BASE ANALYSIS					SINGLE ADDITION NAG			Extended Boil NAGpH	Calculated NAG	ARD Classification	
		Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$				
4580	Weathered High ANC NAF Basalt Rock	0.01	0	85	-85	277.78	8.4	0	0			NAF	
4581	Weathered High ANC NAF Sedimentary Rock	0.01	0	128	-128	418.30	8.3	0	0			NAF	
4582	Weathered Low ANC NAF Sedimentary Rock	0.17	5	2	3	0.38	7.2	0	0			NAF	
4583	Fresh NAF/PAF-LC A seam Overburden - Feed	0.44	13	6	7	0.45	5.2	0	2			NAF	
4583	Fresh NAF/PAF-LC A seam Overburden - After 76 Weeks of Leaching	0.14	4	2	2	0.47	4.3	0.3	5			NAF	
4584	Fresh PAF A Seam Roof	1.08	33	0	33	0.00	2.6	19	26	3.2	28	PAF	
4585	Fresh PAF/PAF-LC A Seam/B Seam Interburden	0.36	11	0	11	0.00	2.8	6	11	3.6	9	PAF	
3637	Fresh PAF-LC B Seam Floor	0.29	9	0	9	0.00	3.1	5	9	3.5	4	PAF-LC	

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

PAF = Potentially Acid Forming

PAF-LC = PAF Low Capacity

Table 3: Sulphur speciation results for selected column composite samples.

EGi Sample Number	Lithology	Total %S	Pyritic S (%)	Acid Sulphate %S	Total Acid Generating S (%)	Other S Forms (%)	Proportion Total Acid Generating to Total S
4583	Fresh NAF/PAF-LC A seam Overburden - Feed	0.44	0.18	0.04	0.22	0.22	50%
4583 Leached	Fresh NAF/PAF-LC A seam Overburden - After 76 Weeks of Leaching	0.14	0.07	0.00	0.07	0.07	50%
4584	Fresh PAF A Seam Roof	1.08	0.44	0.50	0.94	0.14	87%
4585	Fresh PAF/PAF-LC A Seam/B Seam Interburden	0.36	0.17	0.15	0.32	0.04	89%
3637	Fresh PAF-LC B Seam Floor	0.29	0.09	0.08	0.17	0.12	58%

Pyritic S (%) = CRS (%)

Acid Sulphate S = KCl Acid Sulphate S

Total Acid Generating S = Pyritic S + Acid Sulphate S

Other S Forms = Total S - Total Acid Generating S

Table 4: Multi-element composition (mg/kg except where shown) and geochemical abundance index (GAI) of leach column sample solids.

Element	Detection Limit	Sample Description and Number							Element	Median Soil Abundance*	Sample Description and Number						
		Weathered NAF Basalt Rock High ANC	Weathered NAF Sedimentary Rock High ANC	Weathered NAF Sedimentary Rock Low ANC	Fresh NAF/PAF-LC A seam Overburden	Fresh PAF A Seam Roof	Fresh PAF/PAF-LC A Seam/ B Seam Interburden	Fresh PAF-LC B Seam Floor			Weathered NAF Basalt Rock High ANC	Weathered NAF Sedimentary Rock High ANC	Weathered NAF Sedimentary Rock Low ANC	Fresh NAF/PAF-LC A seam Overburden	Fresh PAF A Seam Roof	Fresh PAF/PAF-LC A Seam/ B Seam Interburden	Fresh PAF-LC B Seam Floor
		4580	4581	4582	4583	4584	4585	3637			4580	4581	4582	4583	4584	4585	3637
Ag	0.01	0.09	0.16	0.08	0.11	0.1	0.05	0.05	Ag	0.05	-	1	-	1	-	-	-
Al	0.01%	7.25%	4.83%	6.86%	6.23%	4.54%	4.38%	5.64%	Al	7.1%	-	-	-	-	-	-	-
As	0.2	0.6	4.1	4.3	11.7	10.6	3.8	4.7	As	6	-	-	-	-	-	-	-
B	10	20	30	70	60	20	30	30	B	20	-	-	1	1	-	-	-
Ba	10	520	250	290	340	350	320	470	Ba	500	-	-	-	-	-	-	-
Be	0.05	0.67	2.32	1.81	2.19	1.42	1.34	1.39	Be	0.3	1	2	2	2	2	2	2
Bi	0.01	0.02	0.18	0.3	0.36	0.18	0.18	0.16	Bi	0.2	-	-	-	-	-	-	-
Ca	0.01%	5.80%	4.04%	0.07%	0.21%	0.04%	0.02%	0.03%	Ca	1.5%	1	1	-	-	-	-	-
Cd	0.02	0.05	0.12	0.03	0.13	0.15	0.07	0.06	Cd	0.35	-	-	-	-	-	-	-
Ce	0.01	29.1	60.9	60.6	64.7	46.3	42.6	51.9	Ce	50	-	-	-	-	-	-	-
Co	0.1	41.4	43.4	5.5	7.9	5.3	3.4	5	Co	8	2	2	-	-	-	-	-
Cr	1	222	91	47	37	27	20	19	Cr	70	1	-	-	-	-	-	-
Cs	0.05	0.52	1.44	5.24	7.83	3.41	4.81	5.56	Cs	4	-	-	-	-	-	-	-
Cu	0.2	46.5	96.3	13.5	18.5	9.6	6.7	6.1	Cu	30	-	1	-	-	-	-	-
F	20	540	550	430	380	240	360	230	F	200	1	1	1	-	-	-	-
Fe	0.01%	7.12%	4.21%	1.59%	3.55%	1.13%	0.56%	0.99%	Fe	4.0%	-	-	-	-	-	-	-
Ga	0.05	17.85	11.85	17.2	16.95	11.95	11.35	14.45	Ga	20	-	-	-	-	-	-	-
Ge	0.05	0.15	0.15	0.1	0.13	0.1	0.08	0.09	Ge	1	-	-	-	-	-	-	-
Hf	0.01	2.8	3.4	5.5	5.8	6.2	7.4	6.1	Hf	6	-	-	-	-	-	-	-
Hg	0.005	0.117	0.171	0.099	0.044	0.023	0.016	0.018	Hg	0.06	-	1	-	-	-	-	-
In	0.005	0.053	0.039	0.055	0.061	0.032	0.028	0.035	In	1	-	-	-	-	-	-	-
K	0.01%	0.33%	0.16%	1%	1.56%	0.82%	1.20%	1.74%	K	1.4%	-	-	-	-	-	-	-
La	0.5	14.2	31.6	31.6	31.2	22.2	22	27.5	La	40	-	-	-	-	-	-	-
Li	0.2	9	13.1	56.1	43.6	30.7	29.8	36.3	Li	25	-	-	1	-	-	-	-
Mg	0.01%	3.85%	2.43%	0.21%	0.39%	0.08%	0.09%	0.13%	Mg	0.5%	2	2	-	-	-	-	-
Mn	5	1280	578	80	520	37	41	107	Mn	1000	-	-	-	-	-	-	-
Mo	0.05	0.8	2.72	0.76	2.4	2.69	1.01	0.39	Mo	1.2	-	1	-	-	1	-	-
Na	0.01%	1.44%	0.12%	0.07%	0.06%	0.03%	0.04%	0.05%	Na	0.5%	1	-	-	-	-	-	-
Nb	0.1	17.3	19.6	14.4	9.7	5.3	7.5	11.5	Nb	10	-	-	-	-	-	-	-
Ni	0.2	188	161.5	16.9	19	15.5	10	12.4	Ni	50	1	1	-	-	-	-	-
P	10	1170	640	220	460	310	150	130	P	800	-	-	-	-	-	-	-
Pb	0.5	2.3	7.9	20	20.1	15.3	16.4	19.1	Pb	35	-	-	-	-	-	-	-
Rb	0.1	8.1	7.3	68.2	109	52.3	76.3	110.5	Rb	150	-	-	-	-	-	-	-
Re	0.002	<0.002	<0.002	<0.002	0.003	0.016	0.004	<0.002	Re								
S	0.01%	<0.0001	0.02%	0.17%	0.45%	1.03%	0.36%	0.28%	S	0.07%	-	-	1	2	**3**	2	1
Sb	0.05	0.07	0.34	0.58	0.62	0.53	0.43	0.45	Sb	1	-	-	-	-	-	-	-
Sc	0.1	17.5	12.2	10.4	10.7	5.7	5.3	6.5	Sc	7	1	-	-	-	-	-	-
Se	1	1	2	1	2	2	1	1	Se	0.4	1	2	1	2	2	1	1
Sn	0.2	1	1.4	3.4	3.2	2	2.4	3	Sn	4	-	-	-	-	-	-	-
Sr	0.2	658	303	92.5	90	121	66.5	52	Sr	250	1	-	-	-	-	-	-
Ta	0.05	1.01	1.14	1.14	0.82	0.44	0.68	0.95	Ta	2	-	-	-	-	-	-	-
Te	0.05	<0.05	0.06	0.07	0.07	0.05	0.06	<0.05	Te								
Th	0.2	1.6	7.6	14.1	12.2	8	9.2	11.6	Th	9	-	-	-	-	-	-	-
Ti	0.005%	0.83%	0.54%	0.44%	0.28%	0.20%	0.19%	0.27%	Ti	0.50%	-	-	-	-	-	-	-
Tl	0.02	0.09	0.12	0.37	0.57	0.59	0.56	0.71	Tl	0.2	-	-	-	1	1	1	1
U	0.1	0.5	1.2	2.5	3	3.9	3	2.8	U	2	-	-	-	-	-	-	-
V	1	127	135	78	100	88	42	33	V	90	-	-	-	-	-	-	-
W	0.1	0.2	0.8	2.3	2	1.2	1.4	1.9	W	1.5	-	-	-	-	-	-	-
Y	0.1	16.2	26.6	19	21.8	13.9	10.7	10.6	Y	40	-	-	-	-	-	-	-
Zn	2	105	110	43	69	44	44	43	Zn	90	-	-	-	-	-	-	-
Zr	0.5	110	133.5	193.5	201	231	283	213	Zr	400	-	-	-	-	-	-	-

< element at or below analytical detection limit.

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

Table 5: Leach column results for weathered high ANC NAF basalt rock (4580).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
0.01	85	-85	8.4	0	0	2000	02/11/12	TAR/4580

Collection Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Collection Week		0	4	8	12	16	20	24	28	32	36	40	44	48	52
Volume	ml	346	351	360	363	370	373	377	379						
pH	-	7.77	8.21	8.25	8.22	8.28	8.13	8.11	8.22						
EC	dS/m	0.71	0.30	0.30	0.21	0.19	0.18	0.18	0.20						
Alkalinity ($CaCO_3$)	mg/L	99	74	70	85	77	80	82	86						
Acidity ($CaCO_3$)	mg/L														
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Al	mg/L	0.42	0.35	0.73	0.37	0.09	0.49	0.57	0.37						
As	mg/L	0.158	0.166	0.178	0.270	0.151	0.147	0.225	0.124						
B	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.0700	<0.05						
Ba	mg/L	0.040	0.011	0.012	0.007	0.002	0.009	0.008	0.007						
Be	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Ca	mg/L	38	17	13	13	12	11	12	12						
Cd	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001						
Cl	mg/L	66	22	6	2	2	2	3	<1						
Co	mg/L	0.002	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001						
Cr	mg/L	0.002	0.003	0.004	0.003	0.002	0.003	0.003	0.002						
Cu	mg/L	0.02	0.01	0.01	0.02	0.00	0.02	0.00	0.01						
F	mg/L	0.6	0.9	1.1	1.0	1.0	1.0	1.0	0.9						
Fe	mg/L	0.65	0.48	1.02	0.36	0.06	0.45	0.50	0.33						
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001						
K	mg/L	<1	<1	<1	<1	<1	<1	<1	<1						
Mg	mg/L	28	9	6	5	5	5	5	5						
Mn	mg/L	0.1	0.0	0.0	0.0	<0.001	0.0	0.0	0.0						
Mo	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.002	<0.001						
Na	mg/L	40	26	18	21	20	16	17	17						
Ni	mg/L	0.005	0.002	0.005	0.002	<0.001	0.003	0.003	0.002						
P	mg/L	<1	<1	<1	<1	<1	<1	<1	<1						
Pb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
SO_4	mg/L	44	35	13	8	5	4	3	4						
Sb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01						
Si	mg/L	8.47	12.20	13.70	12.90	10.19	11.40	10.90	10.00						
Sn	mg/L	0.02	0.01	0.00	<0.001	<0.001	<0.001	<0.001	<0.001						
Sr	mg/L	0.51	0.19	0.14	0.13	0.08	0.12	0.12	0.12						
Th	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
U	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Zn	mg/L	<0.005	0.01	<0.005	<0.005	<0.005	0.01	<0.005	<0.005						

Table 6: Leach column results for weathered high ANC NAF sedimentary rock (4581).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
0.01	128	-128	8.3	0	0	2000	02/11/12	TAR/4581

Collection Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Collection Week		0	4	8	12	16	20	24	28	32	36	40	44	48	52
Volume	ml	366	370	371	375	382	383	391	391						
pH	-	8.02	8.25	8.31	8.19	8.21	8.11	8.15	8.17						
EC	dS/m	1.26	0.27	0.27	0.18	0.17	0.16	0.16	0.20						
Alkalinity ($CaCO_3$)	mg/L	195	97	92	79	85	75	73	88						
Acidity ($CaCO_3$)	mg/L														
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Al	mg/L	0.02	0.12	0.21	0.09	0.03	0.12	0.25	0.12						
As	mg/L	0.010	0.016	0.013	0.007	0.008	0.007	0.005	0.004						
B	mg/L	<0.05	0.0600	0.0500	<0.05	<0.05	<0.05	0.0500	<0.05						
Ba	mg/L	0.051	0.082	0.072	0.014	0.001	0.004	0.002	0.004						
Be	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Ca	mg/L	40	5	4	3	4	3	3	4						
Cd	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001						
Cl	mg/L	232	5	2	<1	1	2	2	<1						
Co	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Cr	mg/L	<0.001	0.00	0.00	<0.001	<0.001	<0.001	<0.001	<0.001						
Cu	mg/L	0.060	0.010	0.004	0.006	0.002	0.004	0.003	0.003						
F	mg/L	1.2	2.4	2.1	1.1	1.4	1.4	1.3	1.2						
Fe	mg/L	<0.05	0.07	0.15	0.07	<0.05	0.08	0.14	0.06						
Hg	mg/L	0.00	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001						
K	mg/L	1	<1	<1	<1	<1	<1	<1	<1						
Mg	mg/L	48	6	4	3	4	3	4	4						
Mn	mg/L	0.0	0.0	0.0	0.0	<0.001	0.0	0.0	0.0						
Mo	mg/L	0.012	0.015	0.010	0.003	0.002	0.002	0.003	0.001						
Na	mg/L	118	42	30	25	30	23	18	27						
Ni	mg/L	0.002	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
P	mg/L	<1	<1	<1	<1	<1	<1	<1	<1						
Pb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
SO_4	mg/L	67	16	6	3	2	2	1	1						
Sb	mg/L	<0.001	0.0020	0.0020	<0.001	0.0020	0.0010	0.0010	0.0010						
Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01						
Si	mg/L	6.03	7.34	7.52	5.44	5.56	5.66	5.81	5.20						
Sn	mg/L	0.07	0.01	0.00	<0.001	<0.001	<0.001	<0.001	<0.001						
Sr	mg/L	0.62	0.07	0.06	0.03	0.02	0.04	0.05	0.05						
Th	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
U	mg/L	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Zn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	0.01						

Table 7: Leach column results for weathered low ANC NAF sedimentary rock (4582).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
0.17	2	3	7.2	0	0	2000	02/11/12	TAR/4582

Collection Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Collection Week		0	4	8	12	16	20	24	28	32	36	40	44	48	52
Volume	ml	361	375	376	325	310	300	291	276						
pH	-	7.23	8.11	8.21	8.31	8.35	8.39	8.41	8.39						
EC	dS/m	6.41	2.25	2.11	1.25	0.81	0.62	0.61	0.42						
Alkalinity ($CaCO_3$)	mg/L	70	76	69	88	96	126	134	129						
Acidity ($CaCO_3$)	mg/L														
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Al	mg/L	0.02	0.36	0.61	0.10	0.08	0.12	0.58	0.28						
As	mg/L	0.268	0.126	0.082	0.029	0.075	0.011	0.023	0.017						
B	mg/L	0.23	0.18	0.28	0.18	0.06	0.09	0.17	0.18						
Ba	mg/L	0.117	0.016	0.008	0.009	0.001	0.006	0.013	0.009						
Be	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Ca	mg/L	151	138	4	3	6	4	4	6						
Cd	mg/L	0.0002	0.0009	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001						
Cl	mg/L	1380	36	8	4	2	3	4	4						
Co	mg/L	0.003	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Cr	mg/L	<0.001	<0.001	0.00	<0.001	<0.001	<0.001	<0.001	<0.001						
Cu	mg/L	0.05	0.01	0.02	0.02	0.00	0.01	0.01	0.01						
F	mg/L	0.6	1.8	2.5	2.3	1.4	1.6	1.4	1.3						
Fe	mg/L	<0.05	0.18	0.46	<0.05	<0.05	0.06	0.10	<0.05						
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001						
K	mg/L	10	8	2	1	2	<1	2	2						
Mg	mg/L	267	179	5	5	8	5	8	8						
Mn	mg/L	0.17		0.014	0.003	<0.001	0.004	0.003	0.001						
Mo	mg/L	0.003	0.015	0.021	0.011	0.004	0.004	0.007	0.004						
Na	mg/L	761	76	61	50	65	30	55	50						
Ni	mg/L	0.007	0.046	0.002	<0.001	<0.001	<0.001	<0.001	<0.001						
P	mg/L	<1	<1	<1	<1	<1	<1	<1	<1						
Pb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
SO_4	mg/L	723	1120	39	21	7	10	14	11						
Sb	mg/L	0.0010	0.0010	0.0010	<0.001	0.0020	0.0010	<0.001	<0.001						
Se	mg/L	0.04	0.04	0.01	<0.01	<0.01	<0.01	<0.01	<0.01						
Si	mg/L	4.93	4.28	6.36	6.12	7.62	5.70	5.90	5.20						
Sn	mg/L	0.02	0.00	0.00	0.00	<0.001	<0.001	0.00	<0.001						
Sr	mg/L	3.29	0.70	0.06	0.06	0.03	0.06	0.09	0.09						
Th	mg/L	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001						
U	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001						
Zn	mg/L	0.01	0.02	0.01	<0.005	<0.005	<0.005	<0.005	<0.005						

Table 8: Leach column results for fresh NAF/PAF-LC A Seam overburden (4583).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
0.44	6	7	5.2	0	2	2001	02/11/12	TAR/4583

Collection Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Collection Week		0	4	8	12	16	20	24	28	32	36	40	44	48	52
Volume	ml	395	382	388	380	385	389	396	398	399	399	401	406	416	419
pH	-	5.49	7.51	7.55	7.66	7.62	7.76	7.81	7.93	7.82	7.91	7.95	7.81	7.79	7.83
EC	dS/m	10.52	4.11	3.75	3.66	3.14	2.67	2.55	1.67	1.35	0.90	0.86	0.79	0.83	0.79
Alkalinity ($CaCO_3$)	mg/L		41	45	56	36	35	33	40	37	46	39	41	44	51
Acidity ($CaCO_3$)	mg/L	195													
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/L	17.00	0.41	0.22	0.18	0.18	0.26	0.21	0.18	0.17	0.15	0.16	0.22	0.19	0.20
As	mg/L	0.080	0.040	0.048	0.050	0.036	0.033	0.032	0.021	0.020	0.017	0.024	0.027	0.020	0.023
B	mg/L	0.3200	0.0500	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ba	mg/L	0.117	0.030	0.021	0.018	0.016	0.017	0.012	0.011	0.012	0.013	0.014	0.017	0.012	0.014
Be	mg/L	0.034	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Ca	mg/L	610	397	382	322	318	241	121	119	87	71	61	62	59	60
Cd	mg/L	0.0416	0.0022	0.0018	0.0008	0.0004	0.0003	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cl	mg/L	138	23	5	2	2	2	2	1	<1	1	2	<1	2	<1
Co	mg/L	1.180	0.024	0.009	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cr	mg/L	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	mg/L	0.21	0.00	0.00	0.00	<0.001	0.00	<0.001	<0.001	0.00	<0.001	0.00	0.00	0.00	0.00
F	mg/L	1.4	1.0	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.5	0.7	0.5
Fe	mg/L	52.90	1.14	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	0.0002	<0.0001	<0.0001	<0.0001
K	mg/L	76	18	21	22	21	21	14	15	15	11	11	11	11	13
Mg	mg/L	1700	506	523	459	299	222	118	108	78	62	59	58	59	60
Mn	mg/L	87.0	31.7	26.5	7.3	4.4	1.7	0.9	0.5	0.3	0.3	0.2	0.2	0.1	0.1
Mo	mg/L	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Na	mg/L	156	14	12	9	7	7	4	6	4	3	4	4	3	3
Ni	mg/L	3.580	0.126	0.069	0.013	0.006	0.004	0.002	0.002	0.001	<0.001	0.001	<0.001	0.001	<0.001
P	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/L	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO_4	mg/L	9480	2910	2950	2470	1980	1570	983	623	513	394	402	404	365	341
Sb	mg/L	0.0030	0.0010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/L	0.28	0.11	0.10	0.07	0.05	0.04	0.02	0.02	0.01	0.01	<0.01	0.01	0.02	<0.01
Si	mg/L	16.70	1.71	1.82	1.62	1.03	0.98	0.76	0.65	0.57	0.56	0.54	0.58	0.54	0.54
Sn	mg/L	0.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sr	mg/L	5.25	1.93	1.99	1.19	1.23	0.88	0.62	0.41	0.31	0.29	0.25	0.29	0.23	0.24
Th	mg/L	0.005	0.002	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
U	mg/L	0.020	0.004	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	mg/L	6.35	0.04	0.02	0.01	0.01	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.005

Table 8: Leach column results for fresh NAF/PAF-LC A Seam overburden (4583).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
0.44	6	7	5	0	2	2001	02/11/12	TAR/4583

Collection Number		15	16	17	18	19	20	21	22	23	24	25	26	27	28
Collection Week		56	60	64	68	72	76	80	84	88	92	96	100	104	108
Volume	ml	418	421	421	422	422	423								
pH	-	7.61	7.65	7.41	7.51	7.56	7.71								
EC	dS/m	0.83	0.82	0.76	0.66	0.56	0.48								
Alkalinity ($CaCO_3$)	mg/L	46	45	37	46	34	30								
Acidity ($CaCO_3$)	mg/L														
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Al	mg/L	0.06	0.14	0.09	0.12	0.12	0.14								
As	mg/L	0.015	0.026	0.017	0.017	0.015	0.018								
B	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05								
Ba	mg/L	0.014	0.016	0.014	0.014	0.012	0.011								
Be	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Ca	mg/L	59	61	52	46	38	34								
Cd	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001								
Cl	mg/L	<1	<1	1	1	<1	<1								
Co	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Cr	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Cu	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
F	mg/L	0.5	0.6	0.6	0.6	0.6	0.6								
Fe	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05								
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001								
K	mg/L	15	15	15	15	12	9								
Mg	mg/L	62	58	53	48	42	31								
Mn	mg/L	0.1	0.1	0.1	0.1	0.1	0.1								
Mo	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Na	mg/L	3	3	3	2	2	1								
Ni	mg/L	0.001	0.001	<0.001	<0.001	<0.001	<0.001								
P	mg/L	<1	<1	<1	<1	<1	<1								
Pb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
SO_4	mg/L	442	442	413	373	294	216								
Sb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01								
Si	mg/L	0.68	0.78	0.73	0.79	0.85	0.73								
Sn	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Sr	mg/L	0.23	0.28	0.23	0.20	0.17	0.17								
Th	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
U	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Zn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005								

Table 9: Leach column results for fresh PAF A Seam roof (4584).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
1.08	0	33	2.6	19	26	2001	02/11/12	TAR/4584

Collection Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Collection Week		0	4	8	12	16	20	24	28	32	36	40	44	48	52
Volume	ml	391	390	391	388	389	391	398	398	399	413	407	410	419	417
pH	-	2.49	2.38	2.41	2.25	2.11	2.12	2.14	2.32	2.11	2.15	2.25	2.31	2.45	2.51
EC	dS/m	14.35	11.61	10.75	9.35	7.66	9.11	9.29	6.29	5.88	4.38	3.96	3.56	3.25	2.99
Alkalinity ($CaCO_3$)	mg/L														
Acidity ($CaCO_3$)	mg/L	20471	9515	8781	6981	4313	4256	4216	2931	2116	1416	997	829	799	652
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/L	1100.00	757.00	333.00	188.00	114.00	99.60	54.60	46.80	29.10	17.80	14.80	13.00	12.60	8.37
As	mg/L	7.850	1.760	1.490	0.925	0.555	0.580	0.228	0.069	0.047	0.019	0.028	0.016	0.017	0.011
B	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ba	mg/L	0.008	0.009	0.002	0.002	0.003	0.005	0.003	0.006	0.003	0.003	0.003	0.004	0.002	0.001
Be	mg/L	0.190	0.227	0.124	0.0590	0.0270	0.0260	0.0160	0.0100	0.0050	0.0030	0.0030	0.0020	0.0030	0.0030
Ca	mg/L	210	218	131	96	70	52	25	16	9	6	4	3	2	1
Cd	mg/L	0.1440	0.1150	0.0392	0.0166	0.0068	0.0053	0.0020	0.0011	0.0006	0.0004	0.0003	0.0003	0.0002	0.0002
Cl	mg/L	25	21	2	2	1	1	1	<1	<1	<1	<1	<1	<1	<1
Co	mg/L	7.770	4.290	1.370	0.413	0.173	0.087	0.035	0.015	0.009	0.004	0.003	0.002	0.002	0.002
Cr	mg/L	1.29	1.21	0.52	0.38	0.19	0.27	0.14	0.10	0.05	0.03	0.03	0.02	0.04	0.03
Cu	mg/L	5.36	4.48	3.24	1.26	0.98	0.50	0.29	0.17	0.13	0.08	0.10	0.07	0.07	0.06
F	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.2	0.1	0.4	0.4	0.5	0.2
Fe	mg/L	6710.00	4000.00	2240.00	1400.00	790.00	1160.00	631.00	300.00	247.00	137.00	141.00	119.00	122.00	76.20
Hg	mg/L	<0.0001	<0.0001	<0.0001	0.0001	0.0001	0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/L	5	<1	<1	<1	<1	2	<1	2	<1	<1	1	<1	<1	<1
Mg	mg/L	384	258	78	40	15	15	6	4	2	1	<1	<1	<1	<1
Mn	mg/L	17.7	13.0	6.0	2.4	1.4	0.9	0.5	0.3	0.2	0.1	0.1	0.1	0.1	0.1
Mo	mg/L	0.164	0.034	0.061	0.048	0.043	0.048	0.018	0.009	0.005	0.003	0.003	0.002	<0.001	0.001
Na	mg/L	10	<1	<1	<1	2	4	5	2	1	2	3	<1	<1	<1
Ni	mg/L	19.300	11.100	4.540	1.150	0.505	0.291	0.121	0.058	0.037	0.018	0.014	0.009	0.007	0.007
P	mg/L	57	30	19	13	10	10	3	1	1	<1	<1	<1	<1	<1
Pb	mg/L	0.004	<0.001	<0.001	0.0020	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0040	<0.001	<0.001
SO_4	mg/L	25800	15300	8210	5380	4590	5200	2930	1530	1470	974	1030	951	722	603
Sb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/L	0.69	0.48	0.19	0.14	0.12	0.10	0.08	0.04	0.03	0.02	0.03	0.01	0.02	<0.01
Si	mg/L	5.38	19.00	13.80	13.60	15.61	14.40	17.30	7.00	13.50	13.20	7.58	13.30	5.10	6.16
Sn	mg/L	0.04	0.01	0.00	0.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sr	mg/L	2.19	2.59	1.53	0.95	1.38	1.48	0.85	0.63	0.43	0.30	0.28	0.23	0.17	0.12
Th	mg/L	2.360	1.520	1.110	1.020	0.882	0.940	0.703	0.192	0.175	0.078	0.072	0.056	0.066	0.040
U	mg/L	2.010	1.360	0.601	0.274	0.181	0.133	0.073	0.041	0.030	0.017	0.018	0.017	0.017	0.014
Zn	mg/L	38.30	36.20	14.80	4.62	1.75	1.13	0.54	0.28	0.18	0.11	0.11	0.08	0.08	0.07

Table 9: Leach column results for fresh PAF A Seam roof (4584).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
1.08	0	33	3	19	26	2001	02/11/12	TAR/4584

Collection Number		15	16	17	18	19	20	21	22	23	24	25	26	27	28
Collection Week		56	60	64	68	72	76	80	84	88	92	96	100	104	108
Volume	ml	418	420	420	421	423	424								
pH	-	2.42	2.41	2.23	2.29	2.24	2.39								
EC	dS/m	3.75	3.62	3.65	3.52	3.38	2.75								
Alkalinity ($CaCO_3$)	mg/L														
Acidity ($CaCO_3$)	mg/L	812	835	822	832	745	689								
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Al	mg/L	21.30	20.80	17.10	20.60	17.00	10.00								
As	mg/L	0.035	0.036	0.025	0.030	0.024	0.010								
B	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05								
Ba	mg/L	0.002	0.001	0.001	0.001	0.002	0.002								
Be	mg/L	0.006	0.005	0.005	0.0040	0.0030	0.0020								
Ca	mg/L	2	1	1	1	<1	<1								
Cd	mg/L	0.0003	0.0003	0.0002	0.0002	0.0002	0.0001								
Cl	mg/L	<1	<1	<1	<1	<1	<1								
Co	mg/L	0.003	0.003	0.002	0.002	0.002	0.001								
Cr	mg/L	0.06	0.05	0.05	0.04	0.03	0.03								
Cu	mg/L	0.08	0.07	0.09	0.06	0.05	0.04								
F	mg/L	0.4	0.3	0.3	0.3	0.2	0.2								
Fe	mg/L	141.00	130.00	88.60	109.00	89.30	48.90								
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001								
K	mg/L	<1	<1	<1	<1	<1	<1								
Mg	mg/L	1	1	1	1	<1	<1								
Mn	mg/L	0.1	0.1	0.1	0.0	0.0	0.0								
Mo	mg/L	0.002	0.002	0.002	0.002	0.001	0.001								
Na	mg/L	<1	<1	<1	<1	<1	<1								
Ni	mg/L	0.012	0.010	0.009	0.006	0.005	0.003								
P	mg/L	<1	<1	<1	<1	<1	<1								
Pb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
SO_4	mg/L	1270	1180	985	1070	1030	643								
Sb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Se	mg/L	0.03	0.03	0.03	0.03	0.02	0.01								
Si	mg/L	9.45	9.01	9.10	16.30	13.80	18.60								
Sn	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Sr	mg/L	0.18	0.16	0.12	0.11	0.11	0.08								
Th	mg/L	0.138	0.110	0.066	0.080	0.058	0.025								
U	mg/L	0.020	0.016	0.014	0.012	0.010	0.006								
Zn	mg/L	0.12	0.10	0.10	0.08	0.07	0.05								

Table 10: Leach column results for fresh PAF/PAF-LC A Seam/B Seam Interburden (4585).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
0.36	0	11	2.8	6	11	2001	02/11/12	TAR/4585

Collection Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Collection Week		0	4	8	12	16	20	24	28	32	36	40	44	48	52
Volume	ml	390	391	396	390	391	391	395	397	400	402	405	399	404	410
pH	-	2.61	2.21	2.23	2.27	2.21	2.19	2.23	2.38	2.35	2.39	2.49	2.51	2.62	2.75
EC	dS/m	9.51	5.61	4.31	3.95	4.11	4.46	4.52	2.98	2.52	1.91	1.74	1.52	1.43	1.31
Alkalinity ($CaCO_3$)	mg/L														
Acidity ($CaCO_3$)	mg/L	8616	3762	3285	2718	2111	1542	1512	829	556	379	316	237	216	179
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/L	527.00	214.00	114.00	54.10	66.20	57.20	26.40	22.60	11.70	7.31	6.45	5.00	5.28	2.46
As	mg/L	2.000	0.290	0.114	0.048	0.053	0.050	0.016	0.008	0.004	0.002	0.003	0.002	0.002	0.002
B	mg/L	0.0600	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ba	mg/L	0.049	0.002	0.002	<0.001	<0.001	0.001	<0.001	0.001	0.001	0.002	<0.001	<0.001	0.001	0.001
Be	mg/L	0.227	0.194	0.117	0.0500	0.0460	0.0390	0.0190	0.0130	0.0060	0.0050	0.0030	0.0030	0.0030	0.0020
Ca	mg/L	238	129	64	28	30	22	10	8	5	4	3	2	1	1
Cd	mg/L	0.0714	0.0434	0.0204	0.0090	0.0071	0.0061	0.0021	0.0011	0.0007	0.0004	0.0003	0.0003	0.0002	0.0002
Cl	mg/L	42	5	3	1	2	2	2	<1	<1	<1	<1	<1	<1	<1
Co	mg/L	5.480	1.810	0.805	0.210	0.170	0.128	0.048	0.024	0.014	0.008	0.006	0.005	0.005	0.004
Cr	mg/L	0.76	0.42	0.22	0.14	0.11	0.13	0.05	0.03	0.01	0.01	0.01	0.01	0.01	0.00
Cu	mg/L	3.26	2.07	1.39	0.66	0.59	0.54	0.23	0.17	0.11	0.11	0.07	0.06	0.07	0.05
F	mg/L	<0.1	<0.1	<0.1	0.3	0.4	0.4	0.3	0.3	0.2	<0.1	0.2	0.2	<0.1	<0.1
Fe	mg/L	2680.00	994.00	587.00	206.00	240.00	286.00	126.00	68.10	39.50	22.60	17.20	13.60	15.00	7.86
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/L	32	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	2
Mg	mg/L	359	141	56	22	16	13	5	3	1	<1	<1	<1	<1	<1
Mn	mg/L	19.4	12.2	7.2	2.4	2.4	1.6	0.6	0.3	0.2	0.1	0.1	0.1	0.1	0.0
Mo	mg/L	0.040	0.010	0.005	0.003	0.003	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Na	mg/L	30	<1	<1	<1	2	4	4	2	<1	2	3	<1	<1	<1
Ni	mg/L	7.660	5.240	2.760	0.851	0.760	0.597	0.218	0.112	0.060	0.038	0.025	0.019	0.018	0.013
P	mg/L	16	4	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/L	0.08	0.0050	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO_4	mg/L	11500	4930	2550	1540	1880	1820	866	531	427	301	296	277	219	158
Sb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/L	0.29	0.12	0.07	0.04	0.06	0.05	0.03	0.02	<0.01	<0.01	0.01	<0.01	0.01	<0.01
Si	mg/L	10.90	15.60	7.63	8.11	10.42	10.50	9.69	4.54	7.32	8.06	4.34	6.34	3.11	3.94
Sn	mg/L	0.02	0.00	0.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sr	mg/L	2.14	0.81	0.35	0.15	0.21	0.23	0.12	0.10	0.08	0.06	0.06	0.06	0.04	0.03
Th	mg/L	1.380	0.788	1.210	0.931	1.410	1.410	0.672	0.248	0.118	0.049	0.034	0.029	0.040	0.011
U	mg/L	0.974	0.332	0.173	0.100	0.089	0.088	0.037	0.022	0.014	0.008	0.007	0.008	0.008	0.005
Zn	mg/L	35.40	33.10	15.50	4.70	3.37	2.55	0.99	0.61	0.39	0.27	0.22	0.18	0.18	0.14

Table 10: Leach column results for fresh PAF/PAF-LC A Seam/B Seam Interburden (4585).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
0.36	0	11	3	6	11	2001	02/11/12	TAR/4585

Collection Number		15	16	17	18	19	20	21	22	23	24	25	26	27	28
Collection Week		56	60	64	68	72	76	80	84	88	92	96	100	104	108
Volume	ml	415	420	421	421	423	422								
pH	-	2.63	2.61	2.49	2.55	2.67	2.83								
EC	dS/m	1.44	1.49	1.24	1.19	0.94	0.81								
Alkalinity ($CaCO_3$)	mg/L														
Acidity ($CaCO_3$)	mg/L	180	187	166	174	127	116								
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Al	mg/L	4.30	4.14	2.76	3.54	1.96	1.14								
As	mg/L	0.004	0.003	0.003	0.004	0.002	<0.001								
B	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05								
Ba	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	0.002								
Be	mg/L	0.003	0.003	0.003	0.0030	0.0020	0.0020								
Ca	mg/L	1	<1	<1	<1	<1	<1								
Cd	mg/L	0.0002	0.0002	0.0002	0.0002	0.0001	<0.0001								
Cl	mg/L	<1	<1	<1	<1	<1	<1								
Co	mg/L	0.005	0.005	0.004	0.005	0.004	0.003								
Cr	mg/L	0.01	0.01	0.01	0.01	0.00	0.00								
Cu	mg/L	0.06	0.05	0.07	0.04	0.03	0.02								
F	mg/L	0.2	0.2	0.2	0.1	<0.1	<0.1								
Fe	mg/L	9.14	8.24	6.53	5.21	3.19	1.67								
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001								
K	mg/L	1	1	2	2	3	2								
Mg	mg/L	<1	<1	<1	<1	<1	<1								
Mn	mg/L	0.0	0.0	0.0	0.0	0.0	0.0								
Mo	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Na	mg/L	<1	<1	<1	<1	<1	<1								
Ni	mg/L	0.014	0.013	0.011	0.011	0.008	0.006								
P	mg/L	<1	<1	<1	<1	<1	<1								
Pb	mg/L	<0.001	<0.001	<0.001	<0.001	0.0010	<0.001								
SO_4	mg/L	243	224	208	193	145	102								
Sb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01								
Si	mg/L	5.73	6.27	6.44	6.08	5.80	8.57								
Sn	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Sr	mg/L	0.04	0.04	0.03	0.04	0.03	0.03								
Th	mg/L	0.018	0.017	0.010	0.008	0.004	0.002								
U	mg/L	0.005	0.005	0.003	0.003	0.002	0.001								
Zn	mg/L	0.19	0.17	0.14	0.15	0.10	0.08								

Table 11: Leach column results for fresh PAF-LC B Seam floor (3637).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
0.29	0	9	3.1	5	9	2001	02/11/12	TAR/3637

Collection Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Collection Week		0	4	8	12	16	20	24	28	32	36	40	44	48	52
Volume	ml	392	395	391	390	391	392	396	398	397	402	404	401	411	410
pH	-	2.55	2.31	2.35	2.51	2.62	2.58	2.64	2.76	2.75	2.77	2.86	2.85	2.96	2.97
EC	dS/m	6.96	6.52	5.22	4.09	2.76	1.88	1.91	1.21	1.11	0.82	0.71	0.69	0.69	0.67
Alkalinity ($CaCO_3$)	mg/L														
Acidity ($CaCO_3$)	mg/L	3827	2778	2618	2090	1076	729	710	476	210	107	89	71	69	70
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/L	165.00	190.00	31.60	15.10	10.70	9.86	7.58	4.50	3.07	1.69	1.25	1.08	1.43	1.37
As	mg/L	0.624	0.030	0.007	0.007	0.005	0.006	0.017	0.003	0.002	0.001	0.002	0.002	0.002	0.002
B	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ba	mg/L	0.042	<0.001	0.007	<0.001	0.002	0.004	0.003	0.004	0.004	0.005	0.005	0.009	0.010	0.012
Be	mg/L	0.215	0.194	0.065	0.0350	0.0260	0.0210	0.0150	0.0110	0.0070	0.0050	0.0030	0.0030	0.0040	0.0030
Ca	mg/L	195	181	66	42	34	25	16	12	9	6	4	4	4	3
Cd	mg/L	0.0664	0.0581	0.0129	0.0068	0.0043	0.0038	0.0025	0.0014	0.0011	0.0007	0.0004	0.0005	0.0005	0.0004
Cl	mg/L	3	3	4	8	2	2	2	<1	<1	<1	<1	<1	<1	<1
Co	mg/L	6.760	3.970	0.784	0.272	0.158	0.126	0.069	0.044	0.032	0.021	0.015	0.011	0.012	0.012
Cr	mg/L	0.30	0.26	0.04	0.03	0.02	0.01	0.01	0.01	0.00	0.00	<0.001	<0.001	0.00	<0.001
Cu	mg/L	3.31	1.31	0.26	0.14	0.07	0.06	0.05	0.03	0.04	0.02	0.01	0.01	0.02	0.01
F	mg/L	<0.1	<0.1	0.4	0.3	0.3	0.3	0.3	0.2	0.1	<0.1	<0.1	0.1	<0.1	<0.1
Fe	mg/L	957.00	502.00	36.60	13.60	5.65	4.70	2.00	1.20	0.68	0.49	0.36	0.44	0.44	0.17
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/L	11	<1	<1	<1	<1	2	2	3	3	4	4	5	6	7
Mg	mg/L	560	502	108	66	42	32	20	13	9	6	4	4	3	3
Mn	mg/L	55.0	89.5	28.9	14.8	13.4	8.5	5.9	4.1	2.6	1.6	1.0	0.9	0.8	0.7
Mo	mg/L	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Na	mg/L	6	<1	<1	<1	2	3	5	3	1	2	3	1	1	<1
Ni	mg/L	10.700	9.600	1.730	0.753	0.442	0.369	0.196	0.136	0.100	0.064	0.048	0.033	0.035	0.034
P	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/L	0.08	0.0020	<0.001	<0.001	<0.001	0.0020	0.0010	0.0010	<0.001	0.0050	<0.001	<0.001	0.0020	<0.001
SO_4	mg/L	6940	5220	1050	699	502	467	287	209	164	126	114	115	101	92
Sb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Se	mg/L	0.09	0.08	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01
Si	mg/L	4.99	14.60	10.10	14.20	11.03	13.20	10.40	6.55	8.82	9.62	6.53	9.36	5.88	7.76
Sn	mg/L	0.02	0.01	0.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Sr	mg/L	1.23	0.19	0.11	0.10	0.09	0.11	0.09	0.07	0.06	0.05	0.04	0.04	0.05	0.05
Th	mg/L	1.940	1.120	0.193	0.087	0.038	0.031	0.020	0.007	0.003	0.001	<0.001	<0.001	<0.001	0.001
U	mg/L	0.308	0.249	0.051	0.030	0.020	0.018	0.011	0.007	0.005	0.003	0.002	0.002	0.003	0.003
Zn	mg/L	31.60	32.60	5.80	2.84	1.46	1.13	0.71	0.46	0.33	0.22	0.18	0.13	0.15	0.14

Table 11: Leach column results for fresh PAF-LC B Seam floor (3637).

Sample Characteristics								
Sulphur	ANC	NAPP	NAGpH	$NAG_{pH4.5}$	$NAG_{pH7.0}$	Weight	Start	EGi
%S	kgH_2SO_4/t	kgH_2SO_4/t		kgH_2SO_4/t	kgH_2SO_4/t	g	Date	Sample No
0.29	0	9	3	5	9	2001	02/11/12	TAR/3637

Collection Number		15	16	17	18	19	20	21	22	23	24	25	26	27	28
Collection Week		56	60	64	68	72	76	80	84	88	92	96	100	104	108
Volume	ml	417	420	422	422	423	422								
pH	-	2.81	2.83	2.78	2.85	2.86	3.02								
EC	dS/m	0.67	0.67	0.68	0.63	0.63	0.61								
Alkalinity ($CaCO_3$)	mg/L														
Acidity ($CaCO_3$)	mg/L	73	74	89	83	73	68								
Ag	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Al	mg/L	1.45	1.60	1.74	2.28	2.14	2.22								
As	mg/L	0.002	0.002	0.002	0.004	0.002	0.002								
B	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05								
Ba	mg/L	0.012	0.014	0.017	0.020	0.021	0.024								
Be	mg/L	0.003	0.003	0.004	0.0040	0.0030	0.0030								
Ca	mg/L	3	3	3	4	2	2								
Cd	mg/L	0.0004	0.0004	0.0004	0.0004	0.0003	0.0003								
Cl	mg/L	<1	<1	<1	<1	<1	<1								
Co	mg/L	0.010	0.010	0.010	0.010	0.008	0.008								
Cr	mg/L	0.00	0.00	0.00	0.00	0.00	0.00								
Cu	mg/L	0.02	0.02	0.02	0.02	0.01	0.01								
F	mg/L	<0.1	0.2	0.1	0.1	0.1	0.1								
Fe	mg/L	0.25	0.23	0.23	0.22	0.24	0.11								
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001								
K	mg/L	8	9	9	10	10	10								
Mg	mg/L	3	3	2	2	2	2								
Mn	mg/L	0.7	0.6	0.5	0.6	0.4	0.4								
Mo	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Na	mg/L	<1	<1	<1	<1	<1	<1								
Ni	mg/L	0.029	0.029	0.028	0.027	0.024	0.022								
P	mg/L	<1	<1	<1	<1	<1	<1								
Pb	mg/L	0.00	0.0010	0.0020	0.0110	0.0010	<0.001								
SO_4	mg/L	106	116	119	125	113	110								
Sb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Se	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01								
Si	mg/L	7.75	9.64	10.10	10.00	9.27	10.90								
Sn	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
Sr	mg/L	0.05	0.06	0.06	0.07	0.07	0.07								
Th	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001								
U	mg/L	0.002	0.002	0.002	0.002	0.001	0.001								
Zn	mg/L	0.13	0.14	0.13	0.14	0.11	0.10								

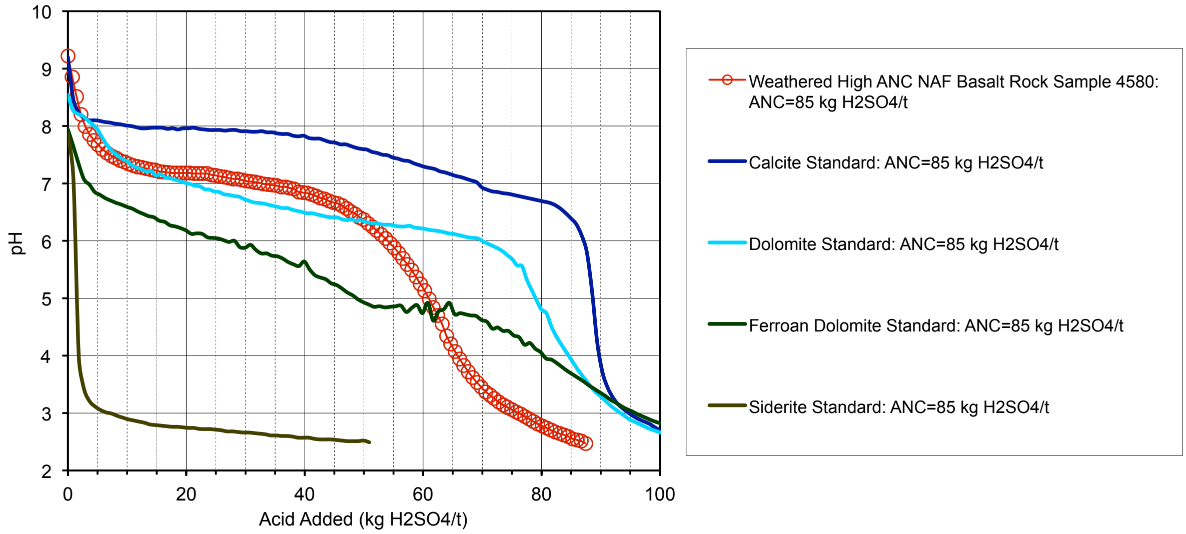

Figure 1: ABCC profile for weathered high ANC NAF basalt column sample 4580 with an ANC value of 85 kg H_2SO_4/t. Carbonate standard curves are included for reference.

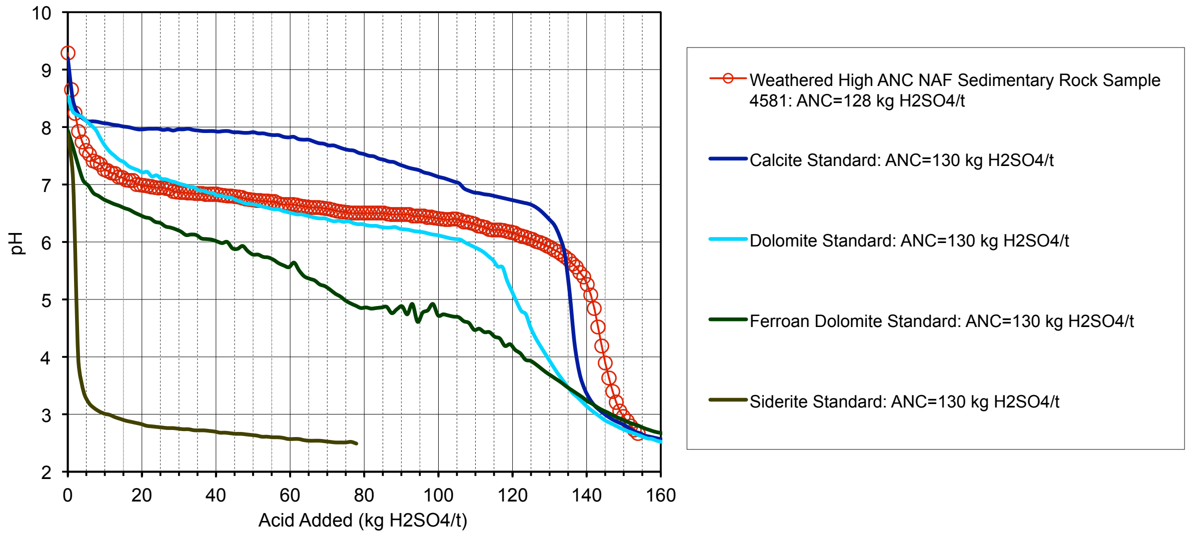

Figure 2: ABCC profile for weathered high ANC NAF sedimentary rock sample 4581 with an ANC value close to 130 kg H_2SO_4/t. Carbonate standard curves are included for reference.

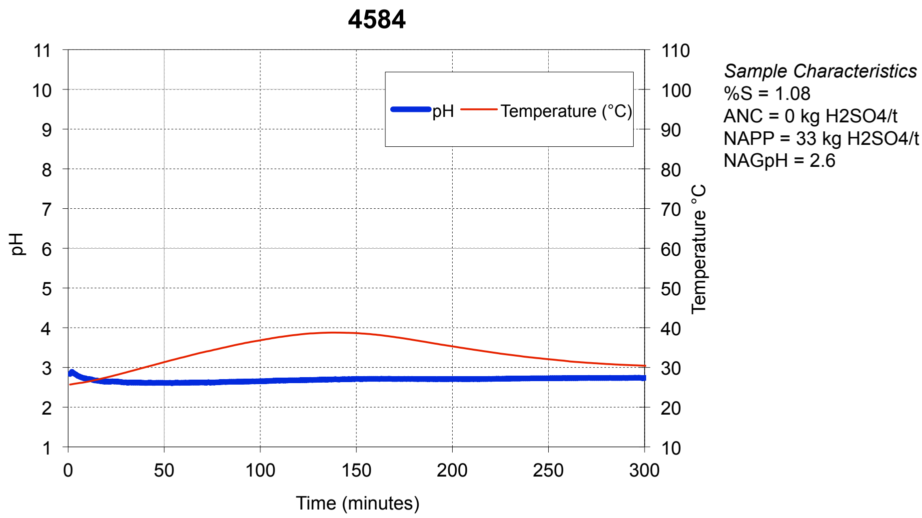

Figure 3: Kinetic NAG graph for fresh PAF A Seam roof sample 4584.

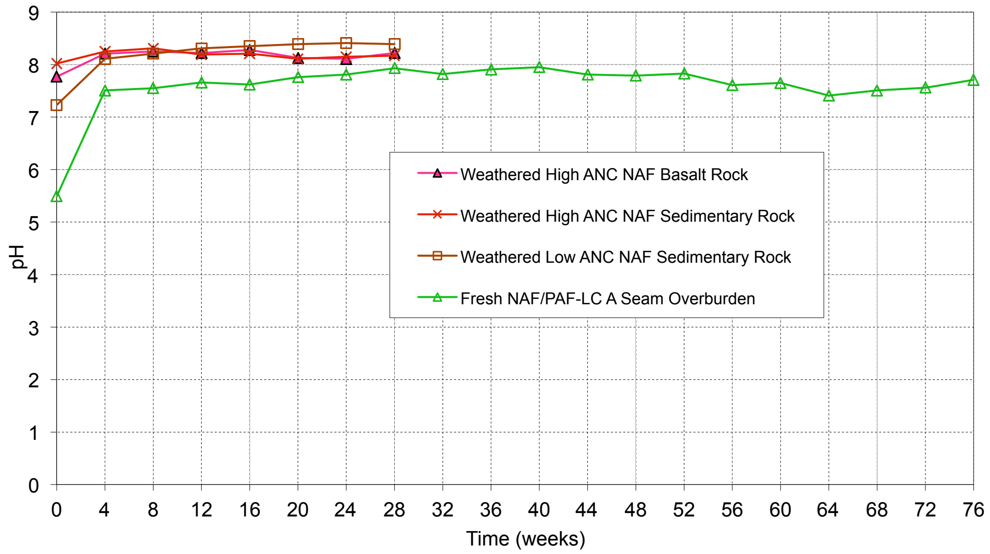

Figure 4: Leachate pH trends for NAF samples.

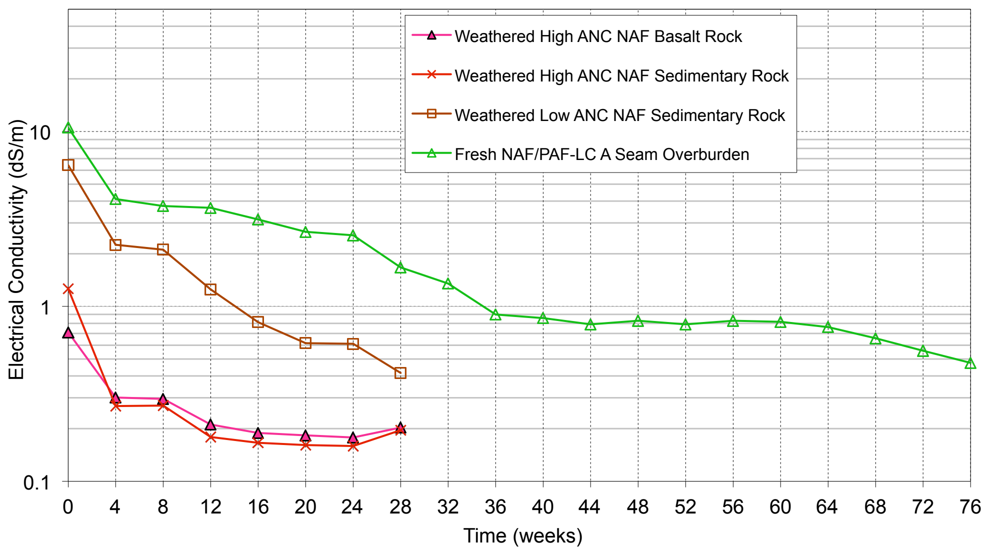

Figure 5: Leachate EC trends for NAF samples.

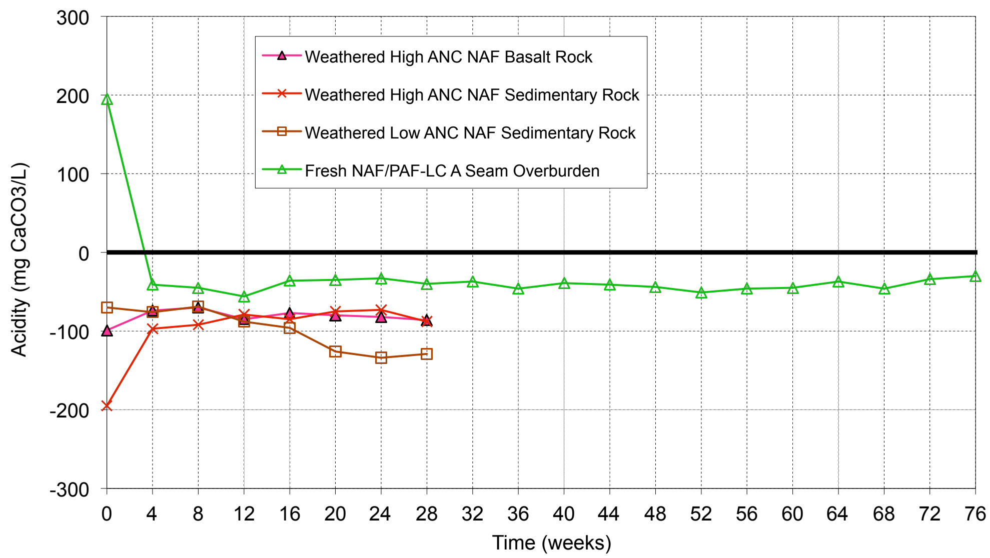

Figure 6: Leachate acidity trends for NAF samples. Alkalinities are shown as negative acidities.

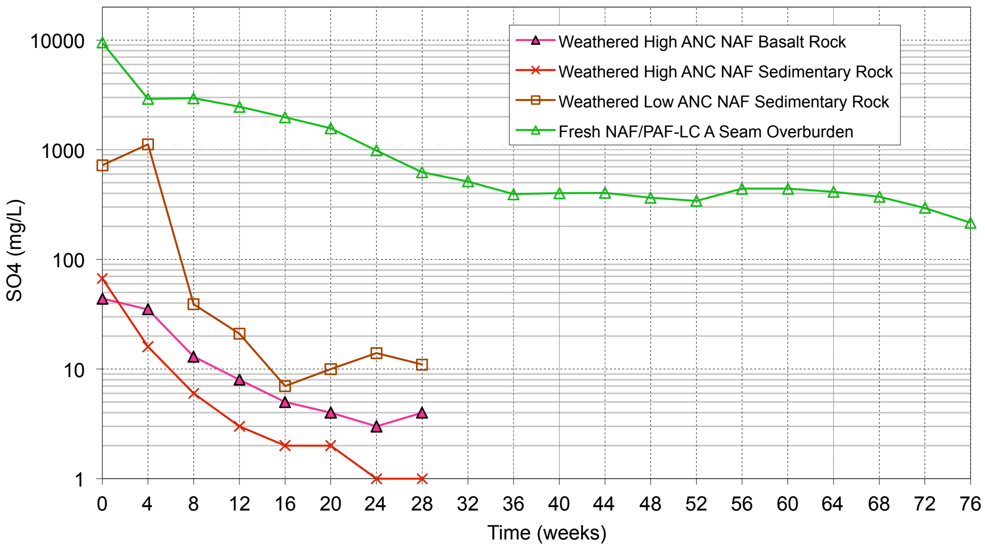

Figure 7: Leachate SO4 trends for NAF samples.

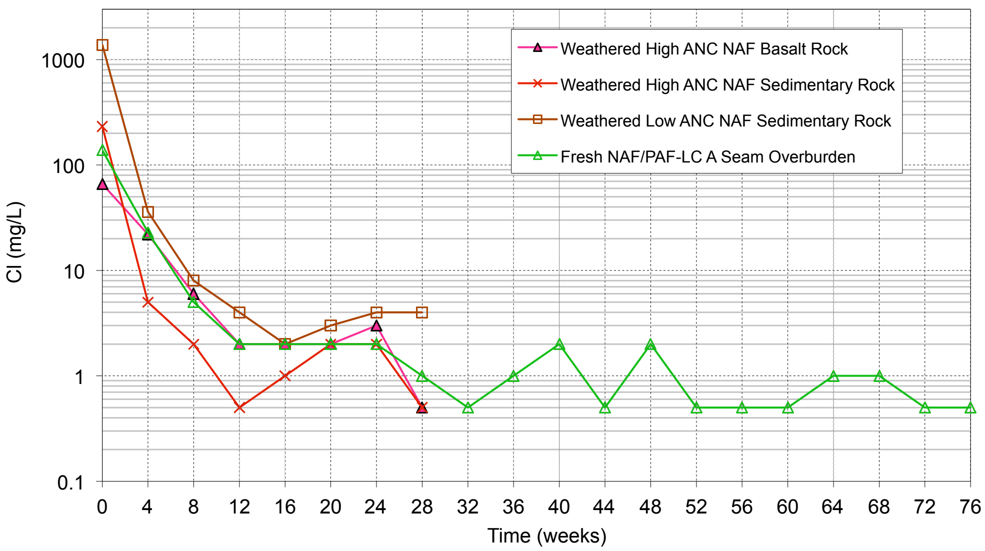

Figure 8: Leachate Cl trends for NAF samples.

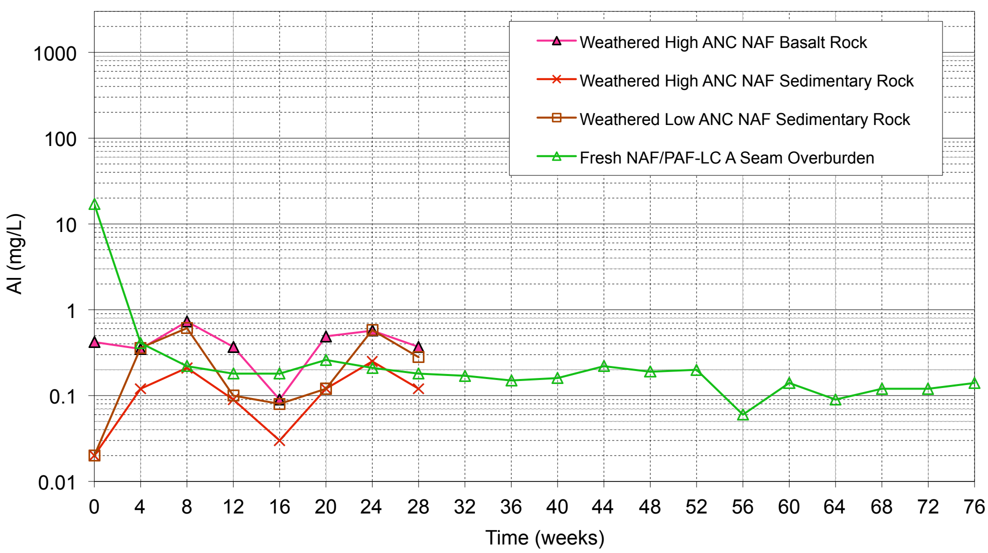

Figure 9: Leachate Al trends for NAF samples.

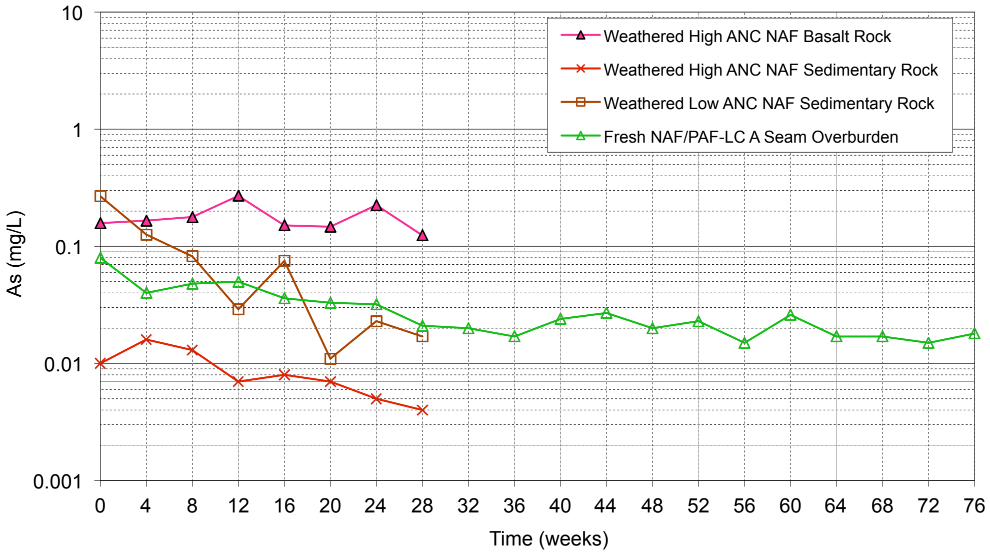

Figure 10: Leachate As trends for NAF samples.

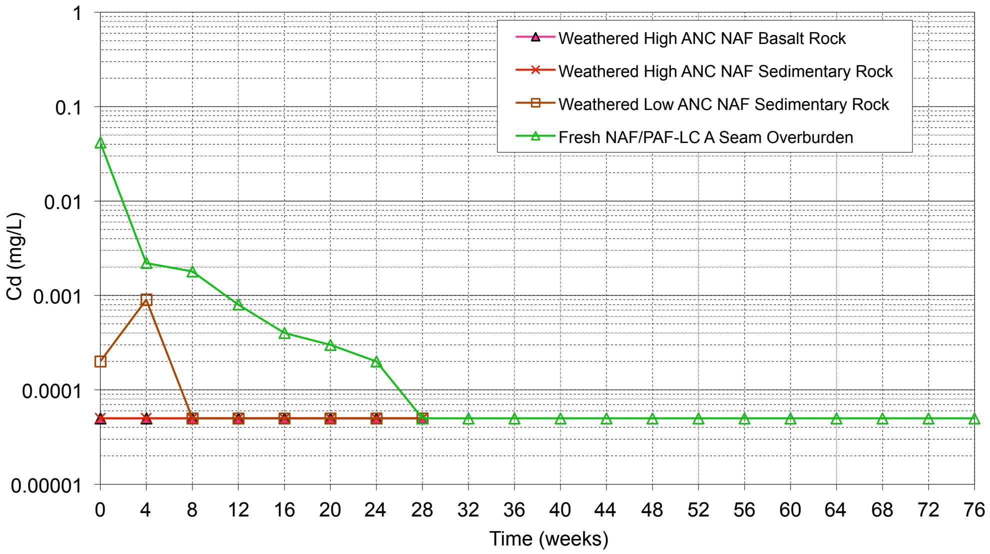

Figure 11: Leachate Cd trends for NAF samples.

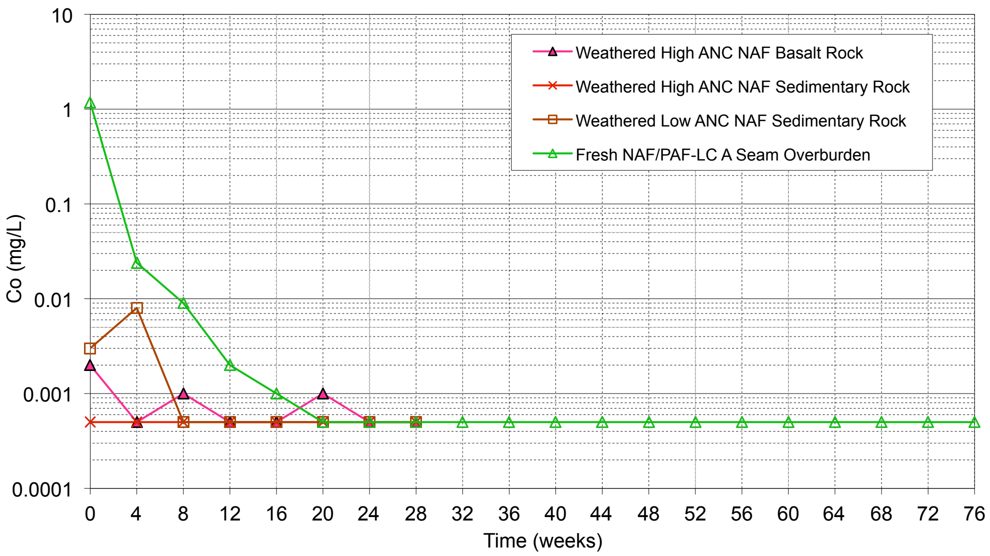

Figure 12: Leachate Co trends for NAF samples.

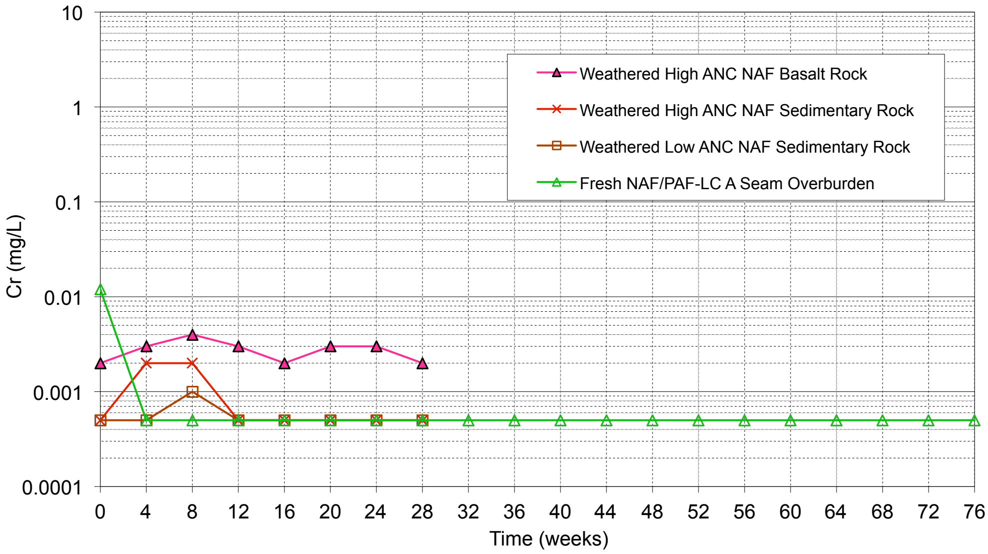

Figure 13: Leachate Cr trends for NAF samples.

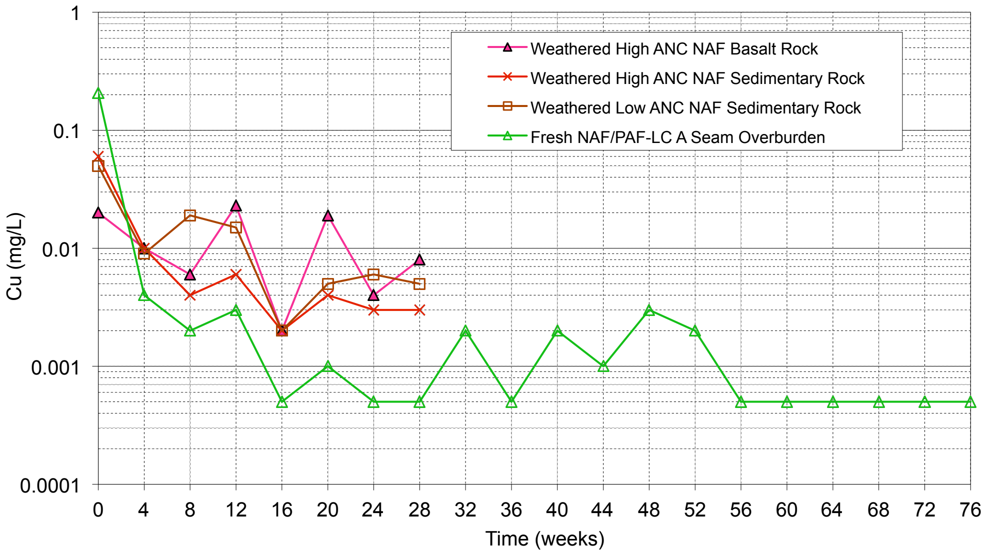

Figure 14: Leachate Cu trends for NAF samples.

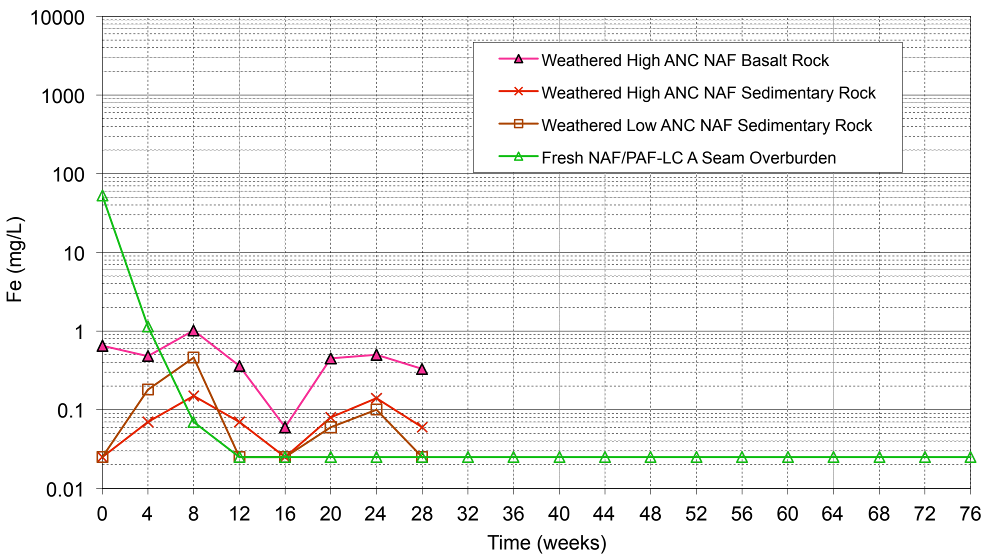

Figure 15: Leachate Fe trends for NAF samples.

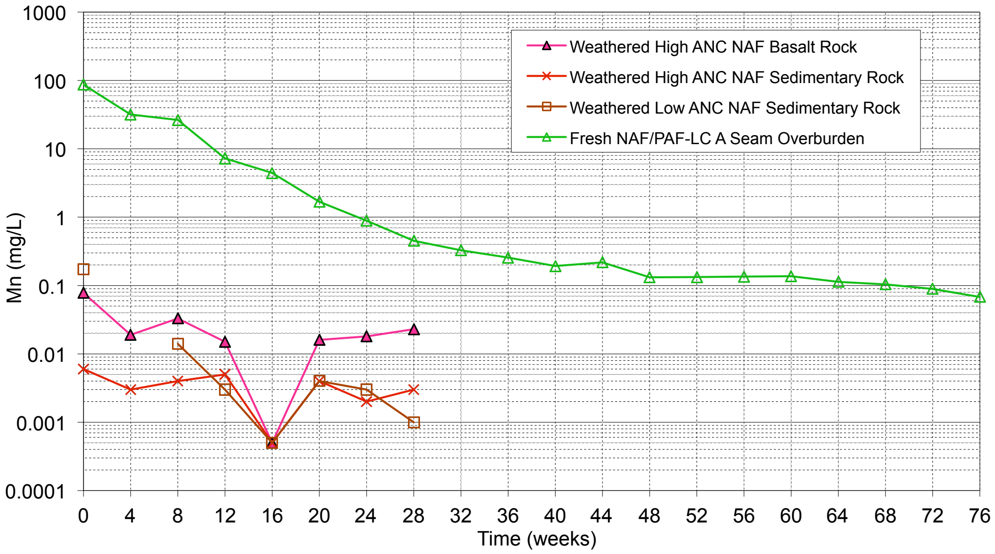

Figure 16: Leachate Mn trends for NAF samples.

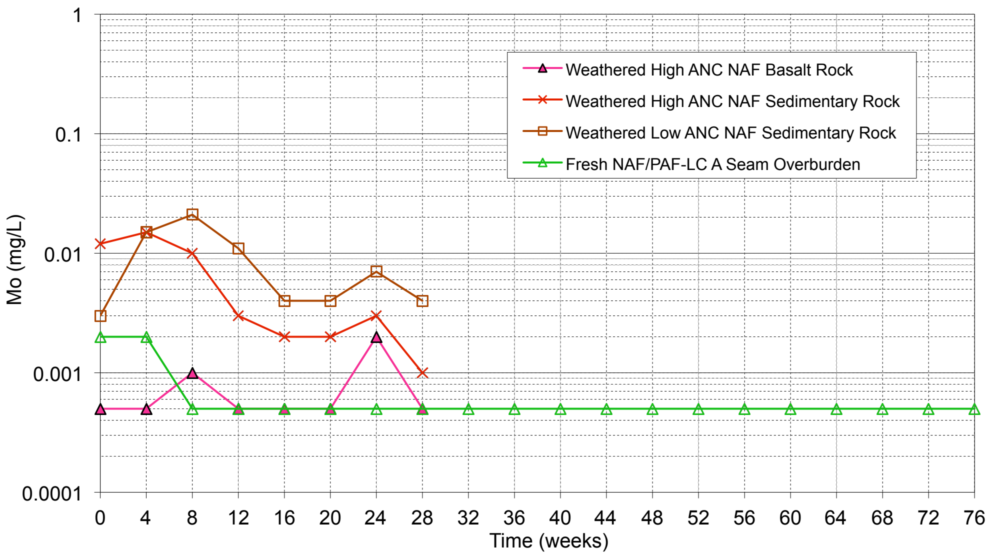

Figure 17: Leachate Mo trends for NAF samples.

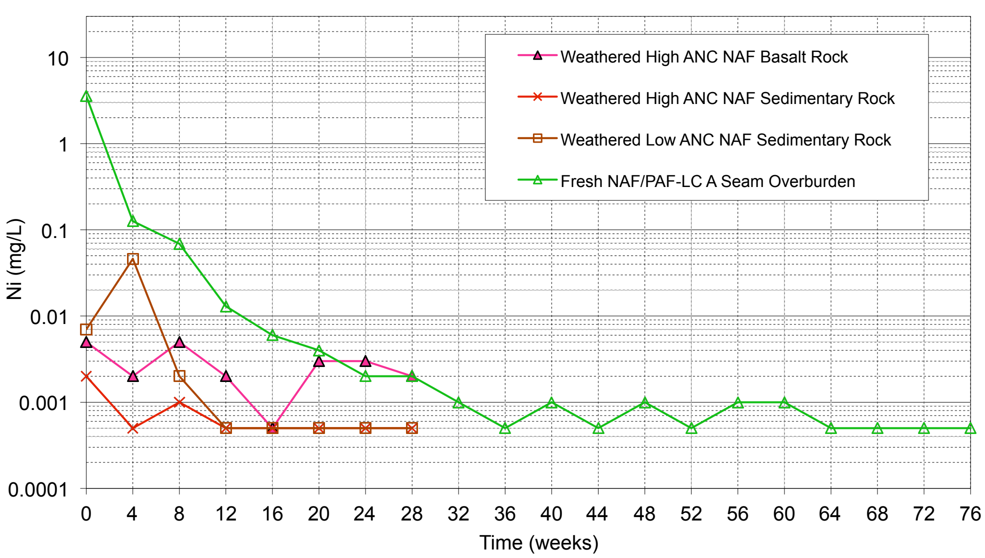

Figure 18: Leachate Ni trends for NAF samples.

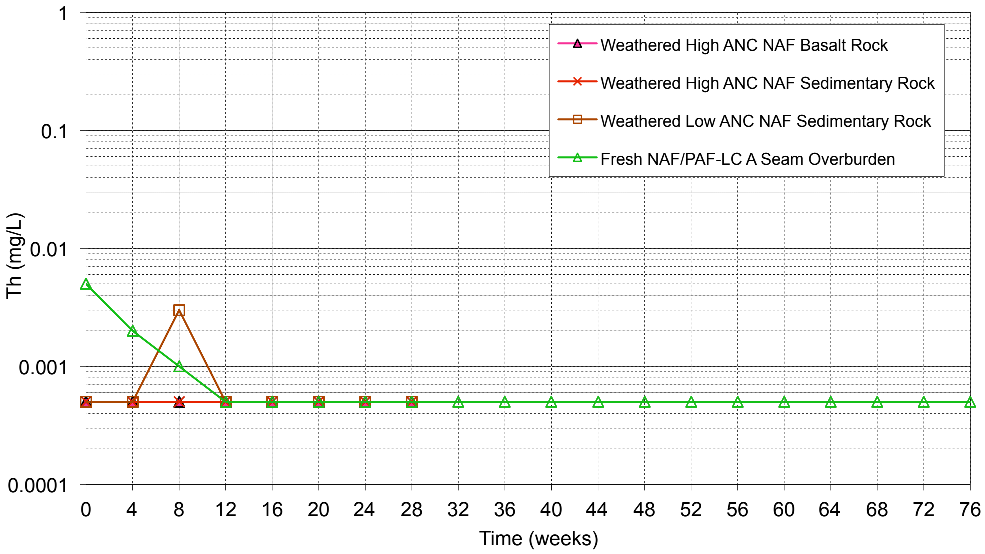

Figure 19: Leachate Th trends for NAF samples.

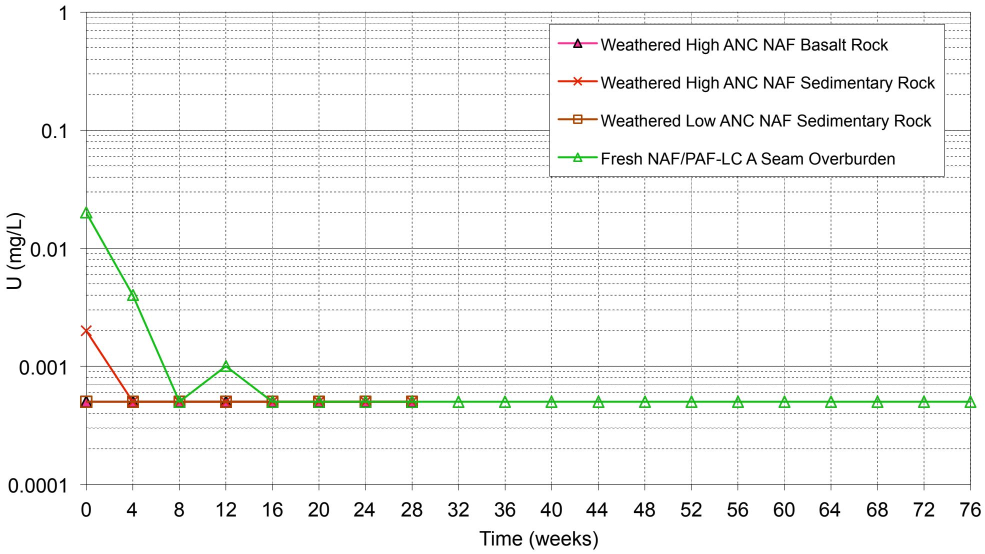

Figure 20: Leachate U trends for NAF samples.

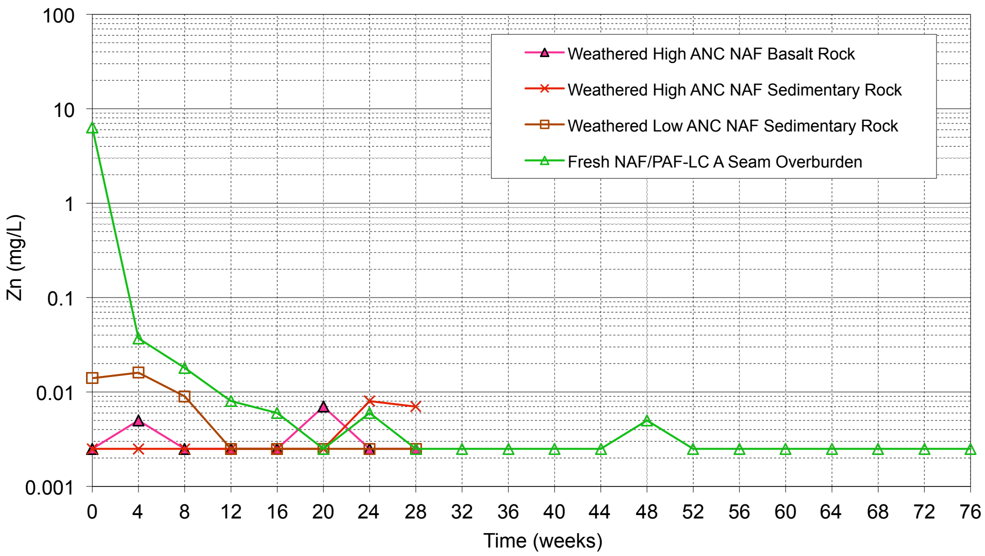

Figure 21: Leachate Zn trends for NAF samples.

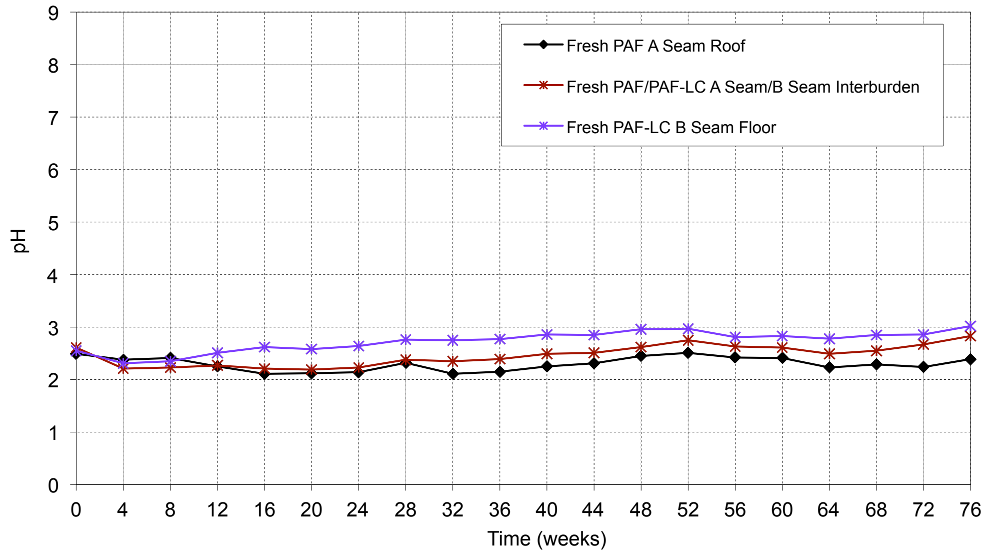

Figure 22: Leachate pH trends for PAF-LC and PAF samples.

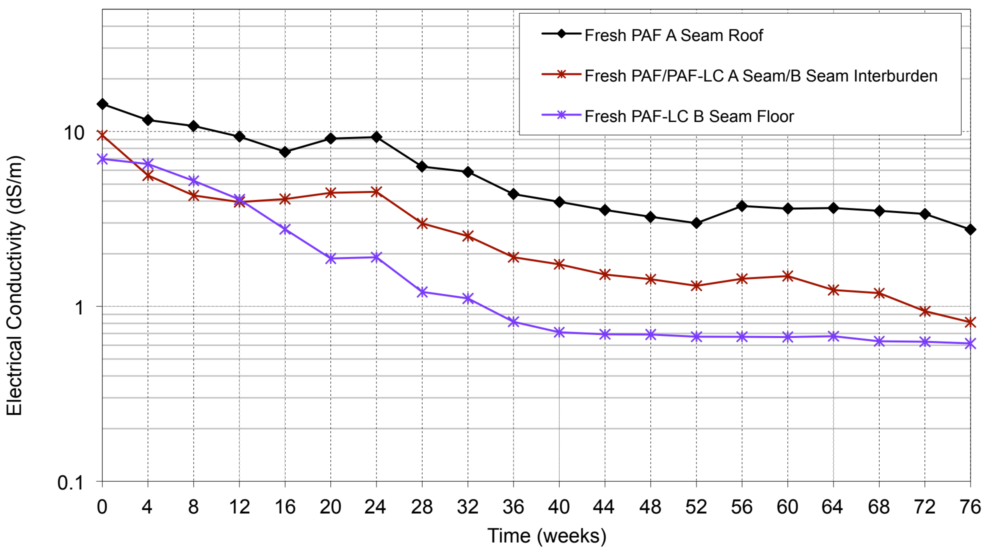

Figure 23: Leachate EC trends for PAF-LC and PAF samples.

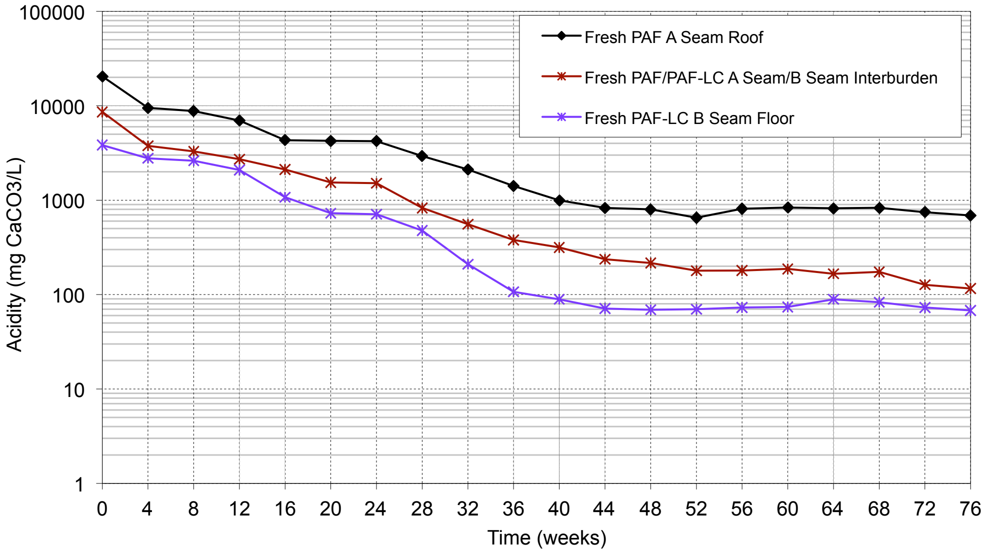

Figure 24: Leachate acidity trends for PAF-LC and PAF samples.

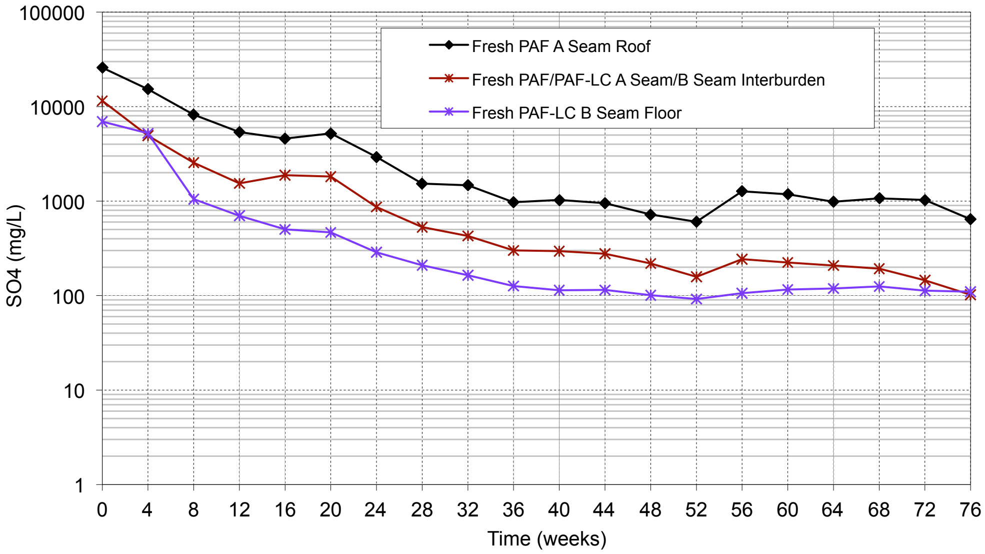

Figure 25: Leachate SO4 trends for PAF-LC and PAF samples.

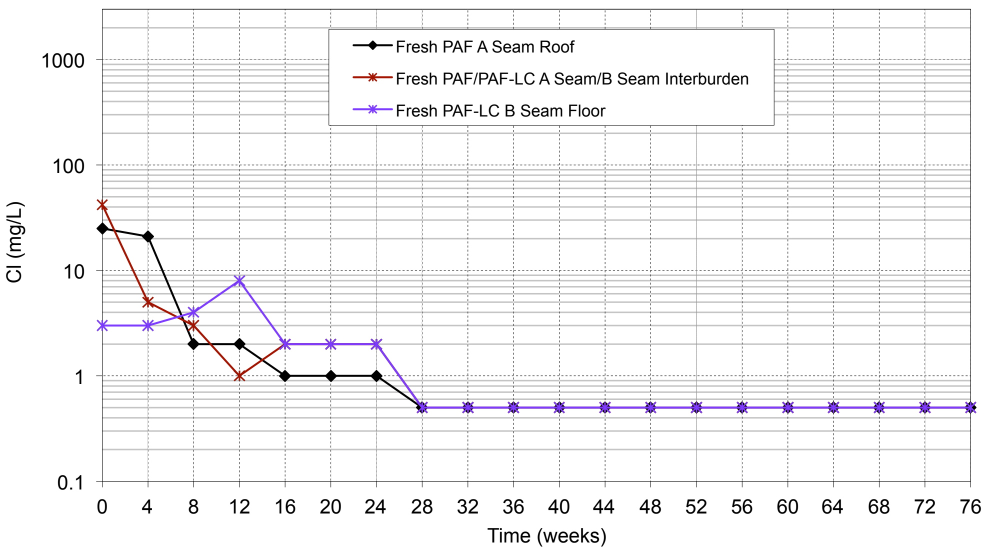

Figure 26: Leachate Cl trends for PAF-LC and PAF samples.

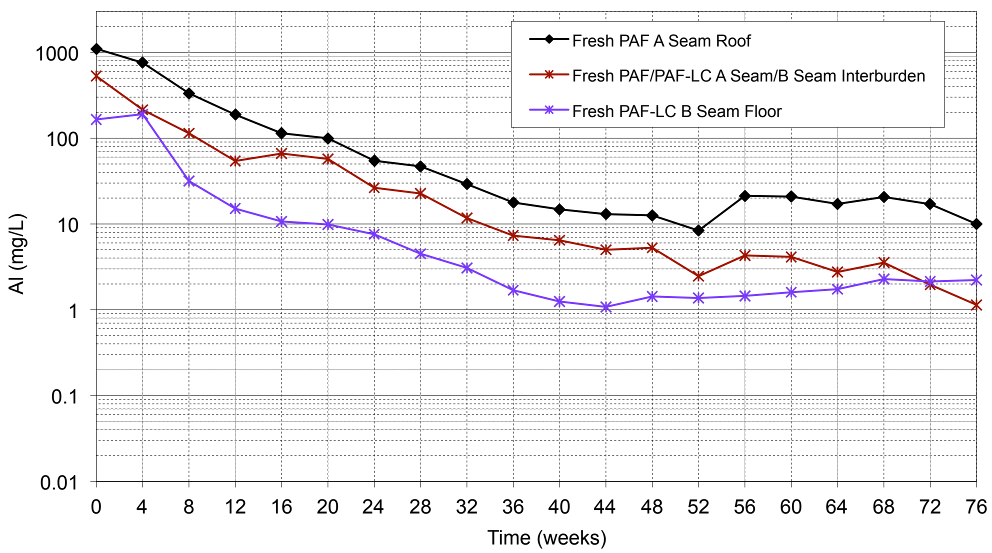

Figure 27: Leachate Al trends for PAF-LC and PAF samples.

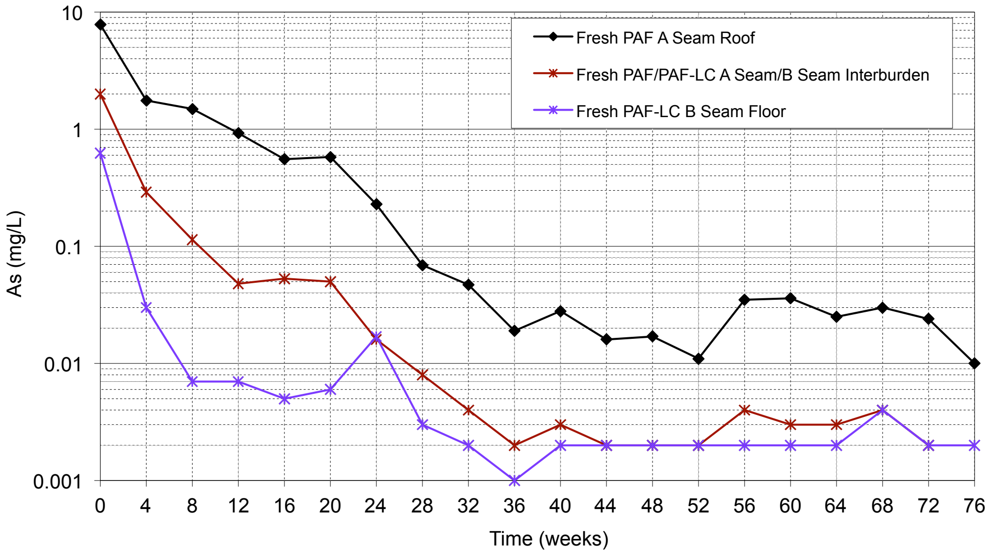

Figure 28: Leachate As trends for PAF-LC and PAF samples.

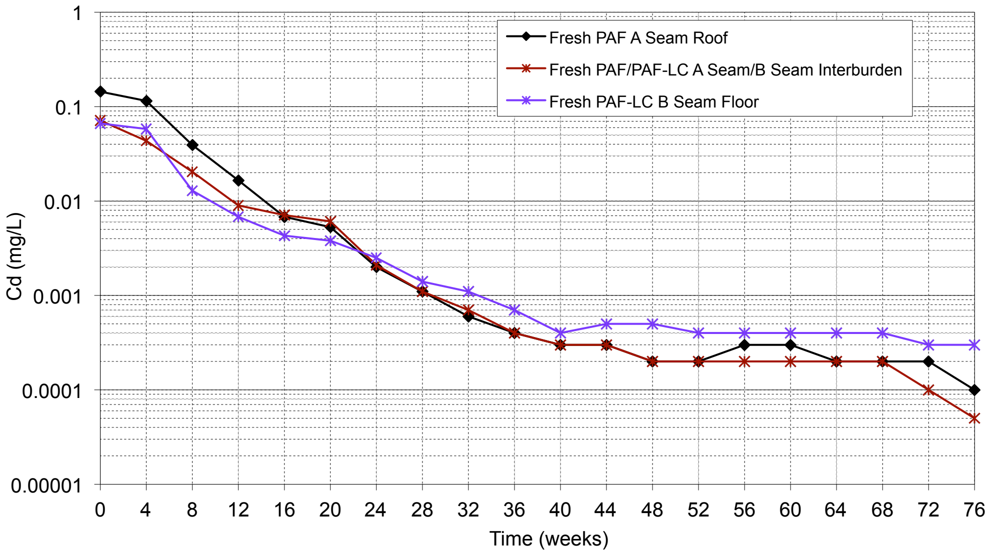

Figure 29: Leachate Cd trends for PAF-LC and PAF samples.

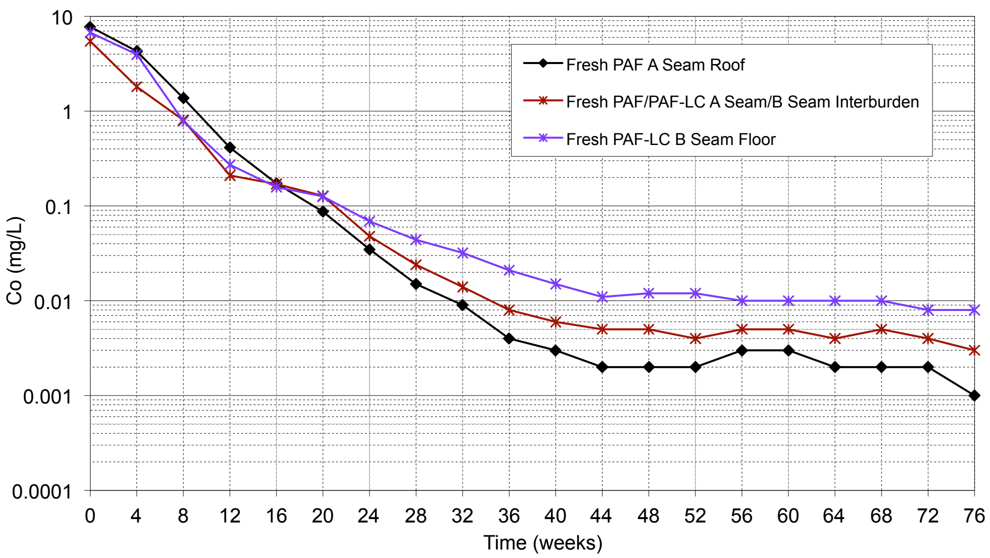

Figure 30: Leachate Co trends for PAF-LC and PAF samples.

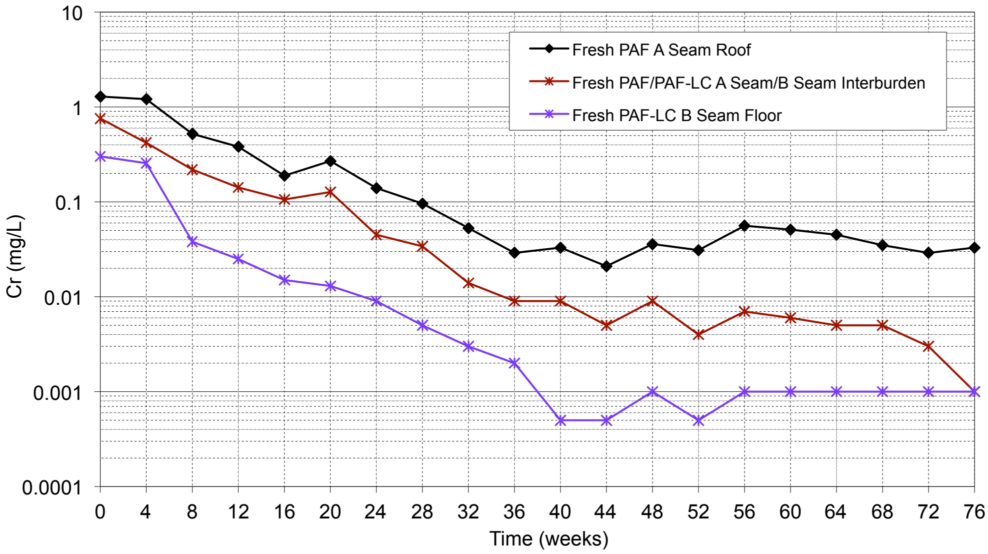

Figure 31: Leachate Cr trends for PAF-LC and PAF samples.

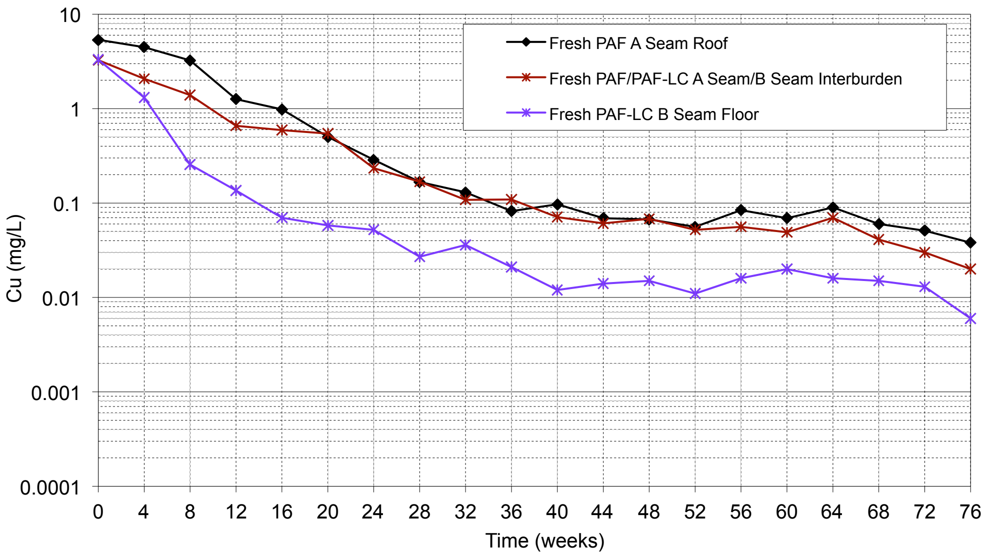

Figure 32: Leachate Cu trends for PAF-LC and PAF samples.

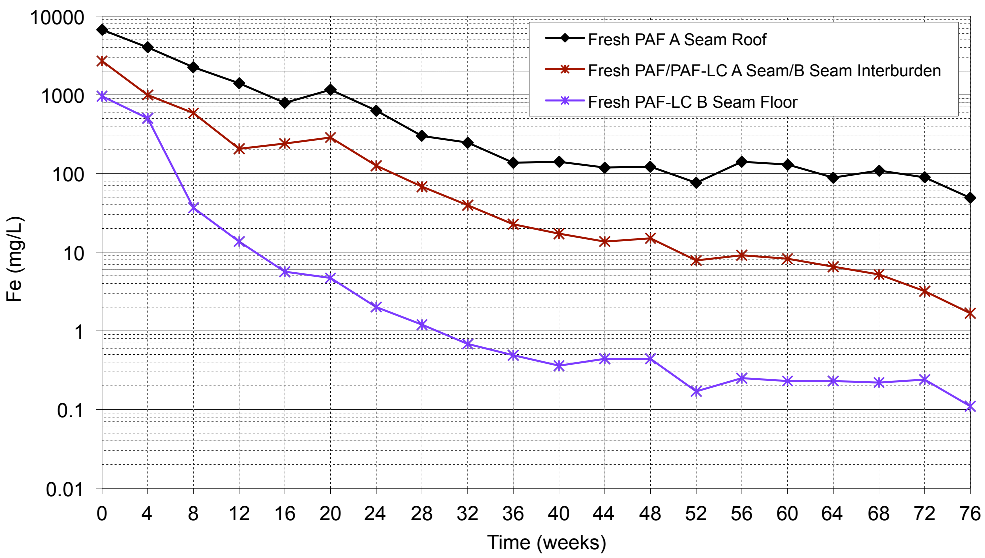

Figure 33: Leachate Fe trends for PAF-LC and PAF samples.

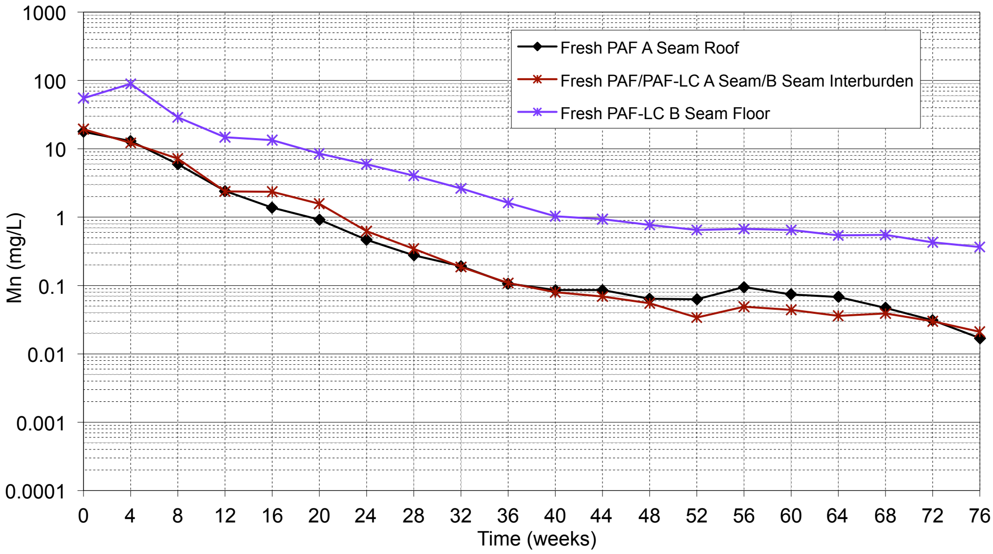

Figure 34: Leachate Mn trends for PAF-LC and PAF samples.

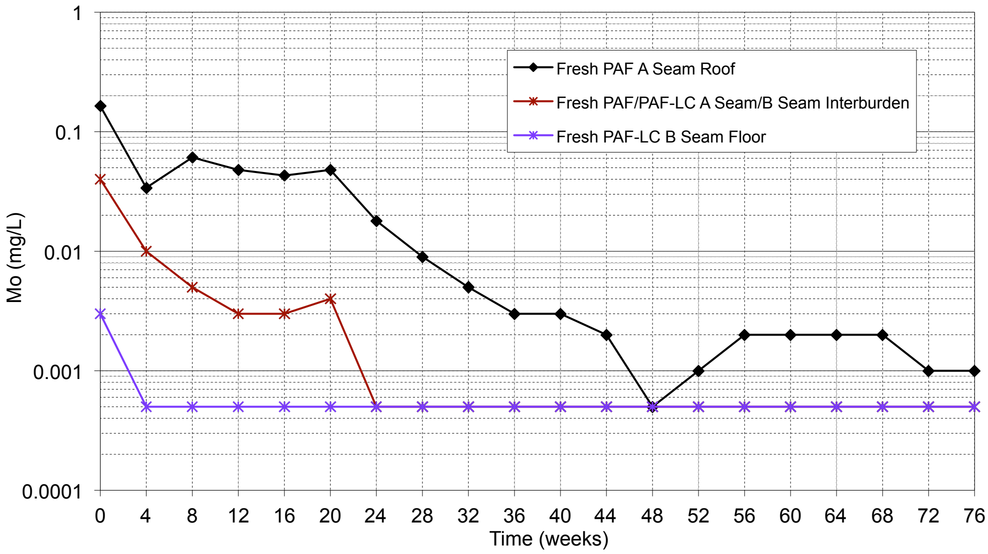

Figure 35: Leachate Mo trends for PAF-LC and PAF samples.

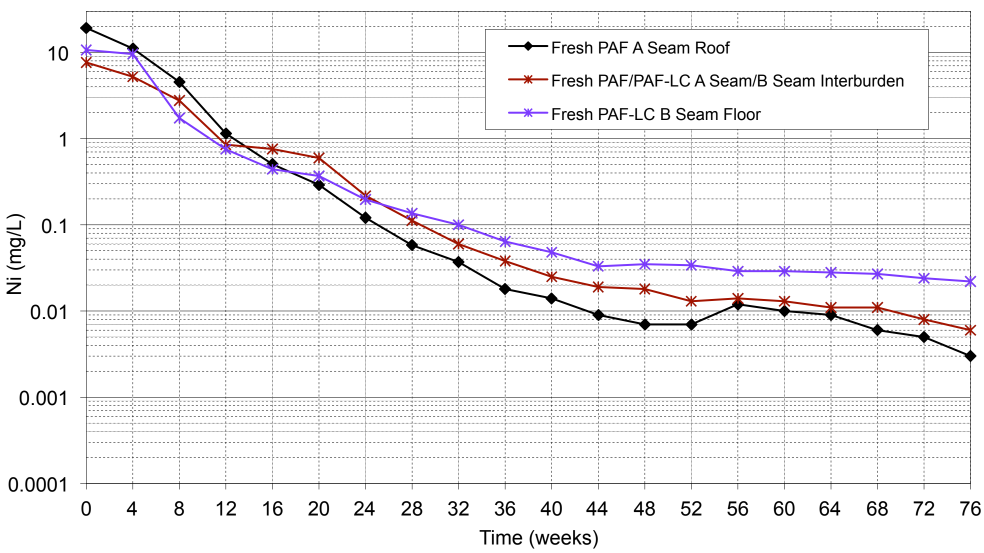

Figure 36: Leachate Ni trends for PAF-LC and PAF samples.

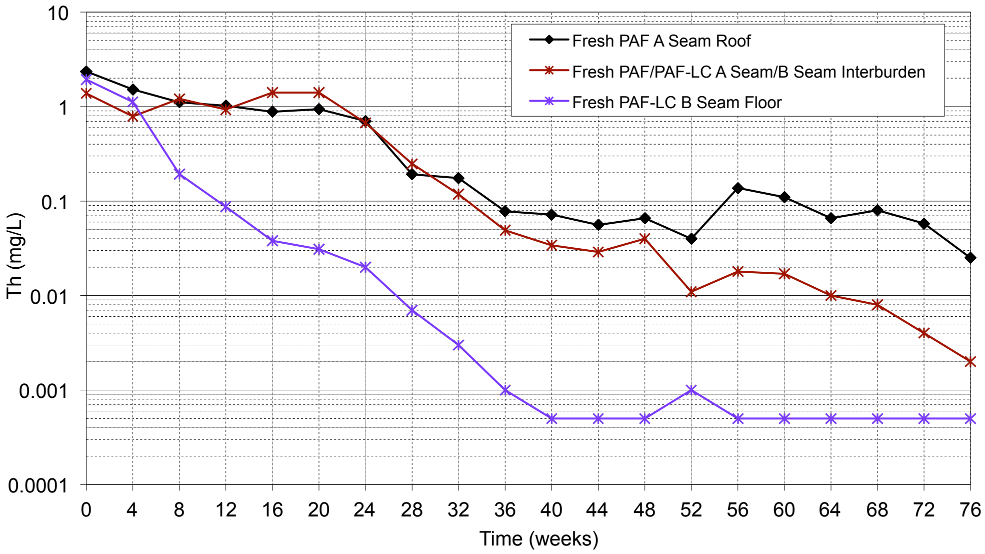

Figure 37: Leachate Th trends for PAF-LC and PAF samples.

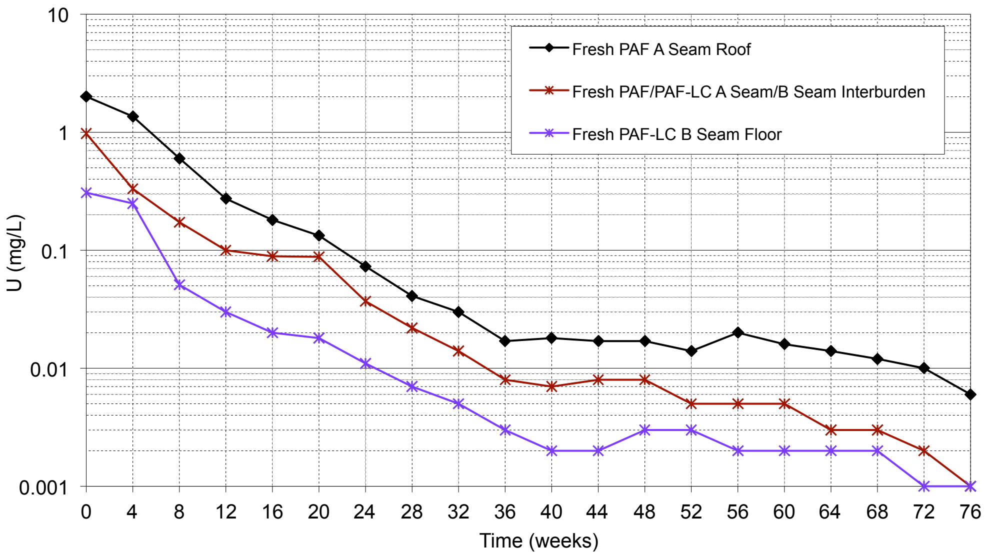

Figure 38: Leachate U trends for PAF-LC and PAF samples.

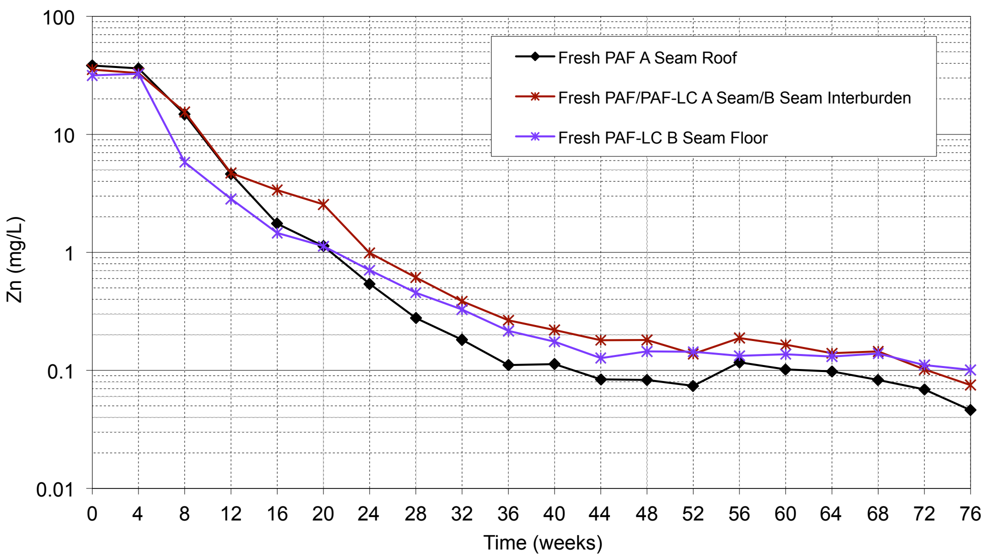

Figure 39: Leachate Zn trends for PAF-LC and PAF samples.

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.

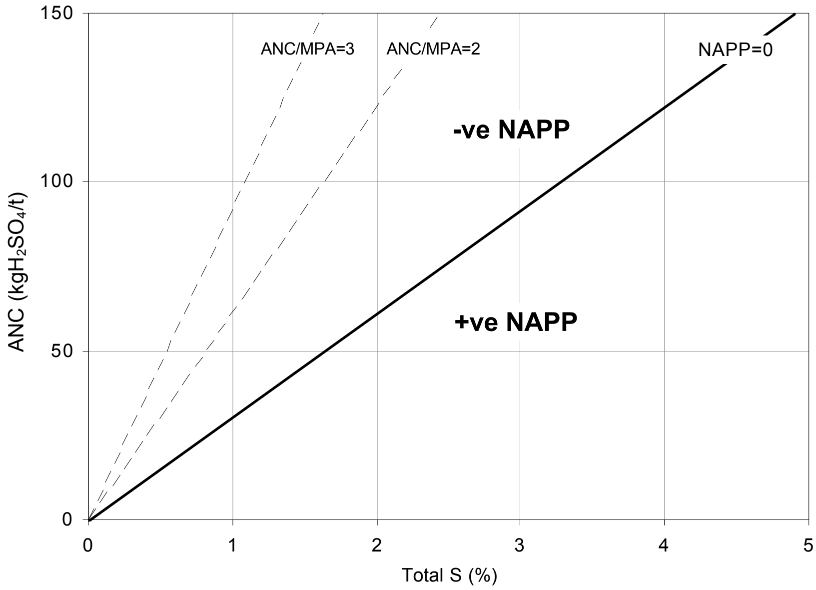

Figure A-1: Acid-base account (ABA) plot

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.

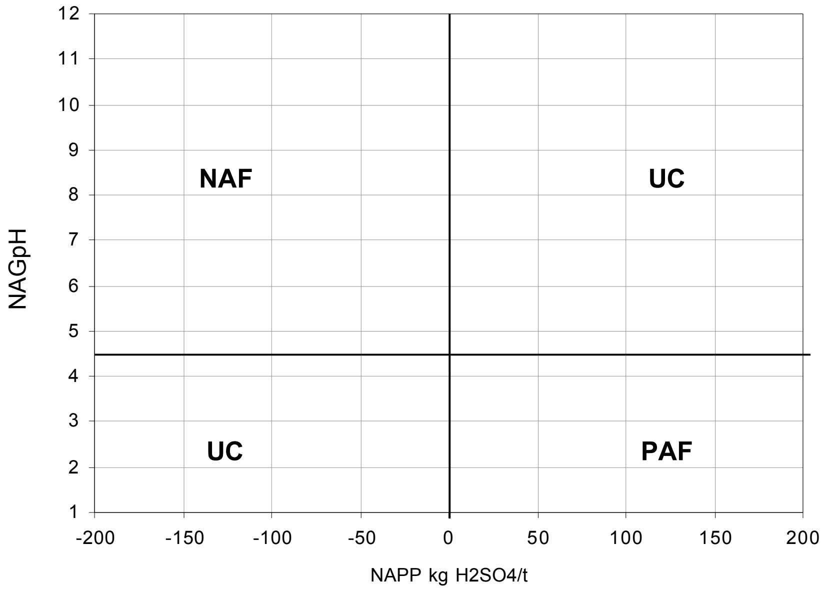

Figure A-2 ARD classification plot

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.