

DIGBY WELLS
ENVIRONMENTAL

**Your Preferred Environmental
and Social Solutions Provider**

Providing innovative and sustainable
solutions throughout the resources sector

Xivono Weltevreden Coal Mining Project near Belfast, Mpumalanga

Geochemistry Assessment and Waste Classification Report

Prepared for:

Xivono Mining (Pty) Ltd

Project Number:




MBU5710

October 2019



This document has been prepared by Digby Wells Environmental.

Report Type:	Geochemistry Assessment and Waste Classification Report
Project Name:	Xivono Weltevreden Coal Mining Project near Belfast, Mpumalanga
Project Code:	MBU5710

Name	Responsibility	Signature	Date
Kgaugelo Thobejane	Reporting		16 October 2019
André van Coller	Review		29 October 2019
Xanthe Taylor	Project Manager		07 November 2019

This report is provided solely for the purposes set out in it and may not, in whole or in part, be used for any other purpose without Digby Wells Environmental prior written consent.



DECLARATION OF INDEPENDENCE

Digby Wells and Associates (South Africa) (Pty) Ltd

Contact Person: Jennifer Grant

Digby Wells House	Tel:	011 789 9495
48 Grosvenor Road	Fax:	011 789 9498
Turnberry Office Park, Bryanston	E-mail:	Jennifer.grant@digbywells.com
2191		

I, Kgaugelo Thobejane , as duly authorised representative of Digby Wells and Associates (South Africa) (Pty) Ltd., hereby confirm my independence (as well as that of Digby Wells and Associates (South Africa) (Pty) Ltd.) and declare that neither I nor Digby Wells and Associates (South Africa) (Pty) Ltd. have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of Xinovo (Pty) Ltd other than fair remuneration for work performed, specifically in connection with the Social Impact Assessment for the Weltevreden Coal Mining Project.

Full Name:	Kgaugelo Thobejane
Title/ Position:	Assistant Geochemist
Qualification(s):	BSc Honours (Mining and Geology)
Experience (Years):	<1
Registration(s):	SACNASP 120881



EXECUTIVE SUMMARY

Digby Wells Environmental (hereafter Digby Wells) was appointed by Xivono Mining (Pty) Ltd (hereafter Xivono) to conduct a geochemical assessment and waste classification to evaluate the acid generation potential of coal and waste material that will be generated as a result of mining.

The waste classification conducted on the coal and waste material is a geochemical classification done in accordance with the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEM: WA) and no physical material or engineering characterisation was undertaken.

A total of four coal samples and two waste rock (discard) from exploration boreholes were available for testing with each sample weighing approximately 1 kg. For acid generating potential and waste classification purposes the provided samples were submitted for the following laboratory test work:

- X-ray Diffraction (XRD) and X-Ray Fluorescence (XRF);
- Acid Base Accounting (ABA), Net Acid Generation (NAG) and sulphur speciation tests;
- Aqua regia digestion to determine total concentrations; and
- Distilled (reagent) water leachate tests to determine the leachable concentrations.

The predominant rocks are the sedimentary rocks of the Eccra Group (Karoo Basin), with the Project Area situated in the Vryheid Formation and consists of deltaic mudstones and sandstones, shale and coal (Wilson & Anhaeusser, 1998). The shale is dark-grey in colour due high carbon content and the presence of coal beds (Lavin, 2013). The Witbank coalfield has up to five coal seams contained in the middle Eccra group sediments. The targeted coal seams, as part of the Vryheid Formation, are the 2, 3, 4S and 4L seams with the 2-seam identified at the south-western part of the site and the 2, 3, 4S and 4L seams identified at the north-western part of the site. The mineralogy of the samples collected indicated there were coal materials demonstrated by amorphous minerals, and there was also presence of sedimentary rocks indicated by clay minerals with sample BT1 HW consisting of ~10% of amorphous mineral. There are acid generating minerals in samples BT1 HW and BT1-BT4.

The Acid Potential (AP) and Neutralising Potential (NP) of a sample is linked to the mineralogy and the reactions formed under aerobic conditions. When these parameters are used to calculate the Net Neutralising Potential ($NNP = NP - AP$) and Neutralising Potential Ratio ($NPR = NP/AP$) an indication of the acid mine drainage potential can be reached. Based on the above-mentioned approach, all waste rock material and coal samples are classified as potentially acid generating and poses a risk for AMD.

The coal and waste materials situated in the boreholes are classified as a Type 3 waste and needs to be disposed at a Class C landfill site or a facility with a similarly performing liner system. The Type 3 waste classification is due to the leachate concentration results being above the LCT0 guideline values. According to the test methodologies followed and the results of the leachable concentrations the risk of elements leaching into the receiving environment from the waste facility is low.

The following mitigation options were proposed to counter metal leach and Acid Mine Drainage (AMD) formation from stockpiles and waste facilities:

- Storm water management and diversion trough trenches and sedimentation dams allowing the capture of dirty water and contaminants to be diverted and pumped to water treatment facilities or pollution control dams;
- The diversion and capturing of dirty water in pollution control dams where water can be treated before being discharged into the environment or allowed to evaporate in evaporation ponds;
- Lining of stockpile areas to minimise potential pollution seepage from coal stockpiles;
- Partial backfilling of the pit with neutralising material and flooding post closure to stop any oxidation processes that will develop AMD;
- If high volumes of AMD water are produced and captured in pollution control dams the water can be treated through lime dosage to buffer the pH and allowing SO₄ and metals to precipitate and settle out before the water is discharged; and
- Monitoring boreholes can help as early warning systems, as well as seepage capturing abstraction holes should groundwater quality decrease.

Based on the geochemical test work findings the following recommendations are made

- Drilling of monitoring boreholes upstream and downstream of hards stockpiles to be incorporated into the groundwater and surface water monitoring program;
- Long term kinetic test work to be done on waste rock samples and coal material to determine the potential of pollution and AMD development over a longer period; and
- Geochemical modelling to allow transient evaluation of the environmental geochemical processes that will be associated with the pit development and pollution sources during the mining processes, as well as the simulation of any chemical mitigation options like lime dosage.

Based on the LCT and TCT results the following recommendations are made for the waste classification:

- The waste and coal materials are classified as a Type 3 waste and disposal of the material should be done to a Class C landfill facility or a facility with a similar performing liner system; and



- The leachate factor of 1:20 used for waste classification is conservative and diluted approach. The leachate results of these tests can lead to a diluted result not always presenting the true concentrations to be expected on site once mining has started. For this reason, the expected sulphate concentration in the seepage water will be more than what has been observed in the results and a conservative approach of SO_4 of more than 1200 mg/L should be used for the contaminant transport modelling in the groundwater assessment.



TABLE OF CONTENTS

1	Introduction	1
1.1	Scope of Work and Methodology.....	1
1.1.1	<i>Site visit and Sampling</i>	1
1.1.2	<i>Laboratory Tests</i>	1
1.2	Deliverables	1
1.3	Study Limitations and Assumptions	1
2	Geology.....	2
3	Sample Description	2
4	Mineralogy and AMD.....	4
4.1	Geochemistry Assessment.....	4
4.1.1	<i>Waste Rock</i>	4
4.1.2	<i>Coal Material</i>	4
4.2	Acid-Base Accounting Results.....	5
4.2.1	<i>Waste Rock Material</i>	6
4.2.2	<i>Coal Material</i>	6
4.3	Conclusion	7
5	Waste Classification.....	9
5.1	Legislative Guidelines	9
5.2	Waste Classification Methodology.....	10
5.3	Results and Classification	11
5.4	Conclusion	11
6	Mitigation Options	16
7	Recommendations	16
8	References.....	17

LIST OF FIGURES



Figure 1-1: Site Layout Showing the Proposed Areas and Surface Infrastructure.	1
Figure 3-1: Regional geology of the project area.....	3
Figure 4-1: Waste rock and coal material AMD – NPR vs Sulphide Sulphur	8
Figure 5-1: Class C Containment Barrier Requirements.....	12

LIST OF TABLES

Table 3-1: Sample descriptions and borehole ID.....	2
Table 4-1: XRD Results for Waste Rock Material.....	4
Table 4-2: XRD Results for Coal Material.....	5
Table 4-3: ABA and SS% Results	6
Table 5-1: Waste Classification Criteria	11
Table 5-2: LCT Classification (mg/L) Results	13
Table 5-3: TCT Classification (mg/kg) Results	14

LIST OF APPENDICES

Appendix A: Laboratory Certificates	
-------------------------------------	--

1 Introduction

Digby Wells Environmental (hereafter Digby Wells) was appointed by Xivono Mining (Pty) Ltd (hereafter Xivono) to conduct a geochemical assessment and waste classification to evaluate the coal and waste rock materials that will be generated as a result of mining. The aim is to determine if the materials have acid producing potential and to classify the waste materials in terms of the National Environmental: Waste Management Act, 2008 (Act No. 59 of 2008), as amended (hereafter NEM: WA). The following terms of reference were provided:

- Assess the acid generating potential of the coal material that will remain in the opencast pits;
- Assess the leachate potential of the hards stockpile materials as well as the release of heavy metals from the remaining (rehabilitated) opencast pits; and
- Advise on the required liner to be installed for the hards stockpiles.

Refer to Figure 1-1 for the proposed site layout. The methodology applied to the study is in line with the Department of Water Affairs' Best Practice Guideline for Impact Prediction (hereafter BPG: G4) and proposed procedures. With the above in mind, Xivono appointed Digby Wells to conduct X-Ray Fluorescence (XRF), X-Ray Diffraction (XRD), Sulphur Speciation (SS%), Acid Base Accounting (ABA), Net Acid Generation (NAG) and NAG pH, Net Neutralising Potential (NNP) and geochemical leachate tests on the material and advise on its chemical characterisation and potential for Acid Mine Drainage (AMD).

1.1 Scope of Work and Methodology

1.1.1 Site visit and Sampling

Fresh ore and waste samples were collected by a Digby Wells consultant, subsequently the consultant submitted the samples to an accredited laboratory for analysis. Approximately 1 kg per sample of coal and waste rock materials were collected from exploration boreholes. The sampling process is explained in further detail in the sections below.

1.1.2 Laboratory Tests

The following sample preparation and tests were done on the samples submitted as discussed in below:

Coal and Discard Material

Four coal samples and two waste rock (hanging wall and footwall) samples were taken for laboratory analyses. The samples were submitted for the following test work:

- XRD and XRF to determine the mineralogy of each sample;
- ABA, NAG and SS% to determine the acid generating and/or acid neutralising potential of each sample. This allows an evaluation of the potential for AMD;

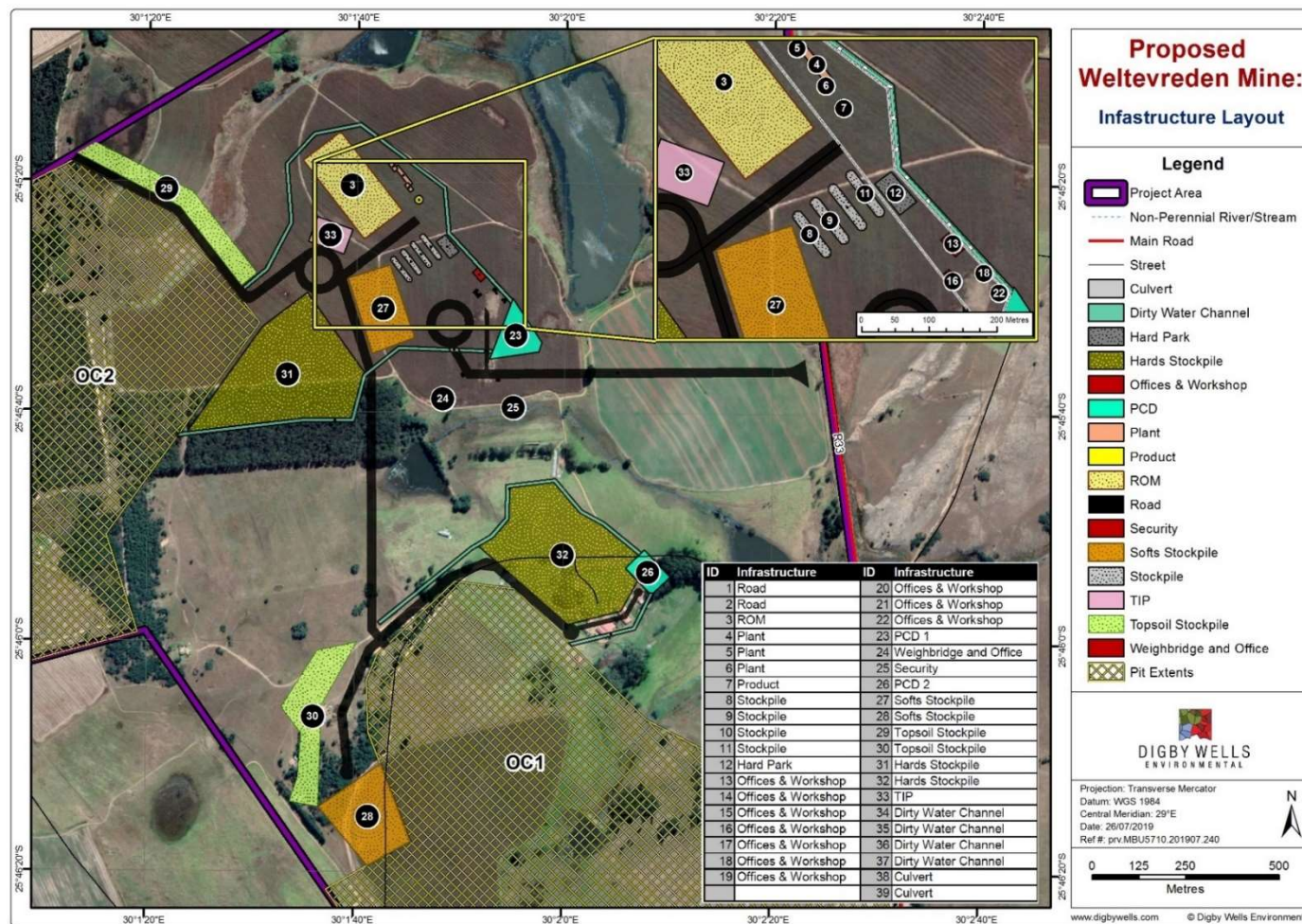


Figure 1-1: Site Layout Showing the Proposed Areas and Surface Infrastructure.

- *Aqua Regia* Digestion with full Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) Quant to evaluate the total chemical makeup of the material and to determine the Total Concentrations (TC) for evaluation against the waste classification Total Concentration Threshold (TCT) guideline values; and
- Distilled water leachate tests at a ratio of 1:20 (solid: liquid) with pH, Electrical Conductivity (EC), Alkalinity, P-Alkalinity (for carbonate and bicarbonate calculations), Total Dissolved Solids (TDS), Fluorine (F), Chlorine (Cl), Nitrate (NO₃), Cyanide (CN), Sulphate (SO₄), Nickel (Ni), Arsenic (As) and Manganese (Mn) to determine the leachable concentrations of the material to compare it to the waste classification Leachable Concentration Threshold (LCT) National Environmental Management: Waste Amendment Act, 2014 (Act No. 26 of 2014) guideline values.

A detailed breakdown of the various test methodologies is provided in Appendix A.

1.2 Deliverables

The following deliverables are provided in this report:

- Laboratory results and interpretations; and
- Conclusions and recommendations on the geochemical characteristics of the material and the handling thereof during operation and backfilling.

1.3 Study Limitations and Assumptions

The following limitations and assumptions apply:

- General Limitation
 - Due to the two waste rock samples sent for analyses, these do not represent the full extent of waste rock materials that will be generated throughout the mining process.
- XRD Results:
 - Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group;
 - Due to preferred orientation and crystallite size effects, a small percentage error may occur in the mineral distribution, but the general proportion of minerals and their presence is accurate; and
 - Samples contained organic carbon and the results presented were checked by the lab against the amount of material losses on ignition during other static tests.
- Sulphur Speciation:
 - Samples were analysed with Pyrolysis at 550°C, as per the Prediction Manual for Drainage Chemistry from Sulphidic Geological Materials MEND Report 1.20.1; and

- Organic Sulphur is not considered and may be included in the results.
- Leachate Tests and Characterisation
 - The distilled water leachate tests are a static method applied to identify potential elements of concern;
 - Distilled water tests were done at a neutral pH (7) at a solid:liquid ratio of 1:20; and
 - NEM: WA classification thresholds were used as a reference point in characterising the leachate quality. This report is intended to serve as a waste classification and guideline on liner requirements

2 Geology

The project area is located approximately 8km south-west of the town Belfast in Mpumalanga, South Africa, on the far eastern edge of the Witbank coalfield. The coalfield extends about 190km east-west between the towns of Springs and Belfast, and about 60km in a north-south direction between the towns of Middelburg and Ermelo. The Witbank coalfield has up to five coal seams contained in the middle Ecca group sediments of the Karoo Supergroup. The targeted coal seams, as part of the Vryheid Formation are the 2, 3, 4S and 4L seams with the 2-seam identified at the south-western part of the site and the 2, 3, 4S and 4L seams identified at the north-western part of the site

The predominant rocks are the sedimentary rocks of the Ecca Group (Karoo Basin), which is subdivided into several formation units based on the cyclic nature of the sedimentary fills. The Project Area is situated in the Vryheid Formation and consists of deltaic mudstones and sandstones, shale and coal (Wilson & Anhaeusser, 1998). The shale is dark-grey in colour due to high carbon content and the presence of coal beds (Lavin, 2013).

3 Sample Description

The waste rock and coal samples are provided in Table 3-1.

Table 3-1: Sample descriptions and borehole ID

No.	Laboratory ID	Origin/Description	Exploration Boreholes
1	BT1	Coal Sample	WTVBH1
2	BT2	Coal Sample	WTVBH2
3	BT3	Coal Sample	WTVBH3
4	BT4	Coal Sample	WTVBH4
5	BT1 HW (Hanging wall)	Roof Sample of TW006	WTVBH1
6	BT1 FW (Footwall)	Floor sample of TW006	WTVBH1

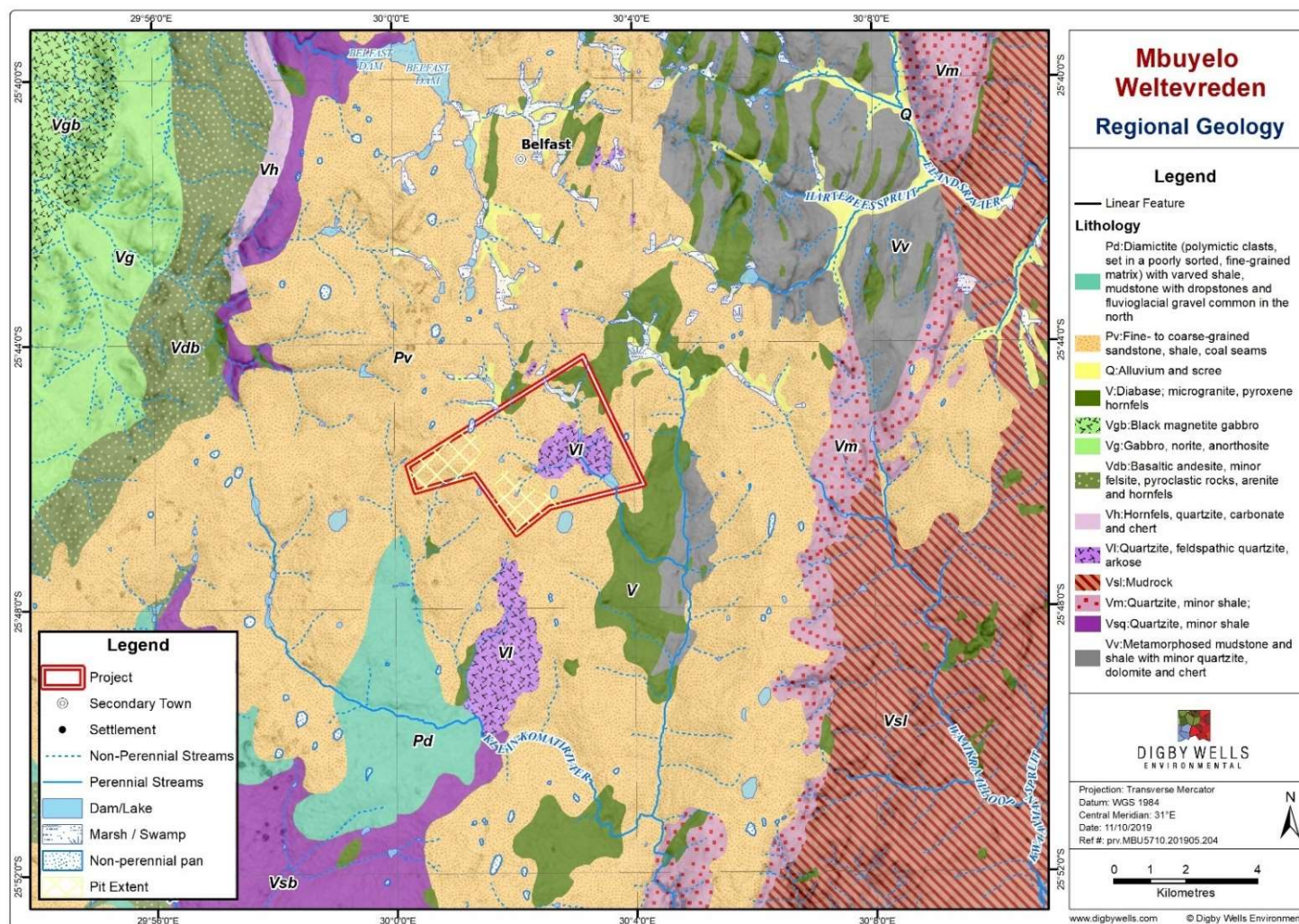


Figure 3-1: Regional geology of the project area

4 Mineralogy and AMD

All laboratory certificates are provided in Appendix A.

4.1 Geochemistry Assessment

4.1.1 Waste Rock

Two samples were taken as representative of the waste rock, one floor and one roof lithologies from exploration borehole WTVBH1. The results are summarised in Table 4-1.

The XRD results indicate that the dominant minerals in both samples BT1 HW and BT1 FW are kaolinite (38.79% and 35.11% respectively) and quartz (27.35% and 42.91% respectively). Both samples are sedimentary rocks with sample BTW1 HW comprising of amorphous material which is either coal or carbon material that was lost on ignition during test work. Pyrite is only detected in the hanging wall (BT1 HW) at concentration of 1.44 % which is above the 0.3 % for acid mine drainage generation. However, there is a presence of an iron rich carbonate mineral siderite (8.44 wt.%) which comprises of neutralising potential. Sample BT1 HW is a carbonaceous shale while BT1 FW is a mudstone.

The XRF results correlates with the XRD, such as high aluminium oxide (Al_2O_3) content which relates with kaolinite and the aluminium in muscovite. High silicon dioxide (SiO_2) which is found in kaolinite, microcline, muscovite and quartz. The iron (III) oxide (Fe_2O_3) also have medium concentration particularly in BT1 HW because of the presence of pyrite and siderite.

Table 4-1: XRD Results for Waste Rock Material

Mineral composition per waste rock sample (%)		
Mineral	BT1 HW	BT1 FW
Amorphous	10.51	
Kaolinite	38.79	35.11
Microcline	6.51	14.87
Muscovite	7.01	7.11
Quartz	27.3	42.91
Pyrite	1.44	
Siderite	8.44	

4.1.2 Coal Material

Four samples were taken as representative of the coal. The results are summarised in Table 4-2.

The XRD results for the four coal samples indicates that these samples consist predominantly of amorphous material which is either coal or carbon material. The second most dominant mineral is kaolinite for all samples with an exception of BT3 where quartz is found. Pyrite is

included in all samples, with an exception of BT4, and it is above 0.3%. BT1 is the only sample encompassing two neutralising potential minerals ankerite (4.45%) and calcite at (1.46 %) while BT4 comprising only the latter at 0.16%.

The XRF results correlate with the XRD results, such as a high SiO₂ content particularly for BT3 due to the highest quartz concentration. The Al₂O₃ concentration is the second highest concentration and it is responsible largely for the formation of kaolinite in these samples with minor minerals such as microcline and muscovite requiring some aluminium especially in sample BT4. The Fe₂O₃ concentration for BT1 is relatively high due to the presence of high pyrite and ankerite concentration.

Table 4-2: XRD Results for Coal Material

Mineral composition per coal sample (%)				
Mineral	BT1	BT2	BT3	BT4
Amorphous	66.21	66.47	59.3	68.16
Ankerite	4.45			
Calcite	1.46			0.16
Kaolinite	14.17	20.84	17.73	15.41
Microcline				2.92
Muscovite				2.45
Pyrite	3.38	0.93	0.39	
Quartz	10.33	11.76	22.58	10.9

4.2 Acid-Base Accounting Results

The AMD potential of materials is determined by assessing the Acid Potential (AP), Neutralising Potential (NP) and the relationship between these two reactions by calculating the Net Neutralising Potential (NNP = NP - AP) and Neutralising Potential Ratio (NPR = NP/AP). The above reactions and potentials are driven by the mineralogy of the materials. Certain minerals are acid buffering/neutralising and others like pyrite are acid producing. Sulphide content is the main driver of acid production and AMD under aerobic conditions and that is why the sulphide sulphur content of the material is also assessed.

The main values used to classify materials as Non-Acid Forming (NAF), Potentially Acid Generating (PAG) are the NPR and sulphide sulphur content. If the NPR is below 1 there is a PAG (red cells), if the NPR is above 3 the sample is NAF (green cells). When the NPR is between 1 and 2, a balance exists between the buffering and acid producing reactions and a clear conclusion cannot be based on the NPR only. When focussing on the Sulphide Sulphur (SS) %, if the SS% is above 0.3 (red cells) it is generally accepted that this material will be PAG. For NAG pH, if pH is less than 3.5 there will be PAG (red cells). The following conclusions were reached from the AMD test work with the main parameters and results shown in Table 4-3 and Figure 4-1

4.2.1 Waste Rock Material

The XRD and XRF results indicate the presence of pyrite in BT1 HW while BT1 FW demonstrates neutral mineralogy. The ABA, NAG and SS% results indicating that both samples are PAG with the following conclusions:

- If NAG pH is greater than or equals to 5.5 it indicates no acid generation potential; however, between 5.5 and 3.5 a low risk acid generation potential is expected. Acid generating potential is expected for NAG pH lower than 3.5. Based on the NAG pH of the samples, BT1 HW NAG pH is at 4.3 which indicates low risk of acid generation and BT1 FW have are PAG with a NAG pH of 2.9;
- A negative NNP indicates an acid generating potential. Based on this, all samples are PAG;
- The NPR is less than 1 for all samples and this means that the samples are PAG, unless sulphide minerals are non-reactive;
- The SS% is above 0.3% and this also confirms they are PAG for all samples; and
- On average all samples can be classified as PAG and therefore have the potential to form AMD.

4.2.2 Coal Material

The XRD and XRF results indicate the presence of pyrite in all samples with an exception of BT4. The following conclusions were reached from the AMD test work:

- NAG pH for BT1-BT3 are below 3.5, indicating a high acid generating potential, while BT4 having a NAG pH of 3.9 which indicates this sample has a low risk of acid generation;
- A negative NNP was indicated for all samples;
- The SS% contents for all samples were above 0.3% with BT1 having the highest concentration of 3.08%; and
- All samples are classified as PAG with a risk of AMD formation.

Table 4-3: ABA and SS% Results

Sample ID	NAG pH	Net Neutralization Potential (NNP) = NP – AP (kg CaCO ₃ /t)	Neutralising Potential Ratio (NPR) (NP: AP)	Total Sulphur (%)	Sulphate (SO ₄ ²⁻) Sulphur (%)	Sulphide (S ²⁻) Sulphur (%)	Acid Generating Potential
BT1	1.9	-34.00	0.65	3.14	0.06	3.08	PAG
BT2	2.2	-35.30	0.18	1.39	0.06	1.33	PAG
BT3	2.3	-25.50	0.01	1.13	0.03	1.1	PAG

Sample ID	NAG pH	Net Neutralization Potential (NNP) = NP – AP (kg CaCO ₃ /t)	Neutralising Potential Ratio (NPR) (NP: AP)	Total Sulphur (%)	Sulphate (SO ₄ ²⁻) Sulphur (%)	Sulphide (S ²⁻) Sulphur (%)	Acid Generating Potential
BT4	3.9	-21.00	0.54	1.47	0.03	1.44	PAG
BT1 HW	4.3	-26.30	0.42	1.43	0.05	1.38	PAG
BT1 FW	2.9	-21.50	0.23	0.90	0.01	0.89	PAG

* Red indicates values are in range to potentially generate acid

4.3 Conclusion

Based on the geochemistry and the AMD results, the following was concluded associated with the potential sources of pollution or AMD on site:

- The coal materials are classed as PAG, with the waste rock material potentially leading to AMD development and pollution of groundwater and surface water resources if not mitigated and managed; and
- Coal material will be stockpiled for short periods on site before being transported or processed. The potential for pollution development and AMD formation is thus low and can be mitigated to reduce the contamination impact.

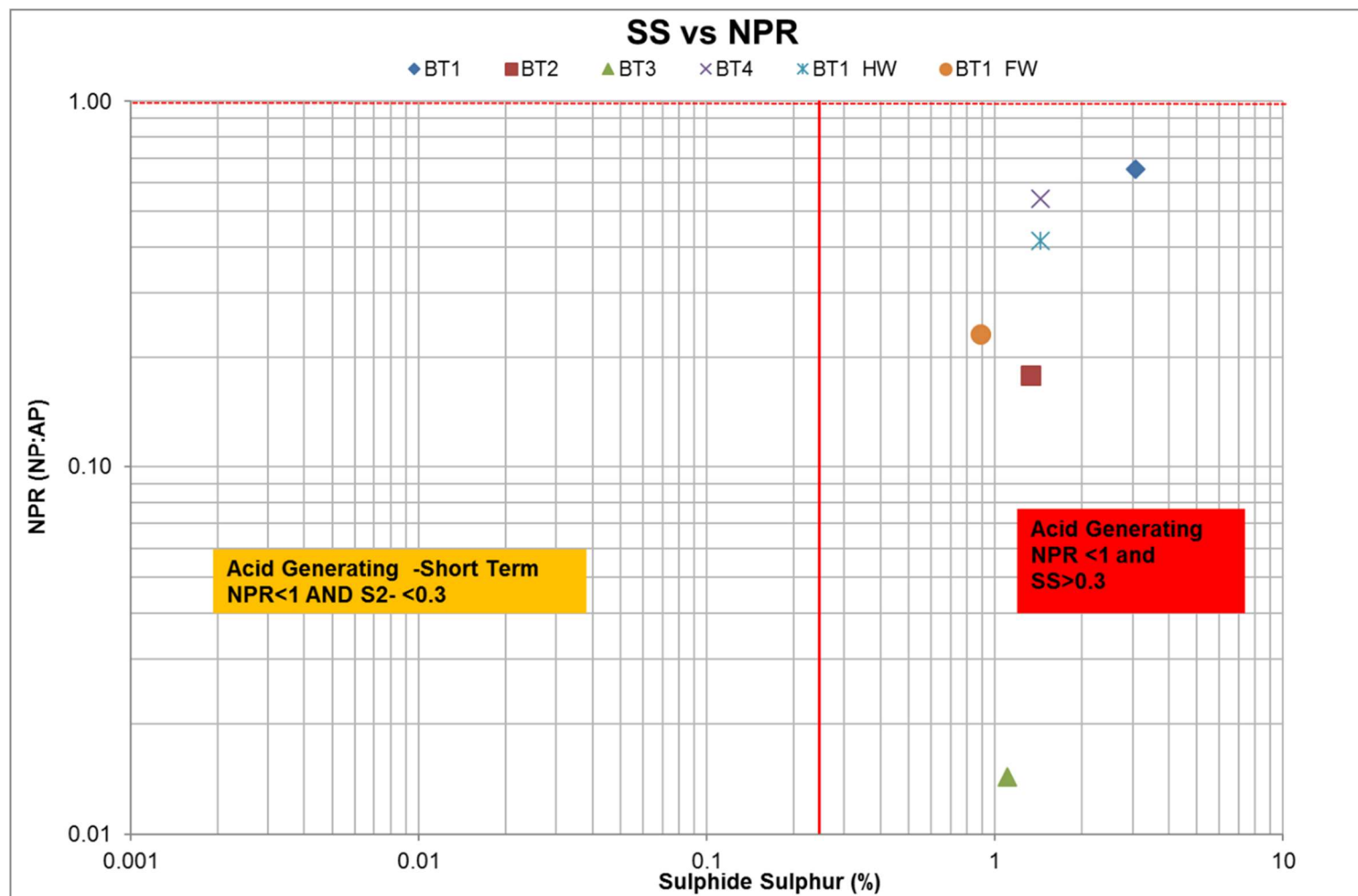


Figure 4-1: Waste rock and coal material AMD – NPR vs Sulphide Sulphur

5 Waste Classification

5.1 Legislative Guidelines

On 2 June 2014, the National Environmental Management: Waste Amendment Act, 2014 (Act No. 26 of 2014) was published, which for the first time included “residue deposits” and “residue stockpiles” under the environmental waste legislation. Previously mining residue was covered under the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA). A new regulation, on the planning and management of residue stockpiles and residue deposits, was included into the NEM: WA in July 2015. The purpose of these regulations is to regulate the planning and the management of residue stockpiles and residue deposits from prospecting, mining, exploration or operation. Residue deposits and residue stockpiles are listed under Schedule 3, under the category “Hazardous Waste”, therefore the understanding is that mine waste is hazardous unless the applicant can prove otherwise.

As residue deposits and residue stockpiles are waste, they are regulated by the following regulations (both promulgated on 23 August 2013):

- GN R 635 – National Norms and Standards for Assessment of Waste for Landfill Disposal; and
- GN R 636 – National Norms and Standards for Disposal of Waste to Landfill.

According to these regulations, waste that is generated must be classified in accordance with South African National Standards (SANS) 10234 within 180 days of generation. SANS 10234 is based on the Globally Harmonised System (GHS). It illustrates a comprehensive classification that is used to determine whether a waste is hazardous based on its physical, health and environmental properties. Classification in terms of SANS 10234 means establishing whether the waste is hazardous based on its properties. The norms and standards specify the waste classification methodologies for determining the waste category, and the specifications for pollution control barrier systems (liners) for each of the waste categories.

The Department of Environmental Affairs (DEA) has published Notice 1005 of 2014 (14 November 2014), Proposed Regulations Regarding the Planning and Management of Residue Stockpiles and Residue Deposits from a Prospecting, Mining, Exploration or Production Operation.

In terms of a waste disposal assessment, these Regulations state that residue stockpiles and residue deposits must be characterised to identify any potential risk to health or safety and environmental impact in terms of physical characteristics, chemical characteristics (toxicity, propensity to oxidise and decompose, propensity to undergo spontaneous combustion, pH and chemical composition of the water separated from the solids, stability and reactivity and the rate thereof, neutralising potential and concentration of volatile organic compounds), and mineral content.

In addition, the quality of seepage from residue facilities needs to be predicted, as contained in Notice 1006 of 2014 (14 November 2014): Proposed Regulations to Exclude a Waste Stream or a Portion of a Waste Stream from the Definition of Waste.

These Regulations state that waste generated from a source listed in Category A of Schedule 3 of NEM: WA may be excluded from being defined as hazardous on demonstration that the waste is non-hazardous in accordance with the Waste Management and Classification regulations. Exclusion of a waste stream from the definition of waste may be considered if it can be demonstrated that any contaminant of concern originating from the waste reaching the receptor will not exceed the acceptable environmental limits for any contaminant of concern for such a receptor. The acceptable environmental limits have not been defined.

5.2 Waste Classification Methodology

In the Regulations, the terms "Total Concentration Threshold" and the abbreviation "TCT" mean the total concentration threshold limit for certain elements or chemical substances in a waste, expressed as mg/kg, prescribed in Section 6 of the Norms and Standards. The terms "Leachable Concentration Threshold" and abbreviation "LCT" mean the leachable concentration threshold limit for certain elements and chemical substances in a waste, expressed as milligrams per litre (mg/L), prescribed in Section 6 of these Norms and Standards.

TCT limits are subdivided into three categories:

- TCT0 limits based on screening values for the protection of water resources, as contained in the Framework for the Management of Contaminated Land (DEA, March 2010);
- TCT1 limits derived from land remediation values for commercial/industrial land (DEA, March 2010); and
- TCT2 limits derived by multiplying the TCT1 values by a factor of 4, as used by the Environmental Protection Agency, Australian State of Victoria.

LCT limits are subdivided into four categories:

- LCT0 limits derived from human health effect values for drinking water, as published by the DWS, SANS, World Health Organization (WHO) or the United States Environmental Protection Agency (USEPA);
- LCT1 limits derived by multiplying LCT0 values by a Dilution Attenuation Factor (DAF) of 50, as proposed by the Australian State of Victoria;
- LCT2 limits derived by multiplying LCT1 values by a factor of 2; and
- LCT3 limits derived by multiplying the LCT2 values by a factor of 4.

GN R 634 identifies waste classes (Waste Types 0 to 4) ranging from high risk (Type 0) to low risk (Type 4), based on comparison of the TCT and LCT of individual constituents in the waste against the following threshold limits. Waste is assessed by comparison of the total and

leachable concentration of elements and chemical substances in the waste material to TCT and LCT limits as specified in the National Norms and Standards for Waste Classification and the National Norms and Standards for Disposal to Landfill as per Table 5-1.

Table 5-1: Waste Classification Criteria

Waste Type	Element or chemical substance concentration	Disposal
0	LC > LCT3 OR TC > TCT2	Not allowed
1	LCT2 < LC ≤ LCT3 OR TCT1 < TC ≤ TCT2	Class A or Hh:HH landfill
2	LCT1 < LC ≤ LCT2 AND TC ≤ TCT1	Class B or GLB+ landfill
3	LCT0 < LC ≤ LCT1 AND TC ≤ TCT1	Class C or GLB- landfill
4	LC ≤ LCT0 AND TC ≤ TCT0 for metal ions and inorganic anions AND all chemical substances are below the total concentration limits provided for organics and pesticides listed	Class D or GLB- landfill

5.3 Results and Classification

Results of the analysis of LC and TC are shown in Table 5-2 and Table 5-3 respectively and compared to threshold concentrations published in the NEM: WA Waste Classification and Management Regulations.

Waste Rock Samples:

- BT1 HW and BT1 FW
 - LCT0 < Chromium (Cr) < LCT1, and LCT0 < Nickel (Ni) < LCT1 values; and
 - Based on total concentrations, all parameters are below the TCT0 values

Coal Samples:

- All coal samples LCT0 < Chromium (Cr) < LCT1, and LCT0 < Nickel (Ni) < LCT1 values; and
- BT1
 - TCT0 < As < TCT1 while the rest of the samples are below the TCT0

5.4 Conclusion

Based on the outcome of leachate concentrations (Table 5-2) Cr and Ni concentrations failed to be below the LCT0 for all samples, and the As concentration was elevated to above the LCT0 limit for two samples. Based on these results the waste rock as well as the coal material are classified as a Type 3 material. If disposed of at a landfill disposal site or alternative site on surface, the material requires a Class C liner or similar performing system demonstrated in Figure 5-1.

Class C Landfill:

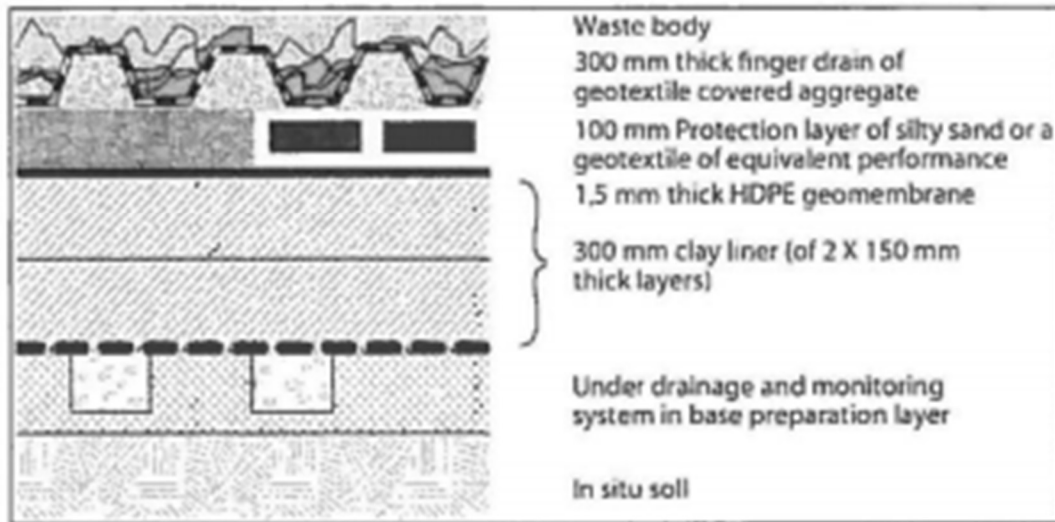


Figure 5-1: Class C Containment Barrier Requirements

Table 5-2: LCT Classification (mg/L) Results

Parameter	Unit	SANS241-2015 Drinking water standards	BT1	BT2	BT3	BT4	BT 1 HW	BT 1 FW	LCT0	LCT1	LCT2	LCT3
As, Arsenic	mg/L	0.01	7.21	2.94	<2.0	<2.0	8.04	<2.0	0,01	0.5	1	4
B, Boron	mg/L	2.4	42	25	23.00	25.00	99	16.14	0,5	25	50	200
Cd, Cadmium	mg/L	0.003	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0,003	0,15	0,3	1,2
Co, Cobalt	mg/L		2.48	1.89	1.98	<0.10	16.82	2.66	0,5	25	50	200
Cr total	mg/L	0.05	0.11	0.11	0.11	0.11	0.11	0.11	0,1	5	10	40
Cu, Copper	mg/L	2	0.12	0.11	0.1	0.11	0.11	0.11	2	100	200	800
Mn, Manganese	mg/L	0.4	0.21	0.27	0.31	0.17	0.18	0.16	0,5	25	50	200
Mo, Molybdenum	mg/L		0.001	<0.001	<0.001	0.01	0.026	0.027	0.07	3.5	7	28
Ni, Nickel	mg/L	0.07	0.11	0.12	0.12	0.11	0.11	0.11	0.07	3.5	7	28
Pb, Lead	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.5	1	4
Chloride as Cl	mg/L	300	28	8.91	1.02	0.58	0.64	0.99	300	15000	30000	120000
Parameter	Unit	SANS241-2015 Drinking water standards	BT1	BT2	BT3	BT4	BT 1 HW	BT 1 FW	LCT0	LCT1	LCT2	LCT3

Parameter	Unit	SANS241-2015 Drinking water standards	BT1	BT2	BT3	BT4	BT 1 HW	BT 1 FW	LCT0	LCT1	LCT2	LCT3
Sulphate as SO ₄	mg/L	500	166.85	63.86	9.54	37.02	52.37	42.13	250	12500	25000	100000
Nitrate as N	mg/L	11	<0.1	<0.1	0.31	<0.1	<0.1	<0.1	11	550	1100	4400
F, Fluoride	mg/L	1.5	0.13	<0.1	0.18	0.14	0.45	0.35	1,5	75	150	600
CN total, Cyanide total	mg/L		0.02	0.054	0	0	0.008	0	0,07	3,5	7	28
pH		5 to 9.7	6.40	7.10	6.40	7.30	7.20	7.00				

* Yellow highlight indicates exceedance of LCT0 limit

Table 5-3: TCT Classification (mg/kg) Results

Parameter	Unit	BT1	BT2	BT3	BT4	BT 1 HW	BT 1 FW	TCT0	TCT1	TCT2
As, Arsenic	mg/kg	7.21	2.94	<2.0	<2.0	8.04	<2.0	5,8	500	2000
B, Boron	mg/kg	42	25	23.00	25.00	99	16.14	150	15000	60000
Cd, Cadmium	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	7,5	260	1040
Co, Cobalt	mg/kg	2.48	1.89	1.98	<0.10	16.82	2.66	50	5000	20000
Cr (IV), Chromium (IV)	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	6,5	500	2000
Hg, Mercury	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0,93	160	640
Mo, Molybdenum	mg/kg	1.34	0.49	1.28	0.72	<0.10	<0.10	40	1000	4000

Parameter	Unit	BT1	BT2	BT3	BT4	BT 1 HW	BT 1 FW	TCT0	TCT1	TCT2
Ni, Nickel	mg/kg	14.01	<0.30	<0.30	<0.30	20	<0.30	91	10600	42400
Sb, Antimony	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	10	75	300
Se, Selenium	mg/kg	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	10	50	200
Chloride as Cl	mg/kg	5	<1	<1	<1	10	<1	n/a	n/a	n/a
Sulphate as SO ₄	mg/kg	0.17	0.19	0.09	0.08	0.15	0.03	n/a	n/a	n/a
Nitrate as N	mg/kg	<0.5	0.28	1.16	2.37	0.72	0.29	n/a	n/a	n/a
F, Fluoride	mg/kg	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	100	10000	40000
CN total, Cyanide total	mg/kg	0.7	1.74	2.78	0.86	0.61	1.52	14	10500	42000
pH		8.3	6.7	7.5	8.7	7.1	9.7			

* Yellow highlight indicates exceedance of LCT0 limit

6 Mitigation Options

The following mitigation options were proposed to counter metal leach and AMD formation from stockpiles and waste facilities:

- Storm water management and diversion through trenches and sedimentation dams allowing the capture of dirty water and contaminants to be diverted and pumped to water treatment facilities or pollution control dams;
- The diversion and capturing of dirty water in pollution control dams where water can be treated before being discharged into the environment or allowed to evaporate in evaporation ponds;
- Lining of stockpile areas to minimise potential pollution seepage from coal stockpiles;
- Partial backfilling of the pit with neutralising material and flooding post closure to stop any oxidation processes that will develop AMD;
- If high volumes of AMD water are produced and captured in pollution control dams the water can be treated through lime dosage to buffer the pH and allowing SO_4 and metals to precipitate and settle out before the water is discharged; and
- Monitoring boreholes, as recommended for this Project, can help as early warning systems, as well as seepage capturing abstraction holes should groundwater quality decrease.

7 Recommendations

Based on the geochemical test work findings the following recommendations are made:

- Drilling of monitoring boreholes upstream and downstream of hard stockpiles to be incorporated into the groundwater and surface water monitoring program;
- Long term kinetic test work to be done on waste rock samples and coal material to determine the potential of pollution and AMD development over a longer period; and
- Geochemical modelling to allow transient evaluation of the environmental geochemical processes that will be associated with the pit development and pollution sources during the mining processes, as well as the simulation of any chemical mitigation options like lime dosage.

Based on the LCT and TCT results the following recommendations are made for the waste classification:

- The waste and coal materials are classified as a Type 3 waste and disposal of the material should be done to a Class C landfill facility or a facility with a similar performing liner system;
- The leachate factor of 1:20 used for waste classification is conservative and diluted approach. The leachate results of these tests can lead to a diluted result not always presenting the true concentrations to be expected on site once mining has started. For

this reason, the expected sulphate concentration in the seepage water will be more than what has been observed in the results and a conservative approach of SO₄ of more than 1200 mg/L should be used for the contaminant transport modelling in the groundwater assessment.

8 References

- National Environmental Management: Waste Amendment Act 2014 (Act No. 26 of 2014).
- Wilson, M.G.C. and Anhaeusser, C.R., 1998. The mineral resources of South Africa (Handbook 16).



Appendix A: Laboratory Certificates

M and L Laboratory Services (Pty) Ltd
P O Box 82124
Southdale, 2135
40 Modulus Road
Ormonde, 2091

+27 11 661 7900
+27 11 496 2238
joanne.barton@za.bureauveritas.com
www.bureauveritas.com



M & L LABS

Ref. No. : ML-2019-17414

Issued at. : Johannesburg

Date : 10/10/2019

Contract No. : 10887541

Page 1 of 11

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

COMPANY NAME : DIGBY WELLS & ASSOCIATES
ADDRESS : PRIVATE BAG X10046 RANDBURG
SUBJECT : ANALYSIS OF 6 SOLID SAMPLES
PROJECT REFERENCE : SOLID SAMPLES 03/09/2019
INSTRUCTED BY : KGAUGELO THOBEJANE
ORDER NUMBER : PN MBU5710
RECEIVED ON : 03/09/2019
ANALYSIS COMPLETED : 10/10/2019
DATE ANALYSED : 03/9/2019 - 26/09/2019

BDL - Below Detection Limit

*** Denotes test method not accredited to ISO 17025**

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.



T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number			E020320	E020321	E020322
Sampled Date					
Sample Marks			BT 1	BT 2	BT 3
Determinand	Method References	Detection Limit	Result	Result	Result
ANALYSIS WERE CARRIED OUT ON 5% AQUEOUS EXTRACTS OF A SAMPLE AS RECEIVED:METALS					
Silver as Ag(mg/l)*	W044-28-O	0.004	<0.004	<0.004	<0.004
Aluminium as Al(mg/l)*	W044-28-O	0.003	0.088	0.078	0.13
Arsenic as As(mg/l)*	W044-28-O	0.002	0.012	0.007	<0.002
Boron as B(mg/l)*	W044-28-O	0.006	0.049	0.016	<0.006
Barium as Ba(mg/l)*	W044-28-O	0.001	0.29	0.27	0.14
Beryllium as Be(mg/l)*	W044-28-O	0.002	<0.002	<0.002	<0.002
Bismuth as Bi(mg/l)*	W044-28-O	0.005	<0.005	<0.005	<0.005
Calcium as Ca(mg/l)*	W044-28-O	0.05	84	32	2.06
Cadmium as Cd(mg/l)*	W044-28-O	0.001	<0.001	<0.001	<0.001
Cobalt as Co(mg/l)*	W044-28-O	0.001	0.093	0.092	0.098
Chromium as Cr(mg/l)*	W044-28-O	0.003	0.11	0.11	0.11
Copper as Cu(mg/l)*	W044-28-O	0.002	0.12	0.11	0.10
Iron as Fe(mg/l)*	W044-28-O	0.001	0.15	0.16	0.17
Mercury as Hg(mg/l)*	W044-30-C	0.001	<0.001	<0.001	<0.001
Potassium as K(mg/l)*	W044-28-O	0.005	3.84	2.18	2.43
Magnesium as Mg(mg/l)*	W044-28-O	0.01	17.21	12.27	1.13
Manganese as Mn(mg/l)*	W044-28-O	0.001	0.21	0.27	0.31
Molybdenum as Mo(mg/l)*	W044-28-O	0.001	0.001	<0.001	<0.001
Sodium as Na(mg/l)*	W044-28-O	0.02	3.71	2.74	2.06
Nickel as Ni(mg/l)*	W044-28-O	0.003	0.11	0.12	0.12
Lead as Pb(mg/l)*	W044-28-O	0.01	<0.01	<0.01	<0.01
Antimony as Sb(mg/l)*	W044-28-O	0.01	<0.01	<0.01	<0.01
Selenium as Se(mg/l)*	W044-28-O	0.003	<0.003	<0.003	<0.003
Silicon as Si(mg/l)*	W044-28-O	0.007	0.88	0.81	3.00
Tin as Sn(mg/l)*	W044-28-O	0.02	<0.02	<0.02	<0.02
Strontium as Sr(mg/l)*	W044-28-O	0.001	0.96	0.24	0.018
Thorium as Th(mg/l)*	W044-28-O	0.002	<0.002	<0.002	<0.002
Titanium as Ti(mg/l)*	W044-28-O	0.001	<0.001	<0.001	0.005
Thallium as Tl(mg/l)*	W044-28-O	0.009	<0.009	<0.009	<0.009
Uranium as U(mg/l)*	W044-28-O	0.004	<0.004	<0.004	<0.004
Vanadium as V(mg/l)*	W044-28-O	0.002	0.14	0.13	0.12

Ndileka Bangani

Mulalo Mhlanga

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.

T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number			E020320	E020321	E020322
Sampled Date					
Sample Marks			BT 1	BT 2	BT 3
Determinand	Method References	Detection Limit	Result	Result	Result
ANALYSIS WERE CARRIED OUT ON 5% AQUEOUS EXTRACTS OF A SAMPLE AS RECEIVED:METALS					
Zinc as Zn(mg/l)*	W044-28-O	0.005	0.094	0.093	0.091
Zirconium as Zr(mg/l)*	W044-28-O	0.001	0.040	0.040	0.040

Ndileka Bangani

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.



T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number			E020323	E020324	E020325
Sampled Date					
Sample Marks			BT 4	BT 1 HW	BT 1 FW
Determinand	Method References	Detection Limit	Result	Result	Result
ANALYSIS WERE CARRIED OUT ON 5% AQUEOUS EXTRACTS OF A SAMPLE AS RECEIVED:METALS					
Silver as Ag(mg/l)*	W044-28-O	0.004	<0.004	<0.004	<0.004
Aluminium as Al(mg/l)*	W044-28-O	0.003	0.10	0.13	0.24
Arsenic as As(mg/l)*	W044-28-O	0.002	0.010	0.003	0.006
Boron as B(mg/l)*	W044-28-O	0.006	<0.006	0.063	0.018
Barium as Ba(mg/l)*	W044-28-O	0.001	0.30	0.34	0.33
Beryllium as Be(mg/l)*	W044-28-O	0.002	<0.002	<0.002	<0.002
Bismuth as Bi(mg/l)*	W044-28-O	0.005	<0.005	<0.005	<0.005
Calcium as Ca(mg/l)*	W044-28-O	0.05	22	19.32	14.10
Cadmium as Cd(mg/l)*	W044-28-O	0.001	<0.001	<0.001	<0.001
Cobalt as Co(mg/l)*	W044-28-O	0.001	0.092	0.093	0.092
Chromium as Cr(mg/l)*	W044-28-O	0.003	0.11	0.11	0.11
Copper as Cu(mg/l)*	W044-28-O	0.002	0.11	0.11	0.11
Iron as Fe(mg/l)*	W044-28-O	0.001	0.16	0.17	0.16
Mercury as Hg(mg/l)*	W044-30-C	0.001	<0.001	<0.001	<0.001
Potassium as K(mg/l)*	W044-28-O	0.005	3.45	4.85	4.78
Magnesium as Mg(mg/l)*	W044-28-O	0.01	7.45	8.31	5.24
Manganese as Mn(mg/l)*	W044-28-O	0.001	0.17	0.18	0.16
Molybdenum as Mo(mg/l)*	W044-28-O	0.001	0.010	0.026	0.027
Sodium as Na(mg/l)*	W044-28-O	0.02	2.05	3.20	2.43
Nickel as Ni(mg/l)*	W044-28-O	0.003	0.11	0.11	0.11
Lead as Pb(mg/l)*	W044-28-O	0.01	<0.01	<0.01	<0.01
Antimony as Sb(mg/l)*	W044-28-O	0.01	<0.01	<0.01	<0.01
Selenium as Se(mg/l)*	W044-28-O	0.003	<0.003	<0.003	<0.003
Silicon as Si(mg/l)*	W044-28-O	0.007	1.06	2.15	2.96
Tin as Sn(mg/l)*	W044-28-O	0.02	<0.02	<0.02	<0.02
Strontium as Sr(mg/l)*	W044-28-O	0.001	0.17	0.20	0.13
Thorium as Th(mg/l)*	W044-28-O	0.002	<0.002	<0.002	<0.002
Titanium as Ti(mg/l)*	W044-28-O	0.001	0.001	0.005	0.034
Thallium as Tl(mg/l)*	W044-28-O	0.009	<0.009	<0.009	0.034
Uranium as U(mg/l)*	W044-28-O	0.004	<0.004	<0.004	<0.004
Vanadium as V(mg/l)*	W044-28-O	0.002	0.13	0.13	0.12

Ndileka Bangani

Mulalo Mhlanga

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.

T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number	E020323		E020324	E020325	
Sampled Date					
Sample Marks	BT 4		BT 1 HW	BT 1 FW	
Determinand	Method References	Detection Limit	Result	Result	Result
ANALYSIS WERE CARRIED OUT ON 5% AQUEOUS EXTRACTS OF A SAMPLE AS RECEIVED:METALS					
Zinc as Zn(mg/l)*	W044-28-O	0.005	0.092	0.092	0.092
Zirconium as Zr(mg/l)*	W044-28-O	0.001	0.040	0.040	0.040

Ndileka Bangani

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.



T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number			E020320	E020321	E020322
Sampled Date					
Sample Marks			BT 1	BT 2	BT 3
Determinand	Method References	Detection Limit	Result	Result	Result
ANALYSIS WERE CARRIED OUT ON 5% AQUEOUS EXTRACTS OF A SAMPLE AS RECEIVED					
Nitrate as NO ₃ (mg/l)*	W044-50-W	0.1	<0.1	<0.1	0.3
Nitrate as N(mg/l)*	W044-50-W	0.1	<0.1	<0.1	0.31
pH value @ 25°C*	W044-27-O		6.40	7.10	6.40
Conductivity mS/m @25°C*	W044-27-O	1.0	48	26	4.30
Chloride, Cl(mg/l)*	W044-50-W	0.1	28	8.91	1.02
Cyanide, CN(mg/l)*			0.020	0.054	0
Total Alkalinity*	W044-50-W	0.01	28	40	<0.01
Fluoride, F(mg/l)*	W044-50-W	0.1	0.13	<0.1	0.18
Sulphate as SO ₄ (mg/l)*			166.85	63.86	9.54

Ndileka Bangani

Mulalo Mhlanga

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.



T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number			E020323	E020324	E020325
Sampled Date					
Sample Marks			BT 4	BT 1 HW	BT 1 FW
Determinand	Method References	Detection Limit	Result	Result	Result
ANALYSIS WERE CARRIED OUT ON 5% AQUEOUS EXTRACTS OF A SAMPLE AS RECEIVED					
Nitrate as NO ₃ (mg/l)*	W044-50-W	0.1	<0.1	<0.1	<0.1
Nitrate as N(mg/l)*	W044-50-W	0.1	<0.1	<0.1	<0.1
pH value @ 25°C*	W044-27-O		7.30	7.20	7.00
Conductivity mS/m @25°C*	W044-27-O	1.0	18.00	18.80	14.10
Chloride, Cl(mg/l)*	W044-50-W	0.1	0.58	0.64	0.99
Cyanide, CN(mg/l)*			0	0.008	0
Total Alkalinity*	W044-50-W	0.01	38	26	13.10
Fluoride, F(mg/l)*	W044-50-W	0.1	0.14	0.45	0.35
Sulphate as SO ₄ (mg/l)*			37.02	52.37	42.13

Ndileka Bangani

Mulalo Mhlanga

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.



T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number			E020320	E020321	E020322
Sampled Date					
Sample Marks			BT 1	BT 2	BT 3
Determinand	Method References	Detection Limit	Result	Result	Result
THE ANALYSIS WAS CARRIED OUT ON ACID DISSOLUTION OF A SAMPLE AS RECEIVED					
Silver as Ag(mg/kg)*	W044-28-O	0.40	<0.40	<0.40	<0.40
Arsenic as As(mg/kg)*	W044-28-O	2.0	7.21	2.94	<2.0
Boron as B(mg/kg)*	W044-28-O	0.6	42	25	23
Beryllium as Be(mg/kg)*	W044-28-O	0.20	<0.20	<0.20	<0.20
Bismuth as Bi(mg/kg)*	W044-28-O	0.50	<0.50	<0.50	<0.50
Cadmium as Cd(mg/kg)*	W044-28-O	0.10	<0.10	<0.10	<0.10
Cobalt as Co(mg/kg)*	W044-28-O	0.10	2.48	1.89	1.98
Mercury as Hg(mg/kg)*	W044-30-C	0.10	<0.10	<0.10	<0.10
Molybdenum as Mo(mg/kg)*	W044-28-O	0.10	1.34	0.49	1.28
Nickel as Ni(mg/kg)*	W044-28-O	0.30	14.01	<0.30	<0.30
Antimony as Sb(mg/kg)*	W044-28-O	1.0	<1.0	<1.0	<1.0
Selenium as Se(mg/kg)*	W044-28-O	3.0	<3.0	<3.0	<3.0
Tin as Sn(mg/kg)*	W044-28-O	2.0	<2.0	<2.0	<2.0
Thorium as Th(mg/kg)*	W044-28-O	0.20	<0.20	<0.20	<0.20
Titanium as Ti(mg/kg)*	W044-28-O	0.10	<0.10	<0.10	<0.10
Thallium as Tl(mg/kg)*	W044-28-O	0.90	<0.90	<0.90	<0.90
Uranium as U(mg/kg)*	W044-28-O	0.40	<0.40	<0.40	<0.40

Ndileka Bangani

Mulalo Mhlanga

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.



T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number			E020323	E020324	E020325
Sampled Date					
Sample Marks			BT 4	BT 1 HW	BT 1 FW
Determinand	Method References	Detection Limit	Result	Result	Result
THE ANALYSIS WAS CARRIED OUT ON ACID DISSOLUTION OF A SAMPLE AS RECEIVED					
Silver as Ag(mg/kg)*	W044-28-O	0.40	<0.40	<0.40	<0.40
Arsenic as As(mg/kg)*	W044-28-O	2.0	<2.0	8.04	<2.0
Boron as B(mg/kg)*	W044-28-O	0.6	25	99	16.14
Beryllium as Be(mg/kg)*	W044-28-O	0.20	<0.20	<0.20	<0.20
Bismuth as Bi(mg/kg)*	W044-28-O	0.50	<0.50	<0.50	<0.50
Cadmium as Cd(mg/kg)*	W044-28-O	0.10	<0.10	<0.10	<0.10
Cobalt as Co(mg/kg)*	W044-28-O	0.10	<0.10	16.82	2.66
Mercury as Hg(mg/kg)*	W044-30-C	0.10	<0.10	<0.10	<0.10
Molybdenum as Mo(mg/kg)*	W044-28-O	0.10	0.72	<0.10	<0.10
Nickel as Ni(mg/kg)*	W044-28-O	0.30	<0.30	20	<0.30
Antimony as Sb(mg/kg)*	W044-28-O	1.0	<1.0	<1.0	<1.0
Selenium as Se(mg/kg)*	W044-28-O	3.0	<3.0	<3.0	<3.0
Tin as Sn(mg/kg)*	W044-28-O	2.0	<2.0	<2.0	<2.0
Thorium as Th(mg/kg)*	W044-28-O	0.20	<0.20	<0.20	<0.20
Titanium as Ti(mg/kg)*	W044-28-O	0.10	<0.10	<0.10	<0.10
Thallium as Tl(mg/kg)*	W044-28-O	0.90	<0.90	<0.90	<0.90
Uranium as U(mg/kg)*	W044-28-O	0.40	<0.40	<0.40	<0.40

Ndileka Bangani

Mulalo Mhlanga

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.



T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number			E020320	E020321	E020322
Sampled Date					
Sample Marks			BT 1	BT 2	BT 3
Determinand	Method References	Detection Limit	Result	Result	Result
THE ANALYSIS WERE CARRIED OUT ON A DRIED MILLED SAMPLE					
pH Value @ 25°C (on a saturated paste)*	W044-27-O		8.3	6.7	7.5
Chloride, Cl(mg/kg)*	ASTM 150696a	1	5	<1	<1
Sulfate, SO ₄ (%)*	GRAVIMETRIC	0.01	0.17	0.19	0.09
Total Nitrate as NO ₃ (mg/kg)*			<0.5	1.25	5.15
Total Nitrate as N(mg/kg)*			<0.5	0.28	1.16
Fluoride, F(mg/kg)*	ASTM D3761-96	0.10	<0.10	<0.10	<0.10
Hexavalent chromium as Cr6+(mg/kg)*	EPA 3060A	0.1	<0.1	<0.1	<0.1
Total cyanide as CN(mg/kg)*	MICRO DIST 10-	0.1	0.70	1.74	2.78

Ndileka Bangani

Mulalo Mhlanga

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.



T0040



M & L LABS

Registration Number 1974/001476/07 VAT Number 4780103505

Consulting Industrial Chemists, Analysts

CONFIDENTIAL

Certificate/Report

Laboratory Number			E020323	E020324	E020325
Sampled Date					
Sample Marks			BT 4	BT 1 HW	BT 1 FW
Determinand	Method References	Detection Limit	Result	Result	Result
THE ANALYSIS WERE CARRIED OUT ON A DRIED MILLED SAMPLE					
pH Value @ 25°C (on a saturated paste)*	W044-27-O		8.7	7.1	9.7
Chloride, Cl(mg/kg)*	ASTM 150696a	1	<1	10	<1
Sulfate, SO ₄ (%)*	GRAVIMETRIC	0.01	0.08	0.15	0.03
Total Nitrate as NO ₃ (mg/kg)*			10.50	3.20	1.30
Total Nitrate as N(mg/kg)*			2.37	0.72	0.29
Fluoride, F(mg/kg)*	ASTM D3761-96	0.10	<0.10	<0.10	<0.10
Hexavalent chromium as Cr ⁶⁺ (mg/kg)*	EPA 3060A	0.1	<0.1	<0.1	<0.1
Total cyanide as CN(mg/kg)*	MICRO DIST 10-	0.1	0.86	0.61	1.52

Ndileka Bangani

Mulalo Mhlanga

BDL - Below Detection Limit

* Denotes test method not accredited to ISO 17025

Denotes test method is outsourced

- o Refer to terms and conditions www.bureauveritas.co.za
- o This report relates to only test items listed herein and analysis on an as received basis.
- o These tests do not apply to any other samples of a similar nature.
- o This certificate cannot be reproduced except in full without the written consent of M and L Laboratory Services (Pty) Ltd.



T0040



M & L LABS

Certificate/Report

RESULTS REPORTED RELATED ONLY TO ITEMS TESTED

COMPANY NAME : DIGBY WELLS & ASSOCIATES (SA) PTY LTD

ADDRESS : PRIVATE BAG X10046

SUBJECT : ANALYSIS OF 6 SOLID SAMPLES

MARKED : AS BELOW

INSTRUCTED BY : ARJAN VANT ZELFDE

ORDER NO. : PN MBU 5710

RECEIVED ON : 03/09/2019

LAB NO(S) : E020320-E020325

DATE ANALYSED : 16/09/2019

ACID-BASE ACCOUNTING

Analysis on the dried and milled samples:

SAMPLE MARKS:	LAB NO:	Total Sulphur, S %	Total Acidity Potential as CaCO ₃ kg/ton	Gross Neutralisation Potential as CaCO ₃ kg/ton	Net Neutralisation Potential as CaCO ₃ kg/ton (By Difference)
BT1	E020320	3.14	98	64	-34.0
BT2	E020321	1.39	43	7.7	-35.3
BT3	E020322	1.13	35	9.5	-25.5
BT4	E020323	1.47	46	25	-21.0
BT1 HW	E020324	1.43	45	18.7	-26.3
BT1 FW	E020325	0.90	28	6.5	-21.5

Method Reference:

Lawrence, R.W., Polling, G.P. and Marchant, P.B., 1989. Investigation of predictive techniques or acid mine drainage, Report on DSS Contract No. 23440-7-9178/01-SQ, Energy Mines and Resources, Canada, MEND Report 1.16.1(a). Sobek, A.A., Schuller, W.A., Freeman, J.R. and Smith, R.M., 1978. Field and Laboratory Methods Applicable to Overburden and Mine soils, EPA 600/2-78-054, 203 pp.

Certificate/Report

RESULTS REPORTED RELATED ONLY TO ITEMS TESTED

Analysis on the dried and milled samples:

<u>SAMPLE MARKS:</u>	<u>LAB NO:</u>	<u>Total Sulphur, S</u> %	<u>Sulphide Sulphur as S</u> % (by calculation)	<u>Sulphate Sulphur, S</u> %
BT1	E020320	3.14	3.08	0.06
BT2	E020321	1.39	1.33	0.06
BT3	E020322	1.13	1.1	0.03
BT4	E020323	1.47	1.44	0.03
BT1 HW	E020324	1.43	1.38	0.05
BT1 FW	E020325	0.90	0.89	0.01

Notes:

1. The Sulphate content was determined by a Wet Chemical procedure.

Analysis on the dried and milled samples:

<u>SAMPLE MARKS:</u>	<u>LAB NO:</u>	<u>NAG pH @25°C</u>	<u>NET ACID GENERATION AS</u> <u>H₂SO</u> <u>Kg/tonne</u>
BT1	E020320	1.9	10
BT2	E020321	2.2	125
BT3	E020322	2.3	85
BT4	E020323	3.9	81
BT1 HW	E020324	4.3	2.0
BT1 FW	E020325	2.9	<1.0

Method Reference:

Miller, S., Robertson, A. and Donohue, T. (1997). Advances in Acid Drainage Prediction. Prediction using The Net Acid Generation (NAG) Test. Report on Acid Mine Drainage published in Vancouver, BC., Canada.



Certificate/Report

RESULTS REPORTED RELATED ONLY TO ITEMS TESTED

ANALYSIS:

- Qualitative and Quantitative XRD (mineralogy)
- The samples were prepared according to the standardized Panalytical backloading system, which provides nearly random distribution of the particles.
- The samples were analyzed using a PANalytical Aeris powder diffractometer in θ - θ configuration with an X'Celerator detector and fixed divergence- and receiving slits with Fe filtered Co-K α radiation ($\lambda=1.789\text{\AA}$). The phases were identified using X'Pert Highscore plus software.
- The relative phase amounts (weight %) were estimated using the Rietveld method (Autoquan Program). The quantitative results are listed below.

Comment:

- ☐ The samples seem to be coal samples with a high amorphous content.

Amorphous material is invisible for the Rietveld method and the amount of the crystalline phases will be overestimated.

- ☐ After addition of a standard of 20% Si (Aldrich 99% pure) for determination of amorphous content the overestimation of this phase and of all the other phases can be corrected for.



M & L LABS

Certificate/Report

RESULTS REPORTED RELATED ONLY TO ITEMS TESTED

Quantitative Results:

	<u>E020325</u>				
	BT 1 FW				
	wt%				
Ankerite	-				
Calcite	-				
Chlorite	-				
Hematite	-				
Kaolinite	35.11				
Magnetite	-				
Microcline	14.87				
Muscovite	7.11				
Plagioclase	-				
Quartz	42.91				
Sepiolite	-				
Siderite	-				
	<u>E020320</u>	<u>E020321</u>	<u>E020322</u>	<u>E020323</u>	<u>E020324</u>
	BT 1	BT 2	BT 3	BT 4	BT1 HW
	wt%	wt%	wt%	wt%	wt%
Amorphous	66.21	66.47	59.3	68.16	10.51
Ankerite	4.45	-	-	-	-
Calcite	1.46	-	-	0.16	-
Kaolinite	14.17	20.84	17.73	15.41	38.79
Microcline	-	-	-	2.92	6.51
Muscovite	-	-	-	2.45	7.01
Pyrite	3.38	0.93	0.39	-	1.44
Quartz	10.33	11.76	22.58	10.9	27.3
Siderite	-	-	-	-	8.44



M & L LABS

Certificate/Report

RESULTS REPORTED RELATED ONLY TO ITEMS TESTED

Mineral	General Formula
Ankerite	$\text{Ca(Fe, Mg)}(\text{CO}_3)_2$
Calcite	$\text{Ca(CO}_3\text{)}$
Chlorite	$(\text{Mg,Fe})_5\text{Al(AlSi}_3\text{O}_{10})(\text{OH})_8$
Hematite	FeO_3
Kaolinite	$\text{Al}_4(\text{OH})_8(\text{Si}_4\text{O}_{10})$
Magnetite	Fe_3O_4
Microcline	KAlSi_3O_8
Muscovite	$\text{KAl}_3\text{Si}_3\text{O}_{10}(\text{OH})_2$
Plagioclase	$(\text{Na,Ca})(\text{Si,Al})_4\text{O}_8$
Pyrite	FeS_2
Quartz	SiO_2
Sepiolite	$\text{Mg}_8(\text{OH})_4\text{Si}_{12}\text{O}_{30}(\text{H}_2\text{O})_{12}$
Siderite	$\text{Fe(CO}_3\text{)}$

The results were supplied by a sub contracted laboratory



Certificate/Report

RESULTS REPORTED RELATED ONLY TO ITEMS TESTED

ANALYTE	LAB NO	E020320	E020321	E020322	E020323	E020324	E020325
	SAMPLE MARK	BT 1	BT 2	BT 3	BT 4	BT1 HW	BT 1 FW
Fe2O3	%	9.856	4.685	3.086	5.151	9.641	1.587
SiO2	%	49.027	66.759	73.716	62.188	62.828	78.444
Al2O3	%	18.751	25.598	19.107	23.497	22.166	15.010
K2O	%	0.434	0.401	1.567	0.658	2.139	3.505
P2O5	%	0.045	0.078	0.048	0.057	0.100	0.035
Mn3O4	%	0.059	0.091	0.084	0.045	0.186	0.023
CaO	%	8.199	0.570	0.273	2.620	0.436	0.135
MgO	%	3.381	0.369	0.294	1.415	1.108	0.427
TiO2	%	1.215	1.362	1.089	1.142	1.366	0.943
Na2O	%	0.110	0.029	0.071	0.073	0.073	0.168
V2O5	%	0.014	0.012	0.021	0.012	0.022	0.011
BaO	%	0.094	0.055	0.098	0.094	0.091	0.114
SrO	%	0.083	0.034	0.032	0.049	0.020	0.019
ZrO2	%	0.052	0.060	0.052	0.058	0.083	0.081
CuO	%	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
PbO	%	0.008	0.011	0.008	0.009	0.005	0.009
ZnO	%	0.009	0.009	0.012	0.010	0.028	0.021
SO3	%	9.536	0.452	0.268	2.469	0.366	0.325
Total	%	100.895	100.598	99.855	99.568	100.704	100.877
Ash	%	28.425	29.090	39.554	26.591	75.885	93.107

*Ashing done at 815°C. *Samples reported on a dried basis.

*The results relate specifically to the items as tested

The results were supplied by a sub contracted laboratory

Authorised Signature

EXTRACT OF THE BUREAU VERITAS GENERAL TERMS AND CONDITIONS OF BUSINESS

This extract of the Bureau Veritas general terms and conditions of business ("**General Conditions**") shall govern all services, including (but not limited to) laboratory test work, surveys, sampling, site investigations, consultations and opinions, performed for any individual or juristic person (the "**Client**") by M and L Laboratory Services Proprietary Limited, its subsidiary companies and their employees, agents, consultants and subcontractors (collectively referred to as the "**Company**"), whether in terms of a specified contract or not. For the purpose of these General Conditions, the Company and the Client shall collectively be referred to as the "**Parties**" and individually as a "**Party**".

1. QUOTATIONS

Any quotations for Services submitted by the Company to the Client shall be based on information supplied to the Company by the Client and will not under any circumstances be binding on the Company if such information is incorrect or incomplete in any manner.

2. INSTRUCTIONS

The Client will provide the Company with clear and precise written instructions, documents, information and samples prior to the performance of the Services. The Company will not be liable for any error, omission or inaccuracy in the reports or certificates produced by it to the extent that the Company has been given erroneous or incomplete information by the Client. The reports and certificates produced by the Company reflect the findings of the Company at the time of performance of the Services only.

3. SAMPLE MATERIAL

The Client will ensure that all samples/materials submitted by it for test work of any nature are clearly marked and identifiable. Should it be necessary for the Company to carry out any sample preparation, preliminary experimental work, or research prior to carrying out the Services, the Client will be liable for any charges in respect thereof. Unless the Client otherwise instructs in writing, the Company may retain, return to the Client, destroy or dispose of all excess samples, material, specimens or exhibits provided by the Client to the Company as soon as the Services are completed and the results have been reported to the Client. Any destruction or disposal shall exclude normal amounts of reserve sample material which the Company shall retain for a period of three months from date of completion of the Services. If the Client requires the Company to return any samples or materials to it or a third party, all costs associated therewith, including associated telecommunication costs, will be borne and paid for the Client.

4. FEES AND TERMS OF PAYMENT

In consideration for the provision of the Services by the Company, the Client shall pay the fees calculated in accordance with the Company's tariff of fees at the time, copies of which may be requested by the Client at any time. In the event of any changes in the Company's fees, the Company shall provide written notification thereof to the Client within a reasonable time prior to such new fees becoming effective. If the Client does not have an account with the Company, the Client shall be required to pay the whole or part of the fees before the Company will commence the Services or release the results, as the case may be. The Client will pay each valid invoices submitted to it by the Company in full and in cleared funds within 30 days of the date of the invoice. The Company shall be entitled to charge Interest at 2% per month on any amounts not paid on the due date.

5. LIABILITY AND INDEMNITY

Neither Party shall be liable to the other Party for any consequential, indirect, incidental or special losses or damages of any nature whatsoever and howsoever arising. Without prejudice to the foregoing, the total liability of the Company arising out of or in connection with this Agreement or in relation to the Services shall be limited to the fee paid or payable by the Client to the Company for the Services that gave rise to the Company's liability to the Client, if any. The Client indemnifies the Company and holds it harmless against all claims made by third parties for losses, damages or expenses of whatsoever nature and howsoever arising relating to the performance, purported performance or non-performance of any Services to the extent that the aggregate of such claims for any one Service exceeds the limitation of liability set out in this clause 5.

6. PROVISION OF THE SERVICES

The Company shall provide the Services with reasonable care, skill and diligence as expected of a competent body experienced in performing services of a similar nature and under similar circumstances. If the Client is aware of any apparent inaccuracy in any results reported by the Company in respect of the Services, the Client shall immediately advise the Company accordingly, and allow the Company a reasonable opportunity to check such results and amend them if necessary.

7. PUBLICATION OF RESULTS

Any reports or certificates issued by the Company are intended for the exclusive use of the Client and shall not be published, used for advertising purposes, copied or replicated for distribution to any person or entity or otherwise publicly disclosed without the prior written consent of the Company.

8. ALTERATIONS OF TERMS

No employee, agent or representative of the Company is authorised to alter or waive any of the terms contained in these General Conditions unless in writing and signed by or on behalf of the Parties. The performance of any test shall further be subject to any additional special conditions as the Company may impose from time to time. If such special conditions differ from any provisions set out herein, such special conditions shall, to the extent of such difference, take precedence.

9. LAW OF SOUTH AFRICA

These General Conditions shall be governed by and construed in accordance with the laws of the Republic of South Africa. The Parties irrevocably consent to the jurisdiction of the South Gauteng High Court, Johannesburg, if any dispute or claim arises out of or in connection with this Agreement.

For full business terms and conditions please click or visit http://portal.bureauveritas.co.za/downloads/conditions_ml.pdf