Commissiekraal Coal Project, KwaZulu Natal

Geochemical Assessment

Phase 2: Geochemical Characterisation for Underground Mining

SLR Project No.: 710.02038.00004

Report No.: 01

FINAL

May 2015

Tholie Logistics (Pty) Ltd

Commissiekraal Coal Project, KwaZulu Natal

Geochemical Assessment

Phase 2: Geochemical Characterisation for Underground Mining

SLR Project No.: 710.02038.00004

Report No.: 01

FINAL

May 2015

Tholie Logistics (Pty) Ltd

DOCUMENT INFORMATION

Title	Geochemical Assessment: Phase 2 – Geochemical Characterisation for Underground Mining
Project Manager	Alex Pheiffer
Project Manager e-mail	Apheiffer@slrconsulting.com
Author	Jenny Ellerton
Reviewer	Terry Harck
Client	Tholie Logistics (Pty) Ltd
Date last printed	2015/10/15 01:21:00 PM
Date last saved	2015/10/15 01:21:00 PM
Comments	
Keywords	coal, KZN, drainage quality, acid rock drainage, heavy metals
Project Number	710.02038.00004
Report Number	01
Revision Number	Revision No.
Status	FINAL TO CLIENT
Issue Date	May 2015

EXECUTIVE SUMMARY

A preliminary geochemical assessment was undertaken for the Commissiekraal Coal Project located between Wakkerstroom in Mpumalanga and Utrecht in northern KwaZulu-Natal.

The geochemical assessment undertaken and presented in the report has characterised coal material from the Lower and Upper Gus Coal Seams along with 'roof' and 'floor' material of both seams within the proposed underground mining area. The assessment is required as part of the Environmental Impact Assessment (EIA) and Environmental Management Programme (EMP), which will be submitted in support of the mining right application.

This report focusses only on the underground mining aspects.

The site is located on Farm Commissiekraal 90 HT situated in the Amajuba District Municipality of Kwa-Zulu Natal Province, South Africa. The site covers an area of approximately 1,530 hectares (MSA, 2011) and lies approximately 30km north north-east of the town of Utrecht and approximately 30km to the south-east of Wakkerstroom.

The site is located within the Utrecht Coalfield. All the coal measures in the Utrecht Coalfield occur within the Vryheid Formation, part of the Ecca Group, a significant sedimentary sequence within the Karoo Supergroup. The Vryheid Formation predominantly consists of coarse to fine grained sandstone, and is often interbedded and interlaminated with minor shales and mudstones. Dolerite intrusions have been identified across the site through exploration drilling.

Four Coal Seams exist in the Utrecht Coalfield and comprise horizontal to sub-horizontal beds:

- The Coking Seam.
- The Dundas Seam.
- The Gus Seam (predominant).
- The Alfred Seam.

The Gus Seam is the predominant Seam beneath the site and is divided into the Upper and Lower Seam. The Seam will be mined on seam through a decline shaft.

SLR selected twelve samples from three boreholes; MCK01, MCK09 and MCK11 drilled in April 2014 and located in the area in which underground mining is proposed. The samples consisted of:

- '**Roof' material** - consisting of lithologies approximately 1 m above the Upper Gus Seam.

- '**Parting' material** - consisting of the lithologies between the Upper and Lower Gus Seam.
- **'Floor' material** - consisting of lithologies approximately 1 m below the Lower Seam.

All coal units from the MCK boreholes were removed for resource characterisation test work, including total sulphur determination. Residual sample material was provided to SLR by Bureau Veritas Inspectorate Laboratories. However, the majority of the sample material was contaminated by the test reagents and cannot be used for geochemical characterisation. The mass of the 'un-contaminated' samples was insufficient for a full geochemical analysis. Notwithstanding, three coal samples were selected from the 'un-contaminated' samples provided.

The 'roof 'parting' and 'floor' samples were submitted to an accredited laboratory for Acid Base Accounting (ABA), mineralogical testing by X-ray Diffraction (XRD) and Synthetic Precipitation Leaching Procedure (SPLP) leach tests. Due to the limited mass of 'uncontaminated' Gus Seam coal material recovered from the Bureau Veritas laboratory the laboratory analysis for the three coal samples was limited to ABA.

Acid base accounting (ABA) results indicate the potential for generation of acid drainage by a sample based on the balance between acid potential and neutralisation potential. The ABA results suggest that out of the fifteen samples tested:

- Four samples were **Potentially Acid Generating (PAG).** These samples consist of:
  - Sandstone and sandstone / shale.
- Four samples were **inconclusive**. These samples consist of:
  - Sandstone, mudstone and one coal sample.
- Seven samples were **Non Potentially Acid Generating** (Non-PAG). These samples consist of:
  - Sandstone, two samples of coal, sandstone / shale and carbonaceous fines.

The results suggest that the acid generating potential is not linked to lithology but more likely linked to mineralogy.

The mineralogy test work undertaken on the twelve roof, floor and parting samples show that the key minerals of the samples are as follows:

- Quartz, illite (a micaceous mineral which forms through the weathering of silicates and through the degradation of muscovite) and to a lesser extent Kaolinite (a clay mineral) are dominant in the sandstone samples and the sandstone / shale samples.
- Kaolinite is dominant in the two mudstone samples and the carbonaceous fines sample.

- Although not dominant by mass (%) in samples, calcite is present in all but one sample.
- No sulphide minerals were identified in any of the samples.

The final pH of the leachates was higher than the initial pH 7, which indicates the presence of leachable alkalinity in the samples. The leach results reflect the calcite identified in the mineralogy test work. As a preliminary screening to identify potential chemicals of concern, the leachates were compared to relevant water quality and effluent standards. Based on the guideline comparison:

- pH is neutral to slightly alkaline.
- Alkalinity can be leached from the samples.
- A number of metals are leachable at concentrations in excess of relevant water quality standards including aluminium (Al), antimony (Sb), arsenic (As), iron (Fe), selenium (Se) and fluoride (F).

A summary of results show:

- The results show a significant variability that is largely due to the small number of samples.
- Acid generation potential varies significantly within the same lithology. Therefore it is likely that it is not linked to lithology but more likely linked to mineralogy.
- In general, lithologies formed under reducing conditions, such as coal, mudstone, and perhaps siltstone, are more likely to include pyrite. Therefore, these lithologies are more likely to be PAG. However, this is not invariable, as sandstone mineralogy can also include pyrite. Indeed, several sandstone samples tested in this study are PAG.
- The presence of calcite in most samples is significant as this is readily available to neutralise acid generated from pyrite oxidation. The mineralogy results suggest that calcite is common in the sampled lithologies and makes up all of the available neutralisation potential (NP) in the majority of samples. This is a natural AMD mitigation. However, calcite is readily soluble and can be dissolved through interaction of the lithology with water. This may reduce the availability of NP to offset acid generated from pyrite oxidation.
- Although based on limited number of samples, the results suggest that those samples with dominant illite tend to be Non-PAG and those with a high kaolinite content are more likely to be PAG or have an uncertain potential. This is related to clay minerals. Some of the secondary minerals may have deleterious effects on water quality because of the release of additional acidity during their formation.
- There appears to be no trend with regards to the leaching potential of elements and the acid generating potential or lithology.

With regards to potential drainage quality characteristics from Commissiekraal, the following, based on the assessment, are concluded:

- Initially neutral pH. However, acid generation may occur after an initial lag period during which available alkalinity is consumed.
- Contain elevated concentrations of aluminium (Al), antimony (Sb), arsenic (As), iron (Fe), selenium (Se) and fluoride (F).
- Should acid conditions become prevalent, concentrations of sulphate and total dissolved solids will increase significantly.

The presence of PAG characteristics in samples of Gus roof and floor material suggest that the acid generation potential is not evenly distributed in these materials. The potential to generate acid generation in the underground workings will depend on the distribution of PAG material, and the neutralisation potential of non-PAG material that can mitigate acid generation. The limited number of samples collected for this assessment is not sufficient to indicate the potential PAG/non-PAG balance in the underground workings.

If the sample set in this study is considered an indicator of bulk lithological properties associated with the Gus seam underground workings, then the workings are non-PAG. However, much of the NP is attributed to calcite which is subject to dissolution on exposure in the workings. Therefore, not all NP will be available for acid neutralisation. Therefore, uncertainty remains as to whether water in the proposed underground workings will turn acidic in the long term after the available calcite is exhausted. This can only be determined from kinetic testing, which are recommended.

GEOCHEMICAL ASSESSMENT
PHASE 2: GEOCHEMICAL CHARACTERISATION FOR UNDERGROUND MINING

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

Below a list of acronyms and abbreviations used in this report.

Acronyms / Abbreviations	Definition
ABA	Acid Base Accounting
AP	Acid Potential
ARD	Acid Rock Drainage
Cbn Fns	Carbonaceous Fines
CoCs	Chemicals of Concern
EIA	Environmental Impact Assessment
E.N	Electro Neutrality
IFC	International Finance Corporation
Mdst	Mudstone
NNP	Net Neutralising Potential
NP	Neutralising Potential
NPR	Neutralising Potential Ratio
PAG	Potentially acid Generating
SANAS	South African National Accreditation System
SANS	South African national Standards
SPLP	Synthetic Precipitation Leaching Potential
Sst	Sandstone
WHO	World Health Organisation
XRD	X-Ray Diffraction

GEOCHEMICAL ASSESSMENT
PHASE 2: GEOCHEMICAL CHARACTERISATION FOR UNDERGROUND MINING

1 INTRODUCTION

Tholie Logistics (Pty) Limited ("Tholie") has coal interests over a number of farms, between Wakkerstroom in Mpumalanga and Utrecht in northern KwaZulu-Natal. Tholie proposes to establish a new coal mining project, referred to in this report as the Commissiekraal Coal Project ("the Site").

SLR Consulting (Africa) (Pty) Limited ("SLR") has been commissioned by Tholie to undertake a geochemical assessment for the site. The assessment aims to characterise the material likely to be mined and is required as part of the Environmental Impact Assessment (EIA) and Environmental Management Programme (EMP) which will be submitted in support of the mining right application.

1.1 Situation Appraisal

As agreed with Tholie, the geochemical assessment has been undertaken in a phased approached as follows:

- **Phase 1: Preliminary Assessment**
  - To undertake a preliminary assessment through the review of geological and mineralogical data available for the site.
  - To document the findings of the preliminary review.
  - To conclude on whether a second phase of work is required.
- **Phase 2: Sample Selection and Geochemical Characterisation**
  - To select appropriate samples for geochemical characterisation.
  - To submit samples to a laboratory for geochemical test work.
  - To interpret results and undertake a preliminary risk assessment through comparison of results with appropriate water quality standards.

The preliminary assessment (Phase 1); was undertaken by SLR in August 2014 and assessed the site geology based on literature. A preliminary characterisation of material that could be generated during the mining process was provided.

The Phase 1 assessment included a sampling and analysis plan. Sample associated with underground mining were selected from core taken from exploration boreholes and limited ore samples remaining from resource characterisation test work.

This report forms Phase 2 of an the agreed overall geochemical assessment

1.2 LIMITATIONS OF REPORT

This report focusses only on the underground mining aspects. Suitable boreholes located in the opencast reserves footprint were not available. In addition, the opencast reserves do not form part of the current mining right application scope.

The geochemical characterisation of the ore is limited to the acid / neutralising potential of the samples due to the mass of sample available for test work.

1.3 SITE SETTING

The site is located on Farm Commissiekraal 90 HT situated in the Amajuba District Municipality of Kwa-Zulu Natal Province, South Africa. The site covers an area of approximately 1,530 hectares (MSA, 2011) and lies approximately 30km north north-east of the town of Utrecht and approximately 30km to the south-east of Wakkerstroom. The site location is presented in Figure 1-1.

1.4 REPORT STRUCTURE

The report has been divided accordingly:

- Section 2 presents the geological setting.
- Section 3 presents the geochemical characterisation methodology.
- Section 4 presents the results and interpretation of the test works.
- Section 5 presents the potential drainage quality based on the results.
- Section 6 concludes.
- Section 7 provides recommendations for further work.

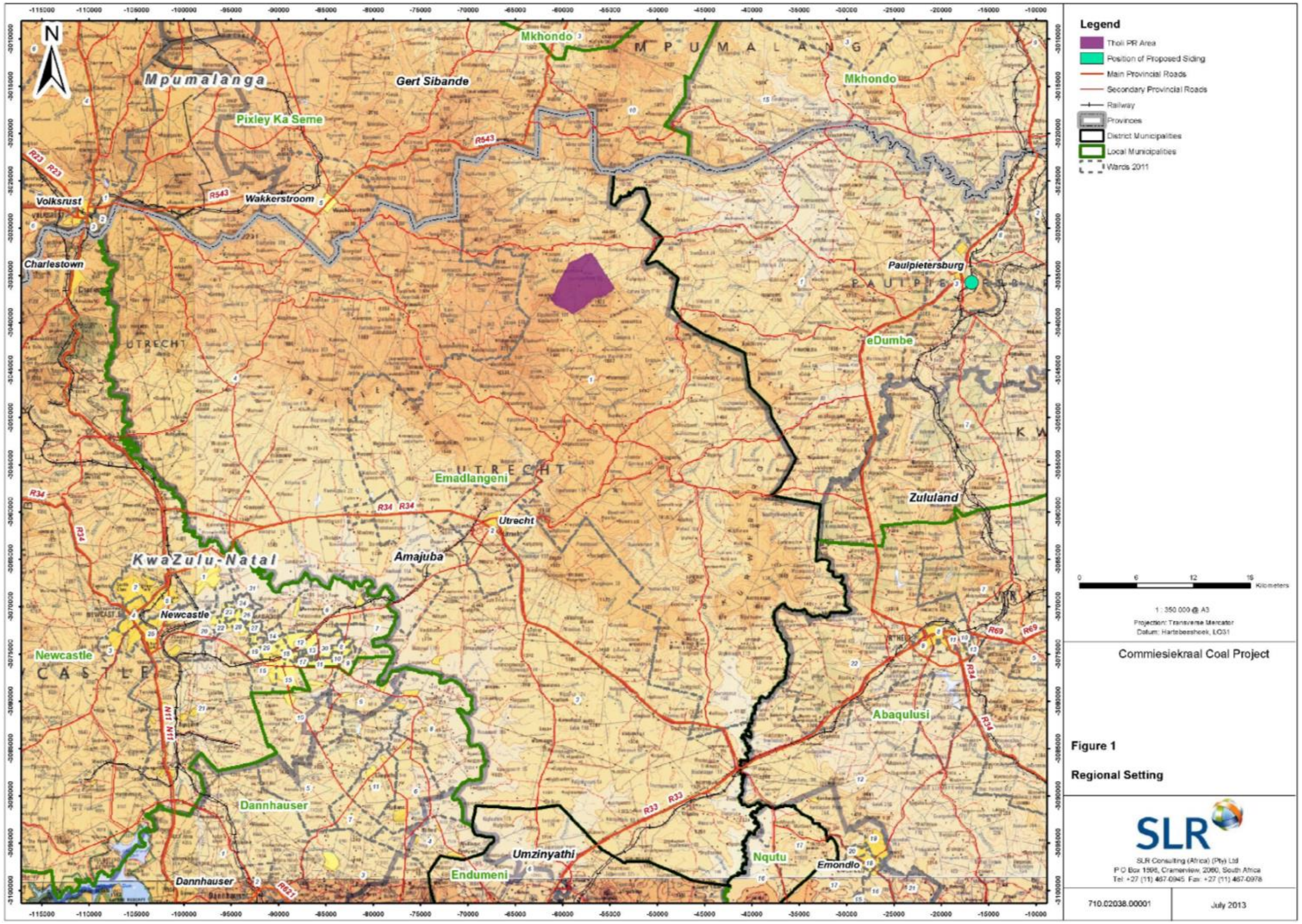

FIGURE 1-1: SITE LOCATION PLAN

2 GEOLOGICAL SETTING

The geological setting is presented in Figure 2-1.

2.1.1 REGIONAL

The site is located within the Utrecht Coalfield, which covers an area of about 2,200 km^2 (MSA, 2011). All the coal measures in the Utrecht Coalfield occur within the Vryheid Formation, part of the Ecca Group, a significant sedimentary sequence within the Karoo Supergroup. Other formations that are present within the project area include the Volksrust Formation, Pietermaritzburg Formation and the Normandien Formation. Dolerite intrusions exist within the project area. A typical stratigraphic column for the area is presented in Table 2-1.

The Vryheid Formation predominantly consists of coarse to fine grained sandstone, and is often interbedded and interlaminated with minor shales and mudstones. Discrete packages of micaceous silt and mudstone is not uncommon (MSA, 2011).

TABLE 2-1: TYPICAL STRATIGRAPHY COLUMN FOR THE AREA

Supergroup	Group	Formation	Description
Karoo Supergroup	Ecca Group	Volksrust Formation	Intercalated mudstones
		Vryheid Formation	Sandstone intercalated carbonaceous shales, mudstones and coal Main Coal Bearing Horizon Ecca Group
		Pietermaritzburg Formation	Predominantly shales
		Normandien Formation	Predominantly Sandstones
	Dwyka Group	Dwyka Formation	Mudrock, diamictite and conglomerates

2.1.2 LOCAL GEOLOGY

Exploration drilling has been undertaken across the project site, consisting of diamond drilling and, more recently downhole geophysical wireline logging. The works have identified dolerite intrusions across the site (MSA, 2011). This confirmed observations made during a field mapping exercise undertaken in 2010. Dolerite was observed on site as thin (<15 m thick) dykes and thick (100 m thick) dykes (Digby Gold, 2013). Numerous thin (<5 m thin) sills have been observed in core logs (Digby Gold, 2013). A massive sill several hundred metres thick overlies the coal-bearing strata at the Site.

Several coal outcrops of the Alfred and Gus seams were observed during a field mapping exercise undertaken in 2010 (Digby Gold, 2013).

2.2 COAL SEAMS

The Coal Seams in the region comprise horizontal to sub-horizontal beds, however significant disturbances are associated with dolerite sills (parallel to sedimentary bedding planes) and dykes (vertical to near-vertical transgressive intrusions), which not only displace and replace the strata but also devolatilise the coal (Johnson *et al*, 2006).

Essentially two types of coal are found beneath the site: a moderate to low volatile bituminous coal, referred to as ‘Lean Coal’, and a moderate to high volatile bituminous coal, referred to as ‘bituminous coal’ (Digby Gold, 2013). This variation is considered to be a function of the dolerite intrusions encountered in the area (MSA, 2011). The coals of the area are inertinite rich (high in organics) and high in ash and originated as peat swamps developed on broad abandoned alluvial plains (Johnson *et al*, 2006).

There are large lateral variations in the physical and chemical nature of the coal seams. It is understood that the volatile nature of the coal increases towards the east (Digby Gold, 2013). It is also noted that the MSA (2011) report suggested that the Gus Seam washed product contains less than 1% sulphur.

Four Coal Seams exist in the Utrecht Coalfield (from base upwards):

- The Coking Seam
- The Dundas Seam
- The Gus Seam (predominant)
- The Alfred Seam

The Gus Seam is the predominant Seam beneath the site, however several outcrops of the Alfred Seam are observed at site. Outcrops of both seams occur in various streams located in the area (MSA, 2011). The water quality of the streams has yet to be determined.

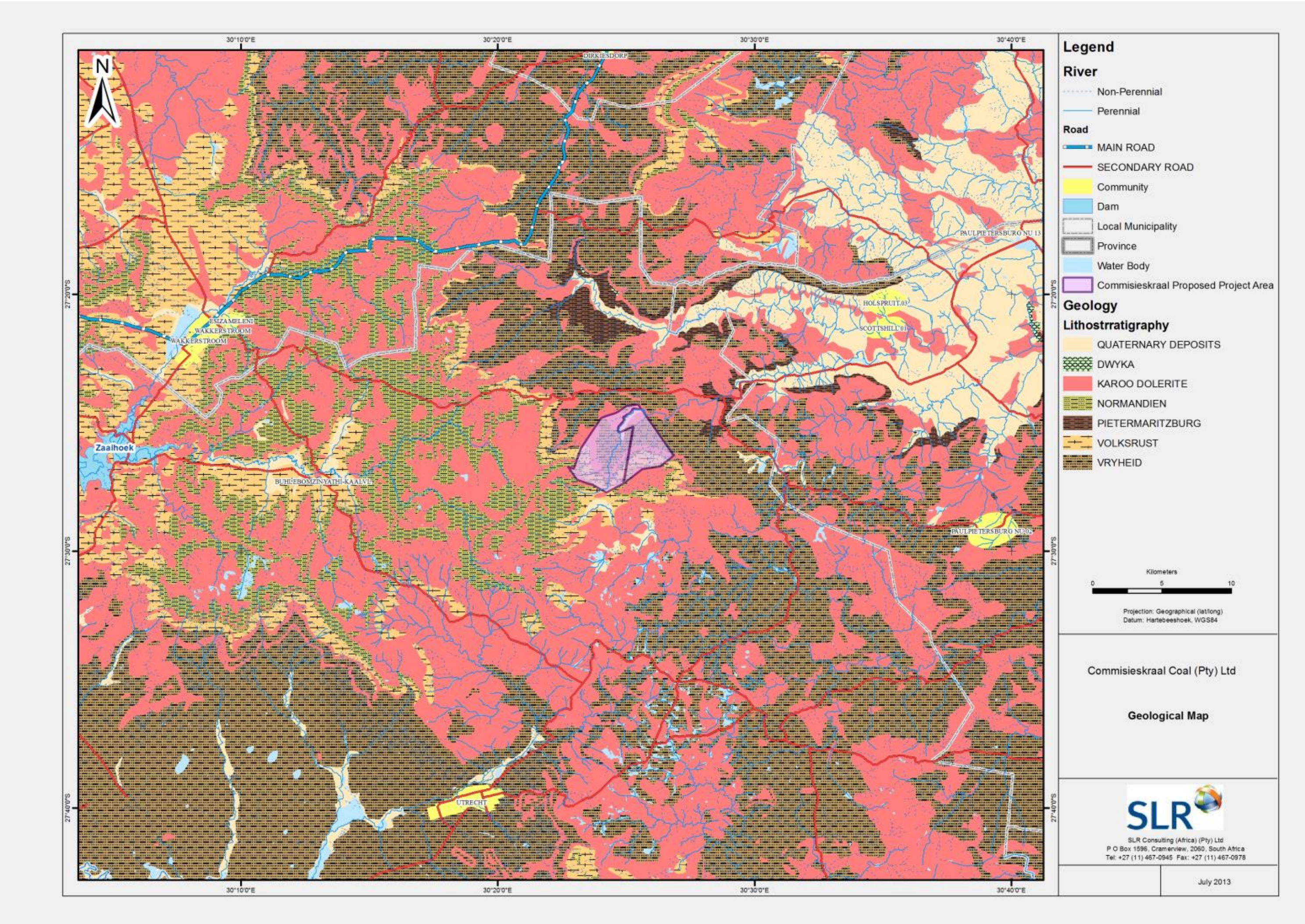

FIGURE 2-1: GEOLOGICAL SETTING

3 GEOCHEMICAL CHARACTERISATION

The following section describes how samples were selected and collected and the methods undertaken to geochemically characterise the waste material.

3.1 SAMPLE SELECTION

The samples were selected as part of the Phase 1 assessment (SLR, 2014).

The samples selected are limited to underground mining only.

SLR reviewed the boreholes logs of twelve (12) boreholes that were drilled in April 2014. These boreholes are located in the area in which underground mining is proposed. The objective of the sampling for the underground mining is to:

- To sample the 'roof' and 'floor' material of the Gus Coal Seams within the proposed underground mining area.
- To sample the coal material that will be exposed in the underground workings. The Lower Gus will be mined through a decline shaft.

Figure 3-1 below illustrates the different units sampled for underground mining at Commissiekraal.

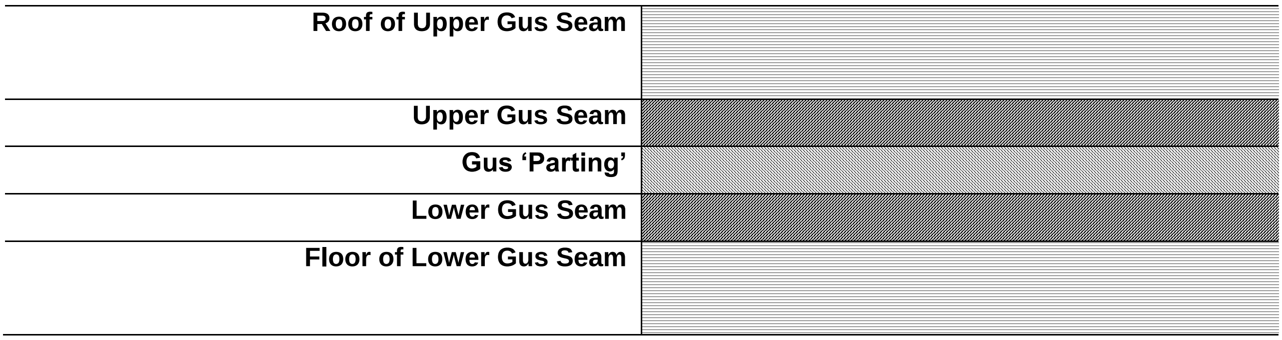

FIGURE 3-1: DIFFERENT UNITS TO BE SAMPLES FO UNDERGROUND MINING AT COMMISSIEKRAAL

3.1.1 ROOF AND FLOOR MATERIAL

SLR has selected samples of roof, parting (floor / roof material of Upper and Lower Gus Seam respectively) and floor material from three boreholes; MCK01, MCK09 and MCK11. These boreholes are considered to be comprehensive and cover all lithologies. Their locations are presented in Figure 3-2.

Those lithologies approximately 1 m above ("roof") and 1 m below ("floor") the Upper Gus Seam and Lower Gus Seam were highlighted. The unit between the Upper and Lower Gus Seam, referred to on the borehole logs as “parting” is generally thin (< m) but was also highlighted. Samples were selected from these highlighted units. Details are presented in Table 3-1.

3.1.2 COAL UNITS

All coal units from the MCK boreholes have been removed for resource characterisation test work, including total sulphur determination. Residual sample material has been provided to SLR by Bureau Veritas Inspectorate Laboratories. However, the majority of the sample material is contaminated by the test reagents and cannot be used for geochemical characterisation and the mass of the ‘un-contaminated’ samples is insufficient for a full geochemical analysis. In addition, a limited mass of Gus Seam sample is available.

Three (3) coal samples were selected from the ‘un-contaminated’ samples provided to SLR by Bureau Veritas Inspectorate Laboratories. The following factors were considered:

- Selection of Lower and Upper Gus samples only.
- Selection of samples with a mass of no less than 50 g (minimum required for Acid Base Accounting).
- Selection of samples from boreholes predominantly located to the east, in the area proposed for underground mine working.

A summary of the sample selection is presented in Table 3-1. Selected boreholes are presented in Figure 3-2.

TABLE 3-1: SAMPLE DETAILS FOR SAMPLES COLLECTED FOR UNDERGROUND MINING

Geochemistry Sample ID	Borehole ID	Commissiekraal Sample ID	Bureau Veritas Sample ID	From (m)	To (m)	Length (m)	Lithology	Details
SLR-01	MCK01	--	--	100.03	101.12	1.09	Silt / Mudstone	Roof of Upper Gus
SLR-02	MCK01	--	--	101.12	101.22	0.1	Medium grained Sandstone	Roof of Upper Gus
		--	--	101.36	101.41	0.05	Medium grained Sandstone	Roof of Upper Gus
SLR-03	MCK01	--	--	102.22	102.40	0.18	shale/sandstone	Gus Parting
SLR-04	MCK01	--	--	105.16	105.4	0.24	Carbonaceous fines	Floor of Lower Gus
SLR-05	MCK01	--	--	105.40	106.46	1.06	Medium grained Sandstone	Floor of Lower Gus
SLR-06	MCK09	--	--	153.08	154.27	1.19	Silt / Mudstone	Roof of Upper Gus
SLR-07	MCK09	--	--	154.55	154.85	0.3	Shale/Sandstone	Gus parting
SLR-08	MCK09	--	--	156.30	157.3	1	Medium grained Sandstone	Floor of Lower Gus
SLR-09	MCK11	--	--	137.40	138.4	1	Medium grained Sandstone	Roof of Upper Gus
SLR-10	MCK11	--	--	138.73	139.34	0.61	Sandstone (sharp upper and lower contacts)	Gus parting
SLR-11	MCK11	--	--	142.10	142.57	0.47	Medium grained Sandstone	Floor of Lower Gus
SLR-12	MCK11	--	--	142.57	143.57	1	Medium grained Sandstone	Floor of Lower Gus
SLR-13	MCK07	B1715	116869	--	--	--	Coal	Upper Gus
SLR-14	MCK07	B1717	116887	--	--	--	Coal	Lower Gus
SLR-15	MCK01	B1733	117709	--	--	--	Coal	Lower Gus

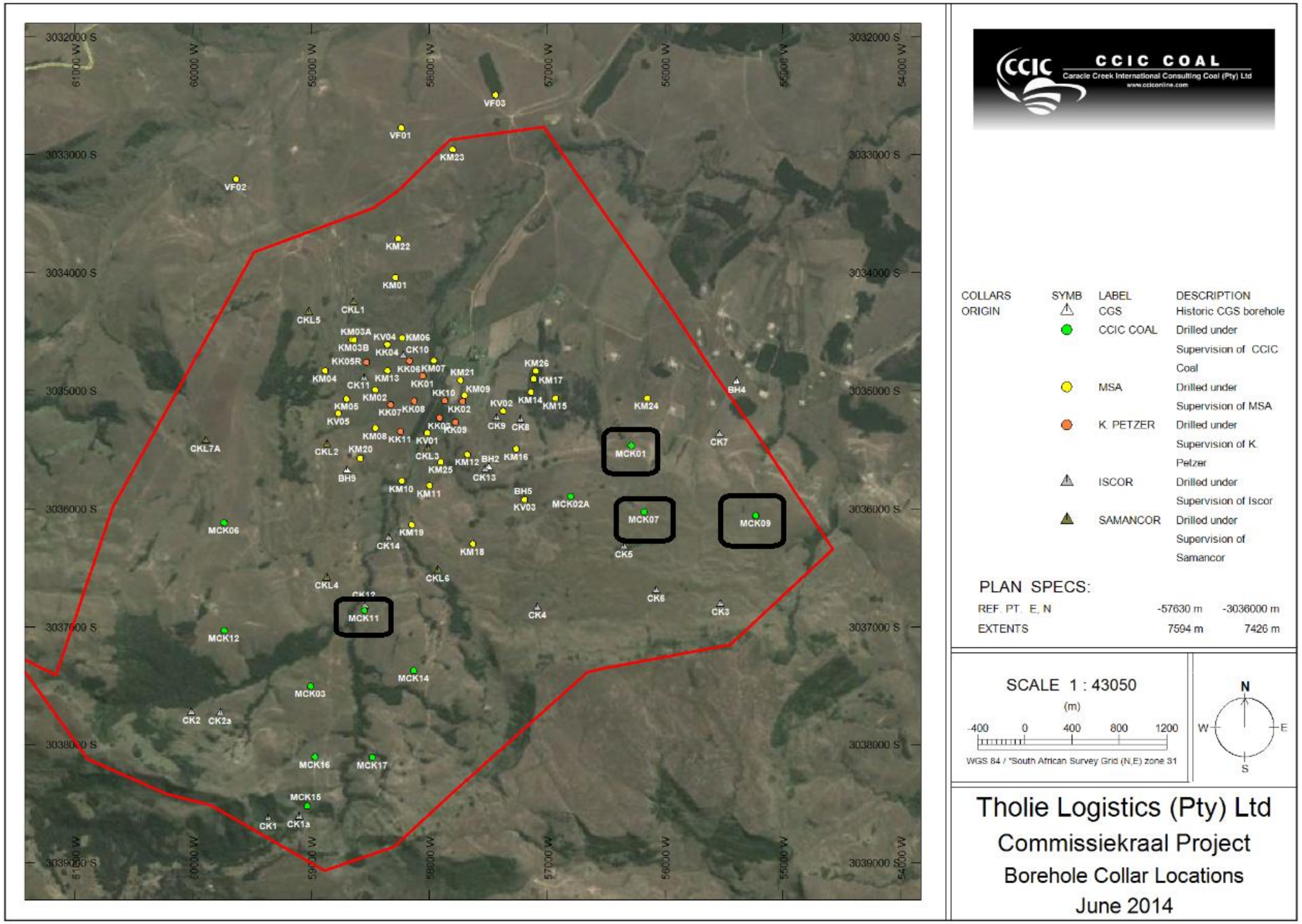

FIGURE 3-2: BOREHOLE LOCATION PLAN

3.2 Laboratory Analysis

All samples were sent to Waterlab Laboratory in Pretoria, South Africa. Waterlab is a SANAS (South African National Accreditation System) accredited laboratory according to ISO/IEC 17025:2005 standards.

The following laboratory tests were undertaken on samples:

- Acid Base Accounting (ABA);
  - Acid Potential (AP) analysis;
  - Neutralising Potential (NP) analysis;
  - Paste pH;
- Mineralogical testing by X-ray Diffraction (XRD);
- Synthetic Precipitation Leaching Procedure (SPLP) test using distilled water.

Due to the limited mass of 'uncontaminated' Gus Seam coal material recovered from the Bureau Veritas laboratory the laboratory analysis for the three coal samples was limited to ABA.

The tests are described in further detail in the following sections.

3.2.1 Acid Base Accounting

3.2.1.1 Acid Potential and Neutralising Potential

Acid–Base Accounting (ABA) is an internationally accepted analytical procedure that was developed to screen the acid-producing and acid-neutralizing potential of rocks.

The Acid Generating Potential (AP) is due to the oxidation of sulphide minerals in a rock sample and is calculated as the total sulphide sulphur content in % multiplied by 31.25.

The Acid Neutralising Potential (NP) is a measure of the total acid a material is capable of neutralising and is predominantly a result of neutralising bases, mostly carbonates and exchangeable alkali and alkali earth cations.

Both AP and NP are reported in units of Kg $CaCO_3$/tonne.

3.2.1.2 Net Neutralising Potential (NNP)

The Net Neutralisation Potential (NNP) is calculated by subtracting the Acid Generating Potential (AP) from the Acid Neutralising Potential (NP):

NNP = NP – AP

Results are reported in kg of calcium carbonate per tonne of overburden (or parts per thousand). For a sample:

- Negative NNP indicates potential to generate acid; and
- Positive NNP indicates excess acid-neutralising potential.

3.2.1.3 Neutralising Potential Ratio (NPR)

The Neutralising Potential Ratio is calculated by dividing the Neutralising Potential (NP) by the acid potential (AP):

NPR = NP/AP

Generally:

- NPR ratios larger than 2 indicate non-potentially acid generation (Non-PAG);
- ratios between 1 and 2 are considered inconclusive / possibly acid generating; and
- NPR ratios below 1 indicate potential acid generation (PAG).

3.2.2 PASTE PH

Paste pH analysis is undertaken in conjunction with the ABA test. The test is a simple, rapid, and inexpensive screening tool that indicates the presence of readily available NP (generally from carbonate) or stored acidity and involves the placement of ‘crushed’ sample with distilled water at a low solid to liquid ratio (to produce a paste) and the pH measured after approximately two minutes.

The outcome of the test is governed by the surficial properties of the solid material being tested, and more particularly, the extent of soluble minerals, which may provide useful information regarding anticipated mine water quality. It represents more closely the water to solid ratio of pore waters in wastes than other analysis procedures

3.2.3 MINERALOGY

Minerals are the building blocks of rocks. Mine drainage quality is generally a function of mineral present dissolution (or precipitation) during interaction of rocks with water. X-ray Diffraction (XRD) analysis identifies the main crystalline mineral phases in each sample.

The relative phase amounts (weight %) were estimated using the Rietveld method.

3.2.4 SYNTHETIC PRECIPITATION LEACHING PROCEDURE (SPLP)

Synthetic Precipitation Leaching Procedure is a laboratory extraction method designed to determine the leachability of both organic and inorganic elements present in liquids, soils, and wastes under certain conditions. The solid phase is extracted over with an extraction fluid, and liquid-to-solid ratio of 4:1 (Modified ASTM D3987). Following extraction, the liquid extract is separated from the solid phase by filtration (combined with any potential initial liquid portion) and analysed.

4 RESULTS AND INTERPRETATION

The results of the testing are presented in the following sections. Copies of laboratory reports are provided in Appendix A.

4.1 DATA VALIDATION

The accuracy of the chemical analysis can be assessed through calculating the electro neutrality for each sample. The electro neutrality (E.N) is calculated using the following equation:

$$E.N.[\%] = \frac{\sum cations\left(\frac{meq}{l}\right) - \sum anions\left(\frac{meq}{l}\right)}{\sum cations\left(\frac{meq}{l}\right) + \sum anions\left(\frac{meq}{l}\right)} * 100\% < 10\%$$

Samples with a calculated E.N value of less than 10% are considered to show an acceptable level of accuracy. Where samples have an error percentage above 10%, results are considered to show an unacceptable level of accuracy and results / interpretation of results should be considered with caution.

The E.N calculation was applied to the leach data. The majority of samples showed an acceptable level of accuracy.

In addition, comparison of the results of the laboratory duplicates indicates that the methods applied show an acceptable level of reproducibility.

4.2 ABA

Acid base accounting results indicate the potential for generation of acid drainage by a sample based on the balance between acid potential and neutralisation potential (expressed as the Neutralisation Potential Ratio or NPR). This assessment uses the criteria of Price (2009) to assess acid drainage potential:

- NPR ratios larger than 2 indicate non-potentially acid generation (Non-PAG);
- ratios between 1 and 2 are considered inconclusive / possibly acid generating; and
- NPR ratios below 1 indicate potential acid generation (PAG).

In addition, sulphur contents higher than about 0.3% are generally considered to present a risk of acid drainage, unless balanced by a suitable neutralisation potential.

The Acid Base Accounting (ABA) Results are presented in Table 4.1. A graph showing the total sulphur content plotted against the NPR is presented as Figure 4-1 and illustrates the classification of each samples based on these two criteria.

4.2.1 POTENTIALLY ACID GENERATING SAMPLES

The ABA results show that four (4) of the fifteen (15) samples (SLR-02, SLR-05, SLR-07 and SLR-08) are classified as Potentially Acid Generating (PAG) due to low neutralising potential ratio (NPR below 1). The acid generating potential of sample SLR-08 is considered short term owning to the lower sulphur content. The samples consist of the following lithologies:

- Three (3) samples of sandstone (Sst).
- One (1) sample of sandstone / Shale (Sst/Shale).

4.2.2 SAMPLES WITH UNCERTAIN ACID POTENTIAL

The neutralising potential ratio (NPR) of four (4) samples (SLR-01, SLR-06, SLR-09 and SLR-13) was between 1 and 2 which indicates an uncertain acid generating potential. The samples consist of the following lithologies:

- Two (2) samples of mudstone (Mdst).
- One (1) sample of coal.
- One (1) sample of sandstone (Sst).

4.2.3 NON-POTENTIALLY ACID GENERATING SAMPLES

The remaining seven (7) samples were all classified as Non-Potentially Acid Generating (Non-PAG) owning to high neutralising potential ratios, and in some cases low sulphur content. The results indicate sufficient neutralising potential to offset the low acid potential in these samples. The samples consist of the following lithologies:

- Three (3) samples of sandstone (Sst).
- Two (2) samples of coal.
- One (1) sample of sandstone / shale (Sst/shale)
- One (1) sample of carbonaceous fines (Cbn fns).

The paste pH for all samples was neutral to alkaline and indicates that there is little potential for the generation of short-term acidity

TABLE 4-1: ACID BASE ACCOUNTING RESULTS FOR COMMISSIEKRAAL SAMPLES

Sample ID	Lab ID	Borehole	Sample From (mbgl)	Sample to (mbgl)	Lithology	Description	Paste pH	Acid Potential (AP) (kg/t)	Neutralization Potential (NP)	Nett Neutralization Potential (NNP) (NP-AP)	Neutralising Potential Ratio (NPR) (NP : AP)	Total Sulphur (%)	NAG pH: (H2O2) pH7	NAG pH7	Class
Criteria							>5.5 (Non-PAG)	-	-	NNP>0 (Non-PAG)	NPR>2 (Non-PAG) NPR<1 (PAG)	-	-	-	
SLR-01	27730	MCK01	100.03	101.12	Mudstone	Roof of Upper Gus	6.5	6.25	11	5	1.80	0.20	6.6	0.392	INC
SLR-02	27731	MCK01	101.12	101.22	Medium grained Sandstone	Roof of Upper Gus	6.3	62	37	-25	0.59	1.98	4.6	21	PAG
		MCK01	101.36	101.41	Medium grained Sandstone	Roof of Upper Gus									
SLR-03	27732	MCK01	102.22	102.4	Shale/sandstone	Gus Parting	5.9	9.06	49	40	5.38	0.29	7.3	<0.01	Non-PAG
SLR-04	27733	MCK01	105.16	105.4	Carbonaceous fines	Floor of Lower Gus	6.0	2.19	4.5	2.31	2.06	0.07	6.4	0.392	Non-PAG
SLR-05	27734	MCK01	105.4	106.46	Medium grained Sandstone	Floor of Lower Gus	6.9	11	10	-0.688	0.94	0.35	4.9	0.784	PAG
SLR-06	27735	MCK09	153.08	154.27	Mudstone	Roof of Upper Gus	7.7	4.69	7	2.31	1.49	0.15	6.5	0.196	INC
SLR-07	27736	MCK09	154.55	154.85	Shale/Sandstone	Gus parting	7.2	23	11	-12	0.48	0.73	4.6	3.72	PAG
SLR-08	27737	MCK09	156.3	157.3	Medium grained Sandstone	Floor of Lower Gus	8.0	7.81	6.5	-1.31	0.83	0.25	6.2	0.392	PAG (Short Term)
SLR-09	27738	MCK11	137.4	138.4	Medium grained Sandstone	Roof of Upper Gus	8.5	5.63	9	3.38	1.60	0.18	8.6	<0.01	INC
SLR-10	27739	MCK11	138.73	139.34	Sandstone (sharp upper and lower contacts)	Gus parting	7.8	3.41	23	19	6.61	0.11	9.2	<0.01	Non-PAG
SLR-11	27740	MCK11	142.1	142.57	Medium grained Sandstone	Floor of Lower Gus	8.0	1.07	5.5	4.43	5.13	0.03	7.2	<0.01	Non-PAG
SLR-12	27741	MCK11	142.57	143.57	Medium grained Sandstone	Floor of Lower Gus	7.8	1.56	3.5	1.94	2.24	0.05	6.8	0.196	Non-PAG
SLR-13	28094	MCK07	-	-	Coal	Upper Gus	6.7	48	65	18	1.37	1.52	-	-	INC
SLR-14	28095	MCK07	-	-	Coal	Lower Gus	6.8	20	81	62	4.13	0.63	-	-	Non-PAG
SLR-15	28096	MCK01	-	-	Coal	Lower Gus	6.5	14	52	39	3.80	0.44	-	-	Non-PAG

Note: PAG refers to Potentially Acid Generating and Non-PAG refers to Non Potentially Acid Generating. INC refers to Inconclusive results

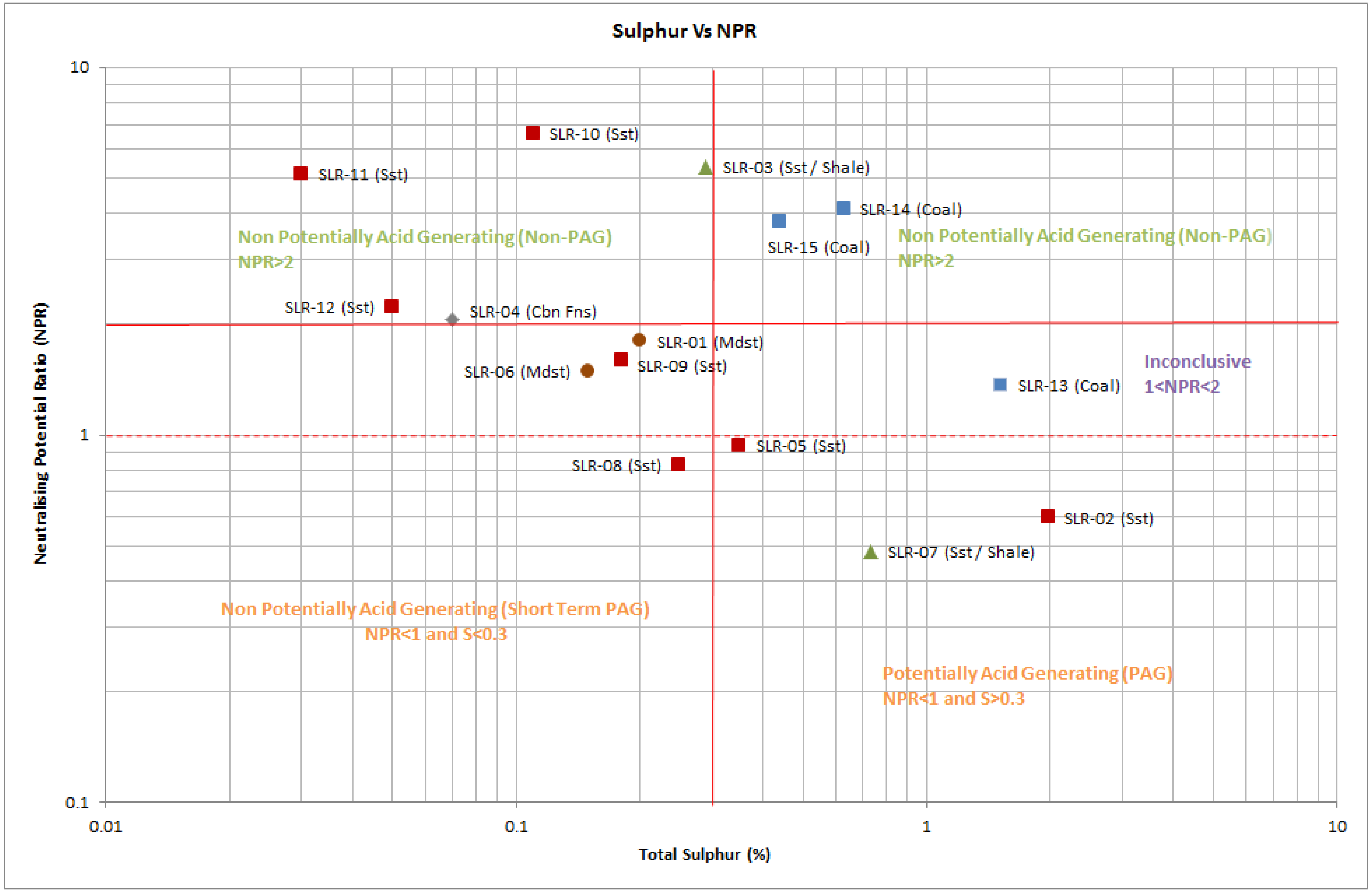

FIGURE 4-1: TOTAL SULPHUR CONTENT VERSUS NEUTRALISING POTENTIAL RATIO FOR SAMPLES

4.3 MINERALOGY

With the exception of the three coal samples, the twelve (12) roof, floor and parting samples were sent to Waterlab (Pty) in Pretoria, South Africa for mineralogical analysis. Waterlab subcontracted the analysis to XRD Analytical and Consulting.

THE CRYSTALLINE MINERALOGY OF THE TWELVE (12) SAMPLES IS DETAILED IN TABLE 4-2 AND PRESENTED GRAPHICALLY IN

Figure 4-2.

The key minerals of each of the twelve samples are consistent with the different lithological units at the site:

- Quartz, illite and to a lesser extent Kaolinite are dominant in the sandstone samples and the sandstone / shale samples.
    - Illite, a micaceous mineral which forms through the weathering of silicates and through the degradation of muscovite, is dominant in the majority of samples from borehole MCK-11. Illite can provide neutralising potential, but only at a low pH due to the dissolution behaviour of illite.
    - Kaolinite, a clay mineral, and quartz were of near equal proportions in two samples; SLR-05 (Borehole MCK01) and SLR-08 (Borehole MCK-09). Kaolinite can provide neutralising potential, but only at a low pH due to the dissolution behaviour of kaolinite.
- Kaolinite is dominant in the two mudstone samples and the carbonaceous fines sample.
- Microline and muscovite were also found in all samples at 10% or higher.
- Although not dominant in samples, calcite is present in all but one sample (SLR-05 - sandstone). Calcite is the most reactive / fastest neutralising carbonate mineral and will provide significant neutralising potential.
- The bulk neutralising potential (NP), determined through the ABA test work, is a measure of all neutralising carbonate minerals. The NP can be calculated based on the calcite content only. A comparison of the two NP values for all samples, as presented in Figure 4-3 shows that for the majority of samples, the values are similar which suggests the bulk NP is attributed to the calcite.
- No sulphide minerals were identified in any of the samples.

TABLE 4-2: MINERALOGY (%) FOR SAMPLES COLLECTED FROM THE SITE

Sample ID	Borehole	Lithology	Description	Calcite	Chlorite	Illite	Kaolinite	Lizardite	Microcline	Muscovite	Quartz
				$CaCO_3$	$(Mg,Fe)5Al(AlSi_3O_{10})(OH)_8$	$K0.7\ Al_2((OH)_2\ Al\ Si_3\ O_{10})$	$Al_2\ Si_2\ O_5(OH)_4$	$Mg_3Si_2O_5(OH)_4$	$K\ Al\ Si_3\ O_8$	$K\ Al_2((OH)_2\ Al\ Si_3\ O_{10})$	SiO_2
SLR-01	MCK01	Mudstone	Roof of Upper Gus	0.22	5.23	12.85	35.56	3.36	10.48	9.98	22.32
SLR-02	MCK01	Medium grained Sandstone	Roof of Upper Gus	2.42	5.58	8.28	21.57	3.3	14.1	9.69	35.07
	MCK01	Medium grained Sandstone	Roof of Upper Gus								
SLR-03	MCK01	Shale/sandstone	Gus Parting	5.46	2.73	7.14	26.51	4.32	13.13	5.56	35.15
SLR-04	MCK01	Carbonaceous fines	Floor of Lower Gus	0.81	4.2	14.85	37.64	5.05	6.77	9.33	21.34
SLR-05	MCK01	Medium grained Sandstone	Floor of Lower Gus	0	3.91	16.47	26.09	4.32	12.42	10.42	26.37
SLR-06	MCK09	Mudstone	Roof of Upper Gus	0.36	4.7	19.68	28.33	2.6	9.11	10.29	24.93
SLR-07	MCK09	Shale/Sandstone	Gus parting	1.8	3.88	12.21	9.7	2.83	15.9	5.93	47.77
SLR-08	MCK09	Medium grained Sandstone	Floor of Lower Gus	0.77	5.39	8.4	29.17	5.45	10.7	10.75	29.38
SLR-09	MCK11	Medium grained Sandstone	Roof of Upper Gus	1.85	3.96	26.52	1.38	0.31	13.85	11.97	40.17
SLR-10	MCK11	Sandstone (sharp upper and lower contacts)	Gus parting	4.45	5.44	34.11	1.49	0.99	10.17	11.45	31.9
SLR-11	MCK11	Medium grained Sandstone	Floor of Lower Gus	1.33	2.1	44.4	3.78	0.92	5.8	12.99	28.67
SLR-12	MCK11	Medium grained Sandstone	Floor of Lower Gus	0.99	5.88	43.15	1.89	1.07	9.08	14.33	23.59
SLR-13	MCK07	Coal	Upper Gus	-	-	-	-	-	-	-	-
SLR-14	MCK07	Coal	Lower Gus	-	-	-	-	-	-	-	-
SLR-15	MCK01	Coal	Lower Gus	-	-	-	-	-	-	-	-

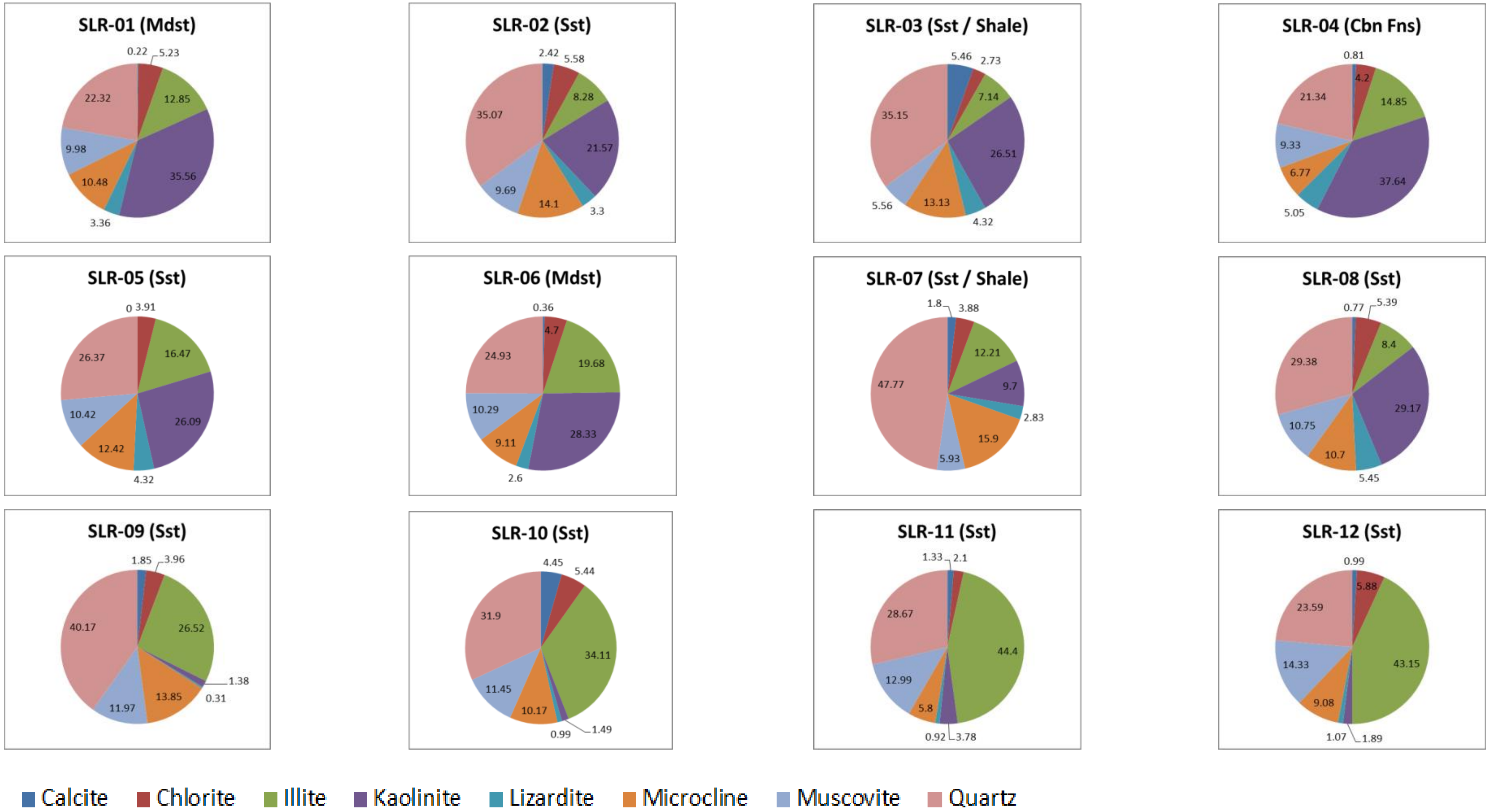

FIGURE 4-2: MINERALOGY OF COMMISSIEKRAAL SAMPLES

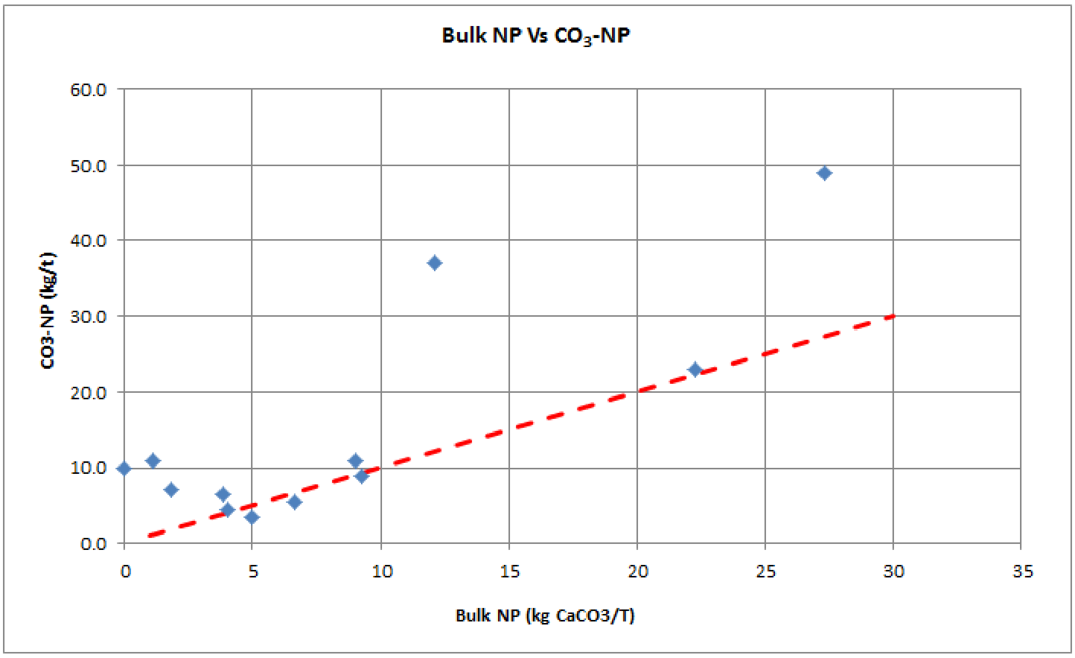

FIGURE 4-3:COMPARISON OF BULK NP AND CO3-NP

4.4 METAL LEACHING POTENTIAL

The SPLP test results are presented in Table 4-3.

The final pH of the leachates was higher than the initial pH 7, which indicates the presence of leachable alkalinity in the samples. The leach results reflect the calcite identified in the mineralogy test work. The results indicate that, in PAG samples, there is likely to be a lag time as readily available alkalinity is consumed before acid generation occurs.

4.5 PRELIMINARY RISK ASSESSMENT

Leach test results are not an indicator of drainage quality as the conditions of the test, especially the liquid-to-solid ratio, do not represent actual field conditions. Therefore, leachate concentrations are not representative of seepage or run-off that could emanate from site. However, the results may indicate chemicals of concern (CoCs) in mine drainage.

As part of this assessment, SPLP tests were undertaken using distilled water (pH 7) to represent neutral drainage conditions. As a preliminary screening to identify potential CoCs, the leachates were compared to the following relevant water quality and effluent standards:

- South African National Standards (SANS) 241 (2011) Drinking Water (SANS 241:2011).
- International Finance Corporation (IFC) Guidelines for Mining Effluents (IFC, 2007).
- World Health Organisation (WHO) Guidelines for drinking-water quality (WHO, 2011).

Use of drinking water guidelines does not suggest that leachates and drainage from mine activities will be used for drinking purposes. Use of these guidelines is purely intended as a preliminary indicator of potential environmental risk.

Based on the guideline comparison:

- pH is neutral to slightly alkaline.
- Alkalinity can be leached from the samples.
- A number of metals are leachable at concentrations in excess of relevant water quality standards including aluminium (Al), antimony (Sb), arsenic (As), iron (Fe), selenium (Se) and fluoride (F).

4.6 SUMMARY OF RESULTS

The results show a significant variability that is largely due to the small number of samples. Acid generation potential varies significantly within the same lithology.

The acid generating potential is not linked to lithology but more likely linked to mineralogy. In general, lithologies formed under reducing conditions, such as coal, mudstone, and perhaps siltstone, are more likely to include pyrite. Therefore, these lithologies are more likely to be PAG. However, this is not invariable, as sandstone mineralogy can also include pyrite. Indeed, several sandstone samples tested in this study are PAG.

The presence of calcite in most samples is significant as this is readily available to neutralise acid generated from pyrite oxidation. The mineralogy results suggest that calcite is common in the sampled lithologies and makes up all of the available neutralisation potential (NP) in the majority of samples. This is a natural AMD mitigation. However, calcite is readily soluble and can be dissolved through interaction of the lithology with water. This may reduce the availability of NP to offset acid generated from pyrite oxidation.

Although based on limited number of samples, the results suggest that those samples with dominant illite tend to be Non-PAG and those with a high kaolinite content are more likely to be PAG or have an uncertain potential. This is related to clay minerals. Some of the secondary minerals may have deleterious effects on water quality because of the release of additional acidity during their formation.

There appears to be no trend with regards to the leaching potential of elements and the acid generating potential or lithology.

TABLE 4-3: SPLP RESULTS FOR SAMPLES COLLECTED FROM THE SITE

							Ag	Al	As	Au	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni
SANS 241 (2011) Operational								0.3																			
SANS 241 (2011) Aesthetic																				0.3				0.1		200	
SANS 241 (2011) Acute Heath																											
SANS 241 (2011) Chronic Health									0.01							0.003	0.5	0.05	2	2				0.5			0.07
IFC (2007)									0.1							0.05			0.3	2							0.5
WHO (2011)									0.01		2.4	0.7				0.003		0.05	2								0.07
							mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Sample Name	Borehole	From (mbgl)	To (mbgl)	Length (m)	Lithology	Description	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
SLR-01	MCK01	100.03	101.12	1.09	Mudstone	Roof of Upper Gus	0.010	0.141	<0.010	<0.010	0.019	0.291	<0.010	<0.010	13	<0.010	<0.010	<0.010	<0.010	0.020	4.5	0.011	4.30	0.013	0.042	12	<0.010
SLR-02	MCK01	101.12	101.22	0.1	Medium grained Sandstone	Roof of Upper Gus	<0.010	0.075	<0.010	0.021	<0.010	0.172	<0.010	<0.010	45	<0.010	<0.010	<0.010	<0.010	0.014	7.0	0.016	14	0.054	0.020	7.12	<0.010
	MCK01	101.36	101.41	0.05	Medium grained Sandstone	Roof of Upper Gus																					
SLR-03	MCK01	102.22	102.4	0.18	Shale/sandstone	Gus Parting	<0.010	0.085	<0.010	<0.010	<0.010	0.236	<0.010	<0.010	24	<0.010	<0.010	<0.010	<0.010	<0.010	3.3	<0.010	4.93	0.011	<0.010	4.83	<0.010
SLR-04	MCK01	105.16	105.4	0.24	Carbonaceous fines	Floor of Lower Gus	<0.010	0.259	<0.010	<0.010	0.019	0.147	<0.010	<0.010	4.95	<0.010	<0.010	<0.010	<0.010	0.021	3.1	<0.010	1.66	<0.010	0.013	6.01	<0.010
SLR-05	MCK01	105.4	106.46	1.06	Medium grained Sandstone	Floor of Lower Gus	<0.010	0.164	<0.010	<0.010	<0.010	0.166	<0.010	<0.010	10	<0.010	<0.010	<0.010	<0.010	0.010	5.5	<0.010	3.43	0.022	0.026	2.99	<0.010
SLR-06	MCK09	153.08	154.27	1.19	Mudstone	Roof of Upper Gus	<0.010	0.819	0.013	<0.010	0.062	0.039	<0.010	<0.010	1.28	<0.010	<0.010	<0.010	<0.010	0.392	1.8	<0.010	0.479	<0.010	0.053	66	<0.010
SLR-07	MCK09	154.55	154.85	0.3	Shale/Sandstone	Gus parting	<0.010	0.204	<0.010	<0.010	<0.010	0.219	<0.010	<0.010	15	<0.010	<0.010	<0.010	<0.010	0.018	5.6	0.010	2.16	0.017	0.005	36	<0.010
SLR-08	MCK09	156.3	157.3	1	Medium grained Sandstone	Floor of Lower Gus	<0.010	1.81	0.011	<0.010	0.025	0.056	<0.010	<0.010	1.54	<0.010	<0.010	<0.010	<0.010	0.494	3.8	<0.010	0.123	0.014	0.041	49	<0.010
SLR-09	MCK11	137.4	138.4	1	Medium grained Sandstone	Roof of Upper Gus	<0.010	0.998	0.010	<0.010	0.028	0.047	<0.010	<0.010	1.13	<0.010	<0.010	<0.010	<0.010	0.173	3.7	<0.010	0.251	<0.010	0.040	50	<0.010
SLR-10	MCK11	138.73	139.34	0.61	Sandstone (sharp upper and lower contacts)	Gus parting	<0.010	0.694	0.043	<0.010	0.043	0.024	<0.010	<0.010	1.08	<0.010	<0.010	<0.010	<0.010	0.066	2.6	<0.010	0.417	<0.010	0.042	63	<0.010
SLR-11	MCK11	142.1	142.57	0.47	Medium grained Sandstone	Floor of Lower Gus	0.017	0.940	0.018	<0.010	0.076	0.044	<0.010	<0.010	0.444	<0.010	<0.010	<0.010	0.029	0.069	0.8	<0.010	0.112	<0.010	0.062	32	0.011
SLR-12	MCK11	142.57	143.57	1	Medium grained Sandstone	Floor of Lower Gus	<0.010	0.812	0.014	<0.010	0.081	0.037	<0.010	<0.010	1.73	<0.010	<0.010	<0.010	<0.010	0.063	1.2	<0.010	0.458	<0.010	0.083	44	0.016

									P	Pb	Sb	Se	Si	Sn	Sr	Ti	U	V	W	Y	Zn	Zr	pH	Electrical Conductivity	Total Alkalinity as CaCO3	Chloride as Cl	Sulphate as SO4	Nitrate as N	Fluoride as F
SANS 241 (2011) Operational																							5 - 9.7						
SANS 241 (2011) Aesthetic																					5			170		300			
SANS 241 (2011) Acute Heath																											250	11	
SANS 241 (2011) Chronic Health										0.01	0.02	0.01					0.015	0.2									500		1.5
IFC (2007)										0.2											0.5		6-9						
WHO (2011)										0.01	0.02	0.04					0.03											11	1.5
									mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	pH Unit	mS/m	mg/l	mg/l	mg/l	mg/l	mg/l
Sample Name	Sample Name	Lab ID	Borehole	From (mbgl)	To (mbgl)	Length (m)	Lithology	Description	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	-	-	-	<5	<5	<0.2	<0.2
SLR-01	SLR-01 (Mdst)	27730	MCK01	100.03	101.12	1.09	Mudstone	Roof of Upper Gus	0.031	<0.010	<0.010	0.015	0.9	<0.010	0.706	0.014	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	7.9	17.2	52.00	<5	32	<0.2	0.2
SLR-02	SLR-02 (Sst)	27731	MCK01	101.12	101.22	0.1	Medium grained Sandstone	Roof of Upper Gus	<0.010	<0.010	<0.010	<0.010	0.6	<0.010	1.38	0.041	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	8.10	38.70	76.00	14.00	124.00	<0.2	<0.2
			MCK01	101.36	101.41	0.05	Medium grained Sandstone	Roof of Upper Gus																					
SLR-03	SLR-03 (Sst / Shale)	27732	MCK01	102.22	102.4	0.18	Shale/sandstone	Gus Parting	<0.010	<0.010	<0.010	<0.010	0.6	<0.010	0.877	0.022	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	7.9	19.4	56.00	<5	43	<0.2	<0.2
SLR-04	SLR-04 (Cbn Fns)	27733	MCK01	105.16	105.4	0.24	Carbonaceous fines	Floor of Lower Gus	<0.010	<0.010	<0.010	<0.010	1.3	<0.010	0.334	0.018	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	7.4	7.7	36.00	<5	<5	<0.2	0.2
SLR-05	SLR-05 (Sst)	27734	MCK01	105.4	106.46	1.06	Medium grained Sandstone	Floor of Lower Gus	0.018	<0.010	<0.010	<0.010	0.8	<0.010	0.577	0.017	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	7.7	11.6	40.00	<5	16	<0.2	<0.2
SLR-06	SLR-06 (Mdst)	27735	MCK09	153.08	154.27	1.19	Mudstone	Roof of Upper Gus	0.365	<0.010	<0.010	0.021	1.3	<0.010	0.023	0.020	<0.010	<0.010	<0.010	<0.010	0.016	<0.010	8.1	32.8	104.00	<5	62	<0.2	1.9
SLR-07	SLR-07 (Sst / Shale)	27736	MCK09	154.55	154.85	0.3	Shale/Sandstone	Gus parting	0.011	<0.010	<0.010	<0.010	0.8	<0.010	1.26	0.019	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	8.1	29.1	76.00	7	73	<0.2	<0.2
SLR-08	SLR-08 (Sst)	27737	MCK09	156.3	157.3	1	Medium grained Sandstone	Floor of Lower Gus	<0.010	<0.010	<0.010	<0.010	1.5	<0.010	0.074	0.011	<0.010	<0.010	<0.010	<0.010	0.010	<0.010	8.5	22.9	108.00	<5	13	0.3	0.8
SLR-09	SLR-09 (Sst)	27738	MCK11	137.4	138.4	1	Medium grained Sandstone	Roof of Upper Gus	0.101	<0.010	<0.010	0.010	1.3	<0.010	0.032	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	8.5	23.5	120.00	<5	12	0.3	0.8
SLR-10	SLR-10 (Sst)	27739	MCK11	138.73	139.34	0.61	Sandstone (sharp upper and lower contacts)	Gus parting	0.349	<0.010	<0.010	0.016	1.3	<0.010	<0.010	0.011	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	8.8	29.1	164.00	<5	5	<0.2	1.3
SLR-11	SLR-11 (Sst)	27740	MCK11	142.1	142.57	0.47	Medium grained Sandstone	Floor of Lower Gus	0.173	<0.010	<0.010	0.014	1.4	<0.010	0.015	0.011	<0.010	<0.010	<0.010	<0.010	0.034	<0.010	8.2	16.2	80.00	<5	9	0.5	2.9
SLR-12	SLR-12 (Sst)	27741	MCK11	142.57	143.57	1	Medium grained Sandstone	Floor of Lower Gus	0.293	<0.010	4.39	<0.010	1.2	<0.010	0.015	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	7.9	21.3	64.00	<5	48	<0.2	1.4

Note: highlighted cells indicate an exceedence of the corresponding water quality limit

5 POTENTIAL DRAINAGE QUALITY

Based on a review of literature, it was assumed that the drainage quality from the coal mine may have the following characteristics (SLR, 2014):

- Acidic nature (low pH)
- Contain elevated concentration of sulphate, total dissolved solids and metals including iron, manganese, aluminium and other heavy metals.

More detailed results from this assessment suggest that the drainage quality from Commissiekraal is likely to have the following characteristics:

- Initially neutral pH. However, acid generation may occur after an initial lag period during which available alkalinity is consumed.
- Contain elevated concentrations of aluminium (Al), antimony (Sb), arsenic (As), iron (Fe), selenium (Se) and fluoride (F).
- Should acid conditions become prevalent, concentrations of sulphate and total dissolved solids will increase significantly.

The presence of PAG characteristics in samples of Gus roof and floor material suggest that the acid generation potential is not evenly distributed in these materials. The potential to generate acid generation in the underground workings will depend on the distribution of PAG material, and the neutralisation potential of non-PAG material that can mitigate acid generation. The limited number of samples collected for this assessment is not sufficient to indicate the potential PAG/non-PAG balance in the underground workings.

If the sample set in this study is considered an indicator of bulk lithological properties associated with the Gus seam underground workings, then the workings are non-PAG. However, much of the NP is attributed to calcite which is subject to dissolution on exposure in the workings. Therefore, not all NP will be available for acid neutralisation. Therefore, uncertainty remains as to whether water in the proposed underground workings will turn acidic in the long term after the available calcite is exhausted. This can only be determined from kinetic testing.

6 CONCLUSIONS

A geochemical assessment was undertaken for the Commissiekraal Coal Project located north of Utrecht in northern KwaZulu-Natal.

The geochemical assessment undertaken and presented in the report has characterised 'roof' and 'floor' material of the Gus Coal Seams within the proposed underground mining area. In addition coal material from the Gus Seams was characterised. Characterisation however was limited to the acid / neutralising generating potential due to limited sample available for geochemical test work after resource characterisation test work.

Based on the results, the following conclusions are drawn:

- The ABA results show a significant variability between samples, with four classified as PAG, four as inconclusive and eight as Non-PAG.
- The acid generating potential is not linked to lithology but more likely linked to mineralogy.
- No sulphide minerals were identified in any of the samples though mineralogy test work, although the number of samples tested was limited.
- The presence of PAG characteristics in samples of Gus roof and floor material however suggest that the acid generation potential is not evenly distributed in these materials and the limited number of samples collected for this assessment is not sufficient to indicate the potential PAG/non-PAG balance in the underground workings.
- Calcite is present in most samples and significant as it is readily available to neutralise acid generated from oxidation of any sulphide minerals. However, calcite is readily soluble and can be dissolved through interaction of the lithology with water. In PAG samples, there is likely to be a lag time as readily available alkalinity is consumed before acid generation occurs.
- There appears to be no trend with regards to the leaching potential of elements and the acid generating potential or lithology.
- The drainage quality from Commissiekraal is likely to have the following characteristics:
    - Initially neutral pH. However, acid generation may occur after an initial lag period during which available alkalinity is consumed.
    - Contain elevated concentrations of aluminium (Al), antimony (Sb), arsenic (As), iron (Fe), selenium (Se) and fluoride (F).
    - Should acid conditions become prevalent, concentrations of sulphate and total dissolved solids will increase significantly
- If the sample set in this study is considered an indicator of **bulk lithological properties** associated with the Gus Seam underground workings, then the workings are non-PAG. However, much of the NP is attributed to calcite which is subject to dissolution on exposure in the workings. Therefore, not

all NP will be available for acid neutralisation. Therefore, uncertainty remains as to whether water in the proposed underground workings will turn acidic in the long term after the available calcite is exhausted. This can only be determined from kinetic testing.

7 RECOMMENDATIONS

Based on the assessment described in this report, SLR recommends the following:

- Conduct additional ABA testing of lithologies exposed in the underground workings (although this can wait until underground development is underway).
- Further geochemical work on coal samples to determine metal leaching potential. Samples must be fresh and uncontaminated and preferably within the underground mining area.
- Conduct kinetic testing of at least two samples representative of the bulk lithology that will be exposed in the workings.

REFERENCES

Digby Gold (2013) *Review of Results of Exploration Programme at Commissiekraal (R1)* Ref.: D081304

Johnson, M.R., Anhaeusser. C.R. and Thomas, R.J (Eds.) (2006). *The Geology of South Africa.* Geological Society if South Africa, Johannesburg / Council for Geoscience, Pretoria, 691 pp.

McCarthy, T.S. and Pretorius, K (2009*) Coal mining on the Highveld and its implications for future water quality in the Vaal River System*. Abstracts of the International Mine Water Conference. Proceedings ISBN Number: 978-0-9802623-5-3.

MSA Group (2011) Commissiekraal Coal Project: Independent Technical Report summarising the scientific and technical information concerning mineral exploration, development and production activities on eDumbe Coal Consortium's Commissiekraal Coal Prospecting Asset, Kwa-Zulu Natal, South Africa. Project Code J1998. NI 43-101 Report.

Jenny Ellerton **(Report Author)**

Alex Pheiffer **(Project Manager)**

Terry Harck **(Project Reviewer)**

APPENDIX A: LABORATORY CERTIFICATES

RECORD OF REPORT DISTRIBUTION

SLR Reference:	710.02038.00004
Title:	Geochemical Assessment. Phase 2 : Geochemical Characterisation for Underground Mining
Site name:	Commissiekraal Coal Project, KwaZulu Natal
Report Number:	01
Client:	Tholie Logistics (Pty) Ltd

Name	Entity	No. of copes	Date issued	Issuer
Alex Pheiffer	SLR	1	Oct 2015	J. Ellerton

global environmental solutions

JOHANNESBURG

Fourways Office
P O Box 1596, Cramerview, 2060,
SOUTH AFRICA

Unit 7, Fourways Manor Office Park,
1 Macbeth Ave (On the corner with Roos Street), Fourways, Johannesburg,
SOUTH AFRICA

T: +27 (0)11 467 0945