SOUTH32 SOUTH AFRICA COAL HOLDINGS (PTY) LTD

WOLVEKRANS COLLIERY: VANDYKSDRIFT CENTRAL MINING INFRASTRUCTURE DEVELOPMENT
COAL SLURRY
GEOCHEMICAL ASSESSMENT AND WASTE CLASSIFICATION REPORT

Report No.: JW103/19/G535 - Rev 0

April 2019

Jones & Wagener
Engineering & Environmental Consultants
Internet presence: www.jaws.co.za

DOCUMENT APPROVAL RECORD

Report No.: JW103/19/G535 - Rev 0

ACTION	FUNCTION	NAME	DATE	SIGNATURE
Prepared	Natural Scientist	Marius van Zyl	18 April 2019	
Reviewed	Geochemist	Louis Naudé	29 April 2019	
Approved	Natural Scientist	Tolmay Hopkins	29 April 2019	

LOCATION:	Lat:	-26.07
(Decimal Degrees)	Long:	29.29

RECORD OF REVISIONS AND ISSUES REGISTER

Date	Revision	Description	Issued to	Issue Format	No. Copies
25/04/2019	A	Draft for internal review	L. Naudé	Electronic	NA
29/04/2019	0	Draft for client review	Goodness Bopape	Electronic	NA

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ACRONYMS AND ABBREVIATIONS	
ABA	Acid base accounting
ATSDR	Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services
°C	Degrees Celsius
CAS	Chemical Abstract Service Number
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
ℓ	Litres
LC	Leach concentration in mg/ℓ
LCT	Leach concentration threshold in mg/ℓ
LC_{50}	The atmospheric or aquatic concentration of substance that is lethal to 50% of the exposed population.
LD_{50}	The amount of a toxic agent (as a poison, virus, or radiation) that is sufficient to kill 50 percent of a population of animals usually within a certain time.
LOAEL	Lowest observed adverse effect level
mg/kg	Milligram per kilogram
mg/ℓ	Milligram per litre
min	minute
mm	millimetre
NAG	Nett acid generation
pH	A sign used for indicating the acidity or alkalinity of a solution on a logarithmic scale on which 7 (pH 7) is neutral, lower values are more acid and higher values more alkaline. The pH is equal to $-\log_{10}c$, where c is the hydrogen ion concentration in moles per litre
SANS	South African National Standard
SDS	Safety Data Sheet
STOT-RE	Specific target organ toxicity – repeat exposure
TC	Total concentration in mg/kg

ACRONYMS AND ABBREVIATIONS	
TCT	Total concentration threshold in mg/kg
TDS	Total dissolved solids
TWA-OEL-RL	Time weighted average: Occupational Exposure Limit – Recommended Limit
XRD	X-Ray Diffraction

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1. INTRODUCTION

1.1 Background

South32 SA Coal Holdings (Pty) Ltd (SAEC), is the holder of an amended mining right for coal granted by the Minister of Mineral Resources in terms of the Mineral and Petroleum Resources Development Act (MPRDA) and notarially executed on the 21st of May 2015 under Department of Mineral Resources (DMR) reference MP30/5/1/2/2/379MR in respect of SAEC's Wolvekrans Colliery.

Wolvekrans Colliery comprises of the following sections:

- Wolvekrans North Section (now referred to as Ifalethu Colliery) consisting of the Hartbeestfontein, Bankfontein (mining now ceased), Goedehoop, Klipfontein sections and the North Processing Plant. This was previously known as Middelburg Colliery; and
- Wolvekrans South Section (now referred to as Wolvekrans Colliery) consisting of the Wolvekrans, Vlaklaagte (mining ceased), Driefontein, Boschmanskrans, Vandyksdrift, Albion, Steenkoolspruit sections and South Processing Plants (Eskom and Export). This was previously known as Douglas Colliery.

The Vandyksdrift Central (VDDC) area falls within the footprint of historic underground mining operations at the old Douglas Colliery. In 2007, an amendment of the Environmental Management Programme Report (EMPR) for the Douglas Colliery operations was approved to allow the opencast mining of the remaining No. 5, No. 4, No. 2 and No. 1 seams. The opencast mining operations include the extraction of the remaining pillars, as well as roof and floor extraction.

Historically fine coal slurry was disposed of in the No. 2 seam mine workings. During the opencast mining process, therefore, the fine coal slurry will be removed together with the coal recovered from the remaining pillars, roof and floor extraction. The fine coal will be in a wet state, due to the historical flooding of the mine and, hence, the mixed Run of Mine (ROM coal) and slurry will be firstly stored on mixed ROM and coal slurry stockpile areas where it will be allowed to dry. The mixed ROM coal and coal slurry will be transported to the existing processing plant.

South32 requested Jones & Wagener Engineering and Environmental Consultants, (Pty) Ltd (J&W) to classify the fine coal slurry as required in terms of the "*Waste Classification and Management Regulations*", Government Notice Regulations (GNR) 634 of August 2013 (DEA, 2013). In addition, a geochemical assessment of the fine coal slurry is also required.

1.2 Objectives

The objectives of this project and, hence this report are as follows:

- Conduct a geochemical assessment of the fine coal slurry;
- Conduct a SANS 10234 classification of the fine coal slurry as required in terms of GNR 634;
- Develop a Safety Data Sheet (SDS) for the fine coal slurry based on the SANS 10234 classification results.

The fine coal slurry classification took the wet and dry states of the fine coal into account.

2. ANALYSES CONDUCTED

2.1 Samples

South32 collected the samples for the geochemical assessment and waste classification by pumping two VDDC boreholes that extends into the mine workings where slurry was historically disposed of, boreholes WBH 2510 and UB 110. During the pumping process significant amounts of water were abstracted together with the fine coal slurry as shown in **Plate 2-1** below.

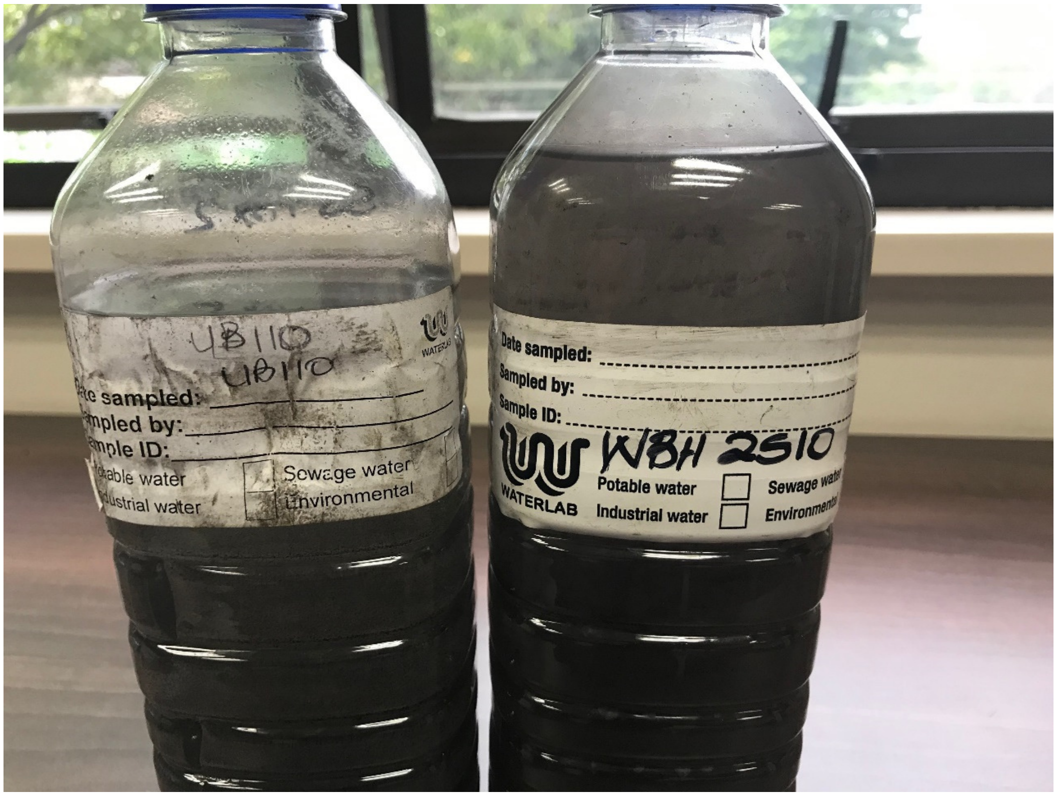

Plate 2-1: Water samples collected from VDDC boreholes

2.2 Analyses conducted

The samples containing the fine coal was submitted to Waterlab, a SANAS accredited laboratory located in Pretoria on 19 February 2019, for the required analyses. Due to the very limited amounts of fine coal in the water samples, the solid fractions were combined after the filtering process of the two water samples in order to ensure sufficient availability of sample for the various tests.

The following analyses were conducted on the fine coal recovered from the samples after drying:

- XRD analysis, including the determination of the amorphous percentage (coal);
- TCLP (pH 5.0) leach test to determine the leachable concentrations (LCs) of the metals, anions and organics of concern;
- Bio-elution, including gastric, intestinal, alveolar and sweat tests, of the metals and anions of interest. These tests are required for the SANS 10234 health classification. The tests were not performed on the;
- Transformation dissolution testing of the metals and anions of interest, This tests are required for the SANS 10234 aquatic environment classification. These tests were not performed on the;
- Total concentration (TC) analyses of the fine coal:
- Sulfur speciation, Nett Acid Generation (NAG) and Acid Base Accounting (ABA).

A paste pH could not be conducted due to the limited fine coal slurry recovered from the two water samples.

Physical hazard tests, such as flammability, could not be performed on the coal slurry due to the limited amount of sample recovered, i.e., 16 grams

The two water fractions from which the fine coal was removed, was also analysed as this information may augment available information for the geohydrological studies undertaken at VDDC.

The laboratory certificates are attached as **Appendix A**.

3. GEOCHEMICAL ASSESSMENT

3.1 Minerology

The results from the XRD analysis of the fine coal are presented in **Table 3-1**. The major minerals in the fine coal sample in descending order are kaolinite, quartz, muscovite, microcline, goethite and dolomite. The amorphous (graphite) percentage in the sample was 54.45%. It is noted the XRD results did not indicate any pyrite (FeS) or siderite ($FeCO_3$), which can result in the generation of Acid Mine Drainage (AMD)[1].

Table 3-2 shows the total concentrations of various heavy metals in the coal slurry sample collected. Also indicated in the table are the Alloway Crustal Abundance concentrations of the particular elements, which is simply an indication of the average abundance of an element in the earth's crust (Alloway *et al.*, 1995). By calculating the ratio of the elemental concentrations to the average composition of the earth's crust (Crustal abundances) an

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[1] Although initially adding to alkalinity, the eventual oxidation of the ferrous iron of the siderite, and the precipitation of iron hydroxide consumes base ions thereby reducing the ability of siderite to off-set acid generation (Skousen *et al.*). This means there is potential for over estimate on of neutralising potential in the laboratory ABA testing.

indication can be obtained whether the concentration of a particular element is raised above the average crustal abundance due to natural processes.

The comparison to the average Crustal Abundance is geochemically accepted as a means of highlighting elements, which may possibly be enriched in the various lithologies. Although enrichment does not necessarily indicate that the element is likely to be an environmental risk, it does, however, indicate where attention should be focussed when assessing metal mobility/solubility.

Based on the information obtained, the coal slurry has concentrations of arsenic, barium, iron, molybdenum and zinc which are elevated above the average Alloway Crustal Abundance- see **Table 3-2**.

Table 3-1: XRD Analysis Results

Fine Coal Slurry Sample from No 2 Seam		
Mineral	**Chemical Formula**	**Amount (weight %)**
Quartz	SiO_2	14.18
Goethite	FeO(OH)	0.51
Kaolinite	$Al_2Si_2O_5(OH)_4$	21.13
Dolomite	$Ca/Mg\ (CO_3)_2$	0.41
Microcline	$KAlSi_3O_8$	4.52
Muscovite	$KAl_2((OH)_2AlSi_3O_{10}$	4.8
Amorphous (likely to be organic carbon)		54.45

Table 3-2: Total concentrations and Alloway Abundance Ratios

	Fine Coal Slurry		Alloway Crystal Abundance
Element	**mg/kg**	**Ratio**	**mg/kg**
Antimony (Sn)	2.00	0.9	2.2
Arsenic (As)	6.00	**4.0**	1.5
Barium (Ba)	548	**1.3**	425
Cadmium (Cd)	<0.400	NA	0.1
Cobalt (Co)	13	0.7	20
Chromium (Cr)	66	0.7	100
Copper (Cu)	26	0.5	50
Iron (Fe)	3.8%	**1.2**	3.2%
Lead (Pb)	1.6	0.1	14
Mercury (Hg)	<0.400	NA	0.05
Manganese (Mn)	412	0.4	950
Molybdenum (Mo)	2	**1.3**	1.5
Nickel (Ni)	36	0.5	80
Selenium (Se)	<4.0	NA	0.05
Vanadium (V)	64	0.4	160

Element	Fine Coal Slurry		Alloway Crystal Abundance
	mg/kg	Ratio	mg/kg
Zinc (Zn)	94	**1.3**	75

4. ACID BASE ACCOUNTING AND NETT ACID GENERATION

4.1 Introduction

Coal deposits and the associated carbonaceous shales are associated with the sulfide mineral pyrite (FeS_2). Sulfide minerals are geochemically unstable and will spontaneously begin to oxidise to produce undesirable effects such as a low pH, high sulfate concentrations and significant increases in the concentrations of certain other elements, such as aluminium, iron and manganese, when exposed to both oxygen and water.

The chemical reactions governing pyrite oxidation (Evangelou and Zhang, 1995) are as follows:

$$FeS_2 + 7/2O_2 + 2H_2O \rightarrow 2Fe^{2+} + 2SO_4^{2-} + 2H^+$$

$$Fe^{2+} + 1/4O_2 + H^+ \rightarrow Fe^{3+} + 1/2H_2O$$

$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3(s) + 3H^+$$

$$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$$

Reactions 1 and 4 indicate that Fe^{3+} and O_2 are the major oxidants of pyrite given rise to a weak sulfuric acid (H_2SO_4), which lowers the pH of the associated water. The low pH then results in the mobilisation of heavy metals, such as manganese. Reaction 1 shows the direct reaction of O_2 with pyrite to produce Fe^{2+} which is then oxidised to Fe^{3+} by O_2 as shown in Reaction 2. Finally, Reaction 3 shows $Fe(OH)_3$ precipitate formation. (Evangelou and Zhang, 1995).

At low pH (< 4.5), Fe^{3+} oxidises pyrite much more rapidly than O_2, and O_2 oxidises dissolved Fe^{2+} to Fe^{3+}. For this reason, Reaction 2 is known to be the rate-limiting step in abiotic pyrite oxidation. However, iron-oxidising bacteria, especially *Thiobacillus ferrooxidans* and *Thiobacillus thiooxidans*, can accelerate the rate of Fe2+ oxidation by a factor of 106. *T. ferrooxidans* is an acidophilic chemolithotrophic organism that is abundant in geologic environments containing pyrite. Thus, in the presence of *T. ferrooxidans* and under low pH conditions, pyrite oxidation can be described by Reactions 2 and 4 (Evangelou and Zhang, 1995).

At neutral to alkaline pH values, the abiotic rate of Fe^{2+} oxidation rises rapidly, but the Fe^{3+} concentration also decreases greatly due to the precipitation of ferric hydroxide as described by Reaction 3. Because there is probably very little bacterial participation in pyrite oxidation at neutral to alkaline pH, some researchers suggested that in such environments, O_2 is a more important pyrite oxidant than Fe^{3+}. This suggestion, however, is contradicted by the finding that that Fe^{3+} is the preferred pyrite oxidant at circum-neutral pH, and the principle role played by O_2 is to oxidise Fe^{2+} and thereby sustain the pyrite oxidation cycle (Evangelou and Zhang, 1995).

Reaction 3, taking place at pH values as low as 3, is a readily reversible dissolution / precipitation reaction that serves as a source, as well as a sink of solution Fe3+, and is a major step in the release of acid to the environment (Evangelou and Zhang, 1995).

4.2 Methodology

Acid Base Accounting methods were used to determine the likelihood of acid generation occurring at some time in the future. In order to do this, a series of analytical tests were undertaken according to the modified Sobek method described in the Mine Environment Neutral Drainage (MEND) Manual 1.16.1b (Coastech Research Inc, 1991). The following procedures and tests were undertaken on the coal slurry sample:

- Drying of the samples at 40^oC;
- Grinding of the samples to < 0.075 mm;
- Total sulfur: determined by the LECO method and sulfate-sulfur determined by pyrolysis at 550^oC reported as % sulfur;
- Sulfide-sulfur: calculated by subtracting sulfate-sulfur from sulfide -sulfur;
- The Acid Generating Potential (AP): calculated from the total sulfur and sulfide sulfur; AP (kg/t $CaCO_3$) = 31.5 x % Sulfur;
- Neutralising Potential (NP): determined by titration of the sample with sulfuric acid and reported as kg/t $CaCO_3$;
- Nett Acid Generation (NAG): determined by complete oxidation of sulfide in the sample using 15% H_2O_2. Two results from the NAG test are reported the final pH of the solution and mass of acid in kg $CaCO_3$/t of required to titrate the solution back to pH 4.5 and 7.

4.3 ABA Assessment Methods

In this ABA study two assessment methods have been used to determine the potential for AMD (also referred to as Acid Rock Drainage [ARD]) from the fine coal slurry, namely the MEND (Price, 1997) method and the AMIRA (2002) method. Both of these methods are widely used in the industry and are internationally accepted.

MEND

The methodology for determining AMD potential according to the MEND method is as follows.

The Neutralising Potential Ratio (NPR) was calculated (NPR = NP/AP) and the sample classified according to the following:

- NPR < 1 : Potentially acid-generating (PAG);
- 1 < NPR < 2 : Uncertain potential for acid-generation; and
- NPR > 2: Non-acid-generating (NAG).

AMIRA

The AMIRA method uses the final NAG pH and Net Acid Producing Potential (NAPP) calculated by:

NAPP = AP – NP (note the AMIRA method uses units of kg H_2SO_4/t)

The criteria for assessment is as follows:

- If NAG pH < 4.5 and NAPP > 0 then the sample is potentially acid generating (PAG),
- If the NAG pH > 4.5 and the NAPP is < 0 then the sample is non-acid generating; otherwise,
- It is uncertain if the sample will be acid generating.

4.4 Coal Slurry

The coal slurry sample was subjected to Acid Base Accounting (ABA) and Net Acid Generation (NAG) potential testing. The results are indicated in **Table 4-1**.

The NPR results of the coal slurry is below one, the Net Acid Producing Potential is positive at NAG pH below 7.0 and the sample is therefore classified as Potentially Acid Generating (PAG) according to both the AMIRA and MEND systems – see **Table 4-1**.

Table 4-1: Acid Generation Potential Results

Parameter	VDDC COAL SLURRY
Paste pH	Not determined
Total Sulfur (%) (LECO)	0.50
Sulfate sulfur	0.43
Sulphide sulfuer	0.07
AMIRA	
Acid Potential (AP) (kg/t)	16
Neutralization Potential (NP)	12
Nett Neutralization Potential (NNP)	-3.64
Neutralising Potential Ratio (NP/AP)	0.766
MEND	
pH 4.5	
NAG pH	6.2
Nett Acid Producing Potential (kg H_2SO_4/t) TS	<0.01
pH 7	
NAG pH	6.2
Nett Acid Producing Potential (kg H_2SO_4/t) TS	0.02
ARD Assessment	
MEND - Based on total sulfur	Potentially Acid Generating
AMIRA - Based on total sulfur	Potentially Acid Generating
Overall	Potentially Acid Generating

5. SANS 10234 CLASSIFICATION

The results from the various analyses were used to classify the coal slurry in terms of SANS 10234 (SABS, 2008). SANS 10234 is similar to the Globally Harmonized System of Classification and Labelling of Chemicals (GHS), except that, as per South African legislation, non-general waste also has to be classified using SANS 10234 (DEA, 2013).

5.1 Physical hazards classification

5.1.1 Explosives

The coal slurry is assumed not to be explosive. Coal in general may, however, generate flammable volatiles, which may lead to explosions in a confined space.

5.1.2 Flammable gases

In terms of SANS 10234, flammable gases are:

1. Gases that, at 20°C and a standard pressure of 101.3 kPa:
   a. are ignitable when in a mixture of 13 % or less, by volume, in air; or
   b. have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit.
2. Gases that, at 20°C and a standard pressure of 101.3 kPa, are flammable while mixed in air.

The coal slurry, which is in a wet state, is not a gas.

5.1.3 Oxidizing gases

The coal slurry is unlikely to generate and or contain any oxidising gases, such as excessive oxygen concentrations or chlorine.

5.1.4 Gases under pressure

The coal slurry is not a gas.

5.1.5 Flammable liquids

SANS 10234 lists four categories for flammable liquids, namely:

1: Closed-cup flash point < 23 °C and initial boiling point < 35 °C

2: Closed-cup flash point < 23 °C and initial boiling point > 35 °C

3: Closed-cup flash point > 23 °C and < 60 °C

4: Closed-cup flash point > 60 °C < 93 °C

It is unlikely that the coal slurry will contain any flammable liquids as it is in a wet state.

5.1.6 Flammable solids

Two categories are distinguished:

Category 1: Substances or mixtures other than metal powders:

a. Burning time < 45 seconds or burning rate > 2.2 mm/s, and the wetted zone does not stop flame propagation for at least 4 min.
b. Metal powders with a burning time < 5 min.

Category 2: Substances or mixtures other than metal powders:

a. Burning time < 45 seconds or burning rate > 2.2 mm/s, and the wetted zone stops flame propagation for at least 4 min.
b. Metal powders with a burning time > 5 min and < 10 min.

It is highly unlikely that the coal slurry will exhibit any of the above characteristics, therefore it falls outside this category. The flammability of the coal slurry was discussed verbally with Mr Kobie Strydom of the CSIR's Firelab and he indicated that it is highly unlikely that the coal slurry will meet the flammability test criteria as stated above.

It is known that coal may contain flammable volatiles that may lead to spontaneous combustion – see **Section 6.4** in this regard.

5.2 Human health hazard classification

5.2.1 Introduction

Infotox conducted the SANS 10234 classification in terms human health hazards, which includes acute toxicity, skin and eye corrosion and irritation, skin and respiratory sensitisation, germ cell mutagenicity, carcinogenicity, reproductive toxicity, specific target organ toxicity and aspiration hazards.

The Infotox report for the coal slurry is attached as **Appendix B**.

5.2.2 Acute toxicity

In terms of SANS 10234 substances are allocated to one of five acute toxicity hazard categories based on acute toxicity (lethal dose data) by the oral, dermal or inhalation route of exposure. Acute toxicity values, namely, the 50 per cent lethal dose (LD_{50}) for oral or dermal exposure and the 50 per cent lethal concentration (LC_{50}) for inhalation exposure, are used for classification purposes.

The bio-elution - and the deionised water leach results conducted by Waterlab were used by Infotox to establish the oral, dermal and inhalation acute toxicity of the coal slurry. Based on the results obtained the slurry is not classified as acutely toxic by the oral, dermal or inhalation routes of exposure – see **Appendix B.**

5.2.3 Skin and eye corrosion and irritation

In terms of SANS 10234, substances may be classified as skin corrosives or skin irritants, depending on the results of animal toxicity studies, or based on the hazard classifications of constituents of the coal slurry. In addition, if the pH of the substance is less than 2.0 or more than 11.5, the substance is classified as a skin corrosive. If none of the criteria are met, the substance is classified as non-hazardous with regard to corrosive or irritant effects on the skin.

For this hazard assessment, Infotox used the sweat bio-elution results for the calculations.

The slurry is not classified as hazardous to the skin or eyes. Although SANS 10234:2008 does not include a specific hazard class for mechanical irritation, it is noted that dust and grit from dry coal slurry may cause mechanical abrasion, and thus irritation in case of prolonged exposure of the unprotected skin and eyes.

5.2.4 Skin and respiratory sensitisation

SANS 10234 defines a respiratory sensitiser as a substance that will cause hypersensitivity of the airways following inhalation of the substance and a skin sensitiser is a substance that will cause an allergic response following skin contact.

Based on the laboratory results evaluated, Infotox concluded that the coal slurry is not classified as a skin or respiratory sensitiser.

5.2.5 Germ cell mutagenicity

In terms of SANS 10234, germ cell mutagenicity entails chemicals that cause mutations in germ cells of humans and that can be transmitted to the progeny. Germ cells are cells in the reproductive tract that develop into sperm and ova.

A germ cell mutagen can be classified in one of two hazard categories according to the weight of evidence available. Test results obtained by animal testing for mutagenic and/or genotoxic effects in germ cells and/or somatic cells are considered.

The slurry is not classified as hazardous with regard to germ cell mutagenicity based on the laboratory results obtained – see **Appendix B**.

5.2.6 Carcinogenicity

SANS 10234 states that the classification of a substance as a carcinogen is based on the inherent properties of a substance and does not provide information on the level of the human cancer risk, which the use of the substance may present. Classification of a chemical or product as a carcinogen identifies a hazard but does not involve or imply any classification of the potential risks associated with exposure in terms of dose.

In terms of SANS 10234, substances with a concentration of 0.1% and above must be considered in terms of carcinogenicity.

Infotox did not classify the coal slurry as hazardous with regard to carcinogenicity – see **Appendix B**.

5.2.7 Reproductive toxicity

In terms of SANS 10234, reproductive toxicity includes the assessment of sexual function, fertility and developmental effects. Adverse effects on sexual function and fertility include alterations to the female and male reproductive system, adverse effects on gamete production and transport, fertility or pregnancy outcomes. Developmental toxicity includes any effect which interferes with normal development of the offspring, either before or after birth.

Infotox could not find any evidence the coal slurry is classifiable as a known or presumed human reproductive toxicant.

5.2.8 Specific target organ toxicity

In terms of SANS 10234 2008, the classification of a substance or mixture as a specific target organ toxicant can be assessed in terms of a single exposure or dose (STOT-S) or prolonged or repeated exposure (STOT-RE).

Based on the presence of quartz in the slurry, the coal slurry is classified as a Category 2 STOT-RE, which may cause damage to the lungs through prolonged or repeated inhalation in the case of dry slurry. As indicated by Infotox, the result of repeated exposure is not necessarily silicosis, but suitable respiratory equipment is recommended if dust is generated during use or handling.

The applicable SANS Hazard Code is:

H373: May cause damage to lungs through prolonged or repeated inhalation.

5.2.9 Aspiration hazards

None of the constituents of the slurry are specifically classified as aspiration hazards and it is not classified as corrosive. However, the slurry is muddy; therefore, it was classified as a Category 2 aspiration hazard by Infotox.

The applicable SANS Hazard Code is:

H305: May be harmful if swallowed and enters airways.

5.3 Aquatic environment hazards

In terms of SANS 10234, the primary objective for the classification of substances and mixtures as hazardous to the environment is to alert the user to the hazards these substances and mixtures present to ecosystems. It is known that certain substances and mixtures simultaneously, or alternatively, affect ecosystems that range from soil microflora to primates.

The GHS recommends the transformation/dissolution test for metals and metal compounds in aqueous media, and therefore Infotox used the results obtained from this test in order to determine whether or not the coal slurry poses an aquatic hazard.

Infotox concluded that the coal slurry is not hazardous to aquatic life, whether during or after short- or long-term exposure in the aquatic environment – see **Appendix B**.

6. OTHER REGULATORY REQUIREMENTS

6.1 Occupational Health and Safety Act

In terms of the South African Occupational Health and Safety Act's hazardous chemical substances regulations, as amended, the time weighted average occupational exposure recommended limit (TWA-OEL-RL) for coal dust is 2 mg/m^3 (Department of Labour, 1995).

6.2 Hazardous Substance Act

Not classified as hazardous.

6.3 SANS 10228

Coal is not listed in SANS 10228 (2012) as a hazardous substance.

6.4 International Maritime Solid Bulk Cargoes Code

The primary aim of the International Maritime Solid Bulk Cargoes Code (IMSBC Code) is to facilitate the safe stowage and shipment of solid bulk cargoes by providing information on the dangers associated with the shipment of certain types of solid bulk cargoes (e.g. structural damage due to improper cargo distribution, loss or reduction of stability during a voyage, chemical reactions of cargoes, such as spontaneous combustion, emission of toxic or explosive gases, corrosion, etc.), and instructions on the procedures to be adopted when the shipment of solid bulk cargoes is contemplated.

The IMSBC Code classifies solid cargoes into three categories:

- Group A – bulk materials that may liquefy;
- Group B – bulk materials possessing chemical hazards;
- Group C – bulk materials that are neither liable to liquefy nor possess chemical hazards.

Coal and anthracite are subject to a schedule under the IMSBC Code and have been assigned to Cargo B since they may create flammable atmospheres, may heat spontaneously, may deplete the oxygen concentration and may corrode metal structures (ARCHE, 2014).

Although not specifically tested for in this project, but based on the above, the coal slurry has been assigned to the IMSBC Code Cargo B shipping requirements.

7. MEASURES TO BE IMPLEMENTED AT THE MIXED ROM COAL AND SLURRY STOCKPILE AREAS

Based on the SANS 10234 classification conducted, the following measures should be implemented at the mixed ROM and coal slurry stockpile areas as specified in the SDS – see **Appendix C**.

The applicable hazard pictogram and hazard labels must appear at the entrances of the mixed ROM coal and coal slurry storage and processing areas, as well as transport vehicles. Signage indicating the required personal protective equipment that must be worn, must also be displayed at the entrances.

The following personal protective equipment must be worn in relation to the fine coal slurry:

- Protective clothing and eye protection;
- Protective gloves when handling the coal slurry by hand;
- Respiratory protection (manufacturer/supplier to specify equipment) in case of repeated exposure to fine coal dust, i.e., employees exposed during working hours on a continuous daily basis.

In addition, air quality monitoring should be conducted to ensure the required Time Weighted Average Occupation Exposure Limit Recommended Limit (TWA-OEL-RL) of 2.0 mg/m^3 is not exceeded as stipulated in the Occupational Health and Safety Act's hazardous chemical substance regulations of August 1995, as amended (Department of Labour, 1995).

As coal dust may cause explosions, all electrical equipment used at the mixed ROM coal and coal slurry storage and processing areas must be earthed, while confined spaces must be well ventilated.

During fire-fighting, full body protective clothing and positive pressure, self-contained breathing apparatus with a full-face piece should be worn.

8. CONCLUSIONS

Based on the assessments conducted, the coal slurry may pose two Category 2 health risks based on the SANS 10234 2008 classification, namely:

- May cause damage to lungs through prolonged or repeated inhalation (SANS 10234 hazard code H373).
- May be harmful if swallowed and enters airways (SANS 10234 hazard code H305).

Based on the two health risks identified and the Category 2 assignment, the following pictogram needs to be displayed at the coal slurry handling and storage facilities:

Although SANS 10234:2008 does not include a specific hazard class for mechanical irritation, dust and grit from the coal slurry may cause mechanical abrasion, and thus irritation in case of prolonged exposure of the unprotected skin and eyes, therefore protective clothing should be worn.

In general, it is well known that coal may:

- Create flammable atmospheres,
- Heat spontaneously,
- Deplete the oxygen concentration, and
- Corrode metal structures.

Based on the geochemical tests conducted on the limited coal slurry sample, the VDDC coal slurry may generate acid mine drainage (AMD).

9. RECOMMENDATIONS

The following is recommended:

- The fine coal slurry SDS must be approved by South32 SA Coal Holdings once reviewed, and the contents of the SDS then brought under the attention of all the employees and contractors working at VDDC.
- The hazard pictogram and hazard labels must appear at the entrances of mixed ROM coal and coal slurry storage and processing areas, as well as transport vehicles. Signage indicating the required personal protective equipment that must be worn, must also be displayed at the entrances.
- Air quality monitoring should be conducted to ensure the required TWA-OEL-RL of 2.0 mg/m^3 for coal dust is not exceeded.
- All electrical equipment used at the mixed ROM coal and coal slurry storage and processing areas must be earthed, while confined spaces must be well ventilated to prevent.
- During fire-fighting, full body protective clothing and positive pressure, self-contained breathing apparatus with a full-face piece should be worn.

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Marius van Zyl Pr Sci Nat

Louis Naudé

Tolmay Hopkins Pr Sci Nat
Project Director
for Jones & Wagener

18 April 2019
Document source: https://joneswagener.sharepoint.com/JonesWagenerProjects/G535VDDCIRP/Shared Documents/PRJ/REP/Slurry Classification/G535_27_REP_Rev0_MvZthln_VDDC_29April2019.docx
Document template: repGen_19r0.dotx

SOUTH32 SOUTH AFRICA COAL HOLDINGS (PTY) LTD

WOLVEKRANS COLLIERY: VANDYKSDRIFT CENTRAL MINING INFRASTRUCTURE DEVELOPMENT
COAL SLURRY
GEOCHEMICAL ASSESSMENT AND WASTE CLASSIFICATION REPORT

Report: JW103/19/G535 - Rev 0

APPENDIX A

WATERLAB LABORATORY CERTIFICATES

WATERLAB

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CERTIFICATE OF ANALYSES
X-RAY DIFFRACTION

Date received: 2019-02-20
Project number: 132

Report number: 81060a

Date completed: 2019-04-12
Order number: PO19-09925

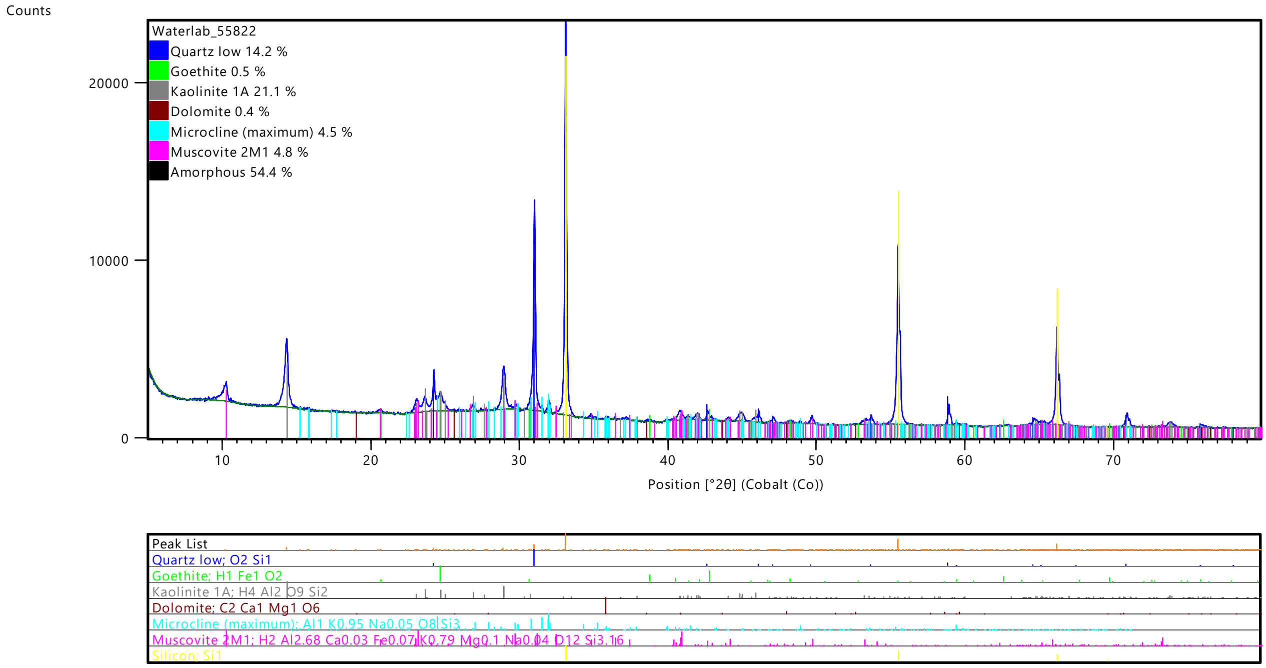
Client name: Jones & Wagener
Address: PO Box 1434, Rivonia, 2128
Telephone: 011 519 0200

Facsimile: 011 519 0201

Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za
Cell: 082 880 1250

Composition (%) [s]	
Coal Slurry	
55822	
Mineral	Amount (weight %)
Quartz	14.18
Goethite	0.51
Kaolinite	21.13
Dolomite	0.41
Microcline	4.52
Muscovite	4.8
Amorphous	54.45

[s] Results obtained from sub-contracted laboratory



E. Botha
Geochemistry Project manager

CERTIFICATE OF ANALYSES
X-RAY DIFFRACTION

Date received: 2019-02-20 **Date completed: 2019-04-12**
Project number: 132 **Report number: 81060a** **Order number: PO19-09925**

Client name: Jones & Wagener **Contact person: Marius van Zyl**
Address: PO Box 1434, Rivonia, 2128 **Email: vanzyl@jaws.co.za**
Telephone: 011 519 0200 **Facsimile: 011 519 0201** **Cell: 082 880 1250**

Note:

The material was prepared for XRD analysis using a back loading preparation method. Additionally the material was scanned after addition of 20 % Si for quantitative determination of amorphous content and micronizing in a McCrone micronizing mill. It was analysed with a Malvern Panalytical Aeris diffractometer with PIXcel detector and fixed slits with Fe filtered Co-Kα radiation. The phases were identified using X'Pert Highscore plus software.The relative phase amounts (weight %) were estimated using the Rietveld method.

Comment:

- In case the results do not correspond to results of other analytical techniques, please let me know for further fine tuning of XRD results – results may have to be verified.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group.
- Due to preferred orientation and crystallite size effects, results may not be as accurate as shown.
- Traces of additional phases may be present.
- Sample may contain organic carbon.
- Amorphous phases, if present, were not taken into consideration during quantification.
- Determination of amorphous content can carry an error of +- 15 weight per cent

Ideal Mineral compositions:

Compound Name	Ideal Chemical Formula
Quartz	SiO2
Goethite	Fe O OH
Kaolinite	Al2 Si2 O5 (OH)4
Dolomite	Ca Mg (C O3)2
Muscovite	K Al2 ((OH)2 Al Si3 O10)
Microcline	K Al Si3 O8

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Geochemistry Project manager

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CERTIFICATE OF ANALYSES
SULPHUR SPECIATION

Methods from: Prediction Manual For Drainage Chemistry from Sulphidic Geological Materials MEND Report 1.20.1

Date received: 2019-02-20
Project number: 132
Report number: 81060
Date completed: 2019-03-22
Order number: PO19-09925

Client name: Jones & Wagener
Address: PO Box 1434, Rivonia, 2128
Telephone: 011 519 0200
Facsimile: 011 519 0201
Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za
Cell: 082 880 1250

Sulphur Speciation*	**Sample Identification**	
	Coal Slurry	**Coal Slurry**
Sample Number	**55822**	**55822 D**
Total Sulphur (%) (LECO)	0.50	0.50
Sulphate Sulphur as S (%)	0.43	0.44
Sulphide Sulphur (%)	0.07	0.06

Notes:

- Samples analysed with Pyrolysis at 550°C as per Prediction Manual For Drainage Chemistry from Sulphidic Geological Materials MEND Report 1.20.1. Multiply Sulphate Sulphur to calculate SO4 % by 2.996. Please see the method for interferences.
- Organic Sulphur is not taken into account and may be included in the results.
- Please let me know if results do not correspond to other data.

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CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2019-02-20
Project number: 132
Report number: 81060
Date completed: 2019-03-22
Order number: PO19-09925

Client name: Jones & Wagener
Address: PO Box 1434, Rivonia, 2128
Telephone: 011 519 0200
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Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za
Cell: 082 880 1250

Acid – Base Accounting Modified Sobek (EPA-600)	**Sample Identification**
	Coal Slurry
Sample Number	**55822**
Paste pH	Insufficient sample
Total Sulphur (%) (LECO)	0.50
Acid Potential (AP) (kg/t)	16
Neutralization Potential (NP)	12
Nett Neutralization Potential (NNP)	-3.64
Neutralising Potential Ratio (NPR) (NP : AP)	0.766
Rock Type	I

*** Negative NP values are obtained when the volume of NaOH (0.1N) titrated (pH: 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 – 2.5 Any negative NP values are corrected to 0.00.**

Please refer to Appendix (p.2) for a Terminology of terms and guidelines for rock classification

E. Botha
Geochemistry Project Manager

Date received: 2019-02-20 **Date completed: 2019-03-22**
Project number: 132 **Report number: 81060** **Order number: PO19-09925**

Client name: Jones & Wagener **Contact person: Marius van Zyl**
Address: PO Box 1434, Rivonia, 2128 **Email: vanzyl@jaws.co.za**
Telephone: 011 519 0200 **Facsimile: 011 519 0201** **Cell: 082 880 1250**

APPENDIX: TERMINOLOGY AND ROCK CLASSIFICATION

TERMINOLOGY (SYNONYMS)

- Acid Potential (AP) ; *Synonyms*: Maximum Potential Acidity (MPA)
  Method: Total S(%) (Leco Analyzer) x 31.25
- Neutralization Potential (NP) ; *Synonyms:* Gross Neutralization Potential (GNP) ; *Syn*: Acid Neutralization Capacity (ANC) (The capacity of a sample to consume acid)
  Method: Fizz Test ; Acid-Base Titration (Sobek & Modified Sobek (Lawrence) Methods)
- Nett Neutralization Potential (NNP) ; *Synonyms:* Nett Acid Production Potential (NAPP)
  Calculation: NNP = NP – AP ; NAPP = ANC – MPA
- Neutralising Potential Ratio (NPR)
  Calculation: NPR = NP : AP

CLASSIFICATION ACCORDING TO NETT NEUTRALISING POTENTIAL (NNP)

If NNP (NP – AP) < 0, the sample has the potential to generate acid
If NNP (NP – AP) > 0, the sample has the potential to neutralise acid produced

Any sample with NNP < 20 is potentiall acid-generating, and any sample with NNP > -20 might not generate acid (Usher *et al*., 2003)

ROCK CLASSIFICATION

TYPE I	Potentially Acid Forming	Total S(%) > 0.25% and NP:AP ratio 1:1 or less
TYPE II	Intermediate	Total S(%) > 0.25% and NP:AP ratio 1:3 or less
TYPE III	Non-Acid Forming	Total S(%) < 0.25% and NP:AP ratio 1:3 or greater

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CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2019-02-20
Project number: 132
Report number: 81060
Date completed: 2019-03-22
Order number: PO19-09925

Client name: Jones & Wagener
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Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za
Cell: 082 880 1250

CLASSIFICATION ACCORDING TO NEUTRALISING POTENTIAL RATIO (NPR)

Guidelines for screening criteria based on ABA (Price *et al.*, 1997; Usher *et al.*, 2003)

Potential for ARD	Initial NPR Screening Criteria	Comments
Likely	**< 1:1**	Likely AMD generating
Possibly	**1:1 – 2:1**	Possibly AMD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides
Low	**2:1 – 4:1**	Not potentially AMD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	**>4:1**	No further AMD testing required unless materials are to be used as a source of alkalinity

CLASSIFICATION ACCORDING TO SULPHUR CONTENT (%S) AND NEUTRALISING POTENTIAL RATIO (NPR)

For sustainable long-term acid generation, at least 0.3% Sulphide-S is needed. Values below this can yield acidity but it is likely to be only of short-term significance. From these facts, and using the NPR values, a number of rules can be derived:

1) Samples with less than 0.3% Sulphide-S are regarded as having insufficient oxidisable Sulphide-S to sustain acid generation.
2) NPR ratios of >4:1 are considered to have enough neutralising capacity.
3) NPR ratios of 3:1 to 1:1 are consider inconclusive.
4) NPR ratios below 1:1 with Sulphide-S above 3% are potentially acid-generating. (Soregaroli & Lawrence, 1998 ; Usher *et al.*, 2003)

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CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2019-02-20
Project number: 132
Report number: 81060
Date completed: 2019-03-22
Order number: PO19-09925

Client name: Jones & Wagener
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CERTIFICATE OF ANALYSES
NET ACID GENERATION

Date received: 2019-02-20
Project number: 132
Report number: 81060
Date completed: 2019-03-22
Order number: PO19-09925

Client name: Jones & Wagener
Address: PO Box 1434, Rivonia, 2128
Telephone: 011 519 0200
Facsimile: 011 519 0201
Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za
Cell: 082 880 1250

Net Acid Generation	**Sample Identification: pH 4.5**
	Coal Slurry
Sample Number	**55822**
NAG pH: (H_2O_2)	6.2
NAG (kg H_2SO_4 / t)	<0.01

Net Acid Generation	**Sample Identification: pH 7**
	Coal Slurry
Sample Number	**55822**
NAG pH: (H_2O_2)	6.2
NAG (kg H_2SO_4 / t)	0.20

Notes:

- Samples analysed with Single Addition NAG test as per Prediction Manual For Drainage Chemistry from Sulphidic Geological Materials MEND Report 1.20.1.
- Please let me know if results do not correspond to other data.

E. Botha
Geochemistry Project Manager

WATERLAB

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CERTIFICATE OF ANALYSES
GENERAL WATER QUALITY PARAMETERS

Date received: 2019 - 02 - 21
Date completed: 2019 - 03 – 07
Project number: 132
Report number: 81065
Order number: PO19-09925

Client name: Jones & Wagener Consulting Civil Engineers
Address: P.O. Box 1434, Rivonia, 2128
Telephone: 011 519 0217
Facsimile: 011 519 0201
Contact person: Mr. M. van Zyl
e-mail: vanzyl@jaws.co.za
Mobile: 082 880 1250

Analyses in mg/ℓ (Unless specified otherwise)	**Method Identification**	**Sample Identification**	
		UB110	**WBH2510**
Sample Number		55842	55843
pH – Value at 25°C	WLAB065	7.4	6.7
Electrical Conductivity in mS/m at 25°C	WLAB002	50.4	14.5
Total Alkalinity as $CaCO_3$	WLAB007	204	80
Chloride as Cl	WLAB046	26	5
Sulphate as SO_4	WLAB046	24	<2
Fluoride as F	WLAB014	1.4	0.3
Nitrate as N	WLAB046	<0.1	0.4
Ortho Phosphate as P	WLAB046	<0.1	<0.1
Hexavalent Chromium as Cr^{6+} *	WLAB032	<0.010	<0.010
Full Quantitative ICP-MS/OES Analysis (Dissolved)*	WLAB050	See Attached Report: 81065-A	
% Balancing *	---	98.1	94.2

*** = Not SANAS Accredited**
Tests marked "Not SANAS Accredited" in this report are not included in the SANAS Schedule of Accreditation for this Laboratory.

Ard van de Wetering
____
Technical Signatory

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CERTIFICATE OF ANALYSES

TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received:	**20/02/2019**		**Date completed:**	**22/03/2019**
Project number:	**132**	**Report number: 81060**	**Order number:**	**PO19-09925**

Client name:	**Jones & Wagener**	**Contact person:**	**Marius van Zyl**
Address:	**PO Box 1434, Rivonia, 2128**	**Email:**	**vanzyl@jaws.co.za**
Telephone:	**0115190200**	**Cell:**	**082 880 1250**

Analyses		
	Coal Slurry	
Sample Number	**55822**	
TCLP / Acid Rain / Distilled Water / H_2O_2	**Distilled Water**	
Dry Mass Used (g)	**2.5**	
Volume Used (mℓ)	**50**	
Inorganic Anions	**mg/ℓ**	**mg/kg**
Chloride as Cl	28	560
Sulphate as SO4	48	960
Nitrate as N	<0.1	<2.0
Fluoride as F	1.0	20
Ortho-Phosphate as P	0.2	4.0
Hexavalent Chromium as Cr6+	<0.010	<0.200
ICP-MS full Quant	See ICP DW tab	
Acid Base Accounting	See attached report 81060 ABA	
Net Acid Generation	See attached report 81060 NAG	
Sulphur Speciation	See attached report 81060 SS	
Bio elution	See attached 81060 Bio-elution	
Transformation / Dissolution Test	See attached 81060 TDT	
X-ray Diffraction [s]	See attached report 81060 XRD	

Please note:

- The blank is subtracted from all leach results, except pH and Electrical Conductivity.
- [s] = Subcontracted
- The water with coal slurry sample were decanted to split the water. We took care not to lose any of the coal slurry. Therefore the sample was dried with some of the water.

E. Botha
Geochemistry Project Manager

WATERLAB (PTY) LTD
CERTIFICATE OF ANALYSES
ICP-MS QUANTITATIVE ANALYSIS

Date received: 20/02/2019
Project number: 132

Date completed: 22/03/2019
Report number: 81060

Client name: Jones & Wagener
Address: PO Box 1434, Rivonia, 2128

Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za

Extract	Sample Mass (g)	Volume (ml)	Factor
Distilled Water	2.5	50	20

Sample Id	Sample Number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	3.35	67	0.002	0.044

Sample Id	Sample Number	Au	Au	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	0.078	1.55	0.248	4.96

Sample Id	Sample Number	Be	Be	Bi	Bi	Ca	Ca
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<1	<20
Coal Slurry	55822	0.001	0.020	<0.001	<0.020	9	180

Sample Id	Sample Number	Cd	Cd	Ce	Ce	Co	Co
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	0.023	0.450	0.006	0.120

Sample Id	Sample Number	Cr	Cr	Cs	Cs	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	0.031	0.620	0.001	0.020	0.018	0.355

Sample Id	Sample Number	Dy	Dy	Er	Er	Eu	Eu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	0.001	0.029	0.001	0.020	0.001	0.020

Sample Id	Sample Number	Fe	Fe	Ga	Ga	Gd	Gd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	9.63	193	0.008	0.164	0.002	0.048

Sample Id	Sample Number	Ge	Ge	Hf	Hf	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	0.002	0.046	<0.001	<0.020

Sample Id	Sample Number	Ho	Ho	In	In	Ir	Ir
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	K	K	La	La	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.5	<10.0	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	6.5	130	0.010	0.196	0.011	0.215

Sample Id	Sample Number	Lu	Lu	Mg	Mg	Mn	Mn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<1	<20	<0.025	<0.500
Coal Slurry	55822	<0.001	<0.020	4	80	0.228	4.56

Sample Id	Sample Number	Mo	Mo	Na	Na	Nb	Nd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<1	<20	<0.001	<0.020
Coal Slurry	55822	0.002	0.031	54	1080	<0.001	<0.020

Sample Id	Sample Number	Nd	Nd	Ni	Ni	Os	Os
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	0.011	0.220	0.017	0.340	<0.001	<0.020

Sample Id	Sample Number	P	P	Pb	Pb	Pd	Pd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	0.346	6.93	0.023	0.465	<0.001	<0.020

Sample Id	Sample Number	Pr	Pr	Pt	Pt	Rb	Rb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	0.003	0.058	<0.001	<0.020	0.014	0.279

Sample Id	Sample Number	Rh	Rh	Ru	Ru	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Sc	Sc	Se	Se	Si	Si
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.2	<4.0
Coal Slurry	55822	0.002	0.038	<0.001	<0.020	7.3	146

Sample Id	Sample Number	Sm	Sm	Sn	Sn	Sr	Sr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	0.002	0.049	<0.001	<0.020	0.149	2.99

Sample Id	Sample Number	Ta	Ta	Tb	Tb	Te	Te
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Th	Th	Ti	Ti	Tl	Tl
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	0.120	2.40	<0.001	<0.020

Sample Id	Sample Number	Tm	Tm	U	U	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	0.001	0.028	0.023	0.460

Sample Id	Sample Number	W	W	Y	Y	Yb	Yb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	<0.001	<0.020	0.005	0.104	<0.001	<0.020

Sample Id	Sample Number	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020
Coal Slurry	55822	0.072	1.44	0.005	0.097

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CERTIFICATE OF ANALYSES

TOTALS

Date received: 20/02/2019
Date completed: 22/03/2019
Project number: 132
Report number: 81060
Order number: PO19-09925

Client name: Jones & Wagener
Address: PO Box 1434, Rivonia, 2128
Telephone: 0115190200
Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za
Cell: 082 880 1250

Analyses		
	Coal Slurry	
Sample Number	55822	
Digestion	HNO3 : HF	
Dry Mass Used (g)	0.25	
Volume Used (mℓ)	100	
Units	mg/ℓ	mg/kg
ICP-MS full Quant	See tab ICP Digestion	

[s] = Subcontracted

E. Botha____________________
Geochemistry Project Manager

WATERLAB (PTY) LTD
CERTIFICATE OF ANALYSES
ICP-MS QUANTITATIVE ANALYSIS

Date received: 20/02/2019
Project number: 132
Date completed: 22/03/2019
Report number: 81060

Client name: Jones & Wagener
Address: PO Box 1434, Rivonia, 2128
Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za

Extract	Sample Mass (g)	Volume (ml)	Factor
HNO3 : HF	0.25	100	400

Sample Id	Sample Number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.100	<40	<0.001	<0.400
Coal Slurry	55822	<0.001	<0.400	108	43200	0.015	6.00

Sample Id	Sample Number	Au	Au	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	<0.001	<0.400	<0.001	<0.400	1.37	548

Sample Id	Sample Number	Be	Be	Bi	Bi	Ca	Ca
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<1	<400
Coal Slurry	55822	0.005	2.00	<0.001	<0.400	8	3200

Sample Id	Sample Number	Cd	Cd	Ce	Ce	Co	Co
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	<0.001	<0.400	0.044	18	0.033	13

Sample Id	Sample Number	Cr	Cr	Cs	Cs	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.164	66	0.011	4.40	0.064	26

Sample Id	Sample Number	Dy	Dy	Er	Er	Eu	Eu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.004	1.60	0.003	1.20	0.001	0.400

Sample Id	Sample Number	Fe	Fe	Ga	Ga	Gd	Gd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<10	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	94	37600	0.070	28	0.004	1.60

Sample Id	Sample Number	Ge	Ge	Hf	Hf	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.007	2.80	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	Ho	Ho	In	In	Ir	Ir
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.001	0.400	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	K	K	La	La	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.5	<200	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	25	10000	0.022	8.80	0.100	40

Sample Id	Sample Number	Lu	Lu	Mg	Mg	Mn	Mn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<1	<400	<0.025	<10
Coal Slurry	55822	<0.001	<0.400	4	1600	1.03	412

Sample Id	Sample Number	Mo	Mo	Na	Na	Nb	Nb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<1	<400	<0.001	<0.400
Coal Slurry	55822	0.005	2.00	6	2400	0.026	10

Sample Id	Sample Number	Nd	Nd	Ni	Ni	Os	Os
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.020	8.00	0.089	36	<0.001	<0.400

Sample Id	Sample Number	P	P	Pb	Pb	Pd	Pd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	1.98	792	0.056	22	0.004	1.60

Sample Id	Sample Number	Pr	Pr	Rb	Rb	Rh	Rh
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg

Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.005	2.00	0.074	30	<0.001	<0.400

Sample Id	Sample Number	Ru	Ru	Sb	Sb	Sc	Sc
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	<0.001	<0.400	<0.001	<0.400	0.088	35

Sample Id	Sample Number	Se	Se	Si	Si	Sm	Sm
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.2	<80	<0.001	<0.400
Coal Slurry	55822	<0.001	<0.400	340	136000	0.004	1.60

Sample Id	Sample Number	Sn	Sn	Sr	Sr	Ta	Ta
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.005	2.00	0.388	155	<0.001	<0.400

Sample Id	Sample Number	Tb	Tb	Te	Te	Th	Th
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.001	0.400	<0.001	<0.400	0.014	5.60

Sample Id	Sample Number	Ti	Ti	Tl	Tl	Tm	Tm
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	8.66	3464	0.002	0.800	<0.001	<0.400

Sample Id	Sample Number	U	U	V	V	W	W
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.008	3.20	0.160	64	0.002	0.800

Sample Id	Sample Number	Y	Y	Yb	Yb	Zn	Zn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400	<0.001	<0.400
Coal Slurry	55822	0.017	6.80	0.003	1.20	0.236	94

Sample Id	Sample Number	Zr	Zr
		mg/l	mg/kg
Det Limit		<0.001	<0.400
Coal Slurry	55822	0.371	148

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CERTIFICATE OF ANALYSES

BIO-ELUTION

Date received: 20/02/2019
Project number: 132
Report number: 81060
Date completed: 22/03/2019
Order number: PO19-09925

Client name: Jones & Wagener
Address: PO Box 1434, Rivonia, 2128
Telephone: 0115190200
Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za
Cell: 082 880 1250

Analyses	**Coal Slurry**		**Coal Slurry**		**Coal Slurry**		**Coal Slurry**	
Sample Number	**55822**		**55822**		**55822**		**55822**	
	Gastric		**Intestinal**		**Sweat**		**Alveolar**	
Dry Mass Used (g)	**1**		**1**		**1**		**1**	
Volume Used (mℓ)	**50**		**50**		**50**		**50**	
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**
Chloride as Cl	5	250	<2	<100	21	1050	133	6650
Sulphate as SO4	17	850	26	1300	12	600	23	1150
Nitrate as N	<0.1	<5.0	<0.1	<5.0	<0.1	<5.0	<0.1	<5.0
Fluoride as F	<0.2	<10	0.5	25	16	800	<0.2	<10
Ortho-Phosphate as P	4.1	205	<0.1	<5.0	<0.1	<5.0	<0.1	<5.0
Hexavalent Chromium as Cr6+	<0.010	<0.5	<0.010	<0.5	0.028	1.40	<0.010	<0.5
ICP-MS full Quant	See tab ICP Bio-Elution							

Bio-Elution Testing
Jones & Wagener
Report No 81060
Order No PO19-09925

Coal Slurry		**Lab ID**	***Coal Slurry***		**Lab ID**	***Coal Slurry***		**Lab ID**	***Coal Slurry***		**Lab ID**
Gastric Extraction		**55822**	**Intestinal**		**55822**	**Alveolar**		**55822**	**Sweat**		**55822**
Sample Weight		**1.0000**	**Sample Weight**		**1.0000**	**Sample Weight**		**1.0000**	**Sample Weight**		**1.0000**
Sample Volume		**50**	**Sample Volume**		**50**	**Sample Volume**		**50**	**Sample Volume**		**50**
Massa / liter		**50**	**Massa / liter**		**50**	**Massa / liter**		**50**	**Massa / liter**		**50**
Element	**mg/l**	**mg/kg**	**Element**	**mg/l**	**mg/kg**	**Element**	**mg/l**	**mg/kg**	**Element**	**mg/l**	**mg/kg**
Al	9.380	469	**Al**	0.014	1	**Al**	0.833	42	**Al**	0.000	0
Ca	77.060	3853	**Ca**	15.430	772	**Ca**	54.670	2734	**Ca**	0.000	0
Fe	195.500	9775	**Fe**	0.000	0	**Fe**	64.620	3231	**Fe**	0.445	22
K	3.090	155	**K**	0.000	0	**K**	0.765	38	**K**	0.000	0
Mg	10.220	511	**Mg**	7.190	360	**Mg**	15.530	777	**Mg**	4.100	205
Mn	6.160	308	**Mn**	0.194	10	**Mn**	4.784	239	**Mn**	0.183	9
Na	26.400	1320	**Na**	0.000	0	**Na**	14.500	725	**Na**	0.000	0
Si	17.560	878	**Si**	1.670	84	**Si**	3.450	173	**Si**	2.760	138
Ag	0.001	0	Ag	0.000	0	Ag	0.000	0	Ag	0.000	0
As	0.013	1	As	0.005	0	As	0.012	1	As	0.002	0
Au	0.009	0	Au	0.000	0	Au	0.001	0	Au	0.000	0
B	0.054	3	B	0.028	1	B	0.028	1	B	0.031	2
Ba	3.186	159	Ba	0.933	47	Ba	0.200	10	Ba	1.454	73
Be	0.010	1	Be	0.000	0	Be	0.000	0	Be	0.003	0
Bi	0.001	0	Bi	0.000	0	Bi	0.000	0	Bi	0.000	0
Cd	0.001	0	Cd	0.000	0	Cd	0.000	0	Cd	0.001	0
Ce	0.064	3	Ce	0.000	0	Ce	0.000	0	Ce	0.004	0
Co	0.104	5	Co	0.001	0	Co	0.003	0	Co	0.068	3
Cr	0.056	3	Cr	0.001	0	Cr	0.000	0	Cr	0.006	0
Cs	0.004	0	Cs	0.000	0	Cs	0.000	0	Cs	0.000	0
Cu	0.230	11	Cu	0.107	5	Cu	0.016	1	Cu	0.036	2
Dy	0.014	1	Dy	0.000	0	Dy	0.000	0	Dy	0.002	0
Er	0.008	0	Er	0.000	0	Er	0.000	0	Er	0.002	0
Eu	0.003	0	Eu	0.000	0	Eu	0.000	0	Eu	0.001	0
Ga	0.067	3	Ga	0.021	1	Ga	0.005	0	Ga	0.033	2
Gd	0.015	1	Gd	0.000	0	Gd	0.000	0	Gd	0.001	0
Ge	0.002	0	Ge	0.000	0	Ge	0.001	0	Ge	0.003	0
Hf	0.006	0	Hf	0.002	0	Hf	0.002	0	Hf	0.000	0
Hg	0.001	0	Hg	0.000	0	Hg	0.000	0	Hg	0.000	0
Ho	0.003	0	Ho	0.000	0	Ho	0.000	0	Ho	0.000	0
In	0.000	0	In	0.000	0	In	0.000	0	In	0.000	0
Ir	0.000	0	Ir	0.000	0	Ir	0.000	0	Ir	0.000	0
La	0.028	1	La	0.000	0	La	0.000	0	La	0.002	0
Li	0.012	1	Li	0.002	0	Li	0.002	0	Li	0.004	0
Lu	0.001	0	Lu	0.000	0	Lu	0.000	0	Lu	0.000	0
Mo	0.000	0	Mo	0.003	0	Mo	0.002	0	Mo	0.002	0
Nb	0.000	0	Nb	0.000	0	Nb	0.000	0	Nb	0.000	0
Pd	0.006	0	Pd	0.001	0	Pd	0.000	0	Pd	0.001	0
Pr	0.009	0	Pr	0.000	0	Pr	0.000	0	Pr	0.001	0
Pt	0.000	0	Pt	0.000	0	Pt	0.000	0	Pt	0.000	0
Rb	0.033	2	Rb	0.002	0	Rb	0.004	0	Rb	0.009	0
Rh	0.000	0	Rh	0.000	0	Rh	0.000	0	Rh	0.000	0
Ru	0.000	0	Ru	0.000	0	Ru	0.000	0	Ru	0.000	0
Sb	0.000	0	Sb	0.001	0	Sb	0.002	0	Sb	0.001	0
Sc	0.008	0	Sc	0.000	0	Sc	0.000	0	Sc	0.001	0
Se	0.000	0	Se	0.003	0	Se	0.000	0	Se	0.000	0
Sm	0.012	1	Sm	0.000	0	Sm	0.000	0	Sm	0.001	0
Sn	0.000	0	Sn	0.000	0	Sn	0.000	0	Sn	0.000	0
Sr	0.755	38	Sr	0.357	18	Sr	0.253	13	Sr	0.544	27
Ta	0.000	0	Ta	0.000	0	Ta	0.000	0	Ta	0.000	0
Tb	0.002	0	Tb	0.000	0	Tb	0.000	0	Tb	0.000	0
Te	0.000	0	Te	0.000	0	Te	0.000	0	Te	0.000	0
Th	0.012	1	Th	0.001	0	Th	0.000	0	Th	0.000	0
Ti	0.010	0	Ti	0.002	0	Ti	0.000	0	Ti	0.005	0
Tl	0.001	0	Tl	0.000	0	Tl	0.000	0	Tl	0.001	0
Tm	0.001	0	Tm	0.000	0	Tm	0.000	0	Tm	0.000	0
U	0.008	0	U	0.001	0	U	0.000	0	U	0.000	0
V	0.000	0	V	0.010	1	V	0.006	0	V	0.003	0
W	0.000	0	W	0.000	0	W	0.000	0	W	0.000	0
Y	0.071	4	Y	0.000	0	Y	0.000	0	Y	0.013	1
Yb	0.006	0	Yb	0.000	0	Yb	0.000	0	Yb	0.002	0
Zn	0.501	25	Zn	0.000	0	Zn	0.000	0	Zn	0.316	16
Zr	0.002	0	Zr	0.000	0	Zr	0.000	0	Zr	0.000	0

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CERTIFICATE OF ANALYSES
TRANSFORMATION / DISSOLUTION

Date received: 20/02/2019
Project number: 132
Report number: 81060
Date completed: 22/03/2019
Order number: PO19-09925

Client name: Jones & Wagener
Address: PO Box 1434, Rivonia, 2128
Telephone: 0115190200
Contact person: Marius van Zyl
Email: vanzyl@jaws.co.za
Cell: 082 880 1250

Analyses	**Coal Slurry**	
Sample Number	**55822**	
Dry Mass Used (g)	**0.1**	
Volume Used (mℓ)	**1000**	
Inorganic Anions	**mg/ℓ**	**mg/kg**
Chloride as Cl	<2	<20000
Sulphate as SO4	<2	<2000
Nitrate as N	<0.1	<1000
Fluoride as F	<0.2	<2000
Ortho-Phosphate as P	<0.1	<1000
Hexavalent Chromium as Cr6+	<0.010	<100
ICP-MS full Quant	See tab ICP TDT	

Transformation / Dissolution testing
Jones & Wagener
Report No 781060
Order No PO19-09925

		Lab ID
Coal Slurry		**55822**
Sample Weight		**0.1**
Sample Volume		**1000**
Massa / liter		**10000**
Element	**mg/l**	**mg/kg**
Al	0.000	0
Ca	0.000	0
Fe	0.000	0
K	0.039	390
Mg	0.070	700
Mn	0.002	20
Na	0.370	3700
Si	0.033	330
Ag	0.000	0
Al	0.000	0
As	0.000	2
Au	0.000	0
B	0.000	0
Ba	0.001	12
Be	0.000	0
Bi	0.000	0
Ca	7.450	74500
Cd	0.000	0
Ce	0.000	0
Co	0.000	1
Cr	0.000	0
Cs	0.000	0
Cu	0.000	0
Dy	0.000	0
Er	0.000	0
Eu	0.000	0
Fe	0.011	110
Ga	0.000	2
Gd	0.000	0
Ge	0.000	0
Hf	0.000	1
Hg	0.000	2
Ho	0.000	0
In	0.000	0
Ir	0.000	0
K	0.000	0
La	0.000	0
Li	0.000	0
Lu	0.000	0
Mg	0.000	0
Mn	0.000	0
Mo	0.000	0
Na	20.900	209000
Nb	0.000	0
Nd	0.000	0
Ni	0.000	0
Os	0.000	0
P	0.000	0
Pb	0.000	0
Pd	0.000	0
Pr	0.000	0
Pt	0.000	0
Rb	0.000	0
Rh	0.000	0
Ru	0.000	0
Sb	0.000	1
Sc	0.000	0
Se	0.000	0
Si	0.000	0
Sm	0.000	0
Sn	0.000	0
Sr	0.001	12
Ta	0.000	0
Tb	0.000	0
Te	0.000	2
Th	0.000	0
Ti	0.009	87
Tl	0.000	0
Tm	0.000	0
V	0.000	3
W	0.000	0
Y	0.000	0
Yb	0.000	0
Zn	0.000	0
Zr	0.000	0

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSIS

Proje
Client : **Jones and Wagener Engineering**
Report Number : **81065-A**

Sample Origin	Sample ID	Ag (mg/L)	Al (mg/L)	As (mg/L)	Au (mg/L)	B (mg/L)	Ba (mg/L)	Be (mg/L)	Bi (mg/L)	Ca (mg/L)	Cd (mg/L)	Ce (mg/L)	Co (mg/L)
		< 0.001	**<0.100**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**<1**	**< 0.001**	**< 0.001**	**< 0.001**
UB110	55842	< 0.001	< 0.100	< 0.001	< 0.001	0.119	0.582	< 0.001	< 0.001	21	< 0.001	< 0.001	0.002
WBH2510	55843	< 0.001	< 0.100	< 0.001	< 0.001	0.019	0.212	< 0.001	< 0.001	8	< 0.001	< 0.001	0.002

Sample Origin	Sample ID	Cr (mg/L)	Cs (mg/L)	Cu (mg/L)	Dy (mg/L)	Er (mg/L)	Eu (mg/L)	Fe (mg/L)	Ga (mg/L)	Gd (mg/L)	Ge (mg/L)	Hf (mg/L)	Hg (mg/L)
		< 0.001	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**<0.025**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
UB110	55842	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.041	0.036	< 0.001	< 0.001	0.001	< 0.001
WBH2510	55843	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.079	0.016	< 0.001	< 0.001	< 0.001	< 0.001

Sample Origin	Sample ID	Ho (mg/L)	In (mg/L)	Ir (mg/L)	K (mg/L)	La (mg/L)	Li (mg/L)	Lu (mg/L)	Mg (mg/L)	Mn (mg/L)	Mo (mg/L)	Na (mg/L)	Nb (mg/L)
		< 0.001	**< 0.001**	**< 0.001**	**<0.5**	**< 0.001**	**< 0.001**	**< 0.001**	**<1**	**<0.025**	**< 0.001**	**<1**	**< 0.001**
UB110	55842	< 0.001	< 0.001	< 0.001	4.3	< 0.001	0.007	< 0.001	13	0.248	0.001	68	< 0.001
WBH2510	55843	< 0.001	< 0.001	< 0.001	2.2	< 0.001	0.004	< 0.001	3	0.315	< 0.001	16	< 0.001

Sample Origin	Sample ID	Nd (mg/L)	Ni (mg/L)	Os (mg/L)	P (mg/L)	Pb (mg/L)	Pd (mg/L)	Pr (mg/L)	Pt (mg/L)	Rb (mg/L)	Rh (mg/L)	Ru (mg/L)	Sb (mg/L)
		< 0.001	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
UB110	55842	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.004	< 0.001	< 0.001	< 0.001
WBH2510	55843	< 0.001	0.002	< 0.001	0.023	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	0.001

Sample Origin	Sample ID	Sc (mg/L)	Se (mg/L)	Si (mg/L)	Sm (mg/L)	Sn (mg/L)	Sr (mg/L)	Ta (mg/L)	Tb (mg/L)	Te (mg/L)	Th (mg/L)	Ti (mg/L)	Tl (mg/L)
		< 0.001	**< 0.001**	**<0.2**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
UB110	55842	< 0.001	< 0.001	5.1	< 0.001	< 0.001	0.293	< 0.001	< 0.001	< 0.001	< 0.001	0.008	< 0.001
WBH2510	55843	< 0.001	< 0.001	10.1	< 0.001	< 0.001	0.091	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001

Sample Origin	Sample ID	Tm (mg/L)	U (mg/L)	V (mg/L)	W (mg/L)	Y (mg/L)	Yb (mg/L)	Zn (mg/L)	Zr (mg/L)
		< 0.001	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**
UB110	55842	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001
WBH2510	55843	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.004	< 0.001

APPENDIX B

INFOTOX WASTE CLASSIFICATION REPORT

INFOTOX (Pty) Ltd

2001/000870/07

Retrieval and scientific interpretation of ecotoxicological information

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Project conducted on behalf of Jones & Wagener

GHS Classification of Coal Slurry

Report No 014 - 2019 Rev 2.0

Compiled by

M H Fourie PhD MSc (Biological Science) MSc (Epidemiology)
Pr Sci Nat (Toxicological Science)

17 April 2019

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INSTITUTE OF PROFESSIONAL ENVIRONMENTAL PRACTICE
WILLEM C.A VAN NIEKERK
QUALIFIED ENVIRONMENTAL PROFESSIONAL
No. 07960160

WCA van Niekerk PhD QEP (USA) Pr Sci Nat (Environmental Science)
Managing Director

17 April 2019

Internal review:

WCA van Niekerk PhD QEP (USA) Pr Sci Nat (Environmental Science)

Expertise and Declaration of Independence

This report was prepared by INFOTOX (Pty) Ltd ("INFOTOX"). Established in 1991, INFOTOX is a professional scientific company, highly focused in the discipline of ecotoxicological risk assessment. Both occupational and environmental human health risks, as well as risks to ecological receptors, are addressed.

Dr Willie van Niekerk, Managing Director of INFOTOX, has BSc, Hons BSc and MSc degrees from the University of Potchefstroom and a PhD from the University of South Africa. He is a Qualified Environmental Professional (QEP), certified by the Institute of Professional Environmental Practice (IPEP) in the USA (No 07960160), and a registered Professional Natural Scientist (Pr Sci Nat, Environmental Science, No 400284/04). Dr Van Niekerk has specialised in chemical toxicology and human health risk assessments, but he has experience in many other areas in the disciplines of analytical and environmental sciences.

Dr Marlene Fourie has BSc and Hons BSc degrees from the University of Stellenbosch and MSc and PhD degrees from the University of Pretoria. Her field of specialisation is reproductive biology/toxicology. Dr Fourie also has an MSc-degree in epidemiology from the University of Pretoria. Following positions as Medical Natural Scientist at the Andrology Unit, Department of Urology, University of Pretoria and the Pretoria Academic Hospital from 1987 to 2001, she joined INFOTOX as a Medical Biological Scientist. Dr Fourie has conducted many health risk assessments and projects relating to the health status of communities. She is a registered Professional Natural Scientist (Pr Sci Nat, Toxicological Science, No 400190/14). Dr Fourie has completed the Globally Harmonised System (GHS) course *Classifying and Labelling Chemicals According to the UN GHS*, presented by the United Nations Institute for Training and Research (UNITAR) in 2017, with previous experience in GHS classification since 2010.

This specialist report was compiled for Jones & Wagener. We do hereby declare that we are financially and otherwise independent of Jones & Wagener.

Signed on behalf of INFOTOX (Pty) Ltd, duly authorised in the capacity of Managing Director:

WILLEM C.A. VAN NIEKERK
No. 07960160

Willem Christiaan Abraham van Niekerk

17 April 2019

Executive Summary

South Africa has adopted the Globally Harmonized System (GHS) of classification and labelling of chemicals, as represented in South African National Standard SANS 10234:2008. The aim of the GHS is to have, worldwide, the same:

- criteria for classifying chemicals according to their physical, health and environmental hazards; and
- hazard communication requirements for labelling and safety data sheets.

The GHS is based on a broad description of hazard classes in the main categories of physical hazards, hazards to human health and hazards to aquatic ecosystems. For each of the hazards a series of hazard statement codes (H-codes) has been developed, to assist in the classification. For each of the hazard statement codes that relates to the intrinsic properties of a hazardous constituent in the slurry under assessment there is a limiting concentration above which the slurry would classify as hazardous and below which it would be non-hazardous. Multi-component materials are dealt with by summation of concentrations of constituents with similar hazards. Where reference is made to the GHS in this report, it means the GHS as represented in SANS 10234:2008. Hazard classification according to the GHS is the basic step in the preparation of safety data sheets (SDSs) that provide information and codes for hazard communication.

A coal slurry sample was submitted for analysis by Jones & Wagener. Results were given to INFOTOX for hazard assessment following the approach and methods prescribed in SANS 10234:2008. INFOTOX has not evaluated any physical hazards as defined in the GHS. Physical hazards refer to explosive properties, flammability, self-reacting and self-heating characteristics, pyrophoric and oxidising properties, generation of hazardous or flammable gases when in contact with water and chemical properties that will materially damage, or even destroy metals.

The slurry is not classified as acutely toxic by the oral, dermal or inhalation routes of exposure. Based on the chemical properties of the constituents of the slurry, coal slurry is not a corrosion or irritation hazard to the skin or eyes. However, although SANS 10234:2008 does not include a specific hazard class for mechanical eye or skin irritation, it is noted that coal slurry may cause mechanical irritation to the skin and eyes after prolonged unprotected exposure. The slurry is not hazardous with regard to skin or respiratory sensitisation. Coal slurry is not classified as a germ cell mutagen and is not a cancer hazard. The slurry is not classified as a reproductive hazard, or as hazardous to specific target organs following single exposures. If the coal slurry should dry out and the dry material should generate dust, prolonged or repeated inhalation may cause damage to the lungs, due to the presence of the quartz mineral. However, the outcome is not necessarily silicosis, but suitable respiratory equipment is recommended if dust is generated during use or handling of dry slurry solids. The slurry precipitate is muddy and presents an aspiration hazard; therefore, the slurry my be harmful if swallowed and enters airways. With regard to the aquatic environment, coal slurry is not harmful to the aquatic environment. However, this does not imply that coal slurry may be disposed of in the aquatic environment and the usual precautionary principles to prevent environmental spills of the slurry are applicable.

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List of Tables

1 Introduction and terms of reference

South Africa has adopted the Globally Harmonized System (GHS) of classification and labelling of chemicals, as represented in South African National Standard SANS 10234:2008. The aim of the GHS is to have, worldwide, the same:

- criteria for classifying chemicals according to their physical, health and environmental hazards; and
- hazard communication requirements for labelling and safety data sheets.

The GHS is based on a broad description of hazard classes in the main categories of physical hazards, hazards to human health and hazards to aquatic ecosystems. For each of the hazard categories a series of hazard statement codes (H-codes) has been developed, to assist in the classification. The assessment of a multi-component material starts with the individual assessment of the constituents of the slurry. A multi-component chemical or mineralogical material is referred to as a mixture or a preparation. For each of the hazard statement codes that relates to the intrinsic properties of hazardous constituents in the slurry under assessment, a limiting concentration is specified above which the slurry would classify as hazardous and below which it would be non-hazardous. Multi-component materials are dealt with by summation of concentrations of constituents with similar hazards. Where reference is made to the GHS in this report, it means the GHS as represented in SANS 10234:2008. Hazard classification according to the GHS is the basic step in the preparation of safety data sheets (SDSs) that provide information and codes for hazard communication.

Material was submitted for analysis by Jones & Wagener. Extractions and analyses were conducted on dried slurry material. Reference to “slurry” in the text thus means “dried slurry material”. Results were given to INFOTOX for hazard assessment following the approach and methods prescribed in SANS 10234:2008.

2 Chemical analyses for the classification of materials

The default hazard classification is based on the total concentration of a substance, expressed as a percentage. However, hazard classification is complex in the case of certain materials that can be described as preparations, for which the default classification approach is not suitable. Examples of such preparations are soil, metallurgical slags and dusts, mineral ores and metal alloys. It should be recognised that these preparations have their own specific physical, chemical and toxicological/ecotoxicological properties distinct from those of their elemental constituents.

Bio-elution testing is a means of estimating the bio-accessibility of inorganic elements from preparations. Bio-elution refers to in vitro methods used to measure the elution of a substance, such as inorganic elements, in artificial biological fluids. Bio-accessibility refers to the amount of a chemical that is available to interact with an organism’s contact surfaces, and is therefore potentially available for absorption. Relevant simulated fluids have been developed for the gastric, intestinal and alveolar systems, saliva and for sweat, since the widely used deionised water leach test is not representative of the biological environment. The bio-accessible concentration of an element is expressed as the mass per cent of an element in the preparation that would be available to interact with relevant physiological contact surfaces according to the specific body fluid. For example, hazards associated with inhalation of elements in dusts from materials can be determined from bio-elution tests in alveolar fluid. The assessment based on the bio-elution tests is accepted as the most relevant, since the tests represent the bio-accessibility of the relevant elements, as opposed to "exhaustive" analyses such as the aqua regia analysis.

Bio-elution tests were conducted by Waterlab (Pty) Ltd. The bio-elution results of the samples are presented in Section 3.1.

The GHS provides guidance on how to deal with hazards to the aquatic ecosystem in the case of preparations that contain poorly soluble elements, such as mineral ores and dusts or mineralogical materials. Assessment of hazards to the aquatic environment requires a test for transformation/dissolution of metals and metal compounds in aqueous media, as described in the GHS. This test provides information on the proportion of a metal, expressed as mass per cent in the slurry, which would be available to exert its toxic effects on aquatic organisms in freshwater systems. Elution is performed at pH 6, pH 7 and pH 8 in a standard aqueous test medium that contains sodium bicarbonate, potassium chloride, calcium chloride and magnesium sulphate.

Transformation/dissolution tests were conducted by Waterlab (Pty) Ltd. The test results of the samples are presented in Section 3.2.

Anions are determined by Waterlab (Pty) Ltd in a separate deionised water leach test at a liquid-to-solids ratio of 20:1 (v/m). The pH is reported, which may be useful in interpretations regarding the potential corrosivity of a preparation. These data are presented in Section 3.3.

Fine particulates of certain mineralogical phases may exert toxic effects, most notably irritation effects, which may not be evident from the interpretation of bio-elution tests. These potential effects are evaluated by examination of the mineralogical properties of the slurry by means of X-Ray Diffraction (XRD). XRD investigates the crystalline structure of materials, and one of the applications is to identify the mineral composition of materials such as metallurgical materials. XRD analysis was done by XRD Analytical Consulting cc on data collected by a PANalytical diffractometer using the Autoquan Rietveld software. The XRD results for the slurry are listed in Section 3.4.

3 Analytical results

3.1 Bio-elution (bio-accessibility) tests

The results of the bio-elution (bio-accessibility) tests are presented in Table 3.1.1. Elements not detected by the analytical laboratory are reported as "not detected". Quantities in mg/kg are reported to the second decimal and values smaller than 0.01 are indicated as < 0.01. Mass per cent values are reported to the fourth decimal and mass percentages smaller than 0.0001 are reported as < 0.0001.

Table 3.1.1: Bio-accessibility of elemental constituents of the slurry (bio-elution tests).

Analyte	Gastro-intestinal elution*		Sweat elution		Alveolar elution	
	mg/kg	Mass %	mg/kg	Mass %	mg/kg	Mass %
Ag	0.07	<0.0001	Not detected		Not detected	
Al	469.00	0.0469	Not detected		41.65	0.0042
As	0.67	0.0001	0.12	<0.0001	0.59	0.0001
B	2.68	0.0003	1.53	0.0002	1.42	0.0001
Ba	159.32	0.0159	72.72	0.0073	10.00	0.0010
Be	0.51	0.0001	0.16	<0.0001	Not detected	
Ca	3 853.00	0.3853	Not detected		2 733.50	0.2734
Cd	0.06	<0.0001	0.04	<0.0001	Not detected	
Co	5.21	0.0005	3.41	0.0003	0.16	<0.0001
Cr (total)	2.78	0.0003	0.32	<0.0001	Not detected	
Cu	11.48	0.0011	1.79	0.0002	0.82	0.0001
Fe	9 775.00	0.9775	22.25	0.0022	3 231.00	0.3231
Hg	0.03	<0.0001	Not detected		0.01	<0.0001
Li	0.59	0.0001	0.19	<0.0001	0.11	<0.0001
Mg	511.00	0.0511	205.00	0.0205	776.50	0.0777
Mn	308.00	0.0308	9.15	0.0009	239.20	0.0239
Mo	0.13	<0.0001	0.08	<0.0001	0.11	<0.0001
Na	1 320.00	0.1320	Not detected		725.00	0.0725
Ni	11.03	0.0011	7.52	0.0008	0.49	<0.0001
Pb	4.25	0.0004	0.08	<0.0001	Not detected	
Sb	0.05	<0.0001	0.07	<0.0001	0.08	<0.0001
Se	0.14	<0.0001	Not detected		Not detected	
Sn	0.01	<0.0001	Not detected		Not detected	
Tl	0.07	<0.0001	0.03	<0.0001	Not detected	
V	0.52	0.0001	0.13	<0.0001	0.31	<0.0001
W	0.02	<0.0001	0.01	<0.0001	0.01	<0.0001
Zn	25.05	0.0025	15.82	0.0016	Not detected	
Zr	0.08	<0.0001	0.02	<0.0001	0.01	<0.0001

* Maximum concentration of the gastric and intestinal elutions

3.2 Transformation/dissolution leach test

Results of the transformation/dissolution test for the assessment of hazards to aquatic ecosystems are presented in Table 3.2.1. Elements not detected by the analytical laboratory are reported as “not detected”. Quantities in mg/kg are reported to the second decimal and values smaller than 0.01 are indicated as < 0.01. Mass per cent values are reported to the fourth decimal and mass percentages smaller than 0.0001 are reported as < 0.0001.

Table 3.2.1: Results of the transformation/dissolution leach tests conducted on the slurry.

Element	Leachable concentration	
	mg/kg	Mass %
Ag	Not detected	
As	1.59	0.0002
Be	Not detected	
Cd	Not detected	
Co	0.75	0.0001
Cr (total)	Not detected	
Cu	Not detected	
Hg	2.02	0.0002
Mn	Not detected	
Ni	Not detected	
Pb	Not detected	
Sb	0.57	0.0001
Se	Not detected	
Tl	0.18	0.0000
Zn	Not detected	

3.3 pH, deionised water leach test and hexavalent chromium

Results of the deionised water leach test at a liquid-to-solids ratio of 20:1 (v/m) are presented in Table 3.3.1. Decimals are as reported by the analytical laboratory. The paste pH is reported, which may be useful in interpretations regarding the potential corrosivity of the slurry. Hexavalent chromium was determined through alkaline digestion and colorimetric analysis by ultraviolet-visible (UV-VIS) spectrophotometry.

Table 3.3.1: pH, anions and hexavalent chromium.

Parameter	Value	
pH	7.4	
Anions	**mg/kg leachable**	**Mass %**
Nitrate as N	0.4	<0.0001
Ortho-phosphate as P	< 0.1	not detected
Fluoride as F	1.4	0.0001
Hexavalent Cr	<0.1	not detected

3.4 X-Ray Diffraction analysis

The XRD results for the slurry are listed in Table 3.4.1. The percentage by mass is rounded as reported by the laboratory.

Table 3.4.1: Mineral composition of the slurry based on XRD.

Mineralogical phase	Chemical formula	CAS number	Mass %
Quartz	SiO_2	14808-60-7	14.18
Goethite	$\alpha FeO(OH)$	1310-14-1	0.51
Kaolinite	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	1318-74-7	21.13
Dolomite	$CaMg(CO_3)_2$	16389-88-1	0.41
Microcline	$K(AlSi_3O_8)$	68476-25-5	4.52
Muscovite	$KAl_2(AlSi_3O_{10})(F,OH)_2$	1318-94-1	4.80
Amorphous	Not applicable	Unknown	54.45

4 Physical hazards assessment

Physical hazards refer to explosive properties, flammability, self-reacting and self-heating characteristics, pyrophoric and oxidising properties, generation of hazardous or flammable gases when in contact with water and chemical properties that will materially damage, or even destroy metals. INFOTOX has not evaluated any physical hazards as defined in the GHS.

5 Human health hazard assessment

5.1 Introduction

The constituents were classified in various GHS hazard categories according to SANS 10234:2008. Classifications were according to the salts of constituents. The classifications were sourced from the Classification and Labelling Inventory (C&L Inventory) of the European Chemical Agency (ECHA online). Salts with appropriate thermodynamic properties were selected. Classifications were done with regard to hazards to human health related to each of the following hazard classes:

- Acute toxicity
- Skin corrosion and skin irritation
- Serious eye damage and eye irritation
- Respiratory sensitisation and skin sensitisation
- Germ cell mutagenicity
- Carcinogenicity
- Reproductive toxicity
- Specific target organ toxicity — single exposure
  Specific target organ toxicity — repeated exposure
- Aspiration hazards

5.2 Acute toxicity data review

According to SANS 10234:2008, substances are allocated to one of five acute toxicity hazard categories based on acute toxicity (lethal dose data) by the oral, dermal or inhalation route of exposure. Acute toxicity values, namely, the 50 per cent lethal dose (LD50[1]) for oral or dermal exposure and the 50 per cent lethal concentration (LC50[2]) for inhalation exposure, are required for classification purposes. These are presented in Tables 5.2.1 to 5.2.3 for oral, dermal and inhalation toxicity, respectively. Acute toxicity values are not rounded to the nearest integer, because the values are used in further calculations that are rounded.

Table 5.2.1: Oral acute toxicity estimates for the constituents of the slurry.

Element	Oral LD50	Acute toxicity category and H-code
	mg/kg	
Al	394.3	4 – H302
As	26.0	2 – H300
Ba	262.7	3 – H301
Be	8.6	2 – H300
Cd	237.7	3 – H301
Co	161.1	3 – H301
Cu	199.1	3 – H301
F	45.0	2 – H300
Fe	183.8	3 – H301
Hg	3.1	1 – H300
Li	63.1	3 – H301
Ni	189.6	3 – H301
Pb	341.6	4 – H302
Sb	229.0	3 – H301
Se	69.0	3 – H301
Tl	4.0	1 – H300
V	209.0	3 – H301
Zn	202.5	3 – H301

---

[1] The LD50 is the amount of a chemical, given all at once, which causes the death of 50 per cent of a group of test animals.

[2] LC50 is the concentration of a chemical in air which causes the death of 50 per cent of a group of test animals exposed through inhalation within the stated study time.

Table 5.2.2: Dermal acute toxicity estimates for the constituents of the slurry.

Element	Dermal LD50	Acute toxicity category and H-code
	mg/kg	
Hg	30.9	1 - H300

Table 5.2.3: Inhalation acute toxicity estimates for the constituents of the slurry.

Element	Inhalation LC50	Acute toxicity category and H-code
	mg/litre	
As	0.1	2 – H330
Ba	0.8	3 – H331
Be	0.004	1 – H330
Cd	0.02	1 – H330
Hg	0.03	1 – H330
Ni	0.68	3 – H331
Pb	1.02	4 – H332
Sb	0.7	3 – H331
Se	0.35	2 – H330
Tl	0.04	1 – H330

The oral, dermal and inhalation toxicity data in Tables 5.2.1 to 5.2.3, the bio-elution results in Table 3.1.1, and the deionised water leach results in Table 3.3.1, are used to calculate the Acute Toxicity Estimates (ATEs) of the slurry with regard to oral, dermal and inhalation toxicity. The oral toxicity ATE was calculated using the gastro-intestinal bio-elution mass percentage reported in Table 3.1.1. The dermal toxicity was calculated with the sweat bio-elution result and the inhalation toxicity with the alveolar bio-elution result.

Table 5.2.4 presents a summary of the acute toxicity classification and the calculated ATEs. The slurry is not classified as acutely toxic by the oral, dermal or inhalation routes of exposure.

Table 5.2.4: Acute toxicity classification of the slurry.

Acute toxicity category	Oral toxicity (mg/kg)	Dermal toxicity (mg/kg)	Inhalation toxicity (mg/litre)
ATE*	>5000	Hg not detected	>5000
Acute toxicity category	Not classified	Not classified	Not classified
H-code	Not applicable	Not applicable	Not applicable
Hazard statement	Not applicable	Not applicable	Not applicable

*ATE: Acute Toxicity Estimate

5.3 Skin and eye corrosion and irritation

According to SANS 10234:2008, substances may be classified as skin corrosives or skin irritants, depending on the results of animal toxicity studies, or based on the hazard classifications of constituents of the slurry. The classification of the constituents of the slurry with regard to potential hazards to the skin is presented in Table 5.3.1.

Table 5.3.1: Skin hazard classification of constituents of the slurry.

Skin hazard category, H-code and hazard statement		
Skin corrosion 1A - H314 - Causes severe skin burns and eye damage	**Skin irritation 2 - H315 - Causes skin irritation**	**Skin irritation 3 - H316 - Causes mild skin irritation**
W Zr	Ag Be Cu F Fe Mo Sn Tl V Ni, provided Ni ≥ 20 mass % P evaluated as PO_4^{3-}	Co

The criteria from SANS 10234:2008 are summarised in Table 5.3.2. The sweat bio-elution results were used for the calculations. In addition, if the pH of the substance under assessment (Table 3.3.1) is less than 2.0 or more than 11.5, the substance is considered a skin corrosive (SANS 10234:2008). If none of the criteria are met, the substance is classified as not hazardous with regard to potential corrosive or irritant effects on the skin. The skin hazard classification is given in Table 5.3.5.

Table 5.3.2: Summary of criteria for the classification of the slurry as hazardous to skin.

Sum of constituents classified as	**Concentration triggering classification of a mixture as:**		
	Skin corrosive	Skin irritant	
	Category 1	Category 2	Category 3
Skin category 1	≥ 5 %	≥ 1 % but < 5 %	
Skin category 2		≥ 10 %	≥ 1 % but < 10 %
Skin category 3			≥ 10 %
(10 x skin category 1) + skin category 2		≥ 10 %	≥ 1 % but < 10 %
(10 x skin category 1) + skin category 2 + skin category 3			≥ 10 %

Regarding eye hazard classifications, irritant and corrosive effects on the eyes are considered, depending on the results of animal toxicity studies, or based on the hazard classifications of constituents of the slurry. The eye hazard classification of constituents of the slurry is given in Table 5.3.3.

Table 5.3.3: Eye hazard classification of constituents in the slurry.

Eye damage 1 - H318 - Causes serious eye damage	**Eye irritation 2A - H319 - Causes serious eye irritation**
Al Cu W Zn	Be Ca Co F Fe Li Mg Mn Mo Na Ni NO_3 Sn Zr Microcline Muscovite P (evaluated as PO_4^{3-})

The slurry was assessed according to criteria explained in SANS 10234:2008, summarised in Table 5.3.4. A specific bio-elution test for the eyes was not done, but the alveolar bio-elution concentrations were used as a best estimate, because the alveolar elution medium is physiologically pH neutral, as are tears.

In addition, if the pH of the substance (Table 3.3.1) is less than 2.0 or more than 11.5, the substance is considered damaging to the eye (SANS 10234:2008). If none of the criteria in Table 5.3.4 are met, and if the pH of the substance is not less than 2 and not more than 11.5, the substance is classified as not potentially damaging or irritating to the eyes.

Table 5.3.4: Criteria for the classification of the slurry in eye categories 1 or 2.

Sum of constituents classified as	**Concentration triggering classification of the slurry as:**	
	Category 1: **serious eye damage/irreversible effects on the eye**	**Category 2:** **eye irritant/reversible effects on the eye**
Eye category 1	$\geq$ 3 %	$\geq$ 1 % but < 3 %
Eye category 2	-	$\geq$ 10 %
Skin category 1 + eye category 1	$\geq$ 3 %	$\geq$ 1 % but < 3 %
(10 x eye category 1) + eye category 2	-	$\geq$ 10 %
10 x (skin category 1 + eye category 1) + eye category 2	-	$\geq$ 10 %

The skin hazard classification is given in Table 5.3.5 and the eye hazard classification in Table 5.3.6. The slurry is not classified as hazardous to the skin or eyes. However, although SANS 10234:2008 does not include a specific hazard class for mechanical irritation, it is noted that dust and grit from the dry material may cause mechanical abrasion and thus irritation in case of prolonged exposure of the unprotected skin and eyes.

Table 5.3.5: Skin hazard classification of the slurry.

Skin hazard category	H-code	Hazard statement
Not classified	Not applicable	Not applicable

Table 5.3.6: Classification of the slurry as hazardous to the eyes.

Eye hazard category	H-code	Hazard statement
Not classified	Not applicable	Not applicable

5.4 Skin and respiratory sensitisation

According to SANS 10234:2008, a respiratory sensitiser is a substance that will lead to hypersensitivity of the airways following inhalation of the substance and a skin sensitiser is a substance that will lead to an allergic response following skin contact. The constituents of the slurry classified as skin or respiratory sensitisers are presented in Table 5.4.1 and the hazard classification of the slurry is presented in Table 5.4.2.

Table 5.4.1: Constituents of the slurry classified as skin contact or respiratory sensitisers.

Skin contact or respiratory sensitiser category, H-code and hazard statement	
Skin sensitisers 1- H317 - May cause an allergic skin reaction	**Respiratory sensitisers 1 - H334 - May cause allergy or asthma symptoms or breathing difficulties if inhaled**
Be Co Ni, with limit 0.01 mass %	Co Ni

Table 5.4.2: Classification of the slurry with regard to skin or respiratory sensitisation.

Hazard class	Classification	H-code	Hazard statement
Skin	Not classified	Not applicable	Not applicable
Respiratory	Not classified	Not applicable	Not applicable

The conclusion is that the slurry is not classified as a skin or respiratory sensitiser.

5.5 Germ cell mutagenicity

According to SANS 10234:2008, this hazard class covers chemicals that cause mutations[3] in the germ cells of humans and that can be transmitted to the progeny. The germ cells in the reproductive tract give rise to the cells that develop into sperm and ova. The terms “genotoxic” and “genotoxicity” are more general than the term “mutagen”. Genotoxicity applies to agents or processes that alter the structure, information content, or segregation of DNA, including those that cause DNA damage by interfering with normal replication processes. Genotoxicity test results are usually taken as indicators for mutagenic effects.

A germ cell mutagen can be classified in one of two hazard categories according to the weight of evidence available. For classification purposes, test results obtained by animal testing for mutagenic and/or genotoxic effects in germ cells and/or somatic cells are considered. The constituents of the slurry classified as germ cell mutagens are listed in Table 5.5.1, and the resultant GHS classification in Table 5.5.2. The slurry is not classified as hazardous with regard to germ cell mutagenicity.

Table 5.5.1: Constituents of the slurry classified as germ cell mutagens.

Germ cell mutagen 1 – H340 - May cause genetic defects	Germ cell mutagen 2 – H341 - Suspected of causing genetic defects
Cd	Co Ni

Table 5.5.2: Germ cell mutagen classification of the slurry.

Hazard category	H-code	Hazard statement
Not classified	Not applicable	Not applicable

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[3] Heritable genetic changes that can be manifested at the phenotypic level, and underlying DNA modifications, e.g., specific base pair changes and chromosomal translocations.

5.6 Carcinogenicity

SANS 10234:2008 states that classification of a substance as carcinogenic is based on the inherent properties of a substance and does not provide information on the level of the human cancer risk which the use of the substance may present. Classification of a product as carcinogenic, therefore, identifies a hazard, but does not involve or imply any classification of the potential risks associated with exposure. The evaluation is based on evidence from all existing, peer-reviewed published studies and additional data accepted by regulatory agencies. The constituents of the slurry classified as presumed or known human carcinogens are presented in Table 5.6.1 and the resultant GHS classification of the slurry is given in Table 5.6.2. The slurry is not classified as hazardous with regard to carcinogenicity.

Table 5.6.1: Constituents of the slurry classified as carcinogenic.

Constituent	Constituent classification			
	Exposure route, if specified	**Hazard category**	**H-code**	**Hazard statement**
As	Not specified	1 - Known or presumed human carcinogen	H350	May cause cancer
Be	Inhalation			
Cd	Not specified			
Co	Inhalation			
Ni	Inhalation			
Pb	Inhalation or ingestion	2 - Suspected human carcinogen	H351	Suspected of causing cancer by inhalation or ingestion

Table 5.6.2: Carcinogenicity classification of the slurry.

Hazard category	H-code	Hazard statement
Not classified	Not applicable	Not applicable

5.7 Reproductive toxicity

Reproductive toxicity includes the assessment of sexual function, fertility and developmental effects. Adverse effects on sexual function and fertility include alterations to the female and male reproductive system, adverse effects on gamete production and transport, fertility or pregnancy outcomes. Developmental toxicity includes any effect which interferes with normal development of the offspring, either before or after birth. The elements classified as reproductive toxicants are presented in Table 5.7.1 and the resultant GHS classification of the slurry in Table 5.7.2. The slurry is not classified as a known or presumed human reproductive toxicant.

Table 5.7.1: Constituents of the slurry classified as reproductive toxicants.

Element	Constituent classification		
	Hazard category	**H-code**	**Hazard statement**
B	1 - Known or presumed human reproductive toxicant; not specified whether fertility or development is affected	H360	May damage fertility or the unborn child
Cd Pb	1 - Known or presumed human reproductive toxicant; fertility and development affected	H360	May damage fertility and the unborn child
Co	1 - Known or presumed human reproductive toxicant; fertility affected	H360	May damage fertility
Ni	1 - Known or presumed human reproductive toxicant; development affected	H360	May damage the unborn child
Pb	Effects on or via lactation	H362	May cause harm to breastfed children

Table 5.7.2: Reproductive hazard classification of the slurry.

Hazard class	Hazard category	H-code	Hazard statement
Reproductive toxicity	Not classified	Not applicable	Not applicable
Reproductive toxicity, effects on or via lactation	Not classified	Not applicable	Not applicable

5.8 Specific target organ toxicity

According to SANS 10234:2008, the classification of a substance or mixture as a specific target organ toxicant following single exposure (STOT-SE), depends on the availability of reliable evidence that a single exposure to the substance or mixture has caused consistent and identifiable toxic effects in humans and test animals. Moreover, the effects should be toxicologically significant; that is, the function and/or morphology of the tissue and/or organ has to be affected. Human data are the primary source of evidence, and the route of exposure by which a substance produces specific target organ toxicity should be identified.

Constituents of the slurry classified as STOT-SE are presented in Table 5.8.1. Only one category of classification was applicable, namely category 3 STOT-SE, with hazard statement “may cause respiratory irritation”. The STOT-SE classification of the slurry is given in Table 5.8.3.

Table 5.8.1: Constituents of the slag classified as STOT-SE.

Constituent		Category, H-code and hazard statement
Be Mo	Sn Microcline	STOT-SE category 3 H335: may cause respiratory irritation

According to SANS 10234:2008, the classification of a substance or mixture as a specific target organ toxicant following prolonged or repeated exposure (STOT-RE), depends on the availability of reliable evidence that prolonged or repeated exposure to the substance or mixture has caused consistent and identifiable toxic effects in humans and test animals. Moreover, the effects should be toxicologically significant; that is, the function and/or morphology of the tissue and/or organ has to be affected. Human data are the primary source of evidence and the route of exposure by which a substance produces specific target organ toxicity should be identified.

The constituents of the slurry classified as STOT-RE are presented in Table 5.8.2.

Table 5.8.2: Constituents classified as STOT-RE.

Category 1. Causes damage to organs through prolonged or repeated exposure (H372)	**Category 2. May cause damage to organs through prolonged or repeated exposure (H373)**
Route not specified: Tl	Route not specified: Se
Lungs by inhalation: Be	Central and/or peripheral nervous system by inhalation: Hg, concentration limit specified as 0.1 mass % Mn Mo
Respiratory organs by inhalation Ni	Respiratory organs by inhalation: Ni, concentration limit specified as ≥0.1 AND <1 mass % Lungs by inhalation: Quartz mineral (SiO_2) (14808-60-7); not the element Si
Kidneys by inhalation: Cd	Brain by inhalation and ingestion: Pb
	Kidneys by ingestion: Hg, concentration limit specified as 0.1 mass %

The STOT classification of the slurry is presented in Table 5.8.3. Based on the presence of quartz in the slurry, it is classified as a category 2 STOT-RE, which may cause damage to the lungs through prolonged or repeated inhalation. The outcome is not necessarily silicosis, but suitable respiratory equipment is recommended if dust is generated during use or handling.

Table 5.8.3: STOT classification of the slurry.

Hazard class	Classification	H-code	Hazard statement
STOT-SE	Not classified	Not applicable	Not applicable
STOT-RE	Category 2	H373	May cause damage to lungs through prolonged or repeated inhalation

5.9 Aspiration hazards

Aspiration hazards are related to the potential entry of secretions or foreign material into the trachea (windpipe) and lungs. A substance or a mixture that poses an aspiration hazard causes severe acute effects such as chemical pneumonia, varying degrees of pulmonary injury or death following aspiration. Aspiration of a substance or a mixture can occur if it is vomited after ingestion, which has consequences for labelling and first-aid recommendations on the safety data sheet. The aspiration hazard is increased with increased corrosivity, volatility and viscosity of the vomited substance, and is mostly a function of the hydrocarbon constituents. None of the constituents of the slurry are specifically classified as aspiration hazards and it is not classified as corrosive. However, the slurry is muddy; therefore, it is classified as an aspiration hazard (Table 5.9.1).

Table 5.9.1: Aspiration hazard classification of material.

Hazard category	H-code	Hazard statement
2	H305	May be harmful if swallowed and enters airways

6 Assessment of hazards to aquatic ecosystems

6.1 Surrogate species and toxicity data

According to the GHS, the intrinsic hazard to aquatic ecosystems is represented by the acute and chronic toxicity of a substance. These are dealt with separately. Acute toxicity normally is determined using a fish 96-hour 50 per cent lethal concentration (LC50[4]), a crustacean species 48-hour 50 per cent effect concentration (EC50[5]) and/or an algal species 72- or 96-hour 50 per cent effect concentration (EC50). These species are considered as surrogate for all aquatic organisms. Chronic toxicity is determined using the corresponding no-observed-effect-concentration (NOEC)[6] values.

6.2 Hazard categories of acute toxicity

The SANS 10234:2008 definitions of the acute toxicity hazard categories of substances hazardous to the aquatic environment are summarised in Table 6.2.1.

Table 6.2.1: Hazard categories of acute toxicity to the aquatic environment.

Hazard category Acute toxicity	Classification criteria
1	96-hr LC50 (for fish): ≤ 1 mg/litre; and/or 48-hr EC50 (for crustacea): ≤ 1 mg/litre; and/or 72- or 96-hr ErC50 (for algae or other aquatic plants): ≤1 mg/litre.
2	96-hr LC50 (for fish): 1 mg/litre < LC50 ≤ 10 mg/litre; and/or 48-hr EC50 (for crustaceans): 1 mg/litre < EC50 ≤ 10 mg/litre; and/or 72- or 96-hr ErC50 (for algae or other aquatic plants): 1 mg/litre < ErC50 ≤ 10 mg/litre.
3	96-hr LC50 (for fish): 10 mg/litre < LC50 ≤ 100 mg/litre; and/or 48-hr EC50 (for crustaceans): 10 mg/litre < EC50 ≤ 100 mg/litre; and/or 72- or 96-hr ErC50 (for algae or other aquatic plants): 10 mg/litre < ErC50 ≤ 100 mg/litre.

6.3 Hazard categories of chronic toxicity

The SANS 10234:2008 definitions of the chronic toxicity hazard categories of substances for which adequate chronic toxicity data are not available, as in the case of the slurry, are summarised in Table 6.3.1. The GHS also specifies a “safety net” classification, presented in Table 6.3.2.

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[4] LC50 is the lethal concentration in water required to kill 50 per cent of the aquatic population.

[5] EC50 is the effective concentration of a substance that causes 50 per cent of the maximum response after exposure for 48, 72- or 96-hours.

[6] NOEC is the highest concentration used in a toxicity test that does not cause a toxic effect that is statistically significantly (usually set at $p \leq 0.05$) different to the control. NOECs typically affect 10 to 30% of a population (Warne and Van Dam 2008).

Table 6.3.1: Hazard categories of chronic toxicity to the aquatic environment.

Hazard category Chronic toxicity	Classification criteria
1	96-hr LC50 (for fish): ≤ 1 mg/litre; and/or 48-hr EC50 (for crustacea): ≤ 1 mg/litre; and/or 72- or 96-hr ErC50 (for algae or other aquatic plants): ≤ 1 mg/litre and the substance is not rapidly degradable; and/or the experimentally determined bioconcentration factor (BCF) ≥ 500; or, if absent the log Kow (log octanol-water partition coefficient) ≥ 4.0
2	96-hr LC50 (for fish): 1 mg/litre < LC50 ≤ 10 mg/litre; and/or 48-hr EC50 (for crustaceans): 1 mg/litre < EC50 ≤ 10 mg/litre; and/or 72- or 96-hr ErC50 (for algae or other aquatic plants): 1 mg/litre < ErC50 ≤10 mg/litre and the substance is not rapidly degradable and/or the experimentally determined BCF ≥ 500; or, if absent the log Kow ≥ 4.0
3	96-hr LC50 (for fish): 10 mg/litre < LC50 ≤100 mg/litre; and/or 48-hr EC50 (for crustaceans): 10 mg/litre < EC50 ≤100 mg/litre; and/or 72- or 96-hr ErC50 (for algae or other aquatic plants): 10 mg/litre < ErC50 ≤100 mg/litre and the substance is not rapidly degradable and/or the experimentally determined BCF ≥ 500; or, if absent the log Kow ≥ 4.0

Table 6.3.2: Chronic toxicity hazard category 4: "safety net" classification.

Classification criteria
"Poorly soluble substances for which no acute toxicity is recorded at levels up to the water solubility, and which are not rapidly degradable and have a log Kow ≥ 4.0, indicating a potential to bioaccumulate, will be classified in this category unless other scientific evidence exists showing classification to be unnecessary. Such evidence would include an experimentally determined BCF < 500, or a chronic toxicity NOECs > 1 mg/litre, or evidence of rapid degradation in the environment."

6.4 Assessment of preparations according to SANS 10234:2008

SANS 10234:2008 makes provision for the assessment of mixtures or preparations that contain poorly soluble elements, such as mineralogical "preparations". The GHS methodology determines that assessment of the slurry is based on the aquatic hazard assessment of individual constituents. According to the GHS, components of a mixture in hazard category 1 with LC50, EC50 and ErC50 well below 1 mg/litre might influence the toxicity of the mixture and must be given additional weight in the assessment. Substances with a classification in a high toxicity band therefore contribute to the classification of a mixture, even though all other substances in the mixture might be classified in a lower band. A multiplication factor (M factor) is applied to account for such contributions. LC50 and EC50 [L(E)C50] categories for acute toxicity, NOEC categories for chronic toxicity and the corresponding M factors are listed in Table 6.4.1.

Table 6.4.1: Aquatic toxicity M factors for highly toxic constituents of mixtures (SANS 10234:2008).

Acute toxicity		Chronic toxicity		
L(E)C50 value	M factor	NOEC value	M factor	
			NRD* constituents	RD** constituents
0.1 < L(E)C50 ≤ 1	1	0.01 < L(E)C50 ≤ 0. 1	1	-
0.01 < L(E)C50 ≤ 0. 1	10	0.001 < L(E)C50 ≤ 0.01	10	1
0.001 < L(E)C50 ≤ 0.01	100	0.0001 < L(E)C50 ≤ 0.001	100	10
0.0001 < L(E)C50 ≤ 0.001	1 000	0.00001 < L(E)C50 ≤ 0.0001	1 000	100
0.00001 < L(E)C50 ≤ 0.0001	10 000	0.000001 < L(E)C50 ≤ 0.00001	10 000	1 000
(Continue with factor 10 intervals)		(Continue with factor 10 intervals)		

*NRD: non-rapidly degradable, showing a lack of biodegradability or other evidence of a lack of rapid degradation

**RD: rapidly degradable

Constituents of the slurry were classified in GHS hazard classes according to the salts of constituents. The classifications and M factors, where applicable, were sourced from the ECHA C&L Inventory (ECHA online). Salts with appropriate thermodynamic properties were selected.

Constituents with the classification “hazardous to the aquatic environment, acute hazard” are presented in Table 6.4.2. Hexavalent chromium is included because it is sometimes present in the slurry. Only one category of classification was applicable, namely aquatic acute hazard category 1. The associated H-code is H400 and the environmental hazard statement is “very toxic to aquatic life”.

Table 6.4.2: Constituents classified as hazardous to the aquatic environment, acute hazard category 1, H400, very toxic to aquatic life.

Constituent	M factor	Constituent	M factor
Ag	1	Hg	1
As	1	Ni	1
Cd	1	Pb	1
Co	10	Se	1
Cu	10	Zn	1

The constituents that classified in the GHS hazard class “hazardous to the aquatic environment, long-term hazard” are presented in Table 6.4.3.

Table 6.4.3: Constituents classified as hazardous to the aquatic environment, long-term (chronic) hazard categories.

Aquatic chronic 1 – H410 - Very toxic to aquatic life with long-lasting effects	M factor	Aquatic chronic 2 – H411 - Toxic to aquatic life with long-lasting effects	M factor
Ag	1	Be	1
As	1	Mn	1
Cd	1	Sb	1
Co	10	Tl	1
Cu	10		
Hg	1		
Ni	1		
Pb	1		
Se	1		
Zn	1		

The classification of a mixture is dependent on the contribution of all classification categories. Therefore, the mass percentage contents of the various categories are summed (and multiplied with the M factor if applicable), according to the equations in Table 6.4.4 for acute hazards and Table 6.4.5 for chronic hazards (SANS 10234:2008).

Table 6.4.4: Equations and limiting concentrations for classification of mixtures regarding acute hazards to the aquatic environment following the summation approach.

Sum of components for classification		Acute hazard category of the mixture
Acute 1 x M	≥ 25 %	1
[(M x 10 x Acute 1) + Acute 2]	≥ 25 %	2
[(M x 100 x Acute 1) + (10 x Acute 2)] + Acute 3	≥ 25 %	3

Table 6.4.5: Equations and limiting concentrations for classification of mixtures regarding chronic hazards to the aquatic environment following the summation approach.

Sum of components for classification		Chronic hazard category of the mixture
Chronic 1 x M	≥ 25 %	1
(M x 10 x Chronic 1) + Chronic 2	≥ 25 %	2
(M x 100 x Chronic 1) + (10 x Chronic 2) + Chronic 3	≥ 25 %	3
Chronic 1 + Chronic 2 + Chronic 3 + Chronic 4	≥ 25 %	4

6.5 Aquatic hazard assessment of the slurry

As pointed out in Section 2, the GHS recommends the transformation/dissolution test for metals and metal compounds in aqueous media. Therefore, the aquatic hazard assessment was based on the results of the transformation/dissolution test in Table 3.2.1.

The classifications regarding hazards to aquatic ecosystems associated with acute and chronic exposures are given in Table 6.5.1 and in Table 6.5.2, respectively.

Table 6.5.1: Acute hazard to the aquatic environment classification.

Hazard category	H-code	Hazard statement
Not classified	Not applicable	Not applicable

Table 6.5.2: Chronic hazard to the aquatic environment classification.

Hazard category	H-code	Hazard statement
Not classified	Not applicable	Not applicable

In summary, the slurry is not hazardous to aquatic life, whether during or after short- or long-term exposure in the aquatic environment.

7 Conclusions - classification according to the GHS

Table 7.1 presents a summary of the hazard classifications pertaining to the slurry, based on SANS 10234:2008.

Table 7.1: Summary of hazard classifications of the slurry.

Hazard class	Classification	Overall hazard classification of the slurry
Physical hazards		
Flammable	Not classified	• Not classified
Human health		
Acute toxicity: Oral	Not classified	• May cause mechanical irritation to the unprotected skin and eyes • May cause damage to lungs through prolonged or repeated inhalation (H373) • May be harmful if swallowed (H305)
Acute toxicity: Dermal	Not classified	
Acute toxicity: Inhalation	Not classified	
Skin corrosive or skin irritant	Not classified	
Eye corrosive or eye irritant	Not classified	
Mechanical irritation to the unprotected skin and eyes	Not a defined GHS class, but the slurry may cause mechanical irritation	
Respiratory sensitisation and skin sensitisation	Not classified	
Germ cell mutagenicity	Not classified	
Carcinogenicity	Not classified	
Reproductive toxicity	Not classified	
Specific target organ toxicity - single exposure	Not classified	
Specific target organ toxicity - repeated exposure	Category 2	
Aspiration hazard	Category 2	
Aquatic ecosystems		
Acute hazards	Not classified	Not classified
Chronic hazards	Not classified	

8 References

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SANS 10234:2008. Globally Harmonized System (GHS) of classification and labelling of chemicals. South African National Standard. Pretoria: Standards South Africa.

Warne MSt-J and Van Dam R. 2008. NOEC and LOEC data should no longer be generated or used. Australasian Journal of Ecotoxicology 14:1-5.

SOUTH32 SOUTH AFRICA COAL HOLDINGS (PTY) LTD

WOLVEKRANS COLLIERY: VANDYKSDRIFT CENTRAL MINING INFRASTRUCTURE
DEVELOPMENT
COAL SLURRY
GEOCHEMICAL ASSESSMENT AND WASTE CLASSIFICATION REPORT

Report: JW103/19/G535 - Rev 0

APPENDIX C

SAFETY DATA SHEET

SDS

South32 SA Coal Holdings (Pty) Ltd

Section	**Description**		
1	**Identification**		
	Name:	Fine Coal Slurry from Vandyksdrift Central	
	Generator	South32 SA Coal Holdings, Wolvekrans Colliery, Vandyksdrift Central Street Address – to be completed by South32 SA Coal Holdings	
	In case of emergency	Telephone number (24-hours): Alternative telephone number:	
	Commercial name	Fine Coal	
	Description	Fine coal removed from underground mine workings at Vandyksdrift Central	
	Hazardous ingredient	Quartz mineral	
2	**Hazards Identification**		
	Hazard Pictograms:	 **Warning**	
	Category	**GHS Codes**	**Hazard Statement**
	Health	H305	May be harmful if swallowed and enters airways
		H373	May cause damage to lungs through prolonged or repeated inhalation
	Category	**GHS Codes**	**Precautionary statements**
	Health	P264	Wash hands thoroughly after handling
		P270	Do not eat, drink or smoke when handling the fine coal
		P271	Use in well ventilated area

South32 SA Coal Holdings (Pty) Ltd

Section	Description			
		P280	Wear protective gloves, protective clothing and eye protection	
		P284	Wear respiratory protection (manufacturer/supplier to specify equipment) in case of repeated exposure to fine coal dust	
	Disposal	P501	Dispose of coal slurry in accordance with South African national legislation and requirements	
3	**Composition**			
	Chemical identity	Coal slurry removed from underground coal mine workings at Vandyksdrift Central of the Wolvekrans Colliery		
	Chemical composition	Description	Percentage (dry weight basis)	CAS
		Quartz (SiO_2)	14.18%	14808-60-7
		Goethite ($FeO(OH)$)	0.51%	20344-49-4
		Kaolinite ($Al_2Si_2O_5(OH)_4$)	21.13%	1318-74-7
		Dolomite ($Ca/Mg\ (CO_3)_2$)	0.41%	16389-88-1
		Microcline ($KAlSi_3O_8$)	4.52%	66402-68-4
		Muscovite ($KAl2((OH)_2AlSi_3O_{10})$)	4.8%	1318-94-1
		Coal	54.45%	RR-14976-8
4	**First Aid Measures**			
	Inhalation	Move patient to fresh air, rest. Artificial respiration may be needed. Refer for medical attention.		
	Eye Contact	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then refer for medical attention.		
	Skin Contact	Remove contaminated clothes. Rinse skin with plenty of water or shower. Refer for medical attention.		
	Ingestion	If swallowed, do not induce vomiting: Seek medical advice immediately.		
5	**Fire-fighting measures**			
	Extinguishing Media	Carbon dioxide, extinguishing powder or water spray. Fight large fires with water spray.		

Section		Description
	Fire Fighting Methods and Protection	Wear full body protective clothing and use positive pressure, self-contained breathing apparatus with a full-face piece.
	Fire and/or Explosion Hazards	Avoid dusting. May become explosive when dispersed in air.
	Hazardous Combustion Products	Carbon dioxide, carbon monoxide, sulfur dioxide.
6	**Accidental release measures**	
		Evacuate danger area. Sweep and scoop spilled filter cake into sealable containers with appropriate equipment. Protective gloves should be worn when handling the filter cake. Safety glasses or goggles should be worn when removing spills to prevent particles of dust from getting into the eyes. Overall and protective shoes should be worn when removing spills. In case of droplets and aerosols, respiratory protection should be worn.
7	**Handling and storage**	
		Prevent formation of dust – may cause explosive conditions.
8	**Exposure controls and personal protection**	
		Protective gloves should be worn when handling the coal slurry Safety glasses or goggles should be worn Overall and protective shoes should be worn Dust respirator. Use an approved/certified respirator or equivalent TWA OEL-RL may not exceed: 2.0 mg/m^3
9	**Physical and chemical properties**	
	Appearance	Fine material black in colour

South32 SA Coal Holdings (Pty) Ltd

Section	Description	
	Colour	Black
	Odour	Unknown
	Odour threshold	Unknown
	Paste pH	Not determined
	Melting point	Unknown
	Initial boiling point and boiling range	Unknown
	Flash point	Unknown
	Evaporation rate	Unknown
	Flammability	Unknown
	Explosion limits	Unknown
	Vapour pressure	Unknown
	Vapour density	Unknown
	Wet density	Unknown
	Solubility in water	Note readily soluble
	Partition coefficient	Unknown
	Auto ignition temperature	Unknown
	Decomposition temperature	Unknown
10	**Stability and reactivity**	
	Chemical stability	Unknown
	Hazardous reactions	Unknown
	Shock or vibration sensitivity	Unknown
	Incompatible materials	Unknown
	Hazardous decomposition products	May generate weak sulfuric acid and methane
11	**Toxicological information**	
		Unknown

South32 SA Coal Holdings (Pty) Ltd

Section	Description		
12	**Ecological toxicological information**		
		Unknown	
13	**Disposal considerations**		
		Dispose in accordance with South African national legislation and requirements	
14	**Transport information**		
	UN Number	No number	
	CAS Number	Quartz	14808-60-7
		Goethite	20344-49-4
		Kaolinite	1318-74-7
		Dolomite	16389-88-1
		Microcline	66402-68-4
		Muscovite	1318-94-1
		Coal	RR-14976-8
	Proper Shipping Name	Fine Coal	
	IMDG: Hazard Class	Not applicable	
	IMSBC Code	Cargo B	
	SANS 10228 Packaging group	Not applicable	
15	**Regulatory information**		
	National Waste Management Act	Classified as a Category 2 hazardous material in terms of SANS 10234: 2008	
	Hazardous Substances Act	Not classified as hazardous.	
	Occupational Health and Safety Act	Coal dust: Time Weighted Average Occupation Exposure Limit Recommended Limit (TWA-OEL-RL): 2.0 mg/m^3	

South32 SA Coal Holdings (Pty) Ltd		
Section	**Description**	
16	**Other information including information on preparation and revision of the SDS**	
	Prepared by	Jones & Wagener (Pty) Ltd on behalf of South32 SA Coal Holdings
	Revision Summary	This document has been prepared as revision 1 (April 2019) SDS adhering to the Globally Harmonized System of Classification and Labelling of Chemicals (GHS).