ZITHOLELE CONSULTING

KUSILE AND KENDAL POWER STATIONS
ASH DISPOSAL FACILITIES

WASTE CLASSIFICATION REPORT

Report No.: JW030/13/D121 - Rev 3

January 2014

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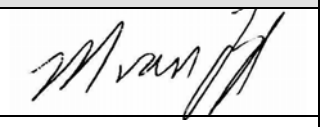
Prepared	Environmental Scientist	M van Zyl	23/12/2013	
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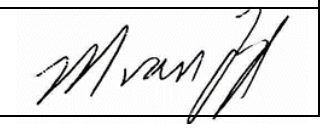
Approved	Environmental Scientist	M van Zyl	14/01/2014	

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Acronyms and abbreviations:

Acronym / abbreviations	Definition
ASLP	Australian Standard Leaching Procedure
BA	Basic Assessment
DEA	Department of Environmental Affairs
DI	Deionised
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EIA	Environmental Impact Assessment
LC	Leach concentration in mg/ℓ
m^3	Cubic metres
M	molar
mg/kg	milligram per kilogram
mg/ℓ	milligram per litre
µm	micrometre
TC	Total concentration in mg/kg
TCLP	Toxic Characteristic Leach Procedure
TDS	Total Dissolved Salts

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1. INTRODUCTION

1.1 Background

Zitholele Consulting was appointed by Eskom to identify, investigate and licence the long term ash disposal facility for the Kusile Power Station, which is currently under construction. Zitholele Consulting appointed Jones & Wagener Engineering and Environmental Consultants (J&W) to, inter alia, classify the ash to be generated by Eskom's Kusile Power Station.

Zitholele Consulting was also appointed to extend and licence the existing ash disposal facility of the Kendal Power Station, as well as identify and licence a new ash disposal facility for the station.

The Kendal Power Station employs a dry ash disposal method. The Kusile Power Station will use a similar methodology.

Classification of the ash is required for two purposes, namely:

- Correctly classify the ash disposal facilities for licensing purposes, and
- Assist in the development an appropriate barrier design system for the ash disposal facilities, based on the outcome of the classification of the ash.

1.2 Objectives

The original objectives of this project were to classify the ash in terms of:

- The Department of Water Affairs and Forestry's (the DWAF's) "*Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste*", Second Edition (DWAF, 1998) (Minimum Requirements) and the Department of Environmental Affairs letters dated June 2009. Based on the classification, a monthly ash disposal rate was also calculated. The Minimum Requirements is the current official waste classification system, but will be replaced once the draft waste classification regulations are promulgated.
- The Department of Environmental Affairs' (DEA's) draft waste classification regulations published for comment in August 2012 in terms of the provisions of the National Environmental Management: Waste Act, Act 59 of 2008. The ash was originally classified in terms of this system, as the ash disposal facility may only be constructed when the new classification system is in place, and Mr K. Legge of the

Department of Water Affairs indicated at the time that the new landfill barrier systems must be implemented once the new classification system is in place (K. Legge, 2011).

- Regulations promulgated in terms of Section 36 of the National Nuclear Regulator Act, Act 47 of 1999, (NNRA) to establish whether or not the ash disposal facilities also have to be licensed in terms of the provisions of the NNRA.

However, on 23 August 2013, the Department of Environmental Affairs promulgated the "*National norms and standards for the assessment of waste for landfill disposal*" (DEA, 2013a). The ash has now only been classified in terms of the new classification regulations and the Minimum Requirements classification removed from this 3rd revision of the waste classification report.

The ash was not classified in terms of the SANS 10234 Globally Harmonized System of classification and labelling of chemicals (GHS). The GHS system deals with the classification of hazardous substances and mixtures, including waste, for their safe transport, use at the workplace or at home, according to their health, environmental and physical hazards.

1.3 Historic overview

The ash generated by the Kendal Power Station was previously classified by Dr D. Baldwin of En-Chem Consultants cc. This work was carried out on behalf of Eskom for the Environmental Team Panel B Consultants in November 2008. The classification was carried out for the short term ash disposal facility of for the new Kusile Power Station (En-Chem, 2008).

Using the South African Acid Rain Leach Procedure (ARLP) as described in the Minimum Requirements it was found that none of the elements tested for in the ARLP leach solution, leached at concentrations higher than their Acceptable Risk Levels (ARLs) and therefore the ash was classified as non-toxic (general) by En-Chem Consultants. For the waste classification conducted by Dr Baldwin, Kendal Power Station ash samples were also used (En-Chem Consultants, 2008).

2. METHODOLOGY

2.1 Samples Collected

Zitholele Consulting collected two representative fresh ash samples from the Kendal Power Station. One sample was collected in a glass bottle and was dated 16 November 2012. The other sample was collected in a plastic bucket and was dated 17 November 2012. The sample collected in the glass bottle was used for the organic analyses, while the one collected in the plastic bucket was used for the inorganic analyses.

A sample from the plastic bucket was collected for the radio-activity analyses to be carried out by NECSA.

J&W delivered the ash samples to the Waterlab on 23 November 2012. The sample for the radioactivity analyses was delivered to NECSA on 26 November 2012.

2.2 Tests Conducted

In order to classify the ash for disposal purposes, the following tests were carried out on the samples obtained:

- South African Acid Rain Leach (ARLP) extract of the ash sample and analysis of the inorganic and organic constituents. Used to classify the ash in terms of the Minimum Requirements waste classification procedure (data not used in this 3rd revision report).
- Total extraction (aqua regia digestion) analysis of the ash sample, including both inorganic and organic constituents.
- Australian de-ionised water leach of the dry ash and analysis of the leach solution. This was required to classify the waste in terms of the DEA's waste classification regulations for disposal purposes. The Waterlab used a distilled water leach.
- Radiological analysis by NECSA for gross alpha/beta-activity and for selected radionuclides in the uranium and thorium decay series.

2.3 Interpretation of Laboratory Results

Following the receipt of the results, the ash was classified in terms of the "*National norms and standards for the assessment of waste for landfill disposal*". For this classification only the distilled water leach and total extraction (TC) results were used. The ARLP results were ignored as they have become obsolete.

The laboratory certificates of the results of the various tests that were conducted are attached in **Appendix A**.

3. DEA WASTE CLASSIFICATION

3.1 Introduction

In order to determine the barrier or liner requirements for the ash disposal facility, the ash needs to be classified for disposal purposes. On 23 August 2013, the DEA promulgated the *"National norms and standards for the assessment of waste for landfill disposal".* These regulations replaced the Minimum Requirements waste classification system developed by the Department of Water Affairs and Forestry in the 1990s and were used to classify the ash for disposal purposes.

3.2 Overview of DEA Waste Classification System

The new waste classification system focuses on the long term storage (in excess of 90 days) and long term disposal of waste on land or waste disposal facilities. The system is based on the Australian State of Victoria's waste classification system for disposal, which uses the Australian Standard Leaching Procedure (ASLP) to determine the leachable concentrations (LCs) of pollutants (DEA, 2013a).

A number of leach solutions can be used for this classification system. For waste to be disposed of with putrescible organic matter, an acetic acid leach solution is used. This leach solution is very similar to the US EPA's TCLP leach solution used in the now outdated Minimum Requirements, except that the pH is 5.0, instead of pH 4.93. In cases where a waste has a high pH, and following an acid neutralisation capacity test, a pH 2.9 leach solution must be used (DEA, 2013a).

In cases where non-organic waste is to be co-disposed with other non-organic waste, a alkaline 0.10 M sodium tetraborate decahydrate (borax) solution of pH 9.2 ± 0.10 should be used in addition to the acetic acid leach (DEA, 2013a). The objective of the sodium tetraborate test is to identify contaminants that are leached above the various leachable concentration thresholds (LCTs) trigger values at a high pH.

For non-putrescible inorganic waste, such as the Kusile ash, to be disposed of without any other wastes (mono-disposal scenario), reagent water (distilled water) is used as a leach agent.

In addition to the above, the TCs of the constituents of concern need to be determined and compared to specified total concentration threshold (TCT) values (DEA, 2013a).

The number of potentially hazardous substances in the new classification system has been significantly reduced from those listed in the old Minimum Requirements of 1998 and brought in line with the potentially hazardous substances being used in other parts of the world to classify waste for disposal purposes. However, if a generator is aware of a hazardous substance other than those listed by the DEA, they are obliged to indicate and analyse for this.

Once the analytical results are known, the waste is classified in line with the following approach:

- Wastes with any element or chemical substance concentration above the LCT3 or TCT2 values (LC >LCT3 or TC>TCT2) are Type 0 Wastes. Type 0 wastes (extremely hazardous waste), require treatment/stabilisation before disposal;
- Wastes with any element or chemical substance concentration above the LCT2 but below LCT3 values, or above the TCT1 but below TCT2 values (LCT2<LC ≤ LCT3 or TCT1<TC ≤ TCT2), are Type 1 Wastes (highly hazardous waste, which must be disposed of on a Class A landfill constructed with the most conservative barrier system);
- Notwithstanding the above, wastes with the TC of an element or chemical substance above the TCT2 limit, and where the concentration cannot be reduced to below the TCT2 limit, but the LC for the particular element or chemical substance is below the LCT3 limit, the waste is considered to be Type 1 Waste;
- Wastes with any element or chemical substance concentration above the LCT1 but below the LCT2 values and all concentrations below the TCT1 values (LCT1 < LC ≤ LCT2 and TC ≤ TCT1) are Type 2 Wastes (moderate hazardous waste, which must be disposed of on a Class B landfill);
- Wastes with any element or chemical substance concentration above the LCT0 but below LCT1 values and all concentrations below the TCT1 values (LCT0 < LC ≤ LCT1 and TC ≤ TCT1) are Type 3 Wastes (low hazardous waste, which must be disposed of on a Class C landfill);
- Wastes with all elements and chemical substance concentration levels for metal ions and inorganic anions below the LCT0 and TCT0 values (LC ≤ LCT0 and TC ≤ TCT0), as well as below the limits for organics and pesticides as in **Table 3-1**, are Type 4 Wastes (near inert wastes, which must be disposed of on sites with some base preparation, but no formal barrier system):

Table 3-1: Organic limits for wastes to be classified as Type 4 wastes

Chemical Substances in Waste	Total Concentration (mg/kg)
Organic constituents	
Total organic carbon (TOC)	30 000 (3%)
Benzene, toluene, ethyl benzene and xylenes (BTEX)	6
Polychlorinated Biphenyls (PCBs)	1
Mineral Oil (C10 to C40)	500

Chemical Substances in Waste	Total Concentration (mg/kg)
Pesticides	
Aldrin + Dieldrin	0.05
DDT + DDD + DDE	0.05
2,4-D	0.05
Chlordane	0.05
Heptachlor	0.05

- Wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 waste, irrespective of the total concentration of elements or chemical substances in the waste, provided that:
  - All chemical substance concentration levels are below the total concentration limits for organics and pesticides in the **Table 3-1**;
  - The inherent physical and chemical character of the waste is stable and will not change over time; and,
  - The waste is disposed of to landfill without any other waste.

4. KUSILE AND KENDAL ASH CLASSIFICATION

Based on the results obtained from the distilled water leach and analyses performed on the leach solution, the ash sample is classified as a Type 3 waste requiring disposal on a waste disposal facility with a Class C barrier system provided there are no site specific risks that require a more conservative barrier system – see **Figure 4-1**Figure 4-1Error! Reference source not found..

The Type 3 waste classification was the result of the LC value of boron exceeding its LC0 value of 0.50 mg/ℓ, and the TC value of barium and fluoride exceeding their respective TC0 values – see **Table 4-1**.

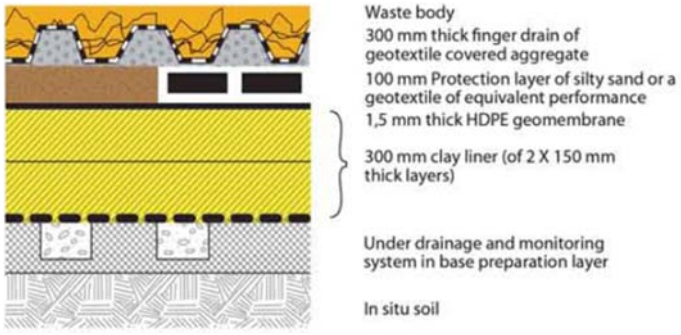

Figure 4-1: Class C landfill barrier system (DEA, 2013b)

Table 4-1: Distilled Water (LC) and Total Concentration (TC) results of Kendal Power Station Ash Sample

Elements & Chemical Substances	Kendal Power				LC0	TCT0		LC1	TCT1		LCT2	TCT1		LCT3	TCT2	
	Distilled Water leach concentration (LC) (mg/ℓ)	Total concentration (TC) (mg/kg)	Limit of Report for LC (mg/ℓ)		(mg/ℓ)	(mg/kg)		(mg/ℓ)	(mg/kg)		(mg/ℓ)	(mg/kg)		(mg/ℓ)	(mg/kg)	
Metal Ions																
As	<0.010	<2.00	0.010		0.01	5.8		0.50	500		1.0	500		4.0	2 000	
B	0.733	82	0.025		0.5	150		25	15 000		50	15 000		200	60 000	
Ba	0.044	570	0.025		0.7	62.5		35	6 250		70	6 250		280	25 000	
Cd	<0.005	2.80	0.005		0.003	7.5		0.15	260		0.3	260		1.2	1 040	
Co	<0.025	<5.00	0.025		0.5	50		25	5 000		50	5 000		200	20 000	
Cr	<0.025	33	0.025		0.1	46 000		2.5	800 000		5.0	800 000		20		
Cr(VI)	0.028[(1)]	NA	0.010		0.05	6.5		2.5	500		5.0	500		20	2 000	
Cu	<0.025	<5.00	0.025		2.0	16		100	19 500		200	19 500		800	78 000	
Hg	<0.001	<0.200	0.001		0.006	0.93		0.3	160		0.6	160		2.4	640	
Mn	<0.025	190.40	0.025		0.5	1 000		25	25 000		50	25 000		200	100 000	
Mo	<0.025	<5.00	0.025		0.07	40		3.5	1 000		7.0	1 000		28	4 000	
Ni	<0.025	<5.00	0.025		0.07	91		3.5	10 600		7.0	10 600		28	42 400	
Pb	<0.010	<2.00	0.020		0.01	20		0.5	1 900		1	1 900		4	7 600	
Sb	<0.010	<2.00	0.010		0.02	10		1.0	75		2	75		8	300	
Se	<0.010	<2.00	0.020		0.01	10		0.5	50		1	50		4	200	
V	0.049	<5.00	0.025		0.2	150		10	2 680		20	2 680		80	10 720	
Zn	<0.025	35	0.025		5.0	240		250	160 000		500	160 000		2 000	640 000	
Inorganic Anions																
TDS	80		10		1000			12 500			25 000			100 000		
Chloride	<5		5		300			15 000			30 000			120 000		
Sulphate as SO_4	36		5		250			12 500			25 000			100 000		
NO_3 as N	<0.2		0.2		11			550			1 100			4 400		
Fluoride	0.40	112	0.01		1.5	100		75	10 000		150	10 000		600	40 000	
Cyanide	<0.05	<0.05	0.05		0.07	14		3.5	10 500		7.0	10 500		28	42 000	
Organics																
Benzene	<0.002	<0.80	0.002					0.01	10		0.02	10		0.08	40	
Benzo(a)pyrene	<0.0001	<0.040	0.0001					0.035	1.7		0.070	1.7		0.28	6.8	
Carbon tetrachloride	<0.005	<2.00	0.005					0.20	4		0.40	4		1.6	16	
Chlorobenzene	<0.002	<0.80	0.002					5.0	8 800		10	8 800		40	35 200	
Chloroform	<0.005	<0.80	0.005					15	700		30	700		120	2 800	
2-Chlorophenol	<0.002	<0.80	0.002					15	2 100		30	2 100		120	8 400	
Di (2-ethylhexyl) phthalate	<0.010	<0.80	0.010					0.50	40		1	40		4	160	
1,2-Dichlorobenzene	<0.002	<0.80	0.002					5	31 900		10	31 900		40	127 600	
1,4-Dichlorobenzene	<0.002	<0.80	0.002					15	18 400		30	18 400		120	73 600	
1,2-Dichloroethane	<0.002	<0.80	0.002					1.5	3.7		3	3.7		12	14.8	
1,1-Dichloroethylene (1,1-Dichloroethene)	<0.010	<4.00	0.010					0.35	150		0.7	150		2.8	600	
1,2-Dichloroethylene	<0.010	<4.00	0.010					2.5	3 750		5.0	3 750		20	15 000	
Dichloromethane	<0.020	<8.00	0.020					0.25	16		0.5	16		2	64	
2,4-Dichlorophenol	<0.002	<0.80	0.002					10	800		20	800		80	3 200	
2,4-Dinitrotoluene	<0.001	<0.40	0.001					0.065	5.2		0.13	5.2		0.52	20.8	

Type 4 Waste | Type 3 Waste | Type 2 Waste | Type 1 Waste | Type 0 Waste

Elements & Chemical Substances	Kendal Power			LC0	TCT0	LC1	TCT1	LCT2	TCT1	LCT3	TCT2
	Distilled Water leach concentration (LC) (mg/ℓ)	Total concentration (TC) (mg/kg)	Limit of Report for LC (mg/ℓ)	(mg/ℓ)	(mg/kg)	(mg/ℓ)	(mg/kg)	(mg/ℓ)	(mg/kg)	(mg/ℓ)	(mg/kg)
Metal Ions											
Ethyl benzene	<0.002	<0.80	0.002			3.5	540	7	540	28	2 160
Formaldehyde	<0.050	<2.0	0.050			25	2 000	50	2 000	200	8 000
Hexachlorobutadiene	<0.002	<0.80	0.002			0.03	2.8	0.06	2.8	0.24	5.4
Methyl ethyl ketone (butanone)	<0.001	<0.001	0.001			100	8 000	200	8 000	800	32 000
MTBE (Methyl t-butyl ether)	<0.005	<2.00	0.005			2.5	1 435	5.0	1 435	20	5 740
Nitrobenzene	<0.001	<0.40	0.001			1	45	2	45	8	180
PAHs (total)	<0.002	<0.80	0.002				50		50		200
Petroleum hydrocarbons (C6 to C9)	<0.025	<10.0	0.025				650		650		2 600
Petroleum hydrocarbons (C10 to C36)	<0.010	<4.0	0.010				10 000		10 000		40 000
Phenols (Total non-halogenated)	<0.020	<8.00	0.020			7	560	14	560	56	2 240
Polychlorinated biphynels (PCBs)	<0.005	<2.00	0.005			0.025	12	0.050	12	0.20	48
Styrene	<0.005	<2.00	0.005			1.0	120	2	120	8	480
1,1,1,2-Tretrachloroethane	<0.010	<4.00	0.010			5	400	10	400	40	1 600
1,1,2,2-Tretrachloroethane	<0.010	<4.00	0.010			0.65	5.0	1.3	5.0	5.3	20
Tetrachloroethylene	<0.010	<4.00	0.010			0.25	200	0.50	200	2	800
Toluene	<0.010	<4.00	0.010			35	1 150	70	1 150	280	4 600
Trichlorobenzenes (Total)	<0.002	<0.80	0.010			3.5	3 300	7.0	3 300	28	13 200
1,1,1-Trichloroethane	<0.005	<2.00	0.005			15	1 200	30	1 200	120	4 800
1,1,2-Trichloroethane	<0.005	<2.00	0.005			0.6	48	1	48	4	192
Trichloroethylene	<0.010	<4.00	0.010			0.25	11 600	2	11 600	8	46 400
2,4,6-Trichlorophenol	<0.002	<0.80	0.002			10	1 770	20	1 770	80	7 080
Vinyl chloride	<0.001	<1.0	0.001			0.015	1.5	0.03	1.5	0.12	6.0
Xylenes (total)	<0.005	<0.100	0.005			25	890	50	890	200	3.560
Pesticides											
Aldrin + Dieldrin	<0.001	<0.04	<0.001		0.05	0.015	1.2	0.03	1.2	0.03	4.8
DDT + DDD + DDE	<0.001	<0.04	<0.001		0.05	1	50	2	50	2	200
2.4-D	<0.001	<0.04	<0.001		0.05	1.5	120	3	120	3	480
Chlordane	<0.001	<0.04	<0.001		0.05	0.05	4	0.1	4	0.1	16
Heptachlor	<0.001	<0.04	<0.001		0.05	0.015	1.2	0.03	1.2	0.03	4.8

	Not applicable
	Not analysed
	LC > LCT3 or TC > TCT2: Type 0 Wastes
	LCT2 < LC ≤ LCT3 or TCT1 < TC ≤ TCT2 : Type 1 Wastes
	LCT1 < LC ≤ LCT2 and TC ≤ TCT1: Type 2 Wastes
	LCT0 < LV ≤ LCT1 and TC ≤ TCT1: Type 3 Wastes
	LC ≤ LCT0 and TC ≤ TCT0: Type 4 wastes
(1)	Waterlab indicated that due to analytical noise, it is possible that the total chromium could be less than chromium VI. They have repeated the analysis.

5. RADIOACTIVITY OF THE ASH

It was agreed that radioactivity analyses of the ash will be conducted and therefore an ash sample was analysed at NECSA for radioactivity.

The potassium-40, gross alpha and gross beta results are presented in **Table 5-1**. The results for each nuclide analysed for are attached as **Appendix B**.

The results indicate that the ash is excluded from regulatory control. None of the individual nuclides and their progeny analysed for had activities above 0.50 Bq/gram, while the total radioactivity of the ash was significantly below the 1000 Bq/gram, which would trigger regulatory control. The radioactivity of potassium-40 was also well below 50 Bq/gram regulatory control value.

In terms of the potential impact on public health, J&W sub-contracted Dr J J van Blerk of AquiSim Consulting to conduct a first order assessment based on the results obtained. Dr Van Blerk's report is attached as **Appendix C** and is summarised below.

For the assessment conducted by Aquisim, the following assumptions were made, namely:

- Members of the public are exposed to the material for a period of 2 000 hours per annum (7.6 hours per day for 260 days per annum - equal to the period normally used for worker radiological safety assessments, such as tailings dam operators).
- During this exposure period, an adult member of the public inhales 1 850 m^3 of air (or 0.93 m^3/hour, which is the average breathing rate for and adult during sleeping, sitting, and for light and heavy exercise). For this study it was assumed that the respirable dust load is 1 x 10^{-4} grams/m^3.

For these assumed conditions, the inhalation dose to adult members of the public will be in the order of 7.0 µSv/annum for the sample analysed, while the external gamma radiation for an adult member of the public (2 000 hours on top of the facility) would be in the order of 197 µSv/annum.

The external gamma radiation dose will decrease linearly with a decrease in exposure period, while the exposure with distance away from the facility will decrease exponentially (i.e., at a small distance away from the facility, the dose will decrease to insignificant levels).

Based on the assessment conducted, Dr Van Blerk concluded that:

- The material is below the limit set for material to be considered as radioactive,
- Assuming very conservative conditions, the potential radiological impact is below the regulatory criteria for the radiological protection of members of the public.

Dr Van Blerk did not consider a scenario where members of the public constructed dwellings on top of the ash disposal facilities, which is unlikely as the sites will not be open for the public. Nevertheless, it is recommended that human settlements must not be allowed on the ash disposal facilities during operation and after closure of the disposal facility.

Table 5-1: Summary of radiological results

Radioactivity in Bq/gram[1]	Kendal Ash	Exclusion Level
^{40}K (Potassium-40)	0.296	50[2]
Gross alpha	2.510	_
Gross beta	1.220	_
Total radioactivity (alpha + beta	**3.730**	**1000**

1: The values in the NECSA report are reported as Bq/kg and were converted to Bg/gram to be in line with the values as stipulated in the legislation (Dept. of Minerals and Energy, 2006).

2: For material to be used in the building industry the potassium 40 level must not exceed 10 Bq/gram.

6. DISCUSSION AND CONCLUSIONS

In terms of the DEA's waste classification regulations, the Kendal ash is classified as a Type 3 waste (low hazard waste), which requires disposal on a landfill with a Class C barrier system. The Type 3 waste classification was the result of the LC value of the boron concentration exceeding its respective LC0 values, and the TC values of barium and fluoride exceeding their respective TC0 values.

From a radioactivity perspective, it was found that the ash is below the limit set for material to be considered as radioactive. Assuming very conservative human exposure conditions (e.g. exposure in excess of 2 000 hours per annum) the potential radiological impact to members of the public is below the regulatory criteria for the radiological protection of members of the public. The assumed conditions did not consider the possibility for members of the public residing on top of the ash disposal facility for extended periods of time, in which case additional exposure conditions would need to be considered (e.g. radon exhalation from the ash body and the subsequent built-up of radon inside a house) (AquiSim, 2013).

7. RECOMMENDATIONS

Based on the findings of this study, it is recommended that:

- The Kusile and Kendal Power Station ash disposal facilities should be licenced as Class C waste disposal facilities, and
- Human settlements are not allowed on top of the ash disposal facilities either during operation or after closure.

8. REFERENCES

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John Glendinning
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13 January 2014

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APPENDIX A

WATERLAB LABORATORY CERTIFICATES

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSES

ICP-MS QUANTITATIVE ANALYSIS [s]

Date received: 23/11/2012
Project number: 132

Date Completed: 09/01/2013
Report number: 37722

Client name: Jones & Wagener Consulting Civil Engineers
Adress: P.O. Box 1434, Rivonia, 2128
Telephone: 011 - 519 - 0200

Contact person: Mr. M. van Zyl
Email: vanzyl@jaws.co.za
Facsimile: 011 - 519 - 0201

Extract	Sample Dry Mass (g)	Volume (ml)	Factor
Acid Rain	50	1000	20

[s]= Results obtained form subcontracted laboratory

Sample Id	Sample Number	Al	Al	As	As	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
Kendall Ash Sample	17069	0.013	0.267	0.064	1.28	0.138	2.77

Sample Id	Sample Number	Cd	Cd	Co	Co	Cr	Cr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.0001	<0.002	<0.001	<0.020	<0.001	<0.020
Kendall Ash Sample	17069	0.0001	0.002	<0.001	<0.020	0.068	1.36

Sample Id	Sample Number	Cu	Cu	Fe	Fe	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.010	<0.200	<0.0001	<0.002
Kendall Ash Sample	17069	<0.001	<0.020	<0.010	<0.200	0.0002	0.004

Sample Id	Sample Number	Mn	Mn	Pb	Pb	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
Kendall Ash Sample	17069	0.011	0.223	<0.001	<0.020	0.007	0.133

Sample Id	Sample Number	Se	Se	Sr	Sr	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
Kendall Ash Sample	17069	0.016	0.316	1.08	22	<0.001	<0.020

Sample Id	Sample Number	V	V	Zn	Zn
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020
Kendall Ash Sample	17069	0.188	3.76	0.002	0.043

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CERTIFICATE OF ANALYSES
TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received: 2012-11-23 | **Date completed: 2012-12-12**
Project number: 132 | **Report number: 37722** | **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS | **Contact person: Mr. M. van Zyl**
Address: P.O. Box 1434 Rivonia 2128 | **Email: vanzyl@jaws.co.za**
Telephone: 011 - 519 - 0200 | **Facsimile: 011 - 519 - 0201** | **Cell: 082 880 1250**

Analyses	Sample Identification	
	Kendall Ash Sample	
Sample number	17069	
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water	
Dry Mass Used (g)	50	
Volume Used (mℓ)	1000	
Units	mg/ℓ	mg/kg
Total Dissolved Solids at 180°C	80	1 600
Chloride as Cl	<5	<100
Sulphate as SO_4	36	720
Nitrate as N	<0.2	<4.0
Fluoride as F	0.4	8.0
Total Cyanide as CN	<0.05	<1.00
Mercury as Hg	<0.001	<0.020
Hexavalent Chromium as Cr^{6+}	0.028	0.560
ICP-OES Quant	See attached report 37722 ICP DW	
Organic Analyses (DW 1:20 Leach) [s]	See attached report 37722 Organics Distilled Water	
X-ray Diffraction [s]	See attached report 37722 XRD	

Sample number	17069	
TCLP / Acid Rain / Distilled Water / H_2O_2	Aqua Regia	
Dry Mass Used (g)	0.5	
Volume Used (mℓ)	100	
Units	mg/ℓ	mg/kg
Mercury as Hg	<0.001	<0.200
Total Cyanide as CN(Solid) ppm	<0.05	
Total Fluoride as F [s] (Solid) ppm	112	
ICP-OES Quant	See attached report 37722 ICP AQR	
Total Organics (solid) [s]	See attached report 37722 Organics Totals	

[s]= Results obtained from subcontracted laboratory

Please note: The blank was subtracted from all leach results.

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CERTIFICATE OF ANALYSES
TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received: 2012-11-23 **Date completed: 2013-01-09**
Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Mr. M. van Zyl**
Address: P.O. Box 1434 Rivonia 2128 **Email: vanzyl@jaws.co.za**
Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Cell: 082 880 1250**

Analyses	Sample Identification	
	Kendall Ash Sample	
Sample number	17069	
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water	
Dry Mass Used (g)	250	
Volume Used (mℓ)	1000	
pH Value at 25˚C	9.0	
Units	mg/ℓ	mg/kg
Fluoride as F	0.6	2.4
Hexavalent Chromium	0.096	0.384
Total Cyanide	<0.05	<0.20
ICP-MS Quant	See attached report 37722 ICP MS Distilled Water (4)	

Please note: The blank was subtracted from all leach results, except pH.

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WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSES

ICP-OES - QUANT

Date received: 23/11/2012
Project number: 132

Date Completed: 12/12/2012
Report number: 37722

Client name: Jones & Wagener Consulting Civil Engineers
Adress: P.O. Box 1434, Rivonia, 2128
Telephone: 011 - 519 - 0200

Contact person: Mr. M. van Zyl
Email: vanzyl@jaws.co.za
Facsimile: 011 - 519 - 0201

Extract	Sample Dry Mass	Volume	Mass (g/l)	Factor
Distilled Water	50	1000	50	20

Sample Id	Sample number	As	As	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.025	<0.500	<0.025	<0.500
Kendall Ash Sample	17069	<0.010	<0.200	0.733	15	0.044	0.880

Sample Id	Sample number	Cd	Cd	Co	Co	Cr	Cr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.005	<0.100	<0.025	<0.500	<0.025	<0.500
Kendall Ash Sample	17069	<0.005	<0.100	<0.025	<0.500	<0.025	<0.500

Sample Id	Sample number	Cu	Cu	Mn	Mn	Mo	Mo
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.025	<0.500	<0.025	<0.500
Kendall Ash Sample	17069	<0.025	<0.500	<0.025	<0.500	<0.025	<0.500

Sample Id	Sample number	Ni	Ni	Pb	Pb	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.010	<0.200	<0.010	<0.200
Kendall Ash Sample	17069	<0.025	<0.500	<0.010	<0.200	<0.010	<0.200

Sample Id	Sample number	Se	Se	V	V	Zn	Zn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<0.200	<0.025	<0.500	<0.025	<0.500
Kendall Ash Sample	17069	<0.010	<0.200	0.049	0.980	<0.025	<0.500

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSES

ICP-MS QUANTITATIVE ANALYSIS [s]

Date received: 23/11/2012
Project number: 132

Date Completed: 09/01/2013
Report number: 37722

Client name: Jones & Wagener Consulting Civil Engineers
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Contact person: Mr. M. van Zyl
Email: vanzyl@jaws.co.za
Facsimile: 011 - 519 - 0201

Extract	Sample Dry Mass (g)	Volume (ml)	Factor
Distilled Water	250	1000	4

[s]= Results obtained form subcontracted laboratory

Sample Id	Sample Number	Al	Al	As	As	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.004	<0.001	<0.004	<0.001	<0.004
Kendall Ash Sample	17069	0.445	1.78	0.017	0.067	0.090	0.359

Sample Id	Sample Number	Cd	Cd	Co	Co	Cr	Cr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.0001	<0.0004	<0.001	<0.004	<0.001	<0.004
Kendall Ash Sample	17069	0.0002	0.0009	<0.001	<0.004	0.093	0.371

Sample Id	Sample Number	Cu	Cu	Fe	Fe	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.004	<0.010	<0.040	<0.0001	<0.0004
Kendall Ash Sample	17069	<0.001	<0.004	0.043	0.171	0.0005	0.0021

Sample Id	Sample Number	Mn	Mn	Pb	Pb	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.004	<0.001	<0.004	<0.001	<0.004
Kendall Ash Sample	17069	0.002	0.008	<0.001	<0.004	0.008	0.031

Sample Id	Sample Number	Se	Se	Sr	Sr	Tl	Tl
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.004	<0.001	<0.004	<0.001	<0.004
Kendall Ash Sample	17069	0.007	0.029	0.583	2.33	<0.001	<0.004

Sample Id	Sample Number	V	V	Zn	Zn
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.004	<0.001	<0.004
Kendall Ash Sample	17069	0.164	0.656	0.011	0.043

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CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Distilled Water Leach

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

Address: P.O. Box 1434 Rivonia 2128 **e-mail: vanzyl@jaws.co.za**

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Volatile Organic Compound (DW leach)		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Benzene	**ug/l**	<2
Carbon Tetrachloride	**ug/l**	<5
Chlorobenzene	**ug/l**	<2
Chloroform	**ug/l**	<5
1,2-Dichlorobenzene	**ug/l**	<2
1,4-Dichlorobenzene	**ug/l**	<2
1,2-Dichloroethane	**ug/l**	<2
Ethylbenzene	**ug/l**	<2
Hexachlorobutadiene	**ug/l**	<2
Isopropylbenzene	**ug/l**	<2
MTBE	**ug/l**	<5
Naphthalene	**ug/l**	<2
Styrene	**ug/l**	<5
1,1,1,2-Tetrachloroethane	**ug/l**	<10
1,1,2,2-Tetrachloroethane	**ug/l**	<10
Toluene	**ug/l**	<10
1,1,1-Trichloroethane	**ug/l**	<5
1,1,2-Trichloroethane	**ug/l**	<5
Xylenes total	**ug/l**	<5
1,2,4 Trichlorobenzene	**ug/l**	<2
1,2,3 Trichlorobenzene	**ug/l**	<2
Dichloromethane	**ug/l**	<20
1,1-Dichloroethylene	**ug/l**	<10
1,2-Dichloroethylene	**ug/l**	<10
Tetrachloroethylene	**ug/l**	<10
Trichloroethylene	**ug/l**	<10

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CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Distilled Water Leach

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

Address: P.O. Box 1434 Rivonia 2128 **e-mail: vanzyl@jaws.co.za**

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Organic Analyses: Polars		
Analyses in mg/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
2-Butanone	**mg/l**	<1
Vinyl Chloride	**mg/l**	<1

Organic Analyses: Semi Volatile Organic Compound		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Benzo(a)pyrene	**ug/l**	<0.1
Di (2 ethylhexyl) Phthalate	**ug/l**	<10
Hexachlorobenzene	**ug/l**	<1
Nitrobenzene	**ug/l**	<1
2,4 Dinitrotoluene	**ug/l**	<1
Hexachloroethane	**ug/l**	<1
Total PAH's	**ug/l**	<2

Organic Analyses: Phenols		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Cresols	**ug/l**	<2
2-Chlorophenol	**ug/l**	<2
2,4-Dichlorophenol	**ug/l**	<2
Pentachlorophenol	**ug/l**	<2
2,4,5-Trichlorophenol	**ug/l**	<2
2,4,6-Trichlorophenol	**ug/l**	<2
Phenols (total,non-halogenated)	**ug/l**	<20

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ORGANIC ANALYSES PARAMETERS [s] Distilled Water Leach

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

Address: P.O. Box 1434 Rivonia 2128 **e-mail: vanzyl@jaws.co.za**

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: PCB		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Ballsmitters Totals	**ug/l**	<5

Organic Analyses: TPH		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Petroleum H/Cs,C6-C9	**ug/l**	<25
Petroleum H/Cs,C10 to C36	**ug/l**	<10

Organic Analyses: Formaldehyde		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Formaldehyde	**ug/l**	<50

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CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Distilled Water Leach

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

Address: P.O. Box 1434 Rivonia 2128 **e-mail: vanzyl@jaws.co.za**

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Pesticides		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
Adrin	**ug/l**	<0.1
Dieldrin	**ug/l**	<0.1
DDT	**ug/l**	<0.1
DDE	**ug/l**	<0.1
DDD	**ug/l**	<0.1
Heptachlor	**ug/l**	<0.1
Chlordane	**ug/l**	<0.1
2,4 Dichlorophenoxyacetic Acid	**ug/l**	<0.1

[s] = Analyses performed by a Sub-contracted Laboratory

E. Botha
Geochemistry Project Manager

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSES

ICP-OES - QUANT

Date received: 23/11/2012
Project number: 132

Date Completed: 09/01/2013
Report number: 37722

Client name: Jones & Wagener Consulting Civil Engineers
Adress: P.O. Box 1434, Rivonia, 2128
Telephone: 011 - 519 - 0200

Contact person: Mr. M. van Zyl
Email: vanzyl@jaws.co.za
Facsimile: 011 - 519 - 0201

Extract	Sample Dry Mass	Volume	Mass (g/l)	Factor
Aqua Regia	0.5	100	5	200

Sample Id	Sample number	As	As	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<2.00	<0.025	<5.00	<0.025	<5.00
Kendall Ash Sample	17069	<0.010	<2.00	0.410	82	2.85	570

Sample Id	Sample number	Cd	Cd	Co	Co	Cr	Cr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.005	<1.00	<0.025	<5.00	<0.025	<5.00
Kendall Ash Sample	17069	0.014	2.80	<0.025	<5.00	0.167	33

Sample Id	Sample number	Cu	Cu	Mo	Mo	Mn	Mn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<0.025	<5.00	<0.025	<5.00
Kendall Ash Sample	17069	<0.025	<5.00	<0.025	<5.00	0.952	190.400

Sample Id	Sample number	Ni	Ni	Pb	Pb	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<5.00	<0.010	<2.00	<0.010	<2.00
Kendall Ash Sample	17069	<0.025	<5.00	<0.010	<2.00	<0.010	<2.00

Sample Id	Sample number	Se	Se	V	V	Zn	Zn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.010	<2.00	<0.025	<5.00	<0.025	<5.00
Kendall Ash Sample	17069	<0.010	<2.00	<0.025	<5.00	0.177	35

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CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Totals

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

Address: P.O. Box 1434 Rivonia 2128 **e-mail: vanzyl@jaws.co.za**

Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Volatile Organic Compound (Total)		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Benzene	**ug/kg**	<40
Carbon Tetrachloride	**ug/kg**	<100
Chlorobenzene	**ug/kg**	<40
Chloroform	**ug/kg**	<100
1,2-Dichlorobenzene	**ug/kg**	<40
1,4-Dichlorobenzene	**ug/kg**	<40
1,2-Dichloroethane	**ug/kg**	<40
Ethylbenzene	**ug/kg**	<40
Hexachlorobutadiene	**ug/kg**	<40
Isopropylbenzene	**ug/kg**	<40
MTBE	**ug/kg**	<100
Naphthalene	**ug/kg**	<40
Styrene	**ug/kg**	<100
1,1,1,2-Tetrachloroethane	**ug/kg**	<200
1,1,2,2-Tetrachloroethane	**ug/kg**	<200
Toluene	**ug/kg**	<200
1,1,1-Trichloroethane	**ug/kg**	<100
1,1,2-Trichloroethane	**ug/kg**	<100
Xylenes total	**ug/kg**	<100
1,2,4 Trichlorobenzene	**ug/kg**	<40
1,2,3 Trichlorobenzene	**ug/kg**	<40
Dichloromethane	**ug/kg**	<400
1,1-Dichloroethylene	**ug/kg**	<200
1,2-Dichloroethylene	**ug/kg**	<200
Tetrachloroethylene	**ug/kg**	<200
Trichloroethylene	**ug/kg**	<200

E. Botha
Geochemistry Project Manager

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CERTIFICATE OF ANALYSES

ORGANIC ANALYSES PARAMETERS [s] Totals

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Organic Analyses: Polars		
Analyses in mg/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X1**	
2-Butanone	**mg/kg**	<1
Vinyl Chloride	**mg/kg**	<1

Organic Analyses: Semi Volatile Organic Compound		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Benzo(a)pyrene	**ug/kg**	<2
Di (2 ethylhexyl) Phthalate	**ug/kg**	<200
Hexachlorobenzene	**ug/kg**	<20
Nitrobenzene	**ug/kg**	<20
2,4 Dinitrotoluene	**ug/kg**	<20
Hexachloroethane	**ug/kg**	<20
Total PAH's	**ug/kg**	<40

Organic Analyses: Phenols		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Cresols	**ug/kg**	<40
2-Chlorophenol	**ug/kg**	<40
2,4-Dichlorophenol	**ug/kg**	<40
Pentachlorophenol	**ug/kg**	<40
2,4,5-Trichlorophenol	**ug/kg**	<40
2,4,6-Trichlorophenol	**ug/kg**	<40
Phenols (total,non-halogenated)	**ug/kg**	<400

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Organic Analyses: PCB		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Ballsmitters Totals	**ug/kg**	<100

Organic Analyses: TPH		
Analyses in mg/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Petroleum H/Cs,C6-C9	**mg/kg**	<0.5
Petroleum H/Cs,C10 to C36	**mg/kg**	<0.2

Organic Analyses: Formaldehyde		
Analyses in ug/kg (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X40**	
Formaldehyde	**ug/kg**	<50

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ORGANIC ANALYSES PARAMETERS [s] Totals

Date received: : 2012-11-23 **Date completed: 2013-01-09**

Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Marius van Zyl**

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Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Mobile: 082 880 1250**

Organic Analyses: Pesticides		
Analyses in ug/l (Unless specified otherwise)		**Sample Identification**
		Kendall Ash Sample
Sample Number		**17069**
Dilution	**X20**	
Adrin	**ug/l**	<2
Dieldrin	**ug/l**	<2
DDT	**ug/l**	<2
DDE	**ug/l**	<2
DDD	**ug/l**	<2
Heptachlor	**ug/l**	<2
Chlordane	**ug/l**	<2
2,4 Dichlorophenoxyacetic Acid	**ug/l**	<2

[s] = Analyses performed by a Sub-contracted Laboratory

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CERTIFICATE OF ANALYSES
X-RAY DIFFRACTION

Date received: 2012-11-23 **Date completed: 2012-12-12**
Project number: 132 **Report number: 37722** **Order number: D121/MvZ/22292**

Client name: JONES & WAGENER CONSULTING CIVIL ENGINEERS **Contact person: Mr. M. van Zyl**
Address: P.O. Box 1434 Rivonia 2128 **Email: vanzyl@jaws.co.za**
Telephone: 011 - 519 - 0200 **Facsimile: 011 - 519 - 0201** **Cell: 082 880 1250**

Composition (%) [s]		
Kendall Ash Sample		
17069		
Mineral	Amount (weight %)	Error
Amorphous	55.48	1.2
Calcite	3.54	0.36
Mullite	26.84	0.99
Quartz	14.15	0.57

Note:

The material submitted was scanned after addition of 20 % Si for quantitative determination of amorphous content and micronizing in a McCrone micronizing mill using a back loading preparation method.
It was analysed with a PANalytical Empyrean diffractometer with PIXcel detector and fixed slits with Fe filtered Co-K_ radiation.
The phases were identified using X'Pert Highscore plus software.
The relative phase amounts (weight %) were estimated using the Rietveld method.
Errors are on the 3 sigma level in the column to the right of the amount (in weight per cent).

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.
- Errors reported for phases occurring in minor amounts are sometimes larger than that of the quantity reported, indicating the possible absence of those phases.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group.

E. Botha
Geochemistry Project Manager

APPENDIX B

RADIOACTIVITY NALYSIS REPORT

RadioAnalysis
Building 1600
P O Box 582
Pretoria 0001

Telephone: + 27 12 305 5527
Facsimile: + 27 12 305 5944

Contact: ***Mr M van Zyl***
Company: ***Jones & Wagener***
Address: ***PO Box 1434***
Rivonia
2128

Date: ***18 March 2013***
Report number: ***RA-13828-01***
Pages: ***3***
Your reference: ***DIZI/MvZ/22291***

Analysis Report

Radioactivity analysis of solids

Compiled by: ***D Kotze***

Checked by: ***M Raven***

1. SERVICE

Analysis solid samples for gross alpha/beta-activity and for selected radionuclides in the uranium and thorium decay series.

Number of samples received: 1

The samples were received on: 26 November 2012

2. SAMPLE PREPARATION AND ANALYSIS

Method	Description	Completed	Assayer	Verified by
WIN-114	**Dry sample, mill to homogenise**	20/12/2012	E Mothlabane	J Smit
WIN-138	**Gross alpha/beta analysis**	14/02/2012	N Yawa	E Nhlapo
WIN-167	**U and Th by neutron activation analysis**	15/03/2013	A Sathekge	M Raven
WIN-101	^{226}Ra, ^{228}Ra, ^{228}Th, ^{40}K by gamma analysis	18/02/2013	D Matshidiso	M Raven
WIN-158	**^{210}Pb by low energy gamma analysis**	06/02/2013	D Matshidiso	M Raven

Results indicated in **bold in this report were obtained from methods that are not included in the SANAS Schedule of Accreditation fo this laboratory*

3. RESULTS

3.1 Results are attached as an appendix to this report.

3.2 Results report are related only to sample portions tested.

3.3 The method for gross alpha/beta-activity is intended to merely be a screening technique and gives only a first order estimate of total activities. Errors associated with unavoidable differences between particle energies of the calibration standards and samples, are not accounted for in the reported uncertainty which is mainly based on counting statistics. The reported uncertainty may therefore be an underestimation of the true uncertainty.

4. QUALITY ASSURANCE

4.1 RadioAnalysis is a SANAS accredited laboratory (Testing Laboratory T0111) based on ISO/IEC Standard 17025. All analytical methods are documented in the RadioAnalysis Quality System.

4.2 Results in this report were obtained from one or more individual test reports produced by accredited or non-accredit methods.

- Test reports containing results obtained from methods included in the SANAS Schedule of Accreditation, are verified and signed by SANAS Technical Signatories for those methods.
- Test reports containing results obtained from methods not included in the SANAS Schedule of Accreditation, are verified and signed by qualified competent analysts for those methods.
- The individual test reports are available upon request

4.3 The compiler is the Technical Expert for all the methods.

4.4 The compiled report is checked by a person other than the compiler for accuracy of data transcription.

4.5 The RadioAnalysis Laboratory keeps the original signed hard copy of this report on record for three years.

APPENDIX 1: ANALYTICAL RESULTS

Activity concentrations of nuclides

Unit: Bq/kg

Field code	**Kendall Power Station**		
Lab code	**RA-13828X001**		
Nuclide	**Value**	**Unc.**	**MDA**
^{238}U	**164**	**3**	**0.43**
^{234}U	**166**	**3**	**0.44**
^{226}Ra	158	8	16
^{210}Pb	**183**	**27**	**81**
^{235}U	**7.56**	**0.13**	**0.020**
^{232}Th	**148**	**9**	**2.4**
^{228}Ra	197	13	25
^{228}Th	176	10	19
^{40}K	296	34	70
Gross alpha	**2510**	**190**	**350**
Gross beta	**1220**	**20**	**38**

*Results indicated in **bold** in this report were obtained from methods that are not included in the SANAS Schedule of Accreditation for this laboratory*

Notes:

1. If a measured value (**Value** column) was recorded, it is reported regardless if the value is less than the minimum detectable activity concentration (**MDA** column) or even if the value is negative. In the case where a value could not be obtained, a less than MDA ("< MDA") will be indicated.
2. The reported uncertainty (**Unc.** column) is quoted at 1 sigma (or coverage factor k = 1). The uncertainty is calculated mainly from counting statistics and it is not the standard deviation obtained from replicate measurements. No uncertainty value is reported of a less than MDA ("< MDA") is indicated in the **Value** column.
3. The minimum detectable activity concentration (**MDA** column) is calculated with a 95% confidence level.
4. A values is reported with 3 significant digits if it is greater than the MDA value and the associated uncertainty will be reported the same precision. If a value is less than the MDA, the value and its associated uncertainty are reported with 2 significant digits regardless their respective magnitudes. A MDA value is always reported with 2 significant digits.

APPENDIX C

AQUISIM REPORT

Technical Memorandum

AquiSim Consulting (Pty) Ltd

P O Box 51777, Wierda Park, 0149, South Africa

Telephone: + (27) (0)12 654-0212
Facsimile: + (27) (0)866 89-6006
E-mail: aquisim@netactive.co.za

To:	Marius van Zyl	**Date:**	26 March 2013
cc:		**Project No:**	ASC-1037B
From:	Japie van Blerk	**File No:**	01
RE:	**INTERPRETATION OF FULL SPECTRUM RADIOLOGICAL ANALYSIS: KENDAL POWER STATION**		

National Legislation

Materials and residues that contain naturally occurring radionuclides (i.e., radionuclides associated with the U-238, Th-232 and U-235 decay series) are generally referred to as Naturally Occurring Radioactive Material (NORM).

The legal limit in South Africa for material to be classified as radioactive is 0.5 $Bq.g^{-1}$ (nuclide specific). The protection of human health and the environment from adverse effects associated with exposure to ionizing radiation is regulated in terms of the National Nuclear Regulator Act (NNRA) (Act 47 of 1999) and the Nuclear Energy Act (NEA) (Act No. 46 of 1999).

The NNRA established the National Nuclear Regulator (NNR) as the statutory body responsible for regulating the nuclear industry, as well as NORM associated with the mining and mineral processing industry. Due to the presence of naturally occurring radionuclides, NORM has the potential to impact negatively on the health of humans that are exposed to these material.

In terms of its mandate, the NNR must publish requirements, guidelines, and standards for the protection of persons, property, and the environment against exposure to ionizing radiation that are consistent with international requirements and guidelines. Regulation No. 388 (dated 28 April 2006) defines regulations regarding safety standards and regulatory practices promulgated by the NNR. This means that material containing natural occurring radionuclides can only be regarded as radioactive if any of the radionuclides in the 238, U-234, U-235, and Th-232 decay series is above the exemption level of 0.5 $Bq.g^{-1}$.

The regulatory protection criteria defined in Regulation No. 388 for the protection of members of the public is consistent with international guidelines provided by the IAEA and ICRP. In terms of Regulation No. 388 the following limits apply:

- The annual effective dose limits for members of the public from all authorised actions is 1 mSv.
- No action may be authorised which would give rise to any member of the public receiving a radiation dose from all authorised actions exceeding 1 mSv in a year.

Consistent with international guidelines, the regulation makes provision for the application of a dose constraint for authorised actions to ensure optimisation of radiation protection. The following is stated (Section 4.5.2):

> Where applicable in terms of the prior safety assessment, the optimisation of protection must be subject to dose constraints specific to the authorised action, which must not exceed values that can cause the relevant dose limits to be exceeded and which ensure as far as practicable that doses are restricted by application of the ALARA principle on a source-specific basis rather than by dose limits (Section 4.5.2.1).
>
> For members of the public, the dose constraint applicable to the average member of the critical group within the exposure population is 0.25 mSv per year specific to the authorised action unless otherwise agreed by the Regulator on a case-by case basis, taking into account the dose limit specified for exposure of members of the public from all sources (Section 4.5.2.2).

Full Spectrum RadioAnalytical Results

Full spectrum results of an ash samples analysed at the Necsa RadioAnalytical Laboratories (Sanas Accredited) are available and listed in Table 1. From the results it is clear that all nuclides are below the exemption criteria of 0.5 $Bq.g^{-1}$ (or 500 $Bq.kg^{-1}$). This means that the material is not considered as radioactive material *per se*.

Table 1 Summary of the Necsa full spectrum radiological analysis (RA-13828, dated 18 March 2013) of an ash sample from the Kendal Power Station.

Nuclide	Kendal Power Station (RA-13828X001)		
	Value	Uncertainty	MDA
	$Bq.kg^{-1}$		
U-238	1.64E+02	3.00E+00	4.30E-01
U-234	1.66E+02	3.00E+00	4.40E-01
Ra-226	1.58E+02	8.00E+00	1.60E+01
Pb-210	1.83E+02	2.70E+01	8.10E+01
U-235	7.56E+00	1.30E-01	2.00E-02
Th-232	1.48E+02	9.00E+00	2.40E+00
Ra-228	1.97E+02	1.30E+01	2.50E+01
Th-228	1.76E+02	1.00E+01	1.90E+01
K-40	2.96E+02	3.40E+01	7.00E+01
Gross α	2.51E+03	1.90E+02	3.50E+02
Gross β	1.22E+03	2.00E+01	3.80E+01

Radiological Impact to Members of the Public

In order to assess the potential radiological impact to members of the public, information in terms of how these people interact with the material is needed (e.g. period exposed to the material, inhalation of dust particles containing the material, inadvertent ingestion of the material, etc.). This information is not available at present.

As an alternative, conservative assumption can be made regarding some of these parameters, to estimate the potential radiological impact under the assumed conditions. For this purpose, the following assumptions are made:

- Members of the public are exposed to the material for a period of 2000 hours per annum (equal to the period normally used for worker radiological safety assessments, such as tailings dam operators).
- During this exposure period, an adult member of the public inhale 1850 m^3 of air (or 0.93 $m^3.h^{-1}$, which is the average breathing rate during sleeping, sitting, light and heavy exercise). For this purpose it is assume that the inhalable dust load is 1E-04 $g.m^{-3}$.

For these assumed conditions, the inhalation dose to an adult members of the public will be in the order of 7 $\mu Sv.a^{-1}$ for the sample, while the external gamma radiation (normally referred to as ground shine) for an adult member of the public (2000 hour exposure period) would be in the order of 197 $\mu Sv.a^{-1}$. The external gamma radiation dose will decrease linearly with a decrease in exposure period, while the exposure with distance away from the facility will decrease exponentially (i.e., a small distance away from the facility, the dose will decrease to insignificant levels).

Conclusion

The material is below the limit set for material to be considered as radioactive. Assuming very conservative conditions (e.g. exposure for a period of 2000 hours per annum) the potential radiological impact to members of the public is below the regulatory criteria for the radiological protection of members of the public. It should be noted, however, that the assumed conditions does not consider the possibility for members of the public residing on top of the facility for extended periods of time, in which case additional exposure conditions would need to be considered (e.g. radon exhalation and the subsequent built-up of radon inside a house). It is not known whether such conditions is a possibility or realistic in this case.

Please do not hesitate to contact me if something is unclear.

Best Regards

JJ van Blerk (Sent electronically)
DIRECTOR: AquiSim Consulting (Pty) Ltd.