APPENDIX J

SEDIMENT ANALYSIS

MOKOLO CROCODILE Consultants

Our Reference: 00/01/01/L514 PIR/pn

26 October 2015

TCTA
P O Box 10335
CENTURION
0046

Attention: Mr K Mabitsela

PROJECT : MOKOLO CROCODILE WATER AUGMENTATION PROJECT (MCWAP)
CONTRACT No : TCTA 07- 041 CONSULTING SERVICES FOR MCWAP
SUBJECT : VO 09 – INTERIM SEDIMENT QUALITY REPORT

1. Background:

The proposed pumping operation of the future abstraction works at Vlieëpoort will result in the abstraction of a portion of the suspended silt and clay fraction of the total sediment load in the Crocodile River (West). The initial EIA process has identified that, as a result of upstream development, heavy metals may be present in the sediment of the Crocodile River. It is thus required that a silt quality profile be established to guide the management of the silt abstracted.

VO 09 that facilitates the execution of the sediment baseline study process in the Crocodile River (West) includes for the quality and quantity monitoring of the sediment.

The volume of suspended sediment transported during low flow conditions is insignificant (<4g/l) and cannot be practically accurately quantified using approved conventional measuring techniques. The volume of suspended sediment measured during floods is variable and one of the subjects of investigation of the baseline study. Since the commencement of the baseline study in November 2012 there has only been one flood event (2014). The volume of suspended sediment collected during this flood event was also insufficient to allow quality testing.

2. Sampling and testing approach:

In order to assess the quality of the sediment that is likely to be abstracted at the Vlieëpoort Weir, two sediment samples were taken from the river bed in the Crocodile River (West) at the following locations:

- At Nooitgedacht weir – Sample 1 (Upstream of Vlieëpoort)
- At Bridge upstream of Faure weir – Sample 3 (Downstream of Vlieëpoort)

These sediment samples (Approximately 1kg per sample site) were sent for laboratory testing of several quality parameters. The results are presented in two formats:

- The first is the concentration of a particular substance when the sediment is mixed with distilled water in a ratio of 500g sediment to 1000 mℓ water to give a concentration in mg/ℓ.

2nd Floor Outspan House 1006 Lenchen Ave North Centurion 0157
PO Box 8232 Centurion 0046 South Africa
Telephone: +27 12 643 0670
Facsimile: +27 12 663 6238

- The second is the concentration of a particular substance within the sediment only, expressed in mg/kg.

The above approach was followed to expedite the quality analysis of the sediment with the objective of verifying if the silt could potentially be classified as a waste. The chemical composition of the river bed sediment is regarded to be indicative of the potential chemical composition of the suspended sediment transported during floods. For the purpose of this baseline study it is further assumed that the quality of the raw water is directly proportional to the concentration of the suspended sediment.

The concentrations of the chemical composition of the above sediment samples cannot be directly compared with the available water and waste water standards. The sediment concentration in the first test sample is 500g/l. To put it in perspective, this is more than 25 times the expected sediment concentration (18g/l) during a flood with a 50 year return period or more than 5 times the expected sediment concentration (77g/l) during a flood with a 100 year return period. The test sample concentration is more than 1250 times the mean average annual river sediment concentration which is less than 0.4g/l.

For the purpose of this baseline study the test results of the first format is multiplied by a factor 0.05 to adjust the results for comparison with the available water and waste water standards. These adjusted values are reflected in the attached Table B.

The test results from the second format should be compared with available international standards for sediment quality. No adjustment is required for comparison with the standards.

3. Quantitative perspective

For the purpose of calculating indicative rough order of magnitude volumes of silt expected to be abstracted at Vlieëpoort, the following revised estimates are made based on the sediment grading:

- The gravel and sand fraction particles (>300µm) settles before the inlet structure, upstream of the weir, in the gravel trap and in the pump canals. (15%)
- The fine sand fraction particles (Between 300µm and 62 µm) (50%) are in temporary suspension, some settles in the pump canals and the rest in the de-silting works.
- Some of the silt (4 µm to 62 µm) settles in the de-silting works (34% of 25%), but the rest (66% of 25%) is deposited in the balancing dam.
- The clay fraction particles (< 4 µm) (10%) are in suspension for extended periods of time.
- 80% of the clay fraction is pumped to the end users, but this could be more depending on the design of the balancing dam.
- The fine sand, silt and clay fractions represents on average 85% of the total sediment yield.
- The clay fraction represents on average 10% of the total sediment yield.

The following table summarizes the rough order estimated sediment volumes:

Phase	**2A**	**2B**
Projected water demand (million m^3/a.)	75	100
Annual sediment load in river (t/a)	765380	765380
Annual abstracted load (t/a)	19300	25700
Percentage of river load abstracted (%)	2.5%	3.3%
Annual sediment to be flushed back to river from the weir gravel trap(t/a)	2900	3900
Fine Sand, Silt and Clay fraction (85%)	16400	21850
Annual sediment load to be flushed back to river from de-silting works (t/a) (50%+34% of 25%)	11300	15000
Percentage of river load returned (%)	1.5%	2%
Annual sediment load deposited in the balancing dam (t/a) (20% of 10% plus 66% of 25%)	3580	4750
Annual sediment load pump to end users (cannot flush) (t/a) (80% of 10%)	1550	2050

An important principle is that on average less than 4% of the annual sediment load would potentially be abstracted and only up to 2% would be returned. If the sediment concentration in the river is being mimicked by the sediment concentration of the flushing return flow water, the incremental impact would be insignificant. For example 50% of the annual silt load can be flushed within a 3 day flood event not exceeding a sediment concentration of 5g/l using 114 000m^3 of water from the balancing dam and maintaining a return flow rate of 0.44m^3/s.

This interim report reflects the expected quality profile of the sediment scouring return flow.

4. Quality standards:

The chemical and biochemical analysis test results were compared to the following local and international standards for wastewater, water and sediment quality:

4.1. Wastewater Quality:

- National Water Act - Waste Discharge Standards (DWA 2010 guidelines)

4.2. Water Quality:

- South African Water Quality Guidelines – Domestic Use
- South African Water Quality Guidelines – Recreational Use
- South African Water Quality Guidelines – Industrial Use
- South African Water Quality Guidelines – Irrigation Use
- South African Water Quality Guidelines – Livestock Watering
- South African Water Quality Guidelines – Aquaculture Use
- South African Water Quality Guidelines – Aquatic Ecosystem
- World Health Organization Guidelines for drinking-water quality
- Netherlands National Institute of Public Health and the Environment - Maximum Permissible Concentrations for Metals – Fresh Water

4.3. Sediment Quality:

- Sediment Management Standards Chapter 173-204 WAC Benthic Criteria
- Belgium – Flemish Environmental Protection Agency – RV Reference Values

- Europe - Technical Guidance Document on risk assessment - $PNECs_{ed}$ Predicted No Effect Concentration
- Europe - Water Framework Directive - QS_{sed} Quality Standard for sediment
- France - SEQ - eau Quality Criteria
- Canada - Canadian Council for Ministers of the Environment - ISQG Interim Sediment Quality Guidelines
- ICPR - International Commission for the Protection of the Rhine - ICPRRO Reference objectives
- USA - Environmental Protection Agency - SSB Sediment Screening Benchmarks
- Worldwide Use - MacDonald, 2000 - TEC Threshold effect Concentration
- USGS - MacDonald, 2000 - PEL Probable Effect Level
- Netherlands National Institute of Public Health and the Environment - Maximum Permissible Concentrations for Metals - Sediment

4.4. Review of the application of the South African Water Quality Guidelines-Volume 4-Agricultural Use: Irrigation:

In view of the extent of irrigation from the Crocodile River (West), the quality of the water for agricultural use is one of the fundamental drivers determining the environmental impact. The following table summarises the relevant guideline upper limits for the concentration of aluminium, iron and manganese in the water.

Element	Max Concentration mg/l *	Comments
Al	5	Can cause non-productivity in acid soils (pH < 5.5), but more alkaline soils at pH > 7.0 will precipitate the ion and eliminate any toxicity. Soils have the capacity to adsorb complex aluminium ions, thereby reducing their toxicity to plants
Fe	5	Not toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Overhead sprinkling may result in unsightly deposits on plants, equipment and buildings (Stains).
Mn	0.02	Plants vary in their sensitivity to manganese and toxicity has been observed at a fraction of a mg/l in nutrient solution. At fairly low concentrations manganese can cause the clogging of irrigation pipelines, drip and microjet emitters.

* Volume 4: Agricultural Use: Irrigation – Second Edition 1996

4.5. Review of the application of waste discharge standards:

DWS published General and Special Authorisation of waste water discharge limits into a water resource in Government Gazette No. 230526 on 8 October 1999. The following table reflects some of the relevant limits:

Element	General Limit mg/l	Special Limit mg/l
Dissolved Al	No limit provided	No limit provided
Dissolved Fe	0.3	0.3
Dissolved Mn	0.1	0.1

The DWS 2010 Guidelines for waste discharge standards in terms of the National Water Act(NWA) replaced the above with the following:

Element	**General Standards Existing Discharges mg/l**	**General Standards Future Discharges mg/l**
Dissolved Al	No limit provided	0.03
Dissolved Fe	0.3	0.3
Dissolved Mn	No limit provided	No limit provided

It should be recognised that the basic characteristics of a natural sediment scouring return flow is different to that of the return flow from industrial or residential waste water works. Aluminium is one of the fundamental chemical elements of soil and sediment. The constraint imposed by the DWS 2010 Guidelines for waste discharge standards for aluminium is not regarded appropriate for sediment scouring. On the other hand no limit is imposed on Manganese which potentially can have a bigger impact on irrigation water quality. It is not regarded appropriate to have no limit.

It is recommended that the DWS 2010 Guidelines for waste discharge standards be adjusted as follows for this application:

Element	**General Standards Future Discharges mg/l**	**Proposed Revised General Standards Future Sediment Discharges mg/l**
Dissolved Al	0.03	0.3
Dissolved Fe	0.3	0.3
Dissolved Mn	No limit provided	0.1

4.6. Review of the application of the international sediment quality standards:

The Netherlands National Institute of Public Health and the Environment published guidelines for maximum permissible concentrations of metals in sediment. However, the focus is on toxic heavy metals and no limits are provided for aluminium (Al), iron (Fe) and manganese (Mn). This is aligned with the discussion in 4.5 above that these elements are a fundamental part of natural soil and sediment chemical composition.

5. Test Results

In order to determine the heavy trace metals, the inorganic technique of inductively coupled plasma optical emission spectrometry (ICP-OES) was used.

In the attached Summary Table A the two sediment samples are compared to the above standards. Where the measured results exceed the guideline values, the relevant standards are presented in red. Where the measured results are below the guideline values they are presented in green. In some cases the guideline values are below the minimum test limit or not directly comparable due to difference in units, these values are indicated in black text.

The initial interpretation of the test results indicates high levels of aluminium (Al), iron (Fe) and manganese (Mn) present in the sediment samples which probably relates to the metal mining activities in the catchment. The presence of the other heavy metals such as lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), cobalt (Co), mercury (Hg), antimony (Sb), selenium (Se), Vanadium (V) and nickel (Ni) are well within international acceptable norms.

It is also observed from the results that the upstream sample exhibits approximately five times less aluminium (Al) and iron (Fe) concentration compared to the downstream sample. The iron ore mining activities immediately upstream of proposed abstraction site at Vlieëpoort may contribute to these increased concentrations downstream.

The question is whether the higher levels of aluminium (Al), iron (Fe) and manganese (Mn) present in the river bed sediment could result in the abstracted suspended sediment on MCWAP 2 being declared as waste material? The following table summarises the relevant test results:

Element (Inorganic Anions)	**Sample 1**			**Sample 3**			**Indicative Max Guideline Limits**
	mg/l	***mg/l**	**mg/kg**	**mg/l**	***mg/l**	**mg/kg**	**mg/l**
Aluminium (Al)	0.312	0.016	6.24	1.628	0.081	33	0.3
Iron (Fe)	0.688	0.034	14	3.821	0.191	76	0.3
Manganese (Mn)	0.516	0.026	10	0.201	0.004	4	0.1

6. Conclusion

This interim report concludes that:

a) The basis of assessing the potential waste characteristics of the sediment in the Crocodile river (West) is a complex combination of:

- local waste water standards, local irrigation water quality standards and international sediment quality standards;
- an understanding that the abstracted suspended sediment is less than 4% of the total average annual sediment load in the river and that only up to 2% is planned to be returned;
- an understanding that the chemical characteristics of the sediment in the river are the same as the chemical characteristics of the sediment planned to be returned; and
- an understanding that the concentration of the fine sand, silt and water matrix that is planned to be scoured back to the river, largely determines the environmental impact down stream of Vlieëpoort. It is the potential waste characteristics of this return scour stream that is relevant.

b) In comparison to the guidelines for maximum permissible concentrations of metals in sediment published by the Netherlands National Institute of Public Health and the Environment, the test results for heavy metals are well within allowable guideline values. As such the sediment can be considered as a non-waste material;

c) In comparison to the South African Water Quality Guidelines for maximum permissible concentrations of metals in irrigation water use, the test results for heavy metals are well within allowable values except that of manganese that is regarded to be potentially border line problematic. However, it should be noted that the concern about high levels of manganese is river system wide and the return of 2% of the sediment should not have in incremental impact if the sediment concentration in the returned scour flow mimics the sediment concentration in the river during flood events;

d) The DWS 2010 Guidelines for waste discharge standards is not fully applicable for sediment scouring return flows and adjustment is required to deal with the elements contained in natural soils;

e) In comparison to the proposed adjusted DWS 2010 Guidelines for waste discharge standards (applicable to sediments), the test results for heavy metals are well within allowable values.

7. Recommendations

It is recommended that:

a) The proposed approach and adjustments be reviewed and approved by DWS in principle prior to the distribution of the final report; and

b) The legal opinion obtained by TCTA regarding the definition of waste be reviewed in light of this interim report.

Yours sincerely,

J Pienaar
Project Manager

Encl: Table A
Table B

	Analyses	Monitoring 1		Monitoring 3		National Water Act Waste Discharge Standards - DWA 2010 guidelines: Existing General Standards	National Water Act Waste Discharge Standards - DWA 2010 guidelines: Future all discharges	South African Water Quality Guidelines: Domestic Use Target Water Quality Range	South African Water Quality Guidelines: Recreational Use Target Water Quality Range	South African Water Quality Guidelines: Industrial Use Target Water Quality Range	South African Water Quality Guidelines: Irrigation Use Target Water Quality Range	South African Water Quality Guidelines: Livestock Watering Target Water Quality Range	South African Water Quality Guidelines: Aquaculture Use Target Water Quality Range	South African Water Quality Guidelines: Aquatic Ecosystem Target Water Quality Range	World Health Organization Guidelines for Drinking-water Quality	Sediment Management Standards Chapter 173-204 WAC Benthic Criteria: SMS Freshwater Sediment - SCO	Sediment Management Standards Chapter 173-204 WAC Benthic Criteria: SMS Freshwater Sediment - CSL	Belgium - Flemish Environmental Protection Agency - RV Reference Values	Europe - Technical Guidance Document on risk assessment - $PNEC_{sed}$ Predicted No Effect Concentration	Europe - Water Framework Directive - QS_{sed} Quality Standard for sediment	France - SEQ - eau Quality Criteria
	Sample Number	12870		12871																	
	TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water		Distilled Water																	
	Dry Mass Used (g)	500		500																	
	Volume Used (mℓ)	1000		1000																	
	pH Value at 25˚C	8.1		8.3		5.5 - 9.5	5.5 - 7.5	6.0 - 9.0	6.5 - 8.5	7.0 - 8.0	6.5 - 8.4		6.5 - 9.0		6.5 - 8.5						
	Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ		mg/ℓ	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Chloride as Cl	12	24	28	56			0 - 100		0 - 20	0 - 100	0 - 1500	0 - 16 µg/ℓ		< 250						
	Sulphate as SO4	19	38	38	76			0 - 200		0 - 30		0 - 1000			< 400						
	Nitrate as N	<0.2	<0.4	0.3	0.6	15	15	0 - 6				0 - 100	0 - 300		< 50						
	Nitrite as N	<0.1	<0.2	<0.1	<0.2	15	15	0 - 6				0 - 100	0 - 0.05		< 3						
	Fluoride as F	<0.2	<0.4	<0.2	<0.4	1	1	0 - 1.0			0 - 2.0	0 - 2.0		0 - 0.75	< 1.5						
	Free & Saline Ammonia as N	1.1	2.2	2.6	5.2	3	1	0 - 1.0						0 - 7 Fg/ℓ		230	300				
	Mercury as Hg	<0.001	<0.002	<0.001	<0.002	0.005	0.001	0 - 1 Fg/ℓ				0 - 1 Fg/ℓ	0 - 1 Fg/ℓ	0 - 0.04 Fg/ℓ	< 0.006	0.66	0.8	0.10	0.47	0.67	0.20
ICP-OES Quant	Aluminium as Al	0.312	6.24	1.628	33	-	0.03	0 - 0.15			0 - 5	0 - 5	0 - 0.03	0 - 0.01	< 0.1						
ICP-OES Quant	Arsenic as As	<0.010	<0.200	<0.010	<0.200	0.02	0.01	0 - 10 Fg/ℓ			0 - 0.1	0 - 1.0	0 - 0.05	0 - 0.01	< 0.01	14	120				
ICP-OES Quant	Calcium as Ca	22	440	19	380			0 - 32				0 - 1000									
ICP-OES Quant	Cadmium as Cd	<0.005	<0.100	<0.005	<0.100	0.005	0.001	0 - 005 mg/l			0 - 0.01	0 - 0.01	0 - 0.2 Fg/ℓ	0 - 0.15 µg/l	< 0.003	2.1	5.4				
ICP-OES Quant	Cobalt as Co	<0.025	<0.500	<0.025	<0.500						0 - 0.05	0 - 1.0									
ICP-OES Quant	Chromium as Cr	<0.025	<0.500	<0.025	<0.500	0.05	0.02	0 - 0.050			0 - 0.10	0 - 1.0	0 - 20 Fg/ℓ	0 - 0.019	< 0.05	72	88				
ICP-OES Quant	Iron as Fe	0.688	14	3.821	76	0.3	0.3	0 - 0.1		0 - 0.1	0 - 5.0	0 - 10	0 - 0.01		< 0.3						
ICP-OES Quant	Potassium as K	5.1	102	6.3	126			0 - 50													
ICP-OES Quant	Manganese as Mn	0.516	10	0.201	4			0 - 0.05		0 - 0.05	0 - 0.02	0 - 10	0 - 0.1	0 - 0.180	< 0.4						
ICP-OES Quant	Sodium as Na	13	260	28	560			0 - 100													
ICP-OES Quant	Nickel as Ni	<0.025	<0.500	<0.025	<0.500						0 - 0.2	0 - 1.0			< 0.07	26	110	28	2.94	-	22
ICP-OES Quant	Lead as Pb	<0.020	<0.400	<0.020	<0.400	0.01	0.009	0 - 10 Fg/ℓ			0 - 0.2	0 - 0.1	0 - 0.01	0 - 0.2 µg/ℓ	< 0.01	360	1300				
ICP-OES Quant	Antimony as Sb	<0.010	<0.200	<0.010	<0.200										< 0.02						
ICP-OES Quant	Selenium as Se	<0.020	<0.400	<0.020	<0.400	0.02	0.008	0 - 20 Fg/ℓ			0 - 0.02	0 - 50 Fg/ℓ	0 - 0.3	0 - 0.002	< 0.01	11	20				
ICP-OES Quant	Vanadium as V	<0.025	<0.500	0.029	0.58			0 - 0.1			0 - 0.1	0 - 1.0									
ICP-OES Quant	Zinc as Zn	<0.025	<0.500	<0.025	<0.500	0.1	0.05	0 - 3			0 - 1.0	0 - 20	0 - 0.03	0 - 0.002	< 3	3200	4200	168	37	-	120
	E. Coli /1g dry mass	53		<6		20	20														
	Faecal Coliform Bacteria / 1g dry mass	53		<6		20	20	0													
	Carbon [s] in %																				
	Total Carbon [s] in %	0.22		0.18																	
	Organic Carbon [s] in %	0.15		0.18				0 - 5 mg/ℓ													
	Inorganic Carbon [s] in %	0.07		<0.01																	
	Tri-Halomethanes [s] in ppm							0 - 100 Fg/ℓ													
	Chloroform	0.002		<0.001											< 0.3						
	Methane, bromodichloro	0.002		0.003											< 0.06						
	Methane, dibromochloro	<0.001		0.003											< 0.1						
	Bromoform	0.006		0.008											< 0.1						
	Phenol [s] in ppm	<0.001		<0.001		0.1	0.01	0 - 1 Fg/ℓ					0 - 1 mg/ℓ	0 - 0.03 mg/ℓ							

	Analyses	Monitoring 1		Monitoring 3		Canada - Canadian Council for Ministers of the Environment - ISQG Interim Sediment Quality Guidelines	ICPR - International Commission for the Protection of the Rhine - $ICPR_{RO}$ Reference objectives	USA - Environmental Protection Agency - SSB Sediment Screening Benchmarks	Worldwide Use - MacDonald, 2000 - TEC Threshold effect Concentration	USGS - MacDonald, 2000 - PEL Probable Effect Level	Netherlands National Institute of Public Health and the Environment - Maximum Permissible Concentrations for Metals - Fresh Water					Netherlands National Institute of Public Health and the Environment - Maximum Permissable Concentrations for Metals - Sediment				
	Sample Number	12870		12871							MPA - Maximum Permissible Addition	NA - Negligible Addition	Cb - Background Concentration	MPC = Maximum Permissible Concentration	NC - Negligible Concentration	MPA - Maximum Permissible Addition	NA - Negligible Addition	Cb - Background Concentration	MPC = Maximum Permissible Concentration	NC - Negligible Concentration
	TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water		Distilled Water																
	Dry Mass Used (g)	500		500																
	Volume Used (mℓ)	1000		1000																
	pH Value at 25˚C	8.1		8.3																
	Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Chloride as Cl	12	24	28	56															
	Sulphate as SO4	19	38	38	76															
	Nitrate as N	<0.2	<0.4	0.3	0.6															
	Nitrite as N	<0.1	<0.2	<0.1	<0.2															
	Fluoride as F	<0.2	<0.4	<0.2	<0.4															
	Free & Saline Ammonia as N	1.1	2.2	2.6	5.2															
	Mercury as Hg	<0.001	<0.002	<0.001	<0.002	0.17	0.50	0.18	0.18	0.486	0.00023	0.0000023	0.00001	0.00024	0.000012	26	0.26	0.3	26	0.56
ICP-OES Quant	Aluminium as Al	0.312	6.24	1.628	33															
	Arsenic as As	<0.010	<0.200	<0.010	<0.200			9.8		17	0.024	0.00024	0.00077	0.025	0.001	160	1.6	29	190	31
	Calcium as Ca	22	440	19	380															
	Cadmium as Cd	<0.005	<0.100	<0.005	<0.100			0.99		3.53	0.00034	0.0000034	0.00008	0.00042	0.000083	29	0.29	0.8	30	1.1
	Cobalt as Co	<0.025	<0.500	<0.025	<0.500			50			0.0026	0.000026	0.0002	0.0028	0.00023	10	0.1	9	19	9.1
	Chromium as Cr	<0.025	<0.500	<0.025	<0.500			43.4		90	0.0085	0.000085	0.00017	0.0087	0.00026					
	Iron as Fe	0.688	14	3.821	76			20000												
	Potassium as K	5.1	102	6.3	126															
	Manganese as Mn	0.516	10	0.201	4			460												
	Sodium as Na	13	260	28	560															
	Nickel as Ni	<0.025	<0.500	<0.025	<0.500	-	50	22.7	22.7	36	0.0018	0.000018	0.0033	0.0051	0.0033	9.4	0.094	35	44	35
	Lead as Pb	<0.020	<0.400	<0.020	<0.400			35.8		91.3	0.011	0.00011	0.00015	0.011	0.00026	4700	47	85	4800	132
	Antimony as Sb	<0.010	<0.200	<0.010	<0.200			2			0.0062	0.000062	0.00029	0.0065	0.00035	16	0.16	3	19	3.2
	Selenium as Se	<0.020	<0.400	<0.020	<0.400			2			0.0053	0.000053	0.00004	0.0053	0.000093	2.2	0.022	0.7	2.9	0.72
	Vanadium as V	<0.025	<0.500	0.029	0.58						0.0035	0.000035	0.00082	0.0043	0.00086	14	0.14	42	56	42
	Zinc as Zn	<0.025	<0.500	<0.025	<0.500	123	190	121	121	315	0.0066	0.000066	0.0028	0.0094	0.0029	480	4.8	140	620	145
	E. Coli /1g dry mass	53		<6																
	Faecal Coliform Bacteria / 1g dry mass	53		<6																
	Carbon [s] in %																			
	Total Carbon [s] in %	0.22		0.18																
	Organic Carbon [s] in %	0.15		0.18																
	Inorganic Carbon [s] in %	0.07		<0.01																
	Tri-Halomethanes [s] in ppm																			
	Chloroform	0.002		<0.001																
	Methane, bromodichloro	0.002		0.003																
	Methane, dibromochloro	<0.001		0.003																
	Bromoform	0.006		0.008				0.654												
	Phenol [s] in ppm	<0.001		<0.001				0.42												

	Analyses	Monitoring 1		Monitoring 3		National Water Act Waste Discharge Standards - DWA 2010 guidelines		South African Water Quality Guidelines							World Health Organization Guidelines for Drinking-water Quality	Sediment Management Standards Chapter 173-204 WAC Benthic Criteria		Belgium - Flemish Environmental Protection Agency - RV Reference Values	Europe - Technical Guidance Document on risk assessment - $PNEC_{sed}$ Predicted No Effect Concentration	Europe - Water Framework Directive - QS_{sed} Quality Standard for sediment	France - SEQ - eau Quality Criteria
	Sample Number	12870		12871		Existing General Standards	Future all discharges	Domestic Use Target Water Quality Range	Recreational Use Target Water Quality Range	Industrial Use Target Water Quality Range	Irrigation Use Target Water Quality Range	Livestock Watering Target Water Quality Range	Aquaculture Use Target Water Quality Range	Aquatic Ecosystem Target Water Quality Range		SMS Freshwater Sediment - SCO	SMS Freshwater Sediment - CSL				
	TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water		Distilled Water																	
	Dry Mass Used (g)	25		25																	
	Volume Used (mℓ)	1000		1000																	
	pH Value at 25˚C	8.1		8.3		5.5 - 9.5	5.5 - 7.5	6.0 - 9.0	6.5 - 8.5	7.0 - 8.0	6.5 - 8.4		6.5 - 9.0		6.5 - 8.5						
	Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ		mg/ℓ	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Chloride as Cl	0.6	24	1.4	56			0 - 100		0 - 20	0 - 100	0 - 1500	0 - 16 µg/ℓ		< 250						
	Sulphate as SO4	0.95	38	1.9	76			0 - 200		0 - 30		0 - 1000			< 400						
	Nitrate as N	<0.2	<0.4	0.015	0.6	15	15	0 - 6				0 - 100	0 - 300		< 50						
	Nitrite as N	<0.1	<0.2	<0.1	<0.2	15	15	0 - 6				0 - 100	0 - 0.05		< 3						
	Fluoride as F	<0.2	<0.4	<0.2	<0.4	1	1	0 - 1.0			0 - 2.0	0 - 2.0		0 - 0.75	< 1.5						
	Free & Saline Ammonia as N	0.055	2.2	0.13	5.2	3	1	0 - 1.0						0 - 7 Fg/ℓ		230	300				
	Mercury as Hg	<0.001	<0.002	<0.001	<0.002	0.005	0.001	0 - 1 Fg/ℓ				0 - 1 Fg/ℓ	0 - 1 Fg/ℓ	0 - 0.04 Fg/ℓ	< 0.006	0.66	0.8	0.10	0.47	0.67	0.20
ICP-OES Quant	Aluminium as Al	0.016	6.24	0.081	33	-	0.03	0 - 0.15			0 - 5	0 - 5	0 - 0.03	0 - 0.01	< 0.1						
	Arsenic as As	<0.010	<0.200	<0.010	<0.200	0.02	0.01	0 - 10 Fg/ℓ			0 - 0.1	0 - 1.0	0 - 0.05	0 - 0.01	< 0.01	14	120				
	Calcium as Ca	1.1	440	1.0	380			0 - 32				0 - 1000									
	Cadmium as Cd	<0.005	<0.100	<0.005	<0.100	0.005	0.001	0 - 005 mg/l			0 - 0.01	0 - 0.01	0 - 0.2 Fg/ℓ	0 - 0.15 µg/l	< 0.003	2.1	5.4				
	Cobalt as Co	<0.025	<0.500	<0.025	<0.500						0 - 0.05	0 - 1.0									
	Chromium as Cr	<0.025	<0.500	<0.025	<0.500	0.05	0.02	0 - 0.050			0 - 0.10	0 - 1.0	0 - 20 Fg/ℓ	0 - 0.019	< 0.05	72	88				
	Iron as Fe	0.0344	14	0.191	76	0.3	0.3	0 - 0.1		0 - 0.1	0 - 5.0	0 - 10	0 - 0.01		< 0.3						
	Potassium as K	0.3	102	0.3	126			0 - 50													
	Manganese as Mn	0.026	10	0.01005	4			0 - 0.05		0 - 0.05	0 - 0.02	0 - 10	0 - 0.1	0 - 0.180	< 0.4						
	Sodium as Na	0.7	260	1.4	560			0 - 100													
	Nickel as Ni	<0.025	<0.500	<0.025	<0.500						0 - 0.2	0 - 1.0			< 0.07	26	110	28	2.94	-	22
	Lead as Pb	<0.020	<0.400	<0.020	<0.400	0.01	0.009	0 - 10 Fg/ℓ			0 - 0.2	0 - 0.1	0 - 0.01	0 - 0.2 µg/ℓ	< 0.01	360	1300				
	Antimony as Sb	<0.010	<0.200	<0.010	<0.200										< 0.02						
	Selenium as Se	<0.020	<0.400	<0.020	<0.400	0.02	0.008	0 - 20 Fg/ℓ			0 - 0.02	0 - 50 Fg/ℓ	0 - 0.3	0 - 0.002	< 0.01	11	20				
	Vanadium as V	<0.025	<0.500	0.00145	0.58			0 - 0.1			0 - 0.1	0 - 1.0									
	Zinc as Zn	<0.025	<0.500	<0.025	<0.500	0.1	0.05	0 - 3			0 - 1.0	0 - 20	0 - 0.03	0 - 0.002	< 3	3200	4200	168	37	-	120
	E. Coli /1g dry mass	2.65		<6		20	20														
	Faecal Coliform Bacteria / 1g dry mass	2.65		<6		20	20	0													
	Carbon [s] in %																				
	Total Carbon [s] in %	0.011		0.009																	
	Organic Carbon [s] in %	0.0075		0.009				0 - 5 mg/ℓ													
	Inorganic Carbon [s] in %	0.0035		<0.01																	
	Tri-Halomethanes [s] in ppm							0 - 100 Fg/ℓ													
	Chloroform	0.0001		<0.001											< 0.3						
	Methane, bromodichloro	0.0001		0.00015											< 0.06						
	Methane, dibromochloro	<0.001		0.00015											< 0.1						
	Bromoform	0.0003		0.0004											< 0.1						
	Phenol [s] in ppm	<0.001		<0.001		0.1	0.01	0 - 1 Fg/ℓ					0 - 1 mg/ℓ	0 - 0.03 mg/ℓ							

Analyses		Monitoring 1		Monitoring 3		Canada - Canadian Council for Ministers of the Environment - ISQG Interim Sediment Quality Guidelines	ICPR - International Commission for the Protection of the Rhine - $ICPR_{RO}$ Reference objectives	USA - Environmental Protection Agency - SSB Sediment Screening Benchmarks	Worldwide Use - MacDonald, 2000 - TEC Threshold effect Concentration	USGS - MacDonald, 2000 - PEL Probable Effect Level	Netherlands National Institute of Public Health and the Environment - Maximum Permissible Concentrations for Metals - Fresh Water: MPA - Maximum Permissible Addition	NA - Negligible Addition	Cb - Background Concentration	MPC = Maximum Permissible Concentration	NC - Negligible Concentration	Netherlands National Institute of Public Health and the Environment - Maximum Permissable Concentrations for Metals - Sediment: MPA - Maximum Permissible Addition	NA - Negligible Addition	Cb - Background Concentration	MPC = Maximum Permissible Concentration	NC - Negligible Concentration
Sample Number		**12870**		**12871**																
TCLP / Acid Rain / Distilled Water / H_2O_2		**Distilled Water**		**Distilled Water**																
Dry Mass Used (g)		**25**		**25**																
Volume Used (mℓ)		**1000**		**1000**																
pH Value at 25˚C		8.1		8.3																
Inorganic Anions		**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/ℓ**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
Chloride as Cl		0.6	24	1.4	56															
Sulphate as SO4		0.95	38	1.9	76															
Nitrate as N		<0.2	<0.4	0.015	0.6															
Nitrite as N		<0.1	<0.2	<0.1	<0.2															
Fluoride as F		<0.2	<0.4	<0.2	<0.4															
Free & Saline Ammonia as N		0.055	2.2	0.13	5.2															
Mercury as Hg		<0.001	<0.002	<0.001	<0.002	0.17	0.50	0.18	0.18	0.486	0.00023	0.0000023	0.00001	0.00024	0.000012	26	0.26	0.3	26	0.56
ICP-OES Quant	Aluminium as Al	0.016	6.24	0.081	33															
	Arsenic as As	<0.010	<0.200	<0.010	<0.200			9.8		17	0.024	0.00024	0.00077	0.025	0.001	160	1.6	29	190	31
	Calcium as Ca	1.1	440	1.0	380															
	Cadmium as Cd	<0.005	<0.100	<0.005	<0.100			0.99		3.53	0.00034	0.0000034	0.00008	0.00042	0.000083	29	0.29	0.8	30	1.1
	Cobalt as Co	<0.025	<0.500	<0.025	<0.500			50			0.0026	0.000026	0.0002	0.0028	0.00023	10	0.1	9	19	9.1
	Chromium as Cr	<0.025	<0.500	<0.025	<0.500			43.4		90	0.0085	0.000085	0.00017	0.0087	0.00026					
	Iron as Fe	0.0344	14	0.191	76			20000												
	Potassium as K	0.3	102	0.3	126															
	Manganese as Mn	0.026	10	0.01005	4			460												
	Sodium as Na	0.7	260	1.4	560															
	Nickel as Ni	<0.025	<0.500	<0.025	<0.500	-	50	22.7	22.7	36	0.0018	0.000018	0.0033	0.0051	0.0033	9.4	0.094	35	44	35
	Lead as Pb	<0.020	<0.400	<0.020	<0.400			35.8		91.3	0.011	0.00011	0.00015	0.011	0.00026	4700	47	85	4800	132
	Antimony as Sb	<0.010	<0.200	<0.010	<0.200			2			0.0062	0.000062	0.00029	0.0065	0.00035	16	0.16	3	19	3.2
	Selenium as Se	<0.020	<0.400	<0.020	<0.400			2			0.0053	0.000053	0.00004	0.0053	0.000093	2.2	0.022	0.7	2.9	0.72
	Vanadium as V	<0.025	<0.500	0.00145	0.58						0.0035	0.000035	0.00082	0.0043	0.00086	14	0.14	42	56	42
	Zinc as Zn	<0.025	<0.500	<0.025	<0.500	123	190	121	121	315	0.0066	0.000066	0.0028	0.0094	0.0029	480	4.8	140	620	145
E. Coli /1g dry mass		2.65		<6																
Faecal Coliform Bacteria / 1g dry mass		2.65		<6																
Carbon [s] in %																				
Total Carbon [s] in %		0.011		0.009																
Organic Carbon [s] in %		0.0075		0.009																
Inorganic Carbon [s] in %		0.0035		<0.01																
Tri-Halomethanes [s] in ppm																				
Chloroform		0.0001		<0.001																
Methane, bromodichloro		0.0001		0.00015																
Methane, dibromochloro		<0.001		0.00015																
Bromoform		0.0003		0.0004				0.654												
Phenol [s] in ppm		<0.001		<0.001				0.42												