APPENDIX I:
HYDROLOGY REPORT

February 2013

ESKOM HOLDINGS LIMITED

Surface water impact assessment for the Majuba Underground Coal Gasification Project

Submitted to:
Eskom Holding Limited
Majuba Underground Coal Gasification (UCG)
Amersfoort
Mpumalanga

REPORT

Report Number. 11613755-11905-3

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Golder Associates

Executive Summary

Golder Associates Africa (Pty) Ltd (GAA) was approached by Eskom Holding Limited, Majuba Underground Coal Gasification Project, (Majuba UCG) to undertake a surface water impact assessment in and around the trial site in south-eastern Mpumalanga Province.

An Environmental Scoping Study (Eskom, 2013) was undertaken for the UCG project and associated infrastructure on the farm Roodekopjes 67 HS (Portions 1, 2, 3 and remaining extent), Portions 17 and 21 of the farm Bergvliet 65HS and Portions 4 and 5 of the farm Rietfontein 66HS, in support of the co-firing of gas at the Majuba Power Station. This surface water impact assessment report serves to support the Environmental Impact Assessment (EIA) for the project.

The impact assessment has indicated that if mitigation and a comprehensive rehabilitation plan are put in place the impacts on surface water will be low.

The main impact during construction and decommissioning is likely to be the run-off from the construction area to the Geelklipspruit. This can be mitigated by staying out of the 1:50 year flood lines and following good construction practice.

The impact during operation will potentially be medium to high:

- Run-off from dirty areas such as workshop areas, roads and chemical storage areas;
- Discharge of treated effluent from the wastewater treatment work;
- Irrigation of treated condensate;
- Overflow from contaminated storage dams;
- Leaks from pipelines; and
- Undermining.

The highest impact being that of irrigation of treated condensate where extremely high levels of sulphate (1520 mg/l), fluoride (141 mg/l) and chloride (413 mg/l), well above the Resource Water Quality Objectives (RWQOs) set for the catchment have been noted to be expected after ultrafiltration (Golder 2013). The proposed irrigation plan should be followed to mitigate the potential impacts to the groundwater, wetland areas and Geelklipspruit.

In order to ensure that the medium to high impacts are mitigated a storm water management plan that will ensure that clean and dirty water are separated and that pollution control dams are adequately sized must be put in place to comply with GN 704. Flood line delineation will help to ensure that the mine keeps all infrastructure out of the 1:50 flood lines.

During construction and operation the surface water monitoring programme must be kept in place and kept going until decommissioning. Monitoring should be done on a monthly basis for all the parameters that are currently being undertaken and any further that would be written into a water use licence.

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1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd (GAA) was approached by Eskom Holding Limited, Majuba Underground Coal Gasification Project, (Majuba UCG) to undertake a surface water impact assessment in and around the trial site in south-eastern Mpumalanga Province.

In order to meet the fuel requirements for optimal power generation at the Majuba Power Station, Eskom proposes the use of synthesis gas or *syngas (*15 000 Nm^3/hr) produced by the UCG process as a supplementary fuel source within the boilers at the Majuba Power Station. The 15 000 Nm^3/hr plant will be scaled up to 70 000 Nm^3/hr and considering the results of the 70 000 Nm^3/hr may investigate the option of a commercial size UCG technology power plant.

An Environmental Scoping Study (Eskom, 2013) was undertaken for the UCG project and associated infrastructure on the farm Roodekopjes 67 HS (Portions 1, 2, 3 and remaining extent), Portions 17 and 21 of the farm Bergvliet 65HS and Portions 4 and 5 of the farm Rietfontein 66HS, in support of the co-firing of gas at the Majuba Power Station.

This surface water impact assessment report serves to support the Environmental Impact Assessment (EIA) for the project.

1.1 Objectives

The main objectives of the surface water impact assessment are to get an understanding of:

- Background to the catchment into which the site falls;
- The hydrology of the site;
- Baseline surface water quality; and
- Potential surface water impacts from the UCG project during construction, operation and closure.

2.0 PROJECT DESCRIPTION

2.1 Site location

The Majuba UCG trial site is located about 10 km south-west of the town of Amersfoort and 35 km north-north-west of the town of Volksrust in Mpumalanga on farm Roodekopjes 67 HS (Portions 1, 2, 3 and remaining extent), Portions 17 and 21 of the farm Bergvliet 65HS and Portions 4 and 5 of the farm Rietfontein 66HS (Figure 1). The UCG site is 5 km north-east of Eskom's Majuba Power Station. The area falls within the local administrative boundaries of Pixley ka Seme Local Municipality and the Gert Sibande District Municipality.

The Majuba UCG trial site covers an area of approximately 60 ha on the eastern bank of the Witbankspruit located in quaternary catchment C11J in the Upper Vaal Water Management Area (Figure 2). The Witbankspruit flows south to north and to the west of the site and an unknown tributary flows east to west past the site. The confluence of the two watercourses lies directly north of the site flowing to the Geelklipspruit and ultimately the Vaal River.

The topography of the area is characterised by rolling steep-sided hills formed by erosion of the underlying Karoo sediments and dolerite sill. The Majuba UCG lies at an altitude of approximately 1 710 mamsl.

2.2 Background description

Underground Coal Gasification (UCG) is a process whereby coal is converted *in situ* to combustible gas that can be used for power generation. It is one of the cleaner coal technologies being developed for implementation by Eskom. Over the past 11 years Eskom has undertaken considerable research into UCG technology.

The target coal seam is the Gus seam which is approximately 3-4 m thick and at a depth of about 280 m below surface. The underground coal gasification is a process in which coal is burned underground to produce a flammable product gas (syngas) that can be recovered for beneficial use. Syngas is a gas mixture that contains varying amounts of carbon monoxide and hydrogen.

The UCG process involves the reaction of water and oxygen with the coal in the presence of heat to generate syngas. The reaction takes place in an underground void, created by the combustion gasification chamber or cavity termed the gasifier. Water for the process is supplied, either through groundwater inflow to the gasifier from the coal seam and surrounding strata, or by pumping water into the gasifier through injection boreholes.

Injection boreholes are also used to supply oxygen, in the form of compressed air, to the UCG process. The oxygen flow guides the expansion of the cavity since the gasification process will migrate towards higher oxygen concentrations. In this way the expansion of the gasifier can be controlled.

As described in the Scoping Report (Eskom, 2013) in the context of a primary energy supply option for utility scale power generation, the following characteristics of UCG technology are attractive from Eskom's perspective:

- UCG mining, in conjunction with a combined cycle gas turbine power station, is potentially a cleaner method of coal-based power generation. Once Eskom has proven commercial feasibility, the exact technology footprint will be compared to traditional coal power generation technologies;
- The UCG process at commercial scale would likely create a large underground gas and heat storage inventory, making the gas supply very stable and consistent;
- Depending on the area and coal resource, the cavity created by UCG could provide a suitable CO_2 sequestration option. This consideration is however still in an early phase and will be explored by Eskom during further research;
- A commercial scale UCG production plant is essentially made up of a number of modular underground reactors with largely independent outputs. The coal extraction and overall gas output from the gasification process may therefore be optimised by varying and then mixing the outputs of the individual modules;
- No ash or slag removal and handling are necessary as there is minimal particulate carry over in the gas, and most of the solids remain underground;
- The operating pressure of the underground gasifier is such that it maintains a negative hydraulic gradient into the cavity, preventing contamination of surrounding aquifers in the underground environment; and
- Ground water influx into the gasifier creates an effective "steam jacket" around the reactor making the heat loss *in situ* tolerably small.

UCG has the potential to extract coal resources previously regarded as either uneconomic or inaccessible due to depth, seam thickness, seam slope, seam fracturing and displacement, or other mining and safety considerations. UCG offers an opportunity for expanding South Africa's mineable coal reserve base by extracting coal previously disregarded. The UCG concept therefore provides promising prospects for future energy supplies.

A by-product of the gasification process is water condensate that contains organic and inorganic impurities. In terms of Section 21 of the National Water Act (Act 36 of 1998), Eskom is required to obtain a Water Use License in order to irrigate the water. Disposal of the water should be in a manner that is not detrimental to the environment in the longer term. Eskom proposes to dispose of the water by irrigation of farm land planted to predominately *Eragrostis curvula*. The expected volumes of water to be disposed of between now and 2017 range from $27m^3$/d in 2013 and are expected to peak in 2017 at 126 m^3/d.

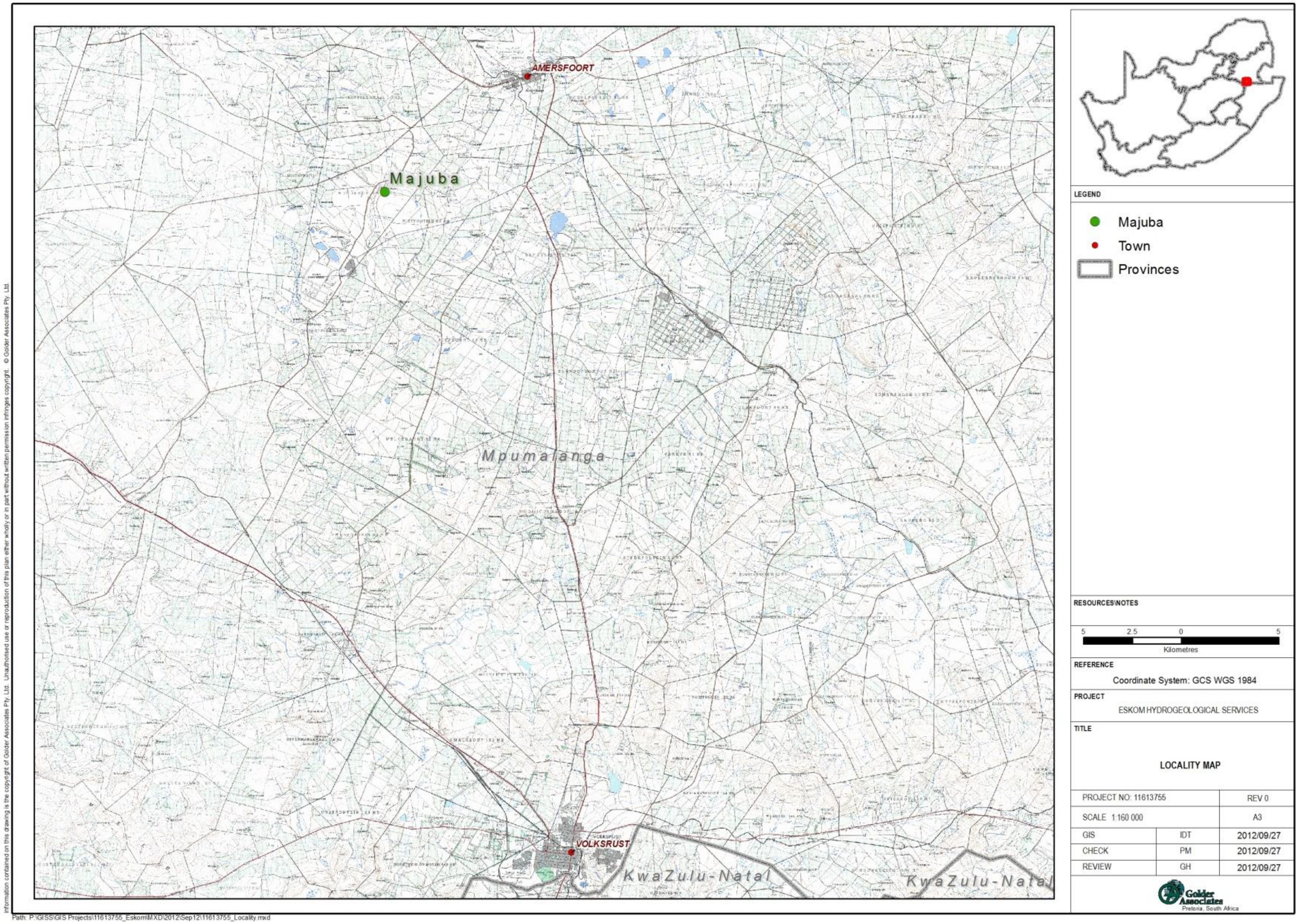

Figure 1: Site location

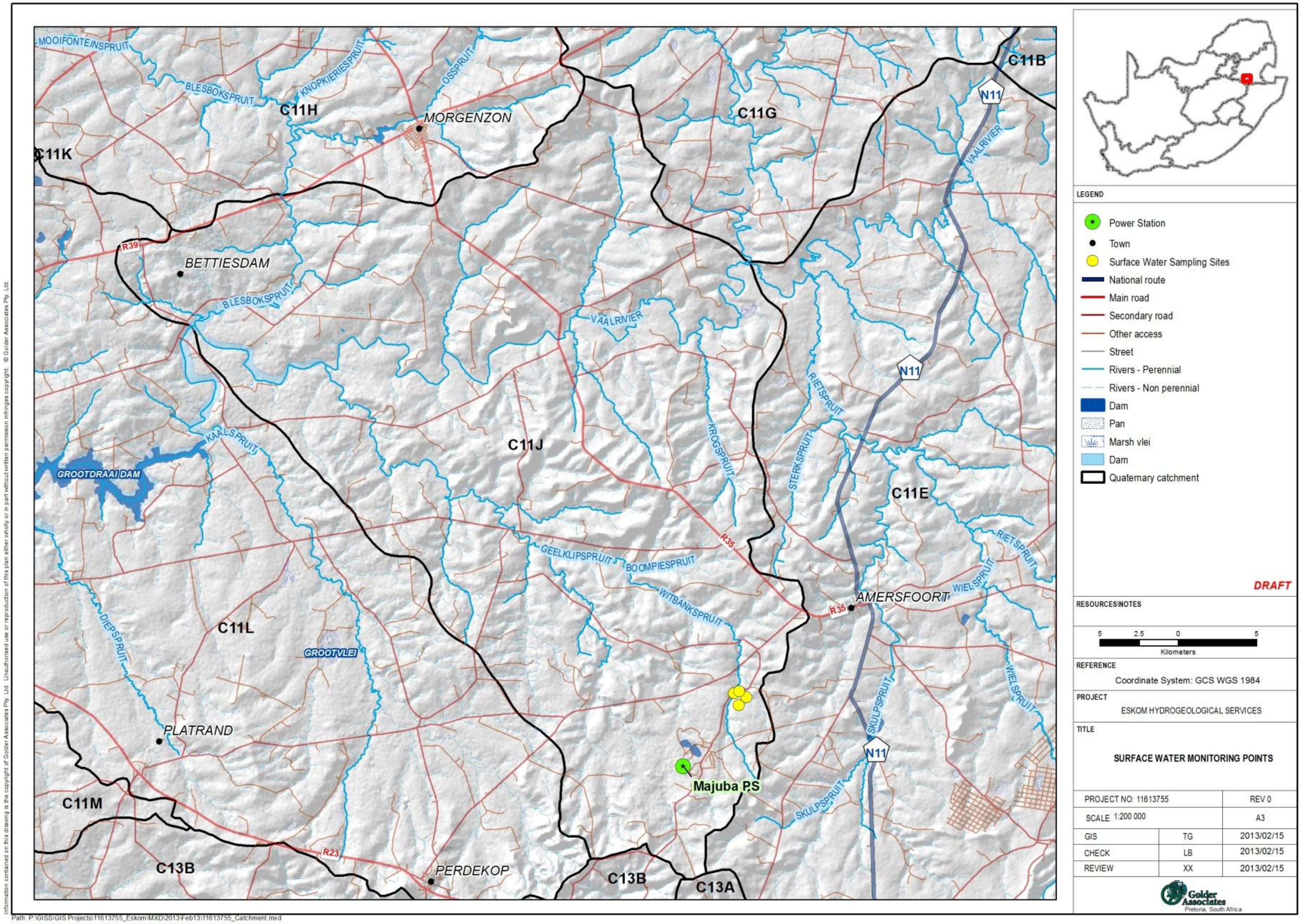

Figure 2: Catchment location

3.0 WATER USERS

The land-use in the area is primarily rural agricultural based, with an urban setting in the nearby town of Amersfoort (Eskom, 2013):

- Agriculture (covering the majority of the proposed development route);
- Mix urban use (in town approximately 7km from proposed development area); and
- Energy production (at Majuba opposite the proposed project area).

Amersfoort Town Area consists of Amersfoort, Perdekop, Daggakraal, Siyasenzele and Ezamokuhle settlements and falls under the management of the Pixley ka Seme Local Municipality in Gert Sibande District Municipality. The Pixley ka Seme Municipality serves as a Water Services Authority and Water Services Provider for the area. The Water Services Development Plan (WSDP, 2009) indicates that Amersfoort Town Area's main water source is the local dam (Amersfoort Dam) from where water is abstracted, purified and distributed. Amersfoort Dam is located on the Schulpspruit with a storage capacity 0.992 million m^3 and a yield of 1.33 million m^3/annum. All water is abstracted from local resources.

The main water users in the area are therefore:

- Urban related water users in the Pixley ka Seme Local Municipal area; and
- Irrigation.

4.0 SURFACE WATER

The site straddles two quaternary catchments, both of which form part of the Grootdraai dam catchment of the Upper Vaal Water Management Area (WMA), C11J and C11E. Of importance is that this area falls within the Grootdraai catchment which is part of the integrated system of water supply to Eskom Power Stations and the Sasol Secunda Complex and is therefore strategically critical to the county's economy.

The Upper Vaal WMA covers approximately 55 562 km^2 including parts of Gauteng, Mpumalanga, Free State and North West Provinces. It consists of the C1, C2 and C8 secondary drainage regions. The main rivers in the secondary drainage regions are listed in Table 1. There are three large dams in the WMA: Grootdraai Dam, Vaal Dam and Sterkfontein Dam.

Table 1: Major catchments and rivers

Primary Catchment	Sub-catchment area	Quaternary catchments	Average gross area (km^2)
C	Wilge	C81A-M; C82AH; C83A-M	18 167
	Klip (Free State)	C13A-H	5 182
	Grootdraai	C11A-L	7 995
	Grootdraai to Vaal Dam	C11M; C12A-L	7 294
	Suikerbosrand	C12A-G	3 541
	Klip (Gauteng)	C22A-E	2 282
	Rietspruit	C22J and C22H	1 123
	Leeu/Taaiboschspruit	C22F; C22G; C22K	1 705
	Mooi	C23D-K	4 494
	Vaal Barrage to Mooi	C23A-C; C23L	3 239

The area that is currently being assessed falls within catchment C11J, part of which is drained by the Witbankspruit, a stream that forms a tributary of the Upper Vaal River to the north of the site (the

Witbankspruit flows from north to south across the site). All wetlands on the Roodekopjes Site drain into the Witbankspruit (Eskom, 2012).

A small part of Roodekopjes property, and the Rietfontein and Bergvliet properties, fall within quaternary catchment C11E. The major rivers/streams in the area are the Skulpspruit (into which all wetlands located in this part of the site drain) and forms a tributary of the Rietspruit, itself a tributary of the Upper Vaal. These properties however, relate to potential future prospecting and are not dealt with in this study.

5.0 RESOURCE QUALITY OBJECTIVES

Classification of the Upper Vaal started in March 2011 and was completed in September 2012 as part of the study for the 'Classification of Significant Water Resources (River, Wetlands, Groundwater and Lakes) in the Upper, Middle and Lower Vaal Water Management Areas (WMA) 8,9,10' undertaken by WRP Consulting Engineers (Pty) Ltd in association with DMM Development Consultants CC, Rivers for Africa eFlows Consulting (Pty) Ltd, Conningarth Economists, Koekemoer Aquatic Services and Zitholele Consulting (Pty) Ltd.

The management classes have however not yet been gazetted. Resource Quality Objectives (RQOs) have not yet been set. The project to determine the RQOs commenced in September 2012 and it is expected that RQOs will be available in 2014.

The classification study has proposed the Management Class for the Grootdraai catchment as a MC II, where MCII is defined as: **Moderately used** (configuration of ecological categories moderately altered from its predevelopment condition).

As part of the development of an Integrated Water Quality Management Plan for the Upper and Middle Vaal (DWAF, 2009) strategic monitoring points were identified within the Vaal River System that would be strategically located and sufficiently widespread to provide an adequate indication of the prevailing water quality status for the development of interim Resource Water Quality Objectives (RWQOs). Strategic monitoring points were identified at two levels:

- Level 1: Points on the Vaal River from its origin to Douglas Barrage; and
- Level 2: Points on the major tributaries of the Vaal River just upstream of their confluences.

Level 1 strategic monitoring points refer to the monitoring points that are located on the Vaal River of which nine are located in the Upper Vaal). Level 2 strategic monitoring points refer to the monitoring points that are located on the major tributaries of the Vaal River, just upstream of their confluences. Fifteen strategic points were identified in the Upper Vaal. The Geelklipspruit falls within that portion of the Vaal River downstream of Rietspruit confluence with the Vaal River and upstream of the Blesbokspruit confluence with the Vaal River.

As part of the development of an Integrated Water Quality Management Plan for the Upper and (DWAF, 2009) the existing RWQO (

Table 2) set for the Vaal main stem and the major tributaries in the Water Management Areas (WMA) were collated and reviewed. The review indicated that the RWQO had been set in isolation on a priority catchment basis. Subsequently the initial set of RWQO was revised. The workshop identified total dissolved solids (TDS), total phosphorus (TP) and *Escherichia coli (E coli)* as the key water quality variables of concern for which RWQOs were set.

- Total dissolved solids (TDS): 150 mg/l
- Total phosphorus (TP): 50 µg/l, and

- *Escherichia coli (E coli):* < 300 Colony forming units (CFU)/100ml.

Table 2: Resource Water Quality Objectives: Grootdraai catchment

Variable	Unit	Ideal	Acceptable	Tolerable	Unacceptable
Conductivity	mS/m	< 10	10 - 15	15 - 25	> 25
Alkalinity ($CaCO_3$)	mg/l	< 20	20 - 45	45 - 75	> 75
pH	pH units				< 6.4 & > 8.5
Phosphate (PO_4)	mg/l	< 0.05	0.05 - 0.08	0.08 - 1	> 1
Sulphate (SO_4)	mg/l	< 10	10 - 20	20 - 30	> 30
Nitrate (NO_3)	mg/l	< 0.05	0.05 - 0.25	0.25 - 0.50	> 0.50
Ammonia (NH_4)	mg/l	< 0.02	0.02 - 0.5	0.5 - 1	> 1
SAR		< 4	4 - 8	8 - 12	> 12
Chloride (Cl)	mg/l	< 10	10 - 15	15 - 20	> 20
Chemical Oxygen Demand (COD)	mg/l	< 10	10 - 15	15 - 25	> 25

6.0 WATER QUALITY

The dominant potential impactors in the Grootdraai catchment are:

- Coal mining activities: abandoned and operational mines in the Ermelo area;
- Camden and Majuba power stations;
- Domestic wastewater treatment works; and
- Large scale agriculture is also thought to contribute to the nutrient and sediment loads in the river system.

6.1 Surface water monitoring points

There are four surface water monitoring points (Table 3) that will indicate potential pollution from the site. The surface water was sampled consistently throughout the monitoring period from four points shown in Figure 3:

- The Witbankspruit (2010 data only);
- Upstream at a non-perennial stream;
- Downstream at a non-perennial stream; and
- The cooling water dam.

Sampling from monitoring points such as WS1 to WS3 was discontinued and therefore are not included in this analysis.

The samples were collected by Eskom personnel and chemical analysis was done by the UIS laboratory. The analytical results from the surface water samples are compared against the RWQOs set out in Section 5.0 or against the water quality guidelines (DWAF, 1996) for irrigation and aquatic systems where RWQOs are not available.

Table 3: Surface water monitoring points in the study area

Site	Co-ordinates	
	Latitude	**Longitude**
Witbankspruit	-27.05878328100	29.79855009400
Upstream	-27.06117004900	29.80556199900
Downstream	-27.05776316500	29.80159599300
Cooling Water Dam	-27.06560543100	29.80135761800

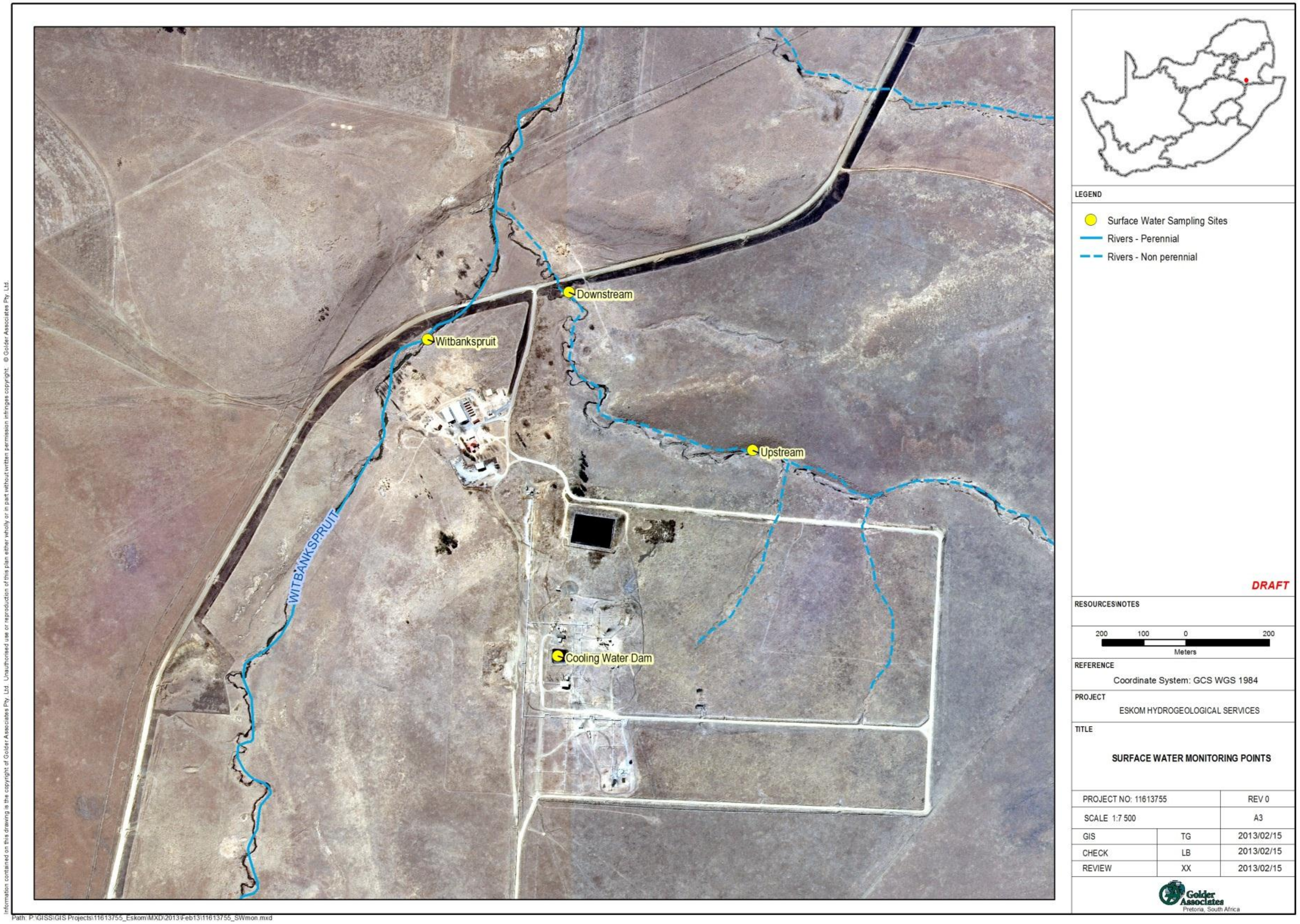

Figure 3: Surface water monitoring points

6.2 Chemical water quality

The surface water quality is presented in **Table 4**. The average values are compared against the acceptable level RWQOs available (Section 5.0) or against the stricter of the water quality guidelines (DWAF, 1996) for aquatic, irrigation or domestic water use. Figure 4 and Figure 5 indicate that there is an impact from the site with average TDS at the upstream at a concentration of 127 mg/l and that at the downstream site 257 mg/l. the same is noted for the average sulphate concentration of 25 mg/l and 37 mg/l at the respective up and downstream sites. The data in **Table 4** also indicates increases at the downstream site of alkalinity, calcium, chloride and nitrate.

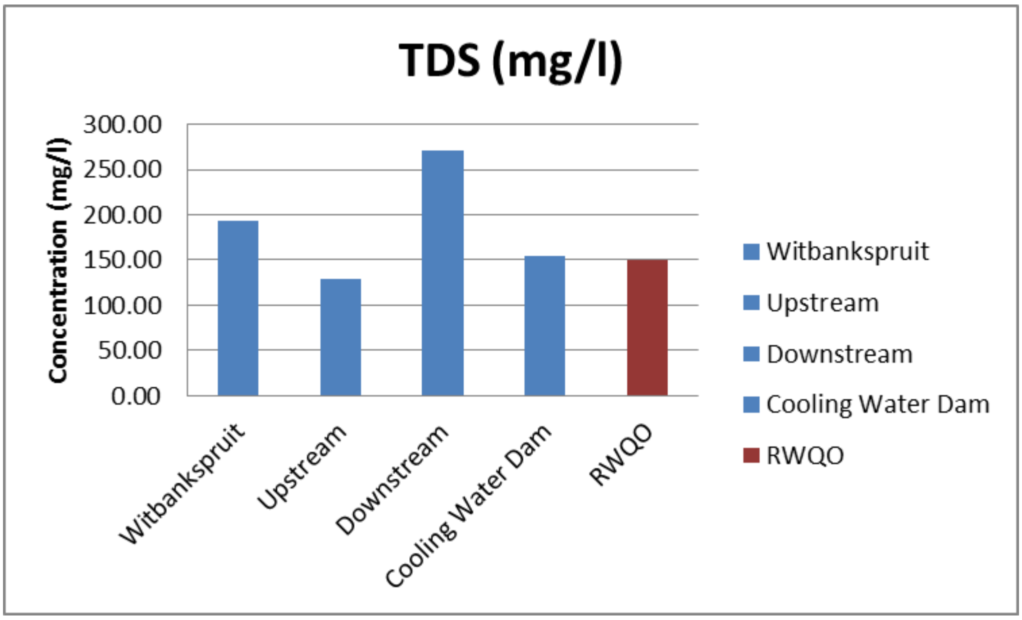

Figure 4: Average TDS concentration at the four surface water sampling points

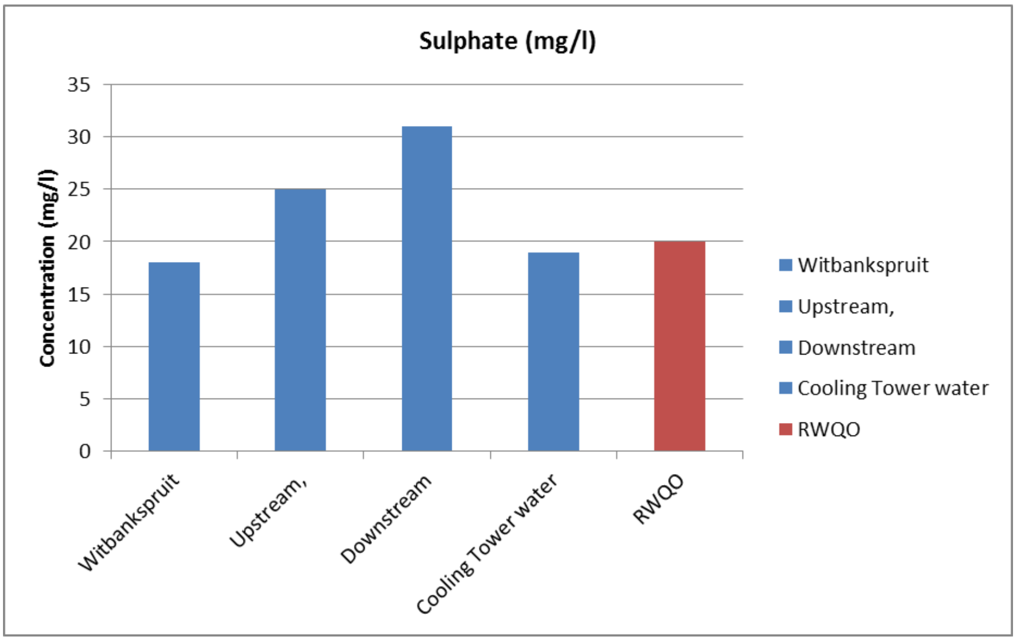

Figure 5: Average sulphate concentration at the four surface water sampling points

Table 4: Water quality results

Sampling point		pH	TDS	T Alk	Ca	Mg	Na	K	F	Cl	NO_3-N	SO_4	Al	Fe	Mn
		6.4-8.5	< 150	< 45	32(D)	30(D)	70(I)	50(D)	0.7(D)	< 15	< 0.25	< 20	0.01(A)	0.1(D)	0.02(I)
Witbankspruit (Jan 2010 to Sept 2010)	Min	7.4	83	-	30	28	5	1	0	4.5	0	13	0	0	-
	Max	8.2	309	-	86	115	26	4.3	0.2	27	1.4	33	0.9	0.2	-
	95%	8.2	296	-	72	92	16	3.6	0.2	19	1.1	27	0.8	0.2	-
	Ave	8	194	-	59	55	10	2.6	0.1	15	0.4	18	0.3	0.11	-
	n	30	30	-	30	30	30	30	30	30	30	30	30	30	-
Upstream (January 2010 to September 2012)	Min	7.1	49	55	10	7	2	0.8	0	3	0	7	0	0	0
	Max	8.6	222	83	64	58	24	2.6	0.4	10	9	56	1.1	0.6	0.5
	95%	8.4	213	82	60	53	19	2.5	0.4	10	8	48	0.7	0.6	0.4
	Ave	7.8	128	65	31	23	10	1.8	0.1	7	2	25	0.1	0.22	0.07
	n	21	21	10	21	21	21	21	21	21	21	21	21	21	21
Downstream (January 2010 to September 2012)	Min	7.3	57	140	18	25	5	0.4	0	4	0	10	0	0	0
	Max	8.5	414	222	89	76	34	17	0.5	39	9	116	1	0.6	0.2
	95%	8.4	393	220	84	54	27	3.3	0.3	28	3.5	71	0.6	0.39	0.1
	Ave	7.9	272	189	48	36	19	2.3	0.2	20	1.2	38	0.2	0.16	0.04
	n	31	31	20	31	31	31	31	29	31	17	31	21	23	13
Cooling Water Dam (Jan 2010 to Sept 2010)	Min	8	99	-	32	18	14	2.3	0.1	14	0	13	-	0	-
	Max	8	99	-	32	18	14	2.3	0.1	14	0	13	-	0	-
	95%	9.1	222	-	62	63	32	5.5	0.3	24	1.3	24	-	0.1	-
	Ave	8.5	155	-	42	39	21	3.8	0.2	19	0.4	19	-	0.03	-
	n	9	9	-	9	9	9	9	9	9	9	9	9	9	-

D: domestic; A: aquatic; I: Irrigation

6.2.1 Water quality trends

Witbankspruit

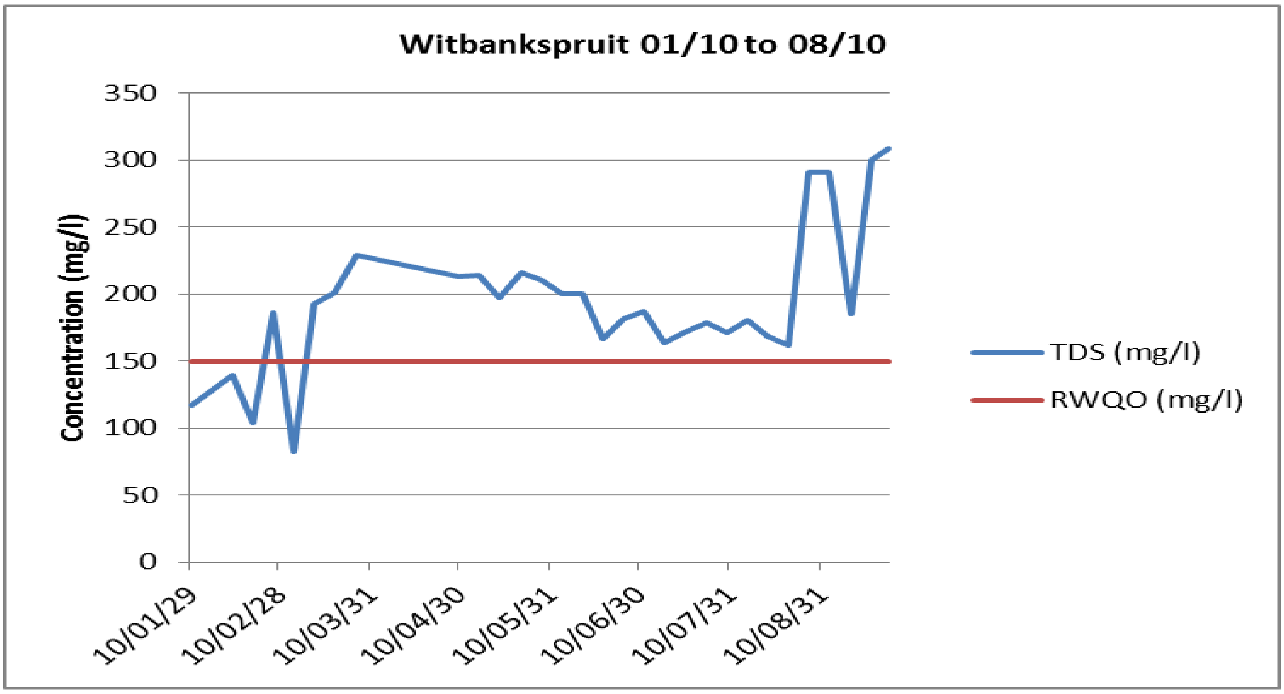

Figure 6: Witbankspruit TDS trends for the period January 2010 to August 2010

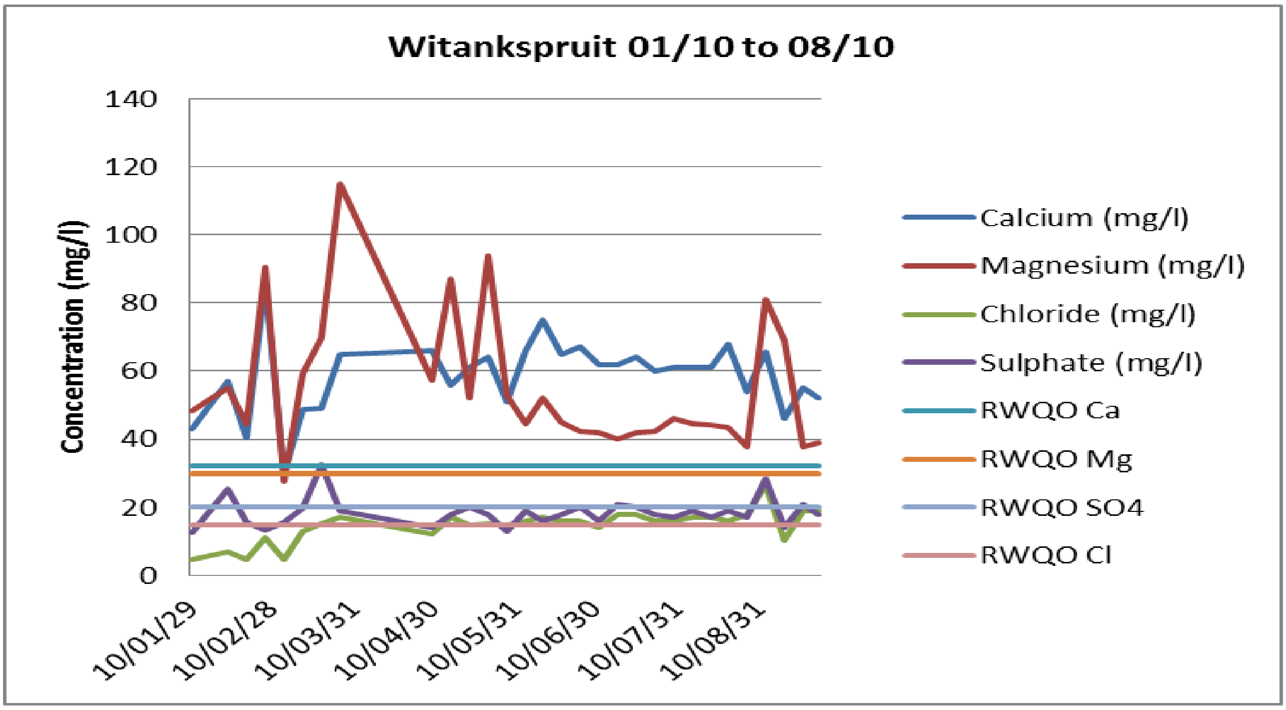

Figure 7: Witbankspruit water quality trends for the period January 2010 to August 2010

Water quality for the period January 2010 to August 2010 indicated that the stream is being impacted on by upstream activities, very likely from overflows from the pollution control dam located east of Majuba Power Station.

Upstream sampling site

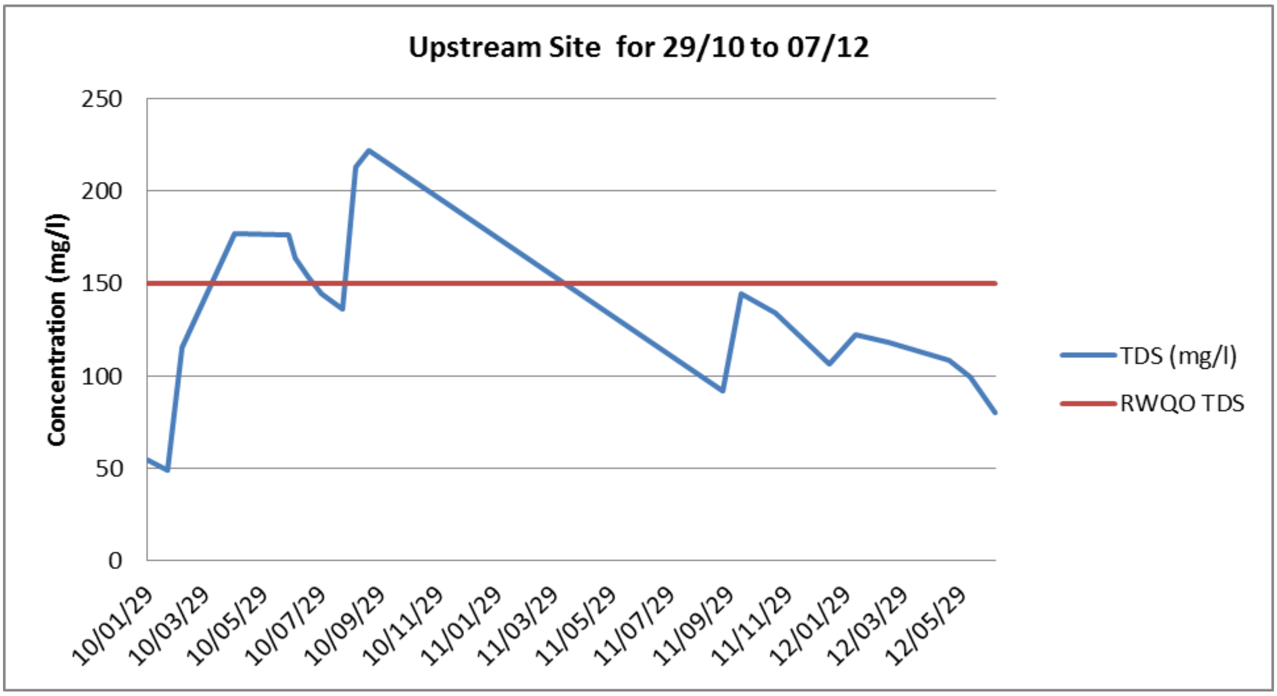

Figure 8: Upstream TDS trends for the period January 2010 to July 2012

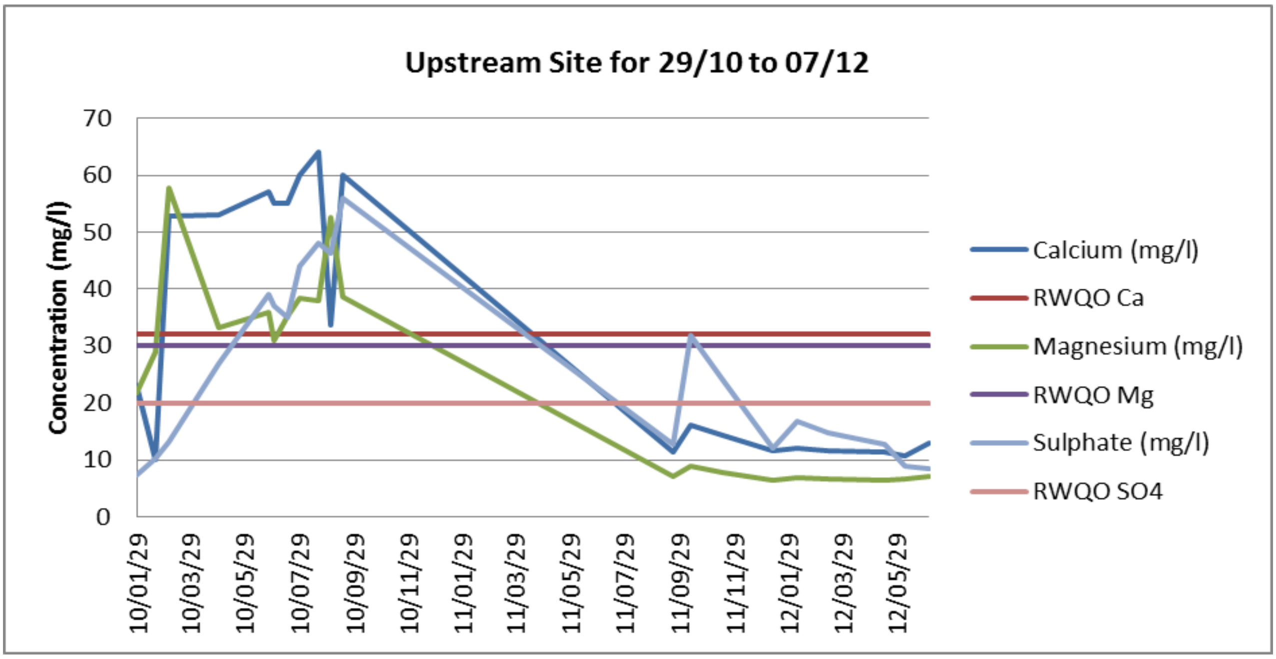

Figure 9: Upstream water quality trends (Calcium, magnesium and sulphate)for the period January 2010 to July 2012

The water quality at the upstream site has improved considerably since May 2011. It is not clear what would have caused the spike in 2010/2011.

Downstream sampling site

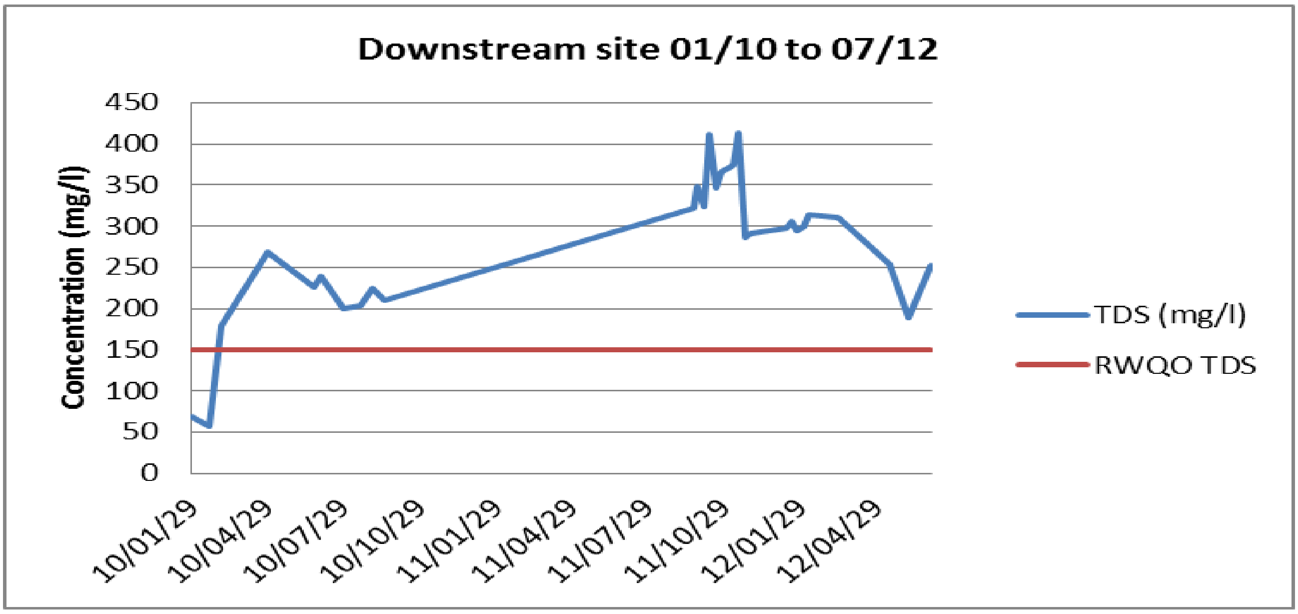

Figure 10: Upstream TDS trends for the period January 2010 to July 2012

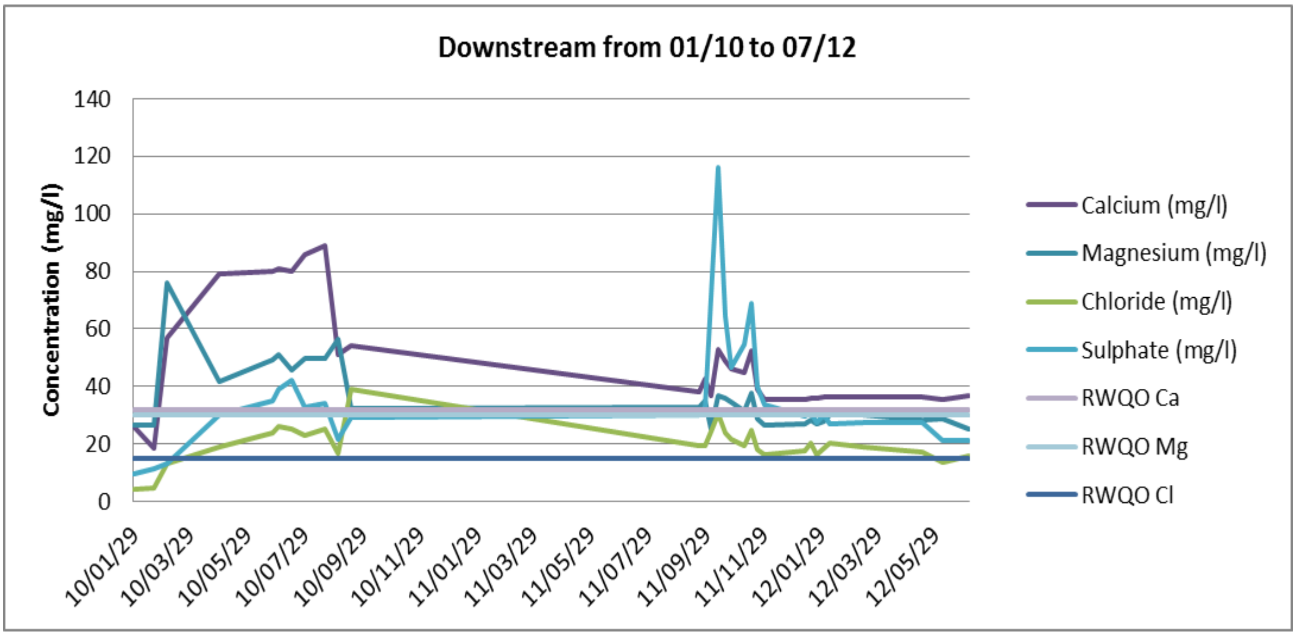

Figure 11: Downstream water quality trends (Calcium, magnesium and sulphate) for the period January 2010 to July 2012

6.2.2 Water quality of irrigation water (treated condensate water)

A study entitled; *A critical evaluation of the soil and water quality in developing an irrigation management plan for ESKOM for a farm near Amersfoort, Report number* Report No GW/A/2013/03 was undertaken to assess the potential for irrigation of treated condensate water.

The water will be collected in a centrally located raw water dam and then treated using ultra filtration (UF) to remove the bulk of the organic impurities to improve the quality. A water treatment plant has been designed by SISTEMA AZUD, S.A. based on laboratory trials that were carried out on actual condensate samples by Eskom Research and development staff. The objective of the laboratory trials was to remove all the particulate organic components from the condensate, but not the inorganic compounds. This will leave what could be considered a liquid fertilizer containing ammonium sulphate, potassium and low concentrations of other elements that could be used for irrigation.

The results have indicated that treated water exhibits a drastic decrease in Polycyclic Aromatic Compounds from the “Raw Feed” to the “UF Product” water to the extent that the Polycyclic Aromatic Compounds cannot be considered as problematic for supplementary irrigation. Of the inorganic compounds remaining in the treated water some, such as ammonium sulphate, potassium and other elements will be beneficial to plant growth, while some, such as fluoride, chloride, boron, and sulphate are present in such high concentrations that they can be considered as problematic for plant growth.

If the South African Water Quality Guidelines for Agriculture (DWAF, 1996) are used, both fluoride and chloride concentrations exceed the Irrigation target water quality guideline ranges, and normally are not recommended for use as irrigation water, except under a very specific management regime. The boron concentration falls within the irrigation sensitive water target water guideline range, also normally not recommended for use as irrigation water, except under a very specific management regime. No irrigation target water quality guideline range specification is available for sulphate, but the very high value of 1 520 mg/l is definitely problematic. The table below is taken from the Institute for Soil Climate and Water**,** Agricultural Research Council, South Africa. (2013) report, Report No GW/A/2013/03 and shows the inorganics water quality results.

Table 5: Quality of condensate water (as taken from Institute for Soil Climate and Water, Agricultural Research Council, South Africa (2013), Report No GW/A/2013/03).

Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Parameter	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K
Raw Feed	<0.05	0.26	0.11	3.45	0.15	<0.05	<0.05	5.92	<0.05	<0.05	<0.05	0.25	2.69	3.19
AC 1	<0.05	<0.05	0.16	0.61	0.17	<0.05	<0.05	8.32	<0.05	<0.05	<0.05	<0.05	0.37	1730
AC 2	<0.05	0.08	0.12	2.17	0.16	<0.05	<0.05	7.14	<0.05	<0.05	<0.05	0.05	2.3	157
UF Product	<0.05	0.17	0.11	0.96	0.15	<0.05	<0.05	25.8	<0.05	<0.05	<0.05	0.51	0.79	713
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Parameter	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr
Raw Feed	<0.05	4.07	0.47	<0.05	62.8	<0.05	0.05	<0.05	969	<0.1	0.2	3.1	<0.05	0.07
AC 1	<0.05	9.37	<0.05	<0.05	175	<0.05	12.7	<0.05	763	<0.1	0.28	12.1	0.06	0.16
AC 2	<0.05	6.81	0.08	<0.05	74.1	<0.05	3.56	<0.05	758	<0.1	0.18	5.74	<0.05	0.12
UF Product	<0.05	20	0.68	<0.05	162	<0.05	5.94	<0.05	610	<0.1	0.14	8	<0.05	0.17
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		
Parameter	Ti	Tl	V	Zn	F	Cl	Br	NO2	NO3	NO3 as N	SO4	PO4		
Raw Feed	<0.05	<0.05	<0.05	0.23	229	546		<0.2	1.29	<0.3	2110	1.01		
AC 1	<0.05	<0.05	<0.05	<0.05	210	395		<0.2	5.92	1.34	2270	17.8		
AC 2	<0.05	<0.05	<0.05	<0.05	214	554		<0.2	6.08	1.37	2200	4.36		
UF Product	<0.05	<0.05	<0.05	0.22	141	413		<0.2	7.91	1.79	1520	7.38		

7.0 SURFACE WATER IMPACTS

7.1 Potential surface water impacts

The potential surface water impacts from the project, both direct and indirect, are summarised in Table 6. In summary these potential impacts contribute to overall surface water impacts of:

- Surface water quality; and
- Erosion of the streams due to potential run-off and discharge.

The surface water quality impacts will ultimately impact on the downstream water users.

Table 6: Potential surface water impacts with respect to UCG project

Aspect	Key Environmental Issue / Potential Impact
Run-off (roads, buildings, paving)	■ Spillage of fuels, lubricants and other chemicals; and ■ Flow modification due to increased run-off
Discharge of treated water to a water resource	■ The discharge of treated wastewater may affect the quality of the resource to which it is discharged and may therefore impact on downstream water users; ■ Erosion of the watercourse may occur due to the discharge; and ■ Flow modification due to discharge
Run-off from irrigation	■ Poor quality irrigation water may impact water quality
Overflow from contaminated storage dams	■ Overflow of contaminated water; ■ Flow modification due to spillages

8.0 SURFACE WATER IMPACT ASSESSMENT

8.1 Impact assessment methodology

The significance of the impacts identified during the impact assessment phase was determined using the approach described. Table 7 provides the method for defining intensity, geographic extent and duration.

Table 7: Impact assessment criteria

CRITERIA	DESCRIPTION			
EXTENT	**National (4)** The whole of South Africa	**Regional (3)** Provincial and parts of neighbouring provinces	**Local (2)** Within a radius of 2 km of the construction site	**Site (1)** Within the construction site
DURATION	**Permanent (4)** Mitigation either by man or natural process will not occur in such a way	**Long-term (3)** The impact will continue or last for the entire operational life of the	**Medium-term (2)** The impact will last for the period of the construction phase, where after it will be	**Short-term (1)** The impact will either disappear with mitigation or will be mitigated through

CRITERIA	DESCRIPTION			
	or in such a time span that the impact can be considered transient	development, but will be mitigated by direct human action or by natural processes thereafter. The only class of impact which will be non-transitory	entirely negated	natural process in a span shorter than the construction phase
INTENSITY	**Very High (4)** Natural, cultural and social functions and processes are altered to extent that they permanently cease	**High (3)** Natural, cultural and social functions and processes are altered to extent that they temporarily cease	**Moderate (2)** Affected environment is altered, but natural, cultural and social functions and processes continue albeit in a modified way	**Low (1)** Impact affects the environment in such a way that natural, cultural and social functions and processes are not affected
PROBABILTY OF OCCURANCE	**Definite (4)** Impact will certainly occur	**Highly Probable (3)** Most likely that the impact will occur	**Possible (2)** The impact may occur	**Improbable (1)** Likelihood of the impact materialising is very low

Low impact (4 - 6 points)	A low impact has no permanent impact of significance. Mitigation measures are feasible and are readily instituted as part of a standing design, construction or operating procedure.
Medium impact (7 - 9 points)	Mitigation is possible with additional design and construction inputs.
High impact (10 - 12 points)	The design of the site may be affected. Mitigation and possible remediation are needed during the construction and/or operational phases. The effects of the impact may affect the broader environment.
Very high impact (13 - 16 points)	Permanent and important impacts. The design of the site may be affected. Intensive remediation is needed during construction and/or operational phases. Any activity which results in a “very high impact” is likely to be a fatal flaw.

8.2 Surface water quality impacts

Table 8 sets out the potential surface water impacts during construction, operation and at closure.

Table 8: Impact assessment during construction, operation and at closure

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Notes
CONSTRUCTION PHASE							
Run-off	■ Spillage of fuels, lubricants and other chemicals; ■ Inadequate storm water management around the site; the dumping of construction material, including fill or excavated material into, or close to surface water features that may then be washed into these features; ■ Construction-related activities such as cement batching ■ Construction equipment, vehicles and workshop areas will be a likely source of pollution as a non-point source. ■ Lack of provision of ablutions that may lead to the conducting of 'informal ablutions' within or close to a surface water;	1	2	2	2	**7 medium**	It is expected that without mitigation a **medium** negative impact can be expected. Mitigation will include: ■ Bunded areas to store chemicals; ■ Clean-up of spills as soon as they occur; ■ Keep construction activities away from the Geelklipspruit; ■ Adequate ablutions for construction employees. The significance of the impact after mitigation is likely to decrease to a **low** negative impact.

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Notes
Construction of pipelines	Potential impacts relating to the construction of pipelines through wetlands could be: ■ the pollution of water within the wetland, through construction activities; ■ the incorrect re-instatement of wetland vegetation that may result in the exposing and erosion of wetland soils that can lead to downstream sedimentation; and ■ the compaction of wetland soils through the use of machinery in the wetland.	2	2/3	2	2	**8/9 medium**	A **medium** impact can be expected. The construction phase needs to have strict rules in place regarding the wetland areas. A Rehabilitation Plan will need to be developed upfront of any construction starting to accompany the Water Use Licence Application to Department of Water Affairs. Mitigation could reduce the impact to **low.**

OPERATIONAL PHASE

Run-off from dirty areas	■ Workshop areas; ■ Chemical storage areas; ■ Access roads	1	2	2	2	**7 medium**	It is expected that without mitigation a **medium** negative impact can be expected. Mitigation will include: Adequate storm water management around the site to comply with GN704. This will mean that clean runoff from the site will be diverted away from dirty areas to the river and that run-off from dirty areas will be contained in an adequately sized (1:50) pollution

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Notes
							control dam for evaporation and reuse. Chemical storage areas will be bunded so that if a spill occurs the chemical will be contained. A Storm Water Management Plan will need to accompany the Water Use Licence application to Department of Water Affairs. The significance of the impact after mitigation is likely to decrease to a **low** negative impact.
Discharge of treated effluent from the wastewater treatment work	An existing wastewater treatment works treats approximately 10 m^3/d. Discharge of poor quality effluent to a small stream like the Geelklipspruit may cause pollution to downstream water users. However, in line with Eskom's no discharge policy, no treated wastewater is expected to be discharged from the plant and associated infrastructure into the adjacent environment unless a failure of the WWTW occurs.	1	1	1	1	**4 low**	Because of Eskom's no discharge policy, the impact is expected to be **low**. There is already a wastewater treatment works in place with no discharge taking place, so no further mitigation is necessary. Ongoing operational and maintenance resources must however be in place to ensure that the plant operates optimally. The impact significance for a potential spill in terms of both quantity and quality.

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Notes
	Erosion of the watercourse	1	1	1	1	**4 low**	
Irrigation of condensate	Irrigation of condensate from the gas treatment plant may cause run-off of contaminated water to the river if the treatment is not done adequately. The condensate recovered from the gas treatment plant and gas pipeline is pumped into a process water dam (12 000 m^3). The dam is lined and has monitoring wells in place to provide an early warning system. UCG condensate from gasifier unit 1 is currently piped to this dam. Once gasifier unit 2 is in operation, the condensate will also be routed to this dam. At the 70 000 Nm^3/hr gas production scale, the expected quantity of condensate produced is 46 000 m^3/a. The condensate will be treated to a quality suitable to either: ■ Support local irrigation activities; ■ Re-inject the water into the	2	3	3	3	**11 high**	The irrigation of treated water of the quality indicated in GAA Report No. 11613755/11857/2, *Management Plan for the disposal of condensate water by irrigation* may cause serious pollution to the resource if irrigation takes place in an uncontrolled manner, with a potential **high** impact. If irrigation is done according to the Management Plan proposed by the Report, GAA Report No. 11613755/11857/2, then it is likely that impact could be reduced to **low.** As a safety precaution, a dam with sufficient capacity will be constructed in order to cater for down-time of the water treatment plant. It is envisaged that for the option of supplying the water for irrigation purposes, the plant will consist of solid sludge filtration, followed by the removal of organic compounds with the use of activated carbon. The resulting largely organic free condensate will pass through a micro-filtration unit after which it will be made available for irrigation purposes.

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Notes
	coal seam aquifer; or ■ Purify to Majuba raw water quality requirements. **Golder, 2013 indicated potential quality for the irrigation water as having very high concentrations of sulphate (1 520 mg/l); fluoride (141 mg/l) and chloride (413 mg/l). These concentrations are well above the RWQOs set out in** Table 2.						Irrigation areas need to be assessed for suitability considering the wetlands on the site.
Overflow from contaminated storage dams	As a safety precaution, a dam with sufficient capacity will be constructed in order to cater for down-time of the UF water treatment plant. Overflow of contaminated water from ponds may therefore have a negative impact on the Geelklipspruit.	2	1	2	2	**7 medium**	The impact from potential overflow from the storage ponds of untreated condensate from the gasifier is likely to be a **medium** impact. It is therefore essential to have adequately sized ponds to contain the contaminated water. In addition ponds should not be in the 1:50 flood line. This should reduce the impact to **low**.
Leaks from pipelines	Leaks of untreated water from pipelines may occur.	2	1	1	2	**6 low**	It is likely that this impact will be **low** as long as pipeline joints are monitored constantly. Any leaks should be fixed immediately

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Notes
							and areas rehabilitated as needed.
Undermining	Potential subsidence of the ground in areas above mining operations. Under a worst-case scenario, the subsidence of ground at the surface may be up to 75 cm below original ground level. It is not known how widely this subsidence would take place across mining areas, and whether it would be localised; however when the policy of non-undermining of wetland areas and associated buffer zones is taken into account this may result in localised variations in micro-topography in certain parts of the catchments of wetlands. This may have significant impacts on the water inputs to the wetland from the catchment as the subsidence could conceivably result in a 'ridge' or embankment forming within part of the wetland's immediate catchment whereby the 'upslope' areas could be lower than the downslope areas. This effect could significantly disrupt	2	3/4	3	2	**10/11 High**	The impact of potential subsidence to the surface water component would be **high**. However, the dynamics of the potential subsidence are unknown at this stage, and will need to be quantified in order to allow the potential impact on wetlands and local catchment hydrological inputs to wetlands in the study area to be further investigated and quantified.

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Notes
	the overland flow of water from the upslope catchment into the wetland, which due to the highly vertic soils across much of the study area is the most important aspect of the hydrology of wetlands and their catchments. The subsidence may prevent water which would normally move downslope through colluvial processes towards the wetland from reaching the wetland. This subsidence may also conceivably have an impact upon the discharge of shallow groundwater to hillslope seepage wetlands in the area.						

CLOSURE

Aspect	Potential Impact	Extent	Duration	Intensity	Probability	Impact	Notes
Pollution of water resources due to infrastructure decommissioning	Decommissioning of infrastructure such as buildings in the workshop and plant area would contain materials which could potentially act as pollutants to surface water resources, including fuel/hydrocarbon storage tanks or wastewater storage dams. The risk of this impact depends on the proximity of infrastructure to surface water receptors, and to links between groundwater and surface water resources in the case of seepage of pollutants into the ground that may pollute groundwater. Residual impacts of mining activities such as development of soil erosion or improperly maintained roads may result in secondary impacts on water resources through the extension of erosion into the wetland or other surface water resources resulting in deposition silt.	2	2	2	2	**8 medium**	The impact during decommissioning is likely to be **medium.** Proper post-operation rehabilitation, removal and disposal of any material that could cause pollution of water resources through seepage or storm water runoff is important if the potential impact is to be reduced to **low.**

9.0 KEY FINDINGS AND CONCLUSIONS

The impact assessment has indicated that if mitigation and a comprehensive rehabilitation plan are put in place the impacts on surface water will be low.

The main impact during construction and decommissioning is likely to be the run-off from the construction area to the Geelklipspruit. This can be mitigated by staying out of the 1:50 year flood lines.

The impact during operation will potentially be medium to high:

- Run-off from dirty areas;
- Discharge of treated effluent from the wastewater treatment work;
- Irrigation of condensate;
- Overflow from contaminated storage dams;
- Leaks from pipelines; and
- Undermining.

The highest impact being that of irrigation of treated condensate where extremely high levels of sulphate, fluoride and chloride, well above the RWQOs were noted (Golder 2013). The proposed irrigation plan should be followed to mitigate the potential impacts to the Geelklipspruit.

10.0 RECOMMENDATIONS

In order to ensure that the medium to high impacts are mitigated a storm water management plan that will ensure that clean and dirty water are separated and that pollution control dams are adequately sized must be put in place. Flood line delineation will help to ensure that the mine keeps all infrastructure out of the 1:50 flood line.

During construction and operation the surface water monitoring programme must be kept in place and kept going until after decommissioning. Monitoring should be done on a monthly basis for all the parameters that are currently being undertaken and any further that would be written into a water use licence.

11.0 REFERENCES

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