GHT CONSULTING SCIENTISTS

Komati Power Station

HYDROLOGICAL & GEOHYDROLOGICAL BASELINE STUDY
DECEMBER 2008

for

Eskom

KOMATI POWER STATION

by

GHT CONSULTING SCIENTISTS

PROJECT TEAM
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24 July 2009 Our ref.: RVN 537.5/909

The Manager
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FOR ATTENTION**: **Me. Venessa Naidoo

Dear Madam

It is our pleasure in enclosing two copies of the report RVN 537.5/909 "KOMATI POWER STATION – Baseline Study Final Report V1.2".

We trust that the report will fulfil the expectations of the Power Station and we will supply any additional information if required.

Yours sincerely,

Louis J van Niekerk (Pr.Sci.Nat.)

Copies: 3 copies to Komati Power Station

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1 INTRODUCTION

1.1 Background

GHT Consulting Scientists was commissioned to conduct a complete Baseline Study on the Hydrology and Geohydrology of Komati Power Station which will be re-commissioned in the near future.

The Eskom owned Komati Power Station were constructed on the property Komati Power Station 56 to exploit the extensive bituminous coal deposits that occur south of Witbank/Middelburg, Mpumalanga Province. Power generation facilities of this type can have a significant impact on site hydrology if poorly managed, for reasons including:

- Extensive water use and the installation of cut-off drains reducing groundwater levels;
- Disruption of stream flow due to stream diversion construction;
- Acid Mine Drainage (AMD) from cola stockyards and mined areas;
- Seepage from dams containing poor quality effluent;
- Leachate migration from ash dumps.

All of these issues are of concern at the facility. Coal was initially extracted from Blinkpan Colliery to the west and north-west of the power station. The proximity of these workings to the watercourse Koring Spruit required the construction of a stream diversion around the pits. Following the exhaustion of these reserves, the pits were partly backfilled with spoils and overburden, and partially rehabilitated. Unfortunately, as is the case throughout Mpumalanga, mine drainage impacted on background site water quality.

Waste ash generated during coal burning is also of concern. A wet ash disposal system has been employed at the site since its inception, whereby slurry comprised of an ash/make-up water mix is pumped to a dam site for disposal. However, due to the slurry’s chemical characteristics and the sheer size of the structures, ash dams and their associated infrastructure have the potential to be a significant point source for pollution.

In order to assess the potential impact of these features on water quality, a good understanding of site hydrology and geohydrology are essential. The site assessment and all the fieldwork for this investigation was done on the 2nd, and 3rd and 4th of December 2008. A map showing the localities of all the sites is presented in Appendix A.

The purpose of the site assessment is first of all to report on the current state of the monitoring network, and secondly to identify pollution sources as well as the target areas that may be impacted upon by these sources. This in turn will then be used to identify any inadequacies of the current monitoring network.

An assessment was also done and the hydro chemical data contained within the water quality database, the data having been collected by laboratory staff as part of a routine monitoring programme. The current Komati Power Station geohydrological database operates on a HydroBase (HydroSolutions, 1996) platform, with approximately eighteen years of historical data (July 1990 to December 2008) for nine groundwater and two surface water-sampling sites. The data base were scrutinised and all unknown / unclear sites and data were removed. All new information that was gathered during this investigation of the old and new sites was entered into the data base. Due to the state of the data base obtained during previous investigations from Komati Power Station the rectification was very time consuming.

While records of sampling depths, major ion concentrations, laboratory pH and Electrical Conductivity (EC) measurements have been maintained, no historical groundwater water level data was entered into the provided database. Water levels were however measured during December 2008 and are included in this report.

This investigation reports on the Baseline Study as well as on the quality of the surface and groundwater at Eskom Komati Power Station as recorded by GHT during the last sample run done in December 2008. It can thus be considered as a continuation of the monitoring programme as well.

A relevant numbering system for these monitoring reports reflecting both the date and the number of the monitoring event were deducted from the number of sample runs undertaken since 1990. This monitoring phase is consequently numbered as follows: December 2008, Phase 39. The previous monitoring report Phase 38 May 2006 was done in September 2006.

1.2 Approach to study

A detailed project of this nature requires the correct desktop planning in advance before conducting the physical fieldwork. The project was therefore divided into four phases or sections, namely:

- A desktop study which includes gathering of data and information;
- A fieldwork investigation;
- Data processing comprising the compilation of GIS MAPS and the capturing of the field information and chemical analyses into the database;
- Evaluating the data and compiling everything into a report format with conclusions and recommendations.

The following different investigations were done as part of the scope of work of this project.

- A description of the physical geography of the area under investigation;
- Hydrocensus survey of the surrounding farms;
- Site assessment of the Komati Power Station area;
- Geophysical investigations
- Hydraulic testing of monitoring boreholes
- EC profiling of monitoring boreholes
- Groundwater numerical model

2 PHYSICAL GEOGRAPHY

2.1 Extent of investigation

This investigation was approximately centred on the area to the north of the Olifants River, south of the Koring Spruit, and west and east of the Middelburg Bethal road.

Komati Power Station is located within a rural area on a gradual slope on the banks of the Koring Spruit approximately 41 km south of the town Middelburg in the Mpumalanga Province of South Africa. The site itself is well developed, due to the presence of the power stations, abandoned mine pits, the existing colliery shafts, the mine offices, and associated infrastructure comprised of stockyards, delivery plant, hostels, and a small town. Prior to development, however, the site was probably a commercial stock and cropping farm similar to those now present along the boundaries of the respective power stations.

2.2 Topography and Surface Drainage

Topographic maps of the area show a recurring block type drainage pattern that seems particularly well developed to the north of the respective power stations, characterized by stream sections orientated southwest-northeast and northwest-southeast. Drainage of this type is often structurally controlled, and thus may provide some insight into the orientation of regional and convergent stresses.

The investigated area is located in the Olifants River catchment and primary drainage region B. Komati Power Station lies within quaternary sub-catchment B11B and can be sub-divided into secondary drainage regions comprised of smaller streams and creeks. The surface topography of the area is typical of the Mpumalanga Highveld, consisting in the main of a gently undulating plateau. The flood plains of the local streams are at an average elevation of approximately 1595 meters above mean sea level (mamsl). Altitudes vary from ±1650 mamsl at the higher parts south of the ashing facility to ±1595 mamsl which defines the base of the Koring Spruit to the north of the Komati Power Station.

The ash stack area is situated between the contour lines of the 1650 – 1615 mamsl. The ashing area has been developed upon gradual slopes and a semi-developed drainage system. The Komati Spruit which originates in this area drains the area west of the ash pile towards the Koring Spruit.

The Power Plant and Coal Stockyard is situated on a topographic flat ±1605 mamsl with a poor drainage pattern. The southeast-northwest orientated Geluk Spruit is another drainage feature of significance and drains the area east and north towards the Koring Spruit. This stream was diverted to prevent ingress into power plant areas, and remains so due to the location the current Komati Power Station.

Several drains and dams have been constructed around the Ashing area, Power Plant area and Coal Stockyard area. These dams are of importance in terms of preventing water quality degradation and serves as pollution control dams. All polluted surface water runoff is diverted to these reservoirs.

Ultimately, all surface water from this area drains into the Olifants River via the Koring Spruit.

Surface run-off from the area is in the order of 5% of the annual rainfall. Groundwater recharge in undisturbed areas is in the order of 3% of the annual rainfall.

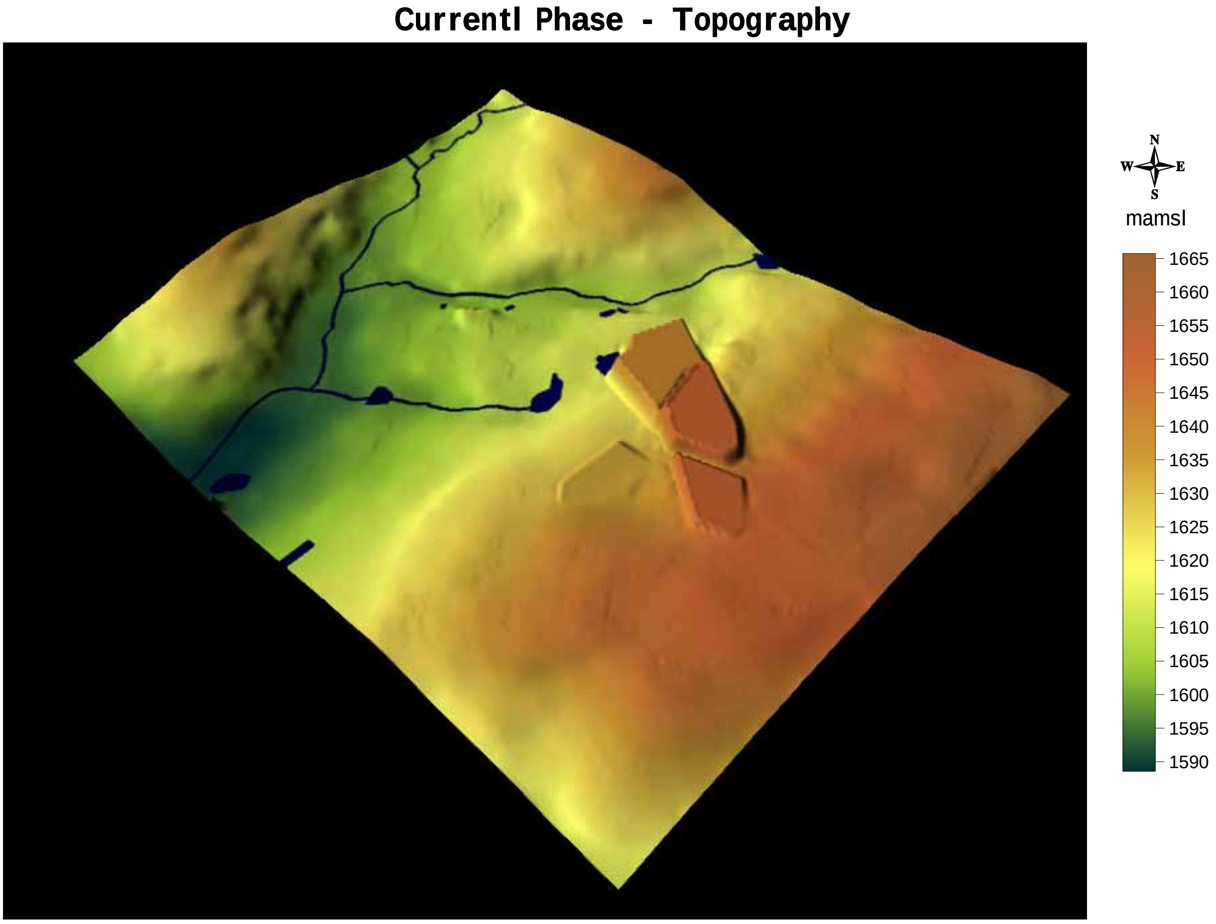


Figure 1. Current Topography of the Komati Power Stations Area.

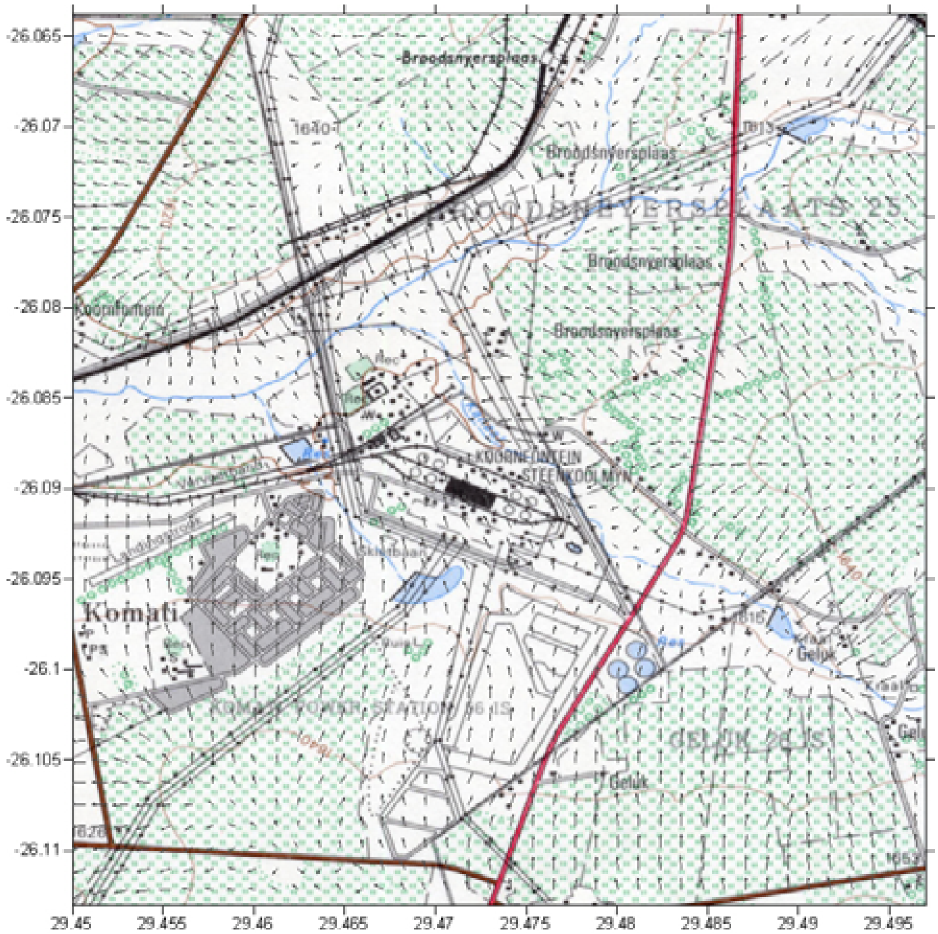


Figure 2. Surface drainage indicating flow directions

2.3 Vegetation

Within the respective power station compounds and surrounds, vegetation is restricted to lawn grasses, small shrubs, and occasional trees, while crops such as maize are grown on adjoining properties. Several pasture species have also been planted with lucerne and other non-native species farmed for commercial purposes.

Reeds are common across the site in areas with a high groundwater table, or where surface water of shallow depth occurs.

2.4 Climate

The project area falls within the highveld climate classification of Viterito (1987), and can thus expect warm, wet summers, and mild, dry winters, with equivalent evaporation depths exceeding precipitation. Regular dust storms can also be expected during periods of prolonged dry weather.

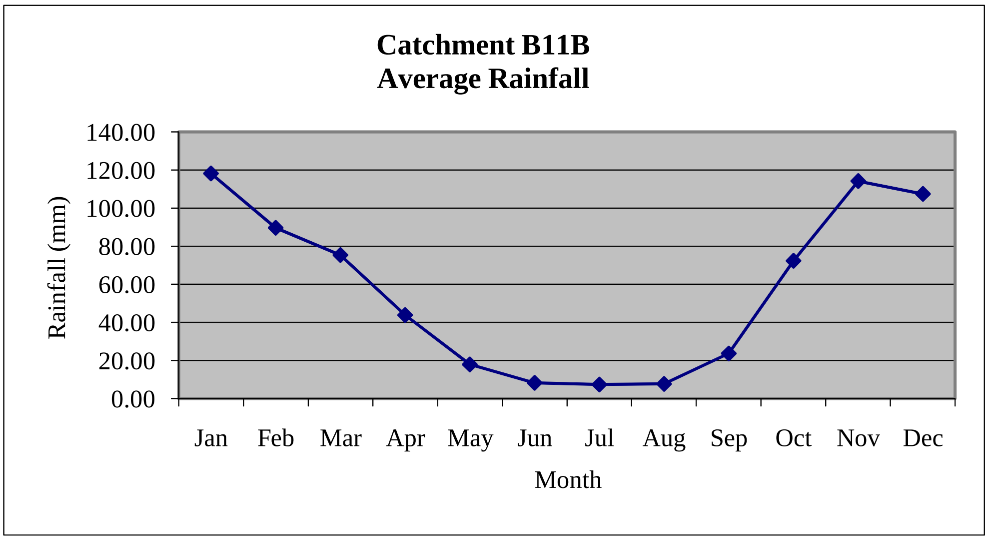
Average daily maximum temperatures vary from 27^{o}C in January to 17^{o}C in July, but in extreme cases these may rise to 38 and 26^{o}C, respectively. In comparison, average daily minima of 13 and 0^{o}C can be expected, with temperatures falling to 1 and –13^{o}C, respectively, on unusually cold days. Frost conditions are also common over the 120-day period from May to September.

Quaternary sub-catchment B11B and Komati Power Station lies within rainfall zone B1A and evaporation zone 4A. To evaluate the local weather conditions, climate data and information from publication Surface Water Resources of South Africa 1990 – WRC Report no. 298/1.1/94 were used.

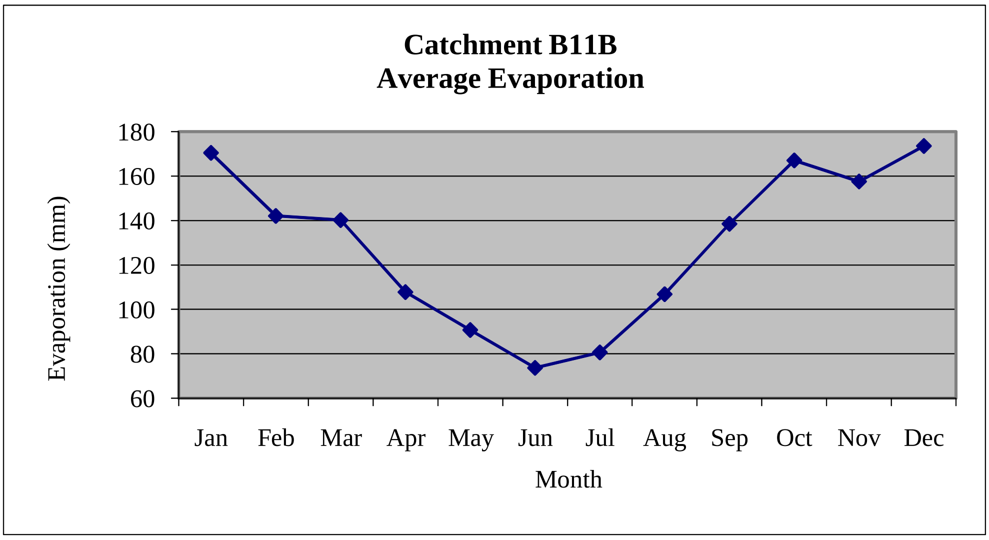
Rainfall is almost exclusively in the form of showers and thunderstorms and falls mainly in the summer months from October to March. The maximum rainfall usually occurs in January. The winter months are usually dry. The mean annual precipitation for Catchment B11B is 687 mm and the mean annual evaporation is 1550 mm. Mean monthly evaporation exceeds the mean monthly precipitation for every month of the year thus a water deficit area.

However water balance analysis undertaken by GHT Consulting at over power station in the area, indicated that while average monthly evaporation exceeds precipitation in all months, consideration of maximum and minimum precipitation values over shorter periods indicated that precipitation surpluses could occur in the months between November and January, and thus recharge through the ash pile could occur.

The average monthly rainfall and evaporation for catchment B11B is summarised and displayed graphically in Figure 3.



Month	Average rainfall Catchment B11B
Jan	118.23
Feb	89.72
Mar	75.43
Apr	43.90
May	18.00
Jun	8.38
Jul	7.49
Aug	7.83
Sep	23.77
Oct	72.41
Nov	114.25
Dec	107.52
MAP	687



Month	Average evaporation Catchment B11B
Jan	170.50
Feb	142.14
Mar	140.28
Apr	107.88
May	90.83
Jun	73.78
Jul	80.76
Aug	106.95
Sep	138.57
Oct	167.09
Nov	157.64
Dec	173.60
MAP	1550

Figure 3. Average rainfall and evaporation for Quaternary sub-catchment B11B

3 SITE ASSESSMENT

The site assessment provides information on the pollution sources and the sufficiency of the monitoring system and the various monitoring sites. This section contains:

- A description of the site assessment to identify contamination sources and impact zones;
- A description of the current state of the water monitoring system and infrastructure at Komati Power Station to identify any problems that may require attention;

3.1 Contaminant Sources and Impact Zones

Various sources of possible contaminants of surface water and groundwater within the four key areas have been identified. These sources were added to the current monitoring system as new sampling and inspection sites in view of the planned re-commissioning of Komati Power Station. Impact zones were also identified through visual inspection, as well as making use of the surface contours, as groundwater generally tends to follow the surface topography. The surface drainage and flow directions are shown in Figure 2.

Four different key areas with possible pollution sources have been identified within the area under investigation, namely:

- The Ashing Area and Domestic Waste Site;
- The Power Station Area;
- The Coal Stockyard Area; and
- The Sewage Plant Area;

These pollution sources impact on groundwater and on three surface drainage regions, namely:

- The groundwater to the north and west of the Ashing area;
- The groundwater to the north and east the of the Power Station Area
- The groundwater to the north, west and east of the Coal Stockyard Area
- A tributary of the Koring Spruit west of the Komati Power Station, henceforth called the Komati Spruit;
- A tributary of the Koring Spruit east of the Komati Power Station, henceforth called the Geluk Spruit.
- The Koring Spruit to the north of the Komati Power Station.

The following tables summarise the sources within each key area, the zone of impact of these sources, current or new monitoring sites and monitoring objective, as well as a description of the monitoring location:

Table 1. *Sources of Contaminant and impact zones within the Ashing Area and the Domestic Waste Site.*

Group / Area	Source of Possible Env. Hazards	Zone of Possible Impact	No. on map	Site Description	Site Type
Ashing Area & Rehabilitated Domestic Waste Site	Domestic Waste Site	Western Drainage towards Komati Spruit Groundwater migrating north	AB01	Monitoring borehole north and downstream of old rehabilitated domestic waste site.	Borehole
			*AC01	Clean water cut off canal between ash dam and old rehabilitated waste site	Canal
	Ash Dump	Western Drainage towards Komati Spruit Groundwater migrating west and northwest	AB02	Monitoring borehole downstream and north of small ash dam as well as west of large ash dams.	Borehole
			AB03	Monitoring borehole downstream and north of small ash dam as well as west of large ash dams.	Borehole
			AB04	Monitoring borehole north-west of ash dams and south of dam AP02.	Borehole
			AP01	Pool areas and dams on top of north-western part of ash dams.	Dam
			*AC02	Marshy area south of new ash water return dam AP08	Canal
	Ash Dump & Ash Water Return Dam	Western Drainage towards Komati Spruit Groundwater migrating west	AP08	New ash water return dam.	Dam
			*AP02	Clean water dam where Komati Spruit originates west of ash water return dam.	Dam
			AB05	Monitoring borehole next to Komati Spruit west of power station.	Borehole
	Ash Dump	Northern Drainage towards Geluk Spruit Groundwater migrating north	AB06	Monitoring borehole north and downstream of ash dams.	Borehole
			*AC04	Clean water canal north-eastern corner of ash dam. Sample at culvert underneath sealed road.	Canal
			AC05	Dirty water canal north of ash dam. Sample at culvert underneath sealed road.	Canal
			*AC09	Small canal running parallel with new ash transfer pipes. Sample at culvert underneath sealed road.	Canal
	Ash Dump & Seepage Recovery Dam	Northern Drainage towards Geluk Spruit Groundwater migrating north	AP03	Seepage recovery dam north of ash dam complex & east of power station.	Dam
			AB07	Monitoring borehole north and downstream of seepage recovery dam AP03.	Borehole
	Ash Dump	Groundwater migrating east	AC03	Dirty ash water return canal on eastern side of ash dam.	Canal
			BB21	Hydrocensus Borehole Farm Geluk 26/7	Borehole
			BB22	Hydrocensus Borehole Farm Geluk 26/7	Borehole
			BB23	Hydrocensus Borehole Farm Geluk 26/7	Borehole
	Ash Dump	Groundwater migrating south	BB24	Hydrocensus Borehole Goedehoop 46/3	Borehole
			BB25	Hydrocensus Borehole Goedehoop 46/3	Borehole
			BB27	Hydrocensus Borehole Bultfontein 187/2	Borehole

Table 2. Sources of Contaminant and impact zones within the Coal Stockyard Area.

Group / Area	**Source of Possible Env. Hazards**	**Zone of Possible Impact**	**No. on map**	**Site Description**	**Site Type**
Coal Stockyard Area	Coal Stockpile & Coal Settling Dam	Northern Drainage towards Geluk Spruit Groundwater migrating north & northwest	CB09	Monitoring borehole north and downstream of coal stockyard dirty water dam CP06.	Borehole
			CC07	Coal stockyard dirty water run-off canal. Sample at security fence.	Canal
			CP06	Coal stockyard settling pond and dirty water run-off dam.	Dam
			CP07	Old coal stockyard settling and dirty water run-off dam.	Dam

Table 3. Sources of Contaminant and impact zones within the Power Station and Sewage Plant Area.

Group / Area	**Source of Possible Env. Hazards**	**Zone of Possible Impact**	**No. on map**	**Site Description**	**Site Type**
Power Station Area	Dirty Water Dams & Oil Skimmers	Northern Drainage towards Geluk Spruit Groundwater migrating north & northwest	PP05	Power station dirty water dams and oil skimmers north of power station.	Dam
			PB08	Monitoring borehole north and downstream of power station dirty water dams PP05.	Borehole
	Run-off from plant area	North-eastern Drainage towards Geluk Spruit	*PC06	North-eastern power station clean water run-off outlet.	Canal
		Western Drainage towards Komati Spruit	*PC08	South-western power station clean water run-off outlet. Sample at culvert underneath sealed road.	Canal
	Raw Water Dam	Artificial recharge to Groundwater	PP04	Raw water dam east of Bethal Middelburg road.	Dam
Sewage Plant Area	Sewage Plant	Northern Drainage towards Komati Spruit Groundwater migrating north	SE01	Purified sewage effluent discharge into natural dam.	Effluent

Table 4. Sources of Contaminant and impact zones within the Geluk-, Komati- and Koring Spruit.

Group / Area	Source of Possible Env. Hazards	Zone of Possible Impact	No. on map	Site Description	Site Type
Geluk Spruit	External Source	Geluk Spruit	*GLR03	Geluk Spruit. Sample at culvert underneath sealed Bethal Middelburg road. Upstream Sample Point	River
	Power Station and Ashing Area	Geluk Spruit	*GLR04	Geluk Spruit. Sample at culvert underneath conveyer. Downstream Sample Point.	River
Komati Spruit	Ash Dump Infrastructure	Komati Spruit	*KMR01	Komati Spruit downstream form dam AP02. Sample at culvert underneath sealed road.	River
	Ash Dump Infrastructure & Township	Komati Spruit	*KMR02	Komati Spruit downstream form dam KMR01. Sample at culvert underneath sealed road.	River
	Ash Dump Infrastructure Township & Sewage Plant	Komati Spruit	*KMR07	Komati Spruit downstream form dam KMR02 and dam receiving purified sewage effluent. Sample at culvert underneath dirt road.	River
Koring Spruit	External Source	Koring Spruit	*KRR05	Koring Spruit upstream of power generation activities. Sample at culvert underneath sealed Bethal Middelburg road.	River
	Power Station and Mining Activities	Koring Spruit	*KRR06	Koring Spruit downstream of KRR05. Sample at culvert underneath sealed road.	River

3.2 Monitoring Survey and Site Assessment

The monitoring sites at Komati Power Station are classified according to their locations relative to the infrastructure and local natural streams. These seven monitoring areas are shown in the location maps of Komati Power Station attached in **Appendix A**. Any major anomalies are noted and recommendations are made to improve the situation with regard to water contamination and environmental impacts at Komati Power Station in order to ensure that the power station adheres to the requirements of the Department of Water Affairs and Forestry (DWA&F) with the intended re-commissioning of the Power Station.

New sites were therefore classified either depending upon the area in which it is located or on the area that it is expected to be impacted upon. A descriptive convention has been adopted for naming the sites, where the first letter is used for the classification of the area of the site and the second letter for classifying the type of site. The first letter is determined as follows:

- **A** for sites from the Ashing Area;
- **P** for sites from the Power Station;
- **C** for sites from the Coal Stockyard Area;
- **S** for sites from the Sewage Plant Area;

- **KM** for sites from the Komati Spruit;
- **GL** for sites from the Geluk Spruit;
- **KR** for sites from the Koring Spruit.

The second letter describes the following:

- **P** for pans and dams;
- **R** for rivers or streams;
- **C** for canals and trenches and
- **E** for effluent and
- **S** for seepage.
- Sites with a * are clean water sites and are supposed not to contain any dirty or contaminated water.

A total of 40 monitoring sites were indentified during Baseline Study and exist currently in and around Komati Power Station. These sites are divided into three different GROUPS and six AREAS. These GROUPS and AREAS are as follows:

- GROUP 1 – 27 Sites: Komati Power Station Monitoring Sites;
  - 17 Sites – Ashing Area
  - 4 Sites – Coal Stockyard Area
  - 6 Sites – Power Station Area
- GROUP 2 – 7 Sites: Natural Water Courses;
  - 2 Sites - Geluk Spruit
  - 3 Sites - Komati Spruit
  - 2 Sites - Koring Spruit
- GROUP 3 – 6 Sites: Private External Users Boreholes;
  - 6 Sites – South and East of Ashing Area.

Descriptions of all the monitoring sites are listed in Table 5 to Table 7. The coordinates of these sites are listed in the tables and can be used to locate all the different sites.

Table 5: GROUP 1 Komati Power Station monitoring sites descriptions.

Group / Area		**Number on map**	**Longitude (^oE)**	**Latitude (^oS)**	**Elevation (mamsl)**	**Site Description**	**Site Tipe**	**Photo No.**	**Current Condition**
GROUP 1 Komati Power Station	**Ashing Area**	AB01	29.46653	-26.10885	1645	Monitoring borehole north and downstream of old rehabilitated domestic waste site.	Borehole	1	No marker post, lock, pin or cap.
		AB02	29.46809	-26.10053	1626	Monitoring borehole downstream and north of small ash dam as well as west of large ash dams.	Borehole	2	No marker post, lock, pin or cap.
		AB03	29.46826	-26.09855	1621	Monitoring borehole downstream and north of small ash dam as well as west of large ash dams.	Borehole	3	No marker post, lock, pin or cap. Colapsed to 7.5m
		AB04	29.46831	-26.09615	1613	Monitoring borehole north-west of ash dams and south of dam AP02.	Borehole	4	No marker post, lock, pin or cap.
		AB05	29.46438	-26.08999	1601	Monitoring borehole next to Komati Spruit west of power station.	Borehole	5	No lock, pin or cap. Colapsed to 8.5m
		AB06	29.47715	-26.09551	1615	Monitoring borehole north and downstream of ash dams.	Borehole	6	No marker post. No lock, pin or cap. Borehole is infested with bees.
		AB07	29.47787	-26.09225	1606	Monitoring borehole north and downstream of seepage recovery dam AP03.	Borehole	7	No marker post. No lock, pin or cap. Illegal dumping of building rubble close to AB07.
		*AC01	29.46700	-26.10879	1646	Clean water cut off canal between ash dam and old rehabilitated waste site	Canal	8	Dry. Canal is Overgrown.
		*AC02	29.47291	-26.09678	1615	Marshy area south of new ash water return dam AP08	Canal	9	Flowing slowly. Canal is Overgrown.
		AC03	29.47941	-26.09947	1618	Dirty ash water return canal on eastern side of ash dam.	Canal	10	Flowing slowly. Canal is Overgrown.
		*AC04	29.48020	-26.09685	1615	Clean water canal north-eastern corner of ash dam. Sample at culvert underneath sealed road.	Canal	11	Stagnant. Canal is Overgrown.
		AC05	29.47773	-26.09571	1615	Dirty water canal north of ash dam. Sample at culvert underneath sealed road.	Canal	12	Satisfactory condition. Flowing moderately.
		*AC09	29.47575	-26.09454	1615	Small canal running parallel with new ash transfer pipes. Sample at culvert underneath sealed road.	Canal	13	Satisfactory condition. Flowing slowly.
		AP01	29.47422	-26.09605	1615	Pool areas and dams on top of north-western part of ash dams.	Dam	14	Satisfactory condition.
		*AP02	29.46882	-26.09543	1612	Clean water dam where Komati Spruit originates west of ash water return dam.	Dam	15	Satisfactory condition. Flowing moderately.
		AP03	29.47755	-26.09321	1610	Seepage recovery dam north of ash dam complex & east of power station.	Dam	16	AP03 has recently overflow.
		AP08	29.47353	-26.09493	1615	New ash water return dam.	Dam	17	Satisfactory condition.
	Coal Stockyard Area	CB09	29.47110	-26.08481	1602	Monitoring borehole north and downstream of coal stockyard dirty water dam CP06.	Borehole	18	No marker post, lock, pin or cap.
		CC07	29.47098	-26.08608	1604	Coal stockyard dirty water run-off canal. Sample at security fence.	Canal	19, 20	Canal currently not in a satisfactory condition. Silted up with coal.
		CP06	29.47096	-26.08510	1602	Coal stockyard settling pond and dirty water run-off dam.	Dam	21, 22	Satisfactory condition. Standing water was detected close to CP06
		CP07	29.46977	-26.08558	1603	Old coal stockyard settling and dirty water run-off dam.	Dam	23, 24	Water is seeping from old dams CP07.
	Power Station & Sewage Plant Area	PB08	29.47429	-26.08780	1606	Monitoring borehole north and downstream of power station dirty water dams PP05.	Borehole	25	No marker post, lock, pin or cap. Standing water detected close to CB08.
		*PC06	29.47664	-26.09042	1606	North-eastern power station clean water run-off outlet.	Canal	26	Satisfactory condition. Maintenance work in progress close to PC06.
		*PC08	29.46644	-26.09138	1606	South-western power station clean water run-off outlet. Sample at culvert underneath sealed road.	Canal	27	Satisfactory condition. Flowing slowly.
		SE01	29.46354	-26.08853	1600	Purified sewage effluent discharge into natural dam.	Effluent	28	Satisfactory condition. Flowing moderately.
		PP04	29.48122	-26.09881	1616	Raw water dam east of Bethal Middelburg road.	Dam	29	Satisfactory condition. Seepage visible north of PP04.
		PP05	29.47386	-26.08865	1606	Power station dirty water dams and oil skimmers north of power station.	Dam	30, 31	The oil skimmers are in process of building. Not yet operational.

Photo 1. *AB01*

Photo 2. *AB02*

Photo 3. *AB03*

Photo 4. *AB04*

Photo 5. *AB05*

Photo 6. *AB06*

Photo 7. *AB07*

Photo 8. *AC01*

Photo 9. AC02

Photo 10. AC03.

Photo 11. AC04.

Photo 12. AC05.

Photo 13. AC09.

Photo 14. AP01

Photo 15. AP02

Photo 16. AP03.

Photo 17. AP08.

Photo 18. CB09

Photo 19. CC07

Photo 20. CC07

Photo 21. CP06

Photo 22. CP06

Photo 23. CP07.

Photo 24. CP07.

Photo 25.   PB08.

Photo 26.   PC06.

Photo 27.   PC08.

Photo 28.   SE01.

Photo 29.   PP04.

Photo 30.   PP05.

Photo 31.   PP05.

Table 6: GROUP 2 Natural water courses monitoring sites descriptions.

Group / Area		Number on map	Longitude (^{o}E)	Latitude (^{o}S)	Elevation (mamsl)	Site Description	Site Tipe	Photo No.	Current Condition
GROUP 2 Natural Water Courses	Geluk Spruit	*GLR03	29.48235	-26.09474	1610	Geluk Spruit. Sample at culvert underneath sealed Bethal Middelburg road.	River	32	Flowing slowly. Stream diversion damaged impeding flow.
		*GLR04	29.47170	-26.08500	1603	Geluk Spruit. Sample at culvert underneath conveyer.	River	33	Flowing slowly. Stream diversion damaged impeding flow.
	Komati Spruit	*KMR01	29.46568	-26.09230	1605	Komati Spruit downstream form dam AP02. Sample at culvert underneath sealed road.	River	34	Satisfactory condition. Flowing slowly.
		*KMR02	29.46368	-26.08950	1600	Komati Spruit downstream form dam KMR01. Sample at culvert underneath sealed road.	River	35	Satisfactory condition. Flowing slowly.
		*KMR07	29.46159	-26.08743	1597	Komati Spruit downstream KMR02 & dam receiving purified sewage. Sample culvert underneath road.	River	~	Satisfactory condition. Flowing moderately.
	Koring Spruit	*KRR05	29.48671	-26.07354	1610	Koring Spruit upstream power generation activities. Sample culvert underneath Bethal Middelburg road.	River	36, 37	Satisfactory condition. Flowing moderately.
		*KRR06	29.44499	-26.08252	1582	Koring Spruit downstream of KRR05. Sample at culvert underneath sealed road.	River	38, 39	Satisfactory condition. Flowing moderately.

Photo 32. GLR03.

Photo 33. GLR04.

Photo 34. KMR01.

Photo 35. KMR02.

Photo 36. KRR05.

Photo 37. KRR05.

Photo 38. *KRR06.*

Photo 39. *KRR06.*

Table 7: *GROUP 3 Private external users boreholes monitoring sites descriptions.*

Group / Area		Number on map	Longitude (°E)	Latitude (°S)	Elevation (mamsl)	Site Description	Site Tipe	Photo No.	Current Condition
GROUP 3 Private External Users Boreholes	South and East of Ashing Area	BB21	29.47954	-26.10598	1636	Hydrocensus Borehole Farm Geluk 26/7	Borehole	40	No Equipment
		BB22	29.47907	-26.10586	1635	Hydrocensus Borehole Farm Geluk 26/7	Borehole	41	Good working condition
		BB23	29.47905	-26.10632	1636	Hydrocensus Borehole Farm Geluk 26/7	Borehole	42	Broken
		BB24	29.47125	-26.11574	1655	Hydrocensus Borehole Goedehoop 46/3	Borehole	43	Good working condition
		BB25	29.47127	-26.11574	1655	Hydrocensus Borehole Goedehoop 46/3	Borehole	44	Good working condition
		BB27	29.47912	-26.11710	1660	Hydrocensus Borehole Bultfontein 187/2	Borehole	45	Good working condition

Photo 40. *BB21.*

Photo 41. *BB22.*

Photo 42. *BB23.*

Photo 43. *BB24.*

Photo 44. BB25.

Photo 45. BB27.

3.3 Hydrocensus Survey and Assessment

This investigates the surface- and groundwater use and possible impacts from power generation activities as well as the general state of equipment installed at these sites. Sites were visited and the following data were recorded at each site: Refer to Table 8 for a summary of the data stipulated below.

- Site coordinates;
- A photograph of the site;
- Casing heights and diameters;
- Type of equipment;
- Diameter of the equipment delivery pipe;
- State of installed equipment (working condition or not);
- Water usage (agricultural, domestic, etc.);
- Measuring of a water level;
- Collecting a sample for chemical analyses;
- Farm detail;
- Farmer / owner detail.

The collected data was entered into a Hydrobase Database with an assigned “Site ID” as well as a designated “Number on Map” for future reference.

3.3.1 Hydrocensus Sites Information

There are at least thirty seven external users boreholes that exist around Komati Power Station on the neighbouring farms as well as nine monitoring boreholes at Komati Power Station (refer to maps in Appendix A). The thirty seven external users boreholes were numbered from BB10 to BB46. The depths of these boreholes varied between 66 m to 11 m with an average depth of 35 m. Six of these boreholes are incorporated into the monitoring system due to its close proximity to the ashing area.

The groundwater monitoring network at Komati Power Station comprises of a total of nine monitoring boreholes installed around the Power Station Area, the Ashing area and the Coal Stockyard Area. The monitoring boreholes have no pizometers installed, but the boreholes are sampled at specific depths. There are seven boreholes installed at the Ashing Area, one in the Coal Stockyard Area and one at the Power Station Area (Refer to maps in Appendix A).

Twenty five (25) surface water monitoring sites which include 7 river sites, 8 dam sites, 9 canals sites and 1 effluent site exist in the vicinity of Komati Power Station of which twenty one (21) sites are sampled as part of the monitoring system. (Refer to maps in Appendix A).

3.3.2 Equipment

The general condition of installed equipment that was encountered during the investigation was found to be good.

A variety of equipment is installed in various boreholes that were inspected. A total of five boreholes are equipped with windmill but none are in a working condition. Three sites were recorded having hand pumps installed. A few sites (four) have mono pumps installed with all four of these pumps in use and in working condition. Submersible pumps were found at sixteen sites with fourteen of the pumps in a working condition.

A total of six boreholes were recorded without any equipment installed.

3.3.3 Groundwater use

Twenty four boreholes are in use with equipment in a working condition. Nineteen of these boreholes are being used for domestic purposes only. A total of seven boreholes are being used for both agricultural stock watering and domestic purposes.

3.3.4 Water levels

Limited access to boreholes because of installed equipment resulted in water levels that were measured at only nineteen boreholes during the hydrocensus. Two boreholes were dry. There is only one set of data available for the water levels of the monitoring boreholes at the Power Station. Groundwater contours with groundwater elevations in meters above mean sea level (mamsl) can be seen in Figure 14.

3.3.5 Sampling sites

Groundwater samples were collected from thirty-six boreholes for analyses. Historical chemical analyses are available for the nine monitoring boreholes of Komati Power Station.

There are twenty one surface water sites that must be sampled as part of the surface water monitoring network of Komati Power Station. Three sites were dry during the time of sampling. Historical analyses are available for some of these sites.

Table 8. Surface and Groundwater sites – Hydrocensus information.

Number on map	Longitude (^{o}E)	Latitude (^{o}S)	Elevation (mamsl)	Site Description	Farm Name	Farmer/ Owner	Site Tipe	Borehole Depth (m)	Casing Hieght (m)	Casing Diameter (mm)	Equipment	Use (Agricultural, Domestic)	Pipe Diameter (mm)	WL Below Colar (mbcl)	Current Condition
AB01	29.46653	-26.10885	1645	Monitoring borehole north and downstream of old rehabilitated domestic waste site.	Komati Power Station 56	Eskom Komati PS	Borehole	35.5	0.340	165	None	Monitoring	~	1.71	No marker post, lock, pin or cap.
AB02	29.46809	-26.10053	1626	Monitoring borehole downstream and north of small ash dam as well as west of large ash dams.	Komati Power Station 56	Eskom Komati PS	Borehole	32.5	0.810	165	None	Monitoring	~	2.56	No marker post, lock, pin or cap.
AB03	29.46826	-26.09855	1621	Monitoring borehole downstream and north of small ash dam as well as west of large ash dams.	Komati Power Station 56	Eskom Komati PS	Borehole	7.5	0.340	165	None	Monitoring	~	1.93	No marker post, lock, pin or cap. Colapsed to 7.5m
AB04	29.46831	-26.09615	1613	Monitoring borehole north-west of ash dams and south of dam AP02.	Komati Power Station 56	Eskom Komati PS	Borehole	38.0	0.280	165	None	Monitoring	~	1.54	No marker post, lock, pin or cap.
AB05	29.46438	-26.08999	1601	Monitoring borehole next to Komati Spruit west of power station.	Komati Power Station 56	Eskom Komati PS	Borehole	8.5	0.370	165	None	Monitoring	~	1.05	No lock, pin or cap. Colapsed to 8.5m
AB06	29.47715	-26.09551	1615	Monitoring borehole north and downstream of ash dams.	Komati Power Station 56	Eskom Komati PS	Borehole	37.0	0.300	165	None	Monitoring	~	1.30	No marker post. No lock, pin or cap. Borehole is infested with bees.
AB07	29.47787	-26.09225	1606	Monitoring borehole north and downstream of seepage recovery dam AP03.	Komati Power Station 56	Eskom Komati PS	Borehole	37.0	0.280	165	None	Monitoring	~	2.96	No marker post. No lock, pin or cap. Illegal dumping of building rubble close to AB07.
*AC01	29.46700	-26.10879	1646	Clean water cut off canal between ash dam and old rehabilitated waste site	Komati Power Station 56	Eskom Komati PS	Canal	~	~	~	~	Monitoring, Livestock		Dry	Dry. Canal is Overgrown.
*AC02	29.47291	-26.09678	1615	Marshy area south of new ash water return dam AP08	Komati Power Station 56	Eskom Komati PS	Canal	~	~	~	~	Monitoring, Livestock		Low	Flowing slowly. Canal is Overgrown.
AC03	29.47941	-26.09947	1618	Dirty ash water return canal on eastern side of ash dam.	Komati Power Station 56	Eskom Komati PS	Canal	~	~	~	~	Monitoring, Pollution Control		Low	Flowing slowly. Canal is Overgrown.
*AC04	29.48020	-26.09685	1615	Clean water canal north-eastern corner of ash dam. Sample at culvert underneath sealed road.	Komati Power Station 56	Eskom Komati PS	Canal	~	~	~	~	Monitoring, Livestock		Low	Stagnant. Canal is Overgrown.
AC05	29.47773	-26.09571	1615	Dirty water canal north of ash dam. Sample at culvert underneath sealed road.	Komati Power Station 56	Eskom Komati PS	Canal	~	~	~	~	Monitoring, Pollution Control		Low	Satisfactory condition. Flowing moderately. Standing water east of AC05, downstream of ash dam.
*AC09	29.47575	-26.09454	1615	Small canal running parallel with new ash transfer pipes. Sample at culvert underneath sealed road.	Komati Power Station 56	Eskom Komati PS	Canal	~	~	~	~	Monitoring, Livestock		Low	Satisfactory condition. Flowing slowly.
AP01	29.47422	-26.09605	1615	Pool areas and dams on top of north-western part of ash dams.	Komati Power Station 56	Eskom Komati PS	Dam	~	~	~	~	Monitoring, Pollution Control		Mod Full	Satisfactory condition.
*AP02	29.46882	-26.09543	1612	Clean water dam where Komati Spruit originates west of ash water return dam.	Komati Power Station 56	Eskom Komati PS	Dam	~	~	~	~	Monitoring, Livestock		Mod Full	Satisfactory condition. Flowing moderately.
AP03	29.47755	-26.09321	1610	Seepage recovery dam north of ash dam complex & east of power station.	Komati Power Station 56	Eskom Komati PS	Dam	~	~	~	~	Monitoring, Pollution Control		Very High	AP03 has recently overflow.
AP08	29.47353	-26.09493	1615	New ash water return dam.	Komati Power Station 56	Eskom Komati PS	Dam	~	~	~	~	Monitoring, Pollution Control		Mod Full	Satisfactory condition.
CB09	29.47110	-26.08481	1602	Monitoring borehole north and downstream of coal stockyard dirty water dam CP06.	Komati Power Station 56	Eskom Komati PS	Borehole	36.5	0.950	165	None	Monitoring	~	1.59	No marker post, lock, pin or cap.
CC07	29.47098	-26.08608	1604	Coal stockyard dirty water run-off canal. Sample at security fence.	Komati Power Station 56	Eskom Komati PS	Canal	~	~	~	~	Monitoring, Pollution Control		Dry	Canal currently not in a satisfactory condition. Silted up with coal.
CP06	29.47096	-26.08510	1602	Coal stockyard settling pond and dirty water run-off dam.	Komati Power Station 56	Eskom Komati PS	Dam	~	~	~	~	Monitoring, Pollution Control		High	Satisfactory condition. Standing water was detected close to CP06
CP07	29.46977	-26.08558	1603	Old coal stockyard settling and dirty water run-off dam.	Komati Power Station 56	Eskom Komati PS	Dam	~	~	~	~	Monitoring, Pollution Control		High	Water is seeping from old dams CP07.
*GLR03	29.48235	-26.09474	1610	Geluk Spruit. Sample at culvert underneath sealed Bethal Middelburg road.	Broodsnyersplaas 25/11	Public Stream	River	~	~	~	~	Monitoring, Livestock		Mod Full	Flowing slowly. Stream diversion damaged impeding flow.
*GLR04	29.47170	-26.08500	1603	Geluk Spruit. Sample at culvert underneath conveyer.	Komati Power Station 56	Public Stream	River	~	~	~	~	Monitoring, Livestock		Low	Flowing slowly. Stream diversion damaged impeding flow.
*KMR01	29.46568	-26.09230	1605	Komati Spruit downstream form dam AP02. Sample at culvert underneath sealed road.	Komati Power Station 56	Public Stream	River	~	~	~	~	Monitoring, Livestock		Low	Satisfactory condition. Flowing slowly.
*KMR02	29.46368	-26.08950	1600	Komati Spruit downstream form dam KMR01. Sample at culvert underneath sealed road.	Komati Power Station 56	Public Stream	River	~	~	~	~	Monitoring, Livestock		Low	Satisfactory condition. Flowing slowly.
*KMR07	29.46159	-26.08743	1597	Komati Spruit downstream form dam KMR02 and dam receiving purified sewage effluent. Sample at culvert underneath dirt road.	Komati Power Station 56	Public Stream	River	~	~	~	~	Monitoring, Livestock		Low	Satisfactory condition. Flowing moderately.
*KRR05	29.48671	-26.07354	1610	Koring Spruit upstream of power generation activities. Sample at culvert underneath sealed Bethal Middelburg road.	Broodsnyersplaas 25/3	Public Stream	River	~	~	~	~	Monitoring, Livestock		Low	Satisfactory condition. Flowing moderately.
*KRR06	29.44499	-26.08252	1582	Koring Spruit downstream of KRR05. Sample at culvert underneath sealed road.	Koornfontein 27/4	Public Stream	River	~	~	~	~	Monitoring, Livestock		Low	Satisfactory condition. Flowing moderately.
PB08	29.47429	-26.08780	1606	Monitoring borehole north and downstream of power station dirty water dams PP05.	Komati Power Station 56	Eskom Komati PS	Borehole	35.5	0.200	165	None	Monitoring	~	3.62	No marker post, lock, pin or cap. Standing water detected close to CB08.
*PC06	29.47664	-26.09042	1606	North-eastern power station clean water run-off outlet.	Komati Power Station 56	Eskom Komati PS	Canal	~	~	~	~	Monitoring, Livestock		Dry	Satisfactory condition. Maintenance work in progress close to PC06.
*PC08	29.46644	-26.09138	1606	South-western power station clean water run-off outlet. Sample at culvert underneath sealed road.	Komati Power Station 56	Eskom Komati PS	Canal	~	~	~	~	Monitoring, Livestock		Low	Satisfactory condition. Flowing slowly.
SE01	29.46354	-26.08853	1600	Purified sewage effluent discharge into natural dam.	Komati Power Station 56	Eskom Komati PS	Effluent	~	~	~	~	Monitoring, Pollution Control		Mod Full	Satisfactory condition. Flowing moderately.
PP04	29.48122	-26.09881	1616	Raw water dam east of Bethal Middelburg road.	Komati Power Station 56	Eskom Komati PS	Dam	~	~	~	~	Monitoring, Pollution Control		Mod Full	Satisfactory condition. Seepage visible north of PP04.
PP05	29.47386	-26.08865	1606	Power station dirty water dams and oil skimmers north of power station.	Komati Power Station 56	Eskom Komati PS	Dam	~	~	~	~	Monitoring, Pollution Control		Low	The oil skimmers are in process of building. Not yet operational.

Number on map	Longitude (°E)	Latitude (°S)	Elevation (mamsl)	Site Description	Farm Name	Farmer/ Owner	Site Tipe	Borehole Depth (m)	Casing Hieght (m)	Casing Diameter (mm)	Equipment	Use (Agricultural, Domestic)	Pipe Diameter (mm)	WL Below Colar (mbcl)	Current Condition
BB10	29.42091	-26.04868	1611	Hydrocensus Borehole	Welverdiend 23/2	Engelbreght	Borehole	~	0.200	165	Submersible	Domestic Drink	30	~	Good working condition
BB11	29.45898	-26.06239	1614	Hydrocensus Borehole	Welverdiend 23/10	G.F. Grobler	Borehole	~	0.520	165	Hand pump	Domestic Drink	~	~	Good working condition
BB12	29.46227	-26.06161	1621	Hydrocensus Borehole	Welverdiend 23/10	G.F. Grobler	Borehole	~	0.300	165	Submersible	Domestic Drink	40	~	Broken
BB13	29.44845	-26.06403	1604	Hydrocensus Borehole	Koornfontein 27/6	G.F. Grobler	Borehole	27.2	0.280	120	Submersible	Domestic Drink	40	16.20	Good working condition
BB14	29.48485	-26.05469	1643	Hydrocensus Borehole	Broodsnyersplaas 25/10	Siyavuma Vervoer	Borehole	~	0.000	165	Submersible	Domestic Drink	60	11.80	Good working condition
BB15	29.49044	-26.05852	1629	Hydrocensus Borehole	Broodsnyersplaas 25/28	H De Beer	Borehole	~	0.350	165	Submersible	Domestic Drink	50	~	Good working condition
BB16	29.50683	-26.07076	1642	Hydrocensus Borehole	Broodsnyersplaas 25/1	P Storm	Borehole	~	0.320	165	Hand pump	Domestic Drink	~	~	Good working condition
BB17	29.49821	-26.07593	1639	Hydrocensus Borehole	Broodsnyersplaas 25/5	P Storm	Borehole	66.0	0.000	165	Submersible	Domestic Drink	60	24.00	Good working condition
BB18	29.49867	-26.07736	1642	Hydrocensus Borehole	Broodsnyersplaas 25/5	P Storm	Borehole	85.0	0.000	165	None	~	~	Dry	Dry hole
BB19	29.49741	-26.07693	1639	Hydrocensus Borehole	Broodsnyersplaas 25/5	P Storm	Borehole	~	0.100	165	Hand pump	Domestic Drink	~	~	Good working condition
BB20	29.48213	-26.08393	1622	Hydrocensus Borehole	Broodsnyersplaas 25/3	D Lee	Borehole	26.1	0.100	165	Submersible	Domestic Drink	50	14.10	Good working condition
BB21	29.47954	-26.10598	1636	Hydrocensus Borehole	Geluk 26/7	MCL Dippenaar	Borehole	26.8	0.200	150	None	~	~	2.20	No Equipment
BB22	29.47907	-26.10586	1635	Hydrocensus Borehole	Geluk 26/7	MCL Dippenaar	Borehole	~	0.000	165	Submersible	Domestic Drink	50	~	Good working condition
BB23	29.47905	-26.10632	1636	Hydrocensus Borehole	Geluk 26/7	MCL Dippenaar	Borehole	11.0	0.230	165	Submersible	Domestic Drink	40	4.50	Broken
BB24	29.47125	-26.11574	1655	Hydrocensus Borehole	Goedehoop 46/3	F Schoeman	Borehole	~	0.300	165	Submersible	Domestic Drink	50	15.00	Good working condition
BB25	29.47127	-26.11574	1655	Hydrocensus Borehole	Goedehoop 46/3	F Schoeman	Borehole	26.5	0.300	165	Submersible	Domestic Drink, Livestock	50	20.50	Good working condition
BB26	29.47783	-26.11699	1659	Hydrocensus Borehole	Bultfontein 187/2	K Van Rensburg	Borehole	6.1	0.100	100	None	~	~	Dry	Dry hole
BB27	29.47912	-26.11710	1660	Hydrocensus Borehole	Bultfontein 187/2	K Van Rensburg	Borehole	42.0	0.440	150	Submersible	Domestic Drink, Livestock	50	32.00	Good working condition
BB28	29.50721	-26.11221	1666	Hydrocensus Borehole	Bultfontein 187/11	Van Niekerk	Borehole	~	0.680	165	Mono pump	Domestic Drink	50	~	Good working condition
BB29	29.49529	-26.12859	1629	Hydrocensus Borehole	Bultfontein 187/12	Von Wielligh	Borehole	52.0	0.520	165	Submersible	Domestic Drink, Livestock	50	13.00	Good working condition
BB30	29.50947	-26.13509	1615	Hydrocensus Borehole	Bultfontein 187/6	E Erasmus	Borehole	40.0	0.480	165	None	~	~	8.50	No Equipment
BB31	29.50961	-26.13511	1615	Hydrocensus Borehole	Bultfontein 187/6	E Erasmus	Borehole	~	0.120	165	Mono pump	Domestic Drink	40	~	Good working condition
BB32	29.53378	-26.14317	1651	Hydrocensus Borehole	Hartebeestkuil 185/2	D Van Woutenberg	Borehole	~	0.370	150	None	~	50	5.00	No Equipment
BB33	29.53470	-26.14244	1651	Hydrocensus Borehole	Hartebeestkuil 185/2	D Van Woutenberg	Borehole	8.0	0.360	165	None	~	~	2.00	No Equipment
BB34	29.53840	-26.14023	1646	Hydrocensus Borehole	Hartebeestkuil 185/2	D Van Woutenberg	Borehole	~	0.100	165	Mono pump	Domestic Drink, Livestock	50	~	Good working condition
BB35	29.49518	-26.15330	1604	Hydrocensus Borehole	Wilmansrust 47/3	C.J. Van der Merwe	Borehole	15.0	0.180	150	Submersible	Domestic Drink, Livestock	50	3.00	Works only in dry season
BB36	29.49503	-26.16079	1626	Hydrocensus Borehole	Wilmansrust 47/3	C.J. Van der Merwe	Borehole	32.0	0.170	150	Submersible	Domestic Drink, Livestock	50	18.00	Good working condition
BB37	29.51189	-26.17976	1611	Hydrocensus Borehole	Dunbar 189/2	Proefplaas	Borehole	12.0	0.150	150	Submersible	Domestic Drink	50	3.50	Good working condition
BB38	29.48366	-26.17902	1629	Hydrocensus Borehole	Middelkraal 50/1	BJ Grobler	Borehole	~	0.450	150	Windmill	~	50	~	Not in use for a long time
BB39	29.48336	-26.17877	1629	Hydrocensus Borehole	Middelkraal 50/1	BJ Grobler	Borehole	~	0.300	165	Mono pump	Livestock	50	~	Good working condition
BB40	29.48339	-26.17864	1628	Hydrocensus Borehole	Middelkraal 50/1	BJ Grobler	Borehole	~	0.280	150	Submersible	Domestic Drink, Livestock	40	3.00	Good working condition
BB41	29.47363	-26.16277	1584	Hydrocensus Borehole	Leeufontein 48/3	BJ Grobler	Borehole	~	0.450	165	Windmill	~	40	~	Not in use for a long time
BB42	29.47537	-26.16495	1588	Hydrocensus Borehole	Leeufontein 48/16	BJ Grobler	Borehole	~	0.000	150	Windmill	~	40	~	Not in use for a long time
BB43	29.42195	-26.12209	1619	Hydrocensus Borehole	Goedehoop 46/7	J Harmse	Borehole	15.0	0.300	165	Submersible	Domestic Drink	40	8.00	Good working condition
BB44	29.42193	-26.12198	1619	Hydrocensus Borehole	Goedehoop 46/7	J Harmse	Borehole	55.0	0.100	165	Submersible	Domestic Drink, Livestock	30	5.00	Good working condition
BB45	29.41625	-26.11591	1602	Hydrocensus Borehole	Goedehoop 46/7	J Harmse	Borehole	~	0.300	165	Windmill	~	~	~	Not in use for a long time
BB46	29.42719	-26.11853	1620	Hydrocensus Borehole	Goedehoop 46/7	J Harmse	Borehole	~	0.600	165	Windmill	~	40	~	Not in use for a long time

Number on map	Photo No.	Date	Time	Sample	Sample Depth (m)	pH	EC mS/m	TDS mg/L	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	C03 mg/L	HCO3 mg/L	F mg/L	NO2-N mg/L	NO3-N mg/L	PO4 mg/L	Fe mg/L	Mn mg/L	B mg/L	Cr mg/L	Anion meq/l	Cation meq/l	Ionbal %
AB01	1	2008-12-03	12:09	Yes	15	7.07	348	2774	362	242	236	30.46	299	1188	1.00	833.00	0.00	0.00	0.00	0.00	4.5800	0.3770	0.0300	0.0076	46.84	48.03	1.25
AB02	2	2008-12-03	14:20	Yes	20	7.11	251	2396	90	281	211	44.94	45	1545	0.00	358.00	0.00	0.00	0.00	0.00	1.6000	1.7650	0.0200	0.0017	39.31	36.49	-3.73
AB03	3	2008-12-03	12:16	Yes	6	6.57	74	435	43	85	25	7.33	41	203	0.00	147.00	0.19	0.00	0.00	0.00	0.5100	0.0051	0.0100	0.0002	7.80	8.38	3.55
AB04	4	2008-12-03	11:00	Yes	19	7.27	235	2092	112	285	165	21.14	66	1237	1.00	404.00	0.00	0.00	4.68	0.00	0.0120	0.0034	0.0500	0.0011	34.59	33.23	-2.00
AB05	5	2008-12-02	14:30	Yes	8.5	7.20	257	1893	374	121	76	7.17	234	879	1.00	398.00	0.00	0.00	2.35	0.00	1.3500	0.0450	0.0300	0.0014	31.62	28.75	-4.75
AB06	6	2008-11-19	13:25	No	~																						
AB07	7	2008-12-03	09:30	Yes	15	6.92	227	1974	145	178	178	10.32	59	1308	0.00	192.00	0.00	0.00	0.00	0.00	1.1200	4.0530	0.0300	0.0004	32.05	30.24	-2.91
*AC01	8	2008-12-03	14:00	No	Surface																						
*AC02	9	2008-12-03	10:45	Yes	Surface	3.14	233	1894	143	306	35	25.14	66	1218	0.00	54.00	0.79	0.00	0.00	0.00	4.2300	3.4850	0.5900	0.0002	27.28	25.11	-4.15
AC03	10	2008-12-03	14:10	Yes	Surface	6.80	83	459	83	48	24	11.86	51	148	0.00	247.00	0.48	0.00	0.00	0.00	0.5600	0.1966	0.1400	0.0001	8.59	8.29	0.75
*AC04	11	2008-12-03	14:26	Yes	Surface	7.39	137	974	87	133	48	10.76	42	418	1.00	346.00	0.79	0.00	0.00	0.00	0.0200	0.0270	0.0900	0.0008	15.62	14.70	-3.02
AC05	12	2008-12-03	14:24	Yes	Surface	7.27	107	719	99	88	22	16.35	49	357	0.00	147.00	0.40	0.00	2.68	0.00	0.0200	0.0026	0.2600	0.0000	11.46	10.95	-2.26
*AC09	13	2008-12-03	14:18	No	Surface																						
AP01	14	2008-12-03	10:32	No	Surface																						
*AP02	15	2008-12-03	11:20	Yes	Surface	7.27	131	965	122	104	27	15.50	40	423	0.00	245.00	0.87	0.00	1.34	0.00	0.0100	0.0001	0.2400	0.0004	14.08	13.13	-3.48
AP03	16	2008-12-03	10:00	Yes	Surface	7.12	114	750	100	86	27	16.58	42	332	0.00	172.00	0.62	0.00	0.00	0.00	0.0200	0.0282	0.2400	0.0010	10.95	11.26	1.38
AP08	17	2008-12-03	10:52	No	Surface																						
CB09	18	2008-12-03	07:40	Yes	31	7.47	69	392	28	64	20	3.48	15	132	0.00	257.00	0.90	0.00	0.47	0.00	12.800	21.260	0.0700	14.740	7.48	6.87	-4.27
CC07	19, 20	2008-12-02	13:00	No	Surface																						
CP06	21, 22	2008-12-03	07:35	Yes	Surface	7.54	66	388	66	42	23	5.89	16	161	0.00	172.00	0.50	0.00	3.80	0.00	0.0020	0.0036	0.1400	0.0008	6.91	6.99	0.60
CP07	23, 24	2008-12-03	07:05	No	Surface																						
*GLR03	32	2008-12-03	10:20	Yes	Surface	7.51	40	193	25	42	12	2.82	13	40	0.00	179.00	0.31	0.00	0.00	0.00	0.2260	0.1365	0.1100	0.0885	4.16	4.17	0.20
*GLR04	33	2008-12-03	07:35	Yes	Surface	7.11	118	771	50	118	46	4.97	18	220	0.00	464.00	0.00	0.00	0.00	0.00	0.0250	0.0274	0.1600	0.0027	12.72	11.96	-3.06
*KMR01	34	2008-12-03	14:11	Yes	Surface	7.15	151	1156	143	132	40	23.24	35	606	0.00	248.00	0.86	0.00	0.00	0.00	0.0056	0.1455	0.4200	0.0966	17.73	16.67	-3.09
*KMR02	35	2008-12-03	14:00	Yes	Surface	7.53	79	485	71	70	18	9.26	30	214	0.00	163.00	0.48	0.00	0.00	0.00	0.0250	0.0239	0.2100	0.0051	8.01	8.33	1.95
*KMR07	~	2008-12-02	12:57	No	Surface																						
*KRR05	36, 37	2008-12-04	09:41	Yes	Surface	7.42	54	272	35	33	29	3.83	27	41	0.00	202.00	0.47	0.00	15.80	0.00	0.0100	0.0004	0.0800	0.0006	6.10	5.66	-3.76
*KRR06	38, 39	2008-12-04	10:22	Yes	Surface	7.38	86	558	68	63	25	6.06	21	254	0.00	174.00	0.60	0.00	3.54	2.24	0.0100	0.0024	0.1400	0.0011	9.03	8.29	-4.24
PB08	25	2008-12-03	08:35	Yes	13	6.65	107	662	122	43	47	3.57	68	261	0.00	275.00	0.87	0.00	0.00	0.00	4.5600	0.2012	0.0400	0.0008	11.92	11.39	-2.27
*PC06	26	2008-12-02	12:40	No	Surface																						
*PC08	27	2008-12-02	14:11	Yes	Surface	6.99	92	574	35	99	39	3.39	29	243	0.00	249.00	0.44	0.00	0.00	0.00	0.0000	0.0000	0.0300	0.0007	10.01	9.79	0.12
SE01	28	2008-12-02	12:50	Yes	Surface	6.57	61	305	57	41	19	7.39	47	63	0.00	179.00	0.19	30.35	0.77	1.52	0.2600	0.0197	0.1500	0.0001	5.64	6.22	4.89
PP04	29	2008-12-02	11:10	No	Surface																						
PP05	30, 31	2008-12-02	12:51	No	Surface																						

Number on map	Photo No.	Date	Time	Sample	Sample Depth (m)	pH	EC mS/m	TDS mg/L	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO4 mg/L	C03 mg/L	HCO3 mg/L	F mg/L	NO2-N mg/L	NO3-N mg/L	PO4 mg/L	Fe mg/L	Mn mg/L	B mg/L	Cr mg/L	Anion meq/l	Cation meq/l	Ionbal %
BB10	46	2008-12-04	14:41	Yes	Tap	7.78	52	229	29	43	20	4.65	21	8	1.00	254.00	0.40	0.00	3.84	0.00	0.0000	0.0000	0.0700	0.0000	5.26	5.14	0.09
BB11	47	2008-12-04	13:31	Yes	Pumped	7.40	75	403	63	59	18	7.62	91	86	0.00	215.00	0.42	0.00	0.00	0.00	0.0200	0.0634	0.0600	0.0000	7.91	7.40	-3.33
BB12	48	2008-12-04	13:46	Yes	Tap	7.90	70	382	44	71	19	3.75	32	61	1.00	280.00	0.56	0.00	0.00	0.00	0.0300	0.0000	0.0500	0.0000	6.82	7.10	1.97
BB13	49	2008-12-04	13:00	Yes	Tap	7.71	51	255	42	41	12	3.34	20	10	1.00	277.00	0.58	0.00	0.00	0.00	0.0000	0.0000	0.0700	0.0001	5.36	4.95	-3.96
BB14	50	2008-12-04	12:00	Yes	Tap	7.82	109	621	41	84	56	3.65	114	103	1.00	253.00	0.00	0.00	21.67	0.00	0.0000	0.0000	0.0500	0.0016	11.10	10.64	-2.10
BB15	51	2008-12-04	11:00	Yes	Dam	7.73	98	576	45	77	48	2.71	52	81	1.00	322.00	0.00	0.00	27.48	0.00	0.0200	0.0000	0.0500	0.0009	10.41	9.84	-2.85
BB16	52	2008-12-03	18:00	Yes	Pumped	7.32	67	353	33	63	27	2.84	82	14	0.00	181.00	0.00	0.94	20.68	0.00	0.5610	1.9110	0.0500	1.3070	7.05	6.91	0.01
BB17	53	2008-12-03	17:00	Yes	Tap	7.79	51	256	25	42	16	3.69	12	7	1.00	263.00	0.37	0.00	0.69	0.00	0.1500	0.1870	0.0700	0.1324	4.88	4.59	-3.14
BB18	54	2008-12-03	17:36	No	~																						
BB19	55	2008-12-03	17:45	Yes	Pumped	7.44	39	156	30	24	10	2.48	9	1	0.00	128.00	0.20	0.00	14.67	0.00	0.1200	0.1994	0.0500	0.0043	3.43	3.40	-0.54
BB20	56	2008-12-04	16:00	Yes	Tap	7.93	53	216	27	45	14	4.98	15	9	1.00	234.00	0.00	0.00	1.39	0.00	0.1500	0.0000	0.0600	0.0001	4.59	4.75	1.73
BB21	57	2008-12-04	08:30	Yes	15	7.39	35	174	20	29	10	3.41	10	5	0.00	126.00	0.22	0.00	11.14	0.00	0.0200	0.0000	0.0500	0.0000	3.26	3.20	-0.95
BB22	58	2008-12-04	08:45	Yes	Tap	7.76	48	226	27	41	14	4.19	13	22	1.00	202.00	0.24	0.00	8.29	0.00	0.0050	0.0053	0.0600	0.0002	4.75	4.47	-3.03
BB23	59	2008-12-04	09:55	No	~																						
BB24	60	2008-12-02	14:40	Yes	Tap	7.58	59	301	26	50	20	15.40	26	7	1.00	256.00	0.53	0.00	14.94	0.00	0.0050	0.0039	0.0800	0.0007	6.20	5.66	-4.53
BB25	61	2008-12-02	15:00	Yes	Krip/Dam	7.42	54	277	45	31	13	12.19	20	8	0.00	255.00	0.35	0.00	0.83	0.00	0.0200	0.0000	0.0900	0.0006	5.01	4.85	0.66
BB26	62	2008-12-03	08:00	No	~																						
BB27	63	2008-12-03	08:15	Yes	Tap	7.18	43	172	23	32	13	9.72	14	2	0.00	198.00	0.35	0.18	0.59	2.17	0.0000	0.0000	0.0700	0.0002	3.76	3.88	1.53
BB28	64	2008-12-04	15:30	Yes	Tap	7.62	43	215	20	33	22	4.19	14	1	0.00	125.00	0.22	0.00	28.23	0.00	0.0000	0.0000	0.0500	0.0003	4.51	4.49	-0.27
BB29	65	2008-12-03	16:00	Yes	Tap	7.60	42	168	24	34	13	3.21	16	11	0.00	174.00	0.25	0.00	0.16	0.00	0.0000	0.0000	0.0600	0.0005	3.57	3.86	3.80
BB30	66	2008-12-03	14:30	Yes	16	7.44	80	399	75	62	23	3.46	112	11	1.00	302.00	0.55	0.00	0.51	0.00	0.0000	0.0000	0.0900	0.0007	8.42	8.37	-0.33
BB31	67	2008-12-03	14:40	Yes	Tap	7.85	55	275	34	46	20	3.17	28	19	1.00	288.00	0.27	0.00	0.00	0.00	0.2900	0.1721	0.0700	0.1193	5.96	5.50	-4.08
BB32	68	2008-12-03	13:00	Yes	12	6.54	57	353	29	33	29	8.21	24	50	0.00	164.00	0.00	0.00	20.89	0.00	0.0100	0.0130	0.0500	0.0000	5.90	5.48	-3.74
BB33	69	2008-12-03	13:15	Yes	6	6.66	56	315	39	33	29	9.99	23	74	0.00	126.00	0.00	0.00	21.70	0.00	0.0100	0.0190	0.0500	0.0000	5.80	6.00	1.77
BB34	70	2008-12-03	13:45	Yes	Dam	7.28	34	158	27	26	6	4.00	7	8	0.00	148.00	0.30	0.00	6.53	0.00	0.0000	0.0000	0.0600	0.0007	3.28	3.12	-2.62
BB35	71	2008-12-03	11:00	Yes	Tap	7.54	87	516	48	63	23	7.23	34	19	0.00	159.00	0.00	0.00	61.82	0.00	0.0200	0.0000	0.0600	0.0000	8.38	7.34	-6.59
BB36	72	2008-12-03	10:30	Yes	Dam	7.46	80	449	48	62	21	7.20	129	20	0.00	140.00	0.00	3.06	19.18	0.00	0.0000	0.0000	0.0600	0.0000	7.72	7.10	-4.21
BB37	73	2008-12-03	12:00	Yes	Tap	7.92	50	207	24	51	12	2.24	10	20	1.00	213.00	0.70	0.00	1.32	0.00	0.0000	0.0000	0.0600	0.0000	4.37	4.64	2.97
BB38	74	2008-12-03	09:30	No	~																						
BB39	75	2008-12-03	09:45	Yes	Dam	8.36	32	163	19	27	11	2.33	9	4	2.00	160.00	0.21	0.00	0.00	0.00	0.0000	0.0000	0.0600	0.0000	3.03	3.20	2.62
BB40	76	2008-12-03	09:50	Yes	Tap	7.37	35	189	18	18	15	3.34	6	4	0.00	141.00	0.25	0.00	6.15	0.00	0.0000	0.0000	0.0600	0.0027	3.02	3.02	0.07
BB41	77	2008-12-03	09:00	No	~																						
BB42	78	2008-12-03	09:10	No	~																						
BB43	79	2008-12-02	13:00	Yes	Dam	6.82	12	56	8	5	3	3.52	4	4	0.00	50.00	0.18	0.00	0.00	1.90	0.0000	0.0000	0.0700	0.0000	1.01	0.93	-3.97
BB44	80	2008-12-02	13:10	Yes	5.1	6.39	22	94	17	11	13	4.13	20	1	0.00	104.00	0.14	0.00	0.00	0.00	0.0050	0.0061	0.0700	0.0006	2.31	2.44	2.89
BB45	81	2008-12-02	13:20	No	~																						
BB46	82	2008-12-02	13:40	No	~																						

Quality of Domestic Water Supplies, DWA&F, Second Edition 1998

Class 0	- **Ideal water quality** - Suitable for lifetime use.
Class 1	- **Good water quality** - Suitable for use, rare instances of negative effects.
Class 2	- **Marginal water quality** - Conditionally acceptable. Negative effects may occur in some sensitive groups
Class 3	- **Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.
Class 4	- **Dangerous water quality** - Totally unsuitable for use. Acute effects may occur.

South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, First Edition 1993 & Second Edition 1996

NR	- **Target water quality range** - No risk.
IR	- **Good water quality** - Insignificant risk. Suitable for use, rare instances of negative effects.
LR	- **Marginal water quality** - Allowable low risk. Negative effects may occur in some sensitive groups
HR	- **Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.

Photo 46. BB10

Photo 47. BB11

Photo 48. BB12

Photo 49. BB13

Photo 50. BB14

Photo 51. BB15

Photo 52. BB16

Photo 53. BB17

Photo 54. BB18

Photo 55. BB19

Photo 56. BB20

Photo 57. BB21

Photo 58. BB22

Photo 59. BB23

Photo 60. BB24

Photo 61. BB25

Photo 62. BB26

Photo 63. BB27

Photo 64. BB28

Photo 65. BB29

Photo 66. BB30

Photo 67. BB31

Photo 68. *BB32*

Photo 69. *BB33*

Photo 70. *BB34*

Photo 71. *BB35*

Photo 72. *BB36*

Photo 73. *BB37*

Photo 74. *BB38*

Photo 75. *BB39*

Photo 76. *BB40*

Photo 77. *BB41*

Photo 78. *BB42*

Photo 79. *BB43*

Photo 80. *BB44*

Photo 81. *BB45*

Photo 82. *BB46*

3.4 Summary of the Site Assessment

A total of 40 monitoring sites were indentified during Baseline Study and exist currently in and around Komati Power Station. These sites are divided into seven areas and can be seen in the locality map, Appendix A. The exact positions for extra groundwater monitoring are not known and were thus not added to these tables or to the locality map.

3.4.1 The Ashing Area and the Domestic Waste Site

- The main contamination sources of this area are the ash dam, the Domestic Waste Site, the ash return water dam, the ash return water canals around the ash dam as well as the pipelines transferring ash and ash water to and from the ash dam.
- These sources impact on groundwater as well as on the Komati and Geluk Spruit.
- Various sampling and inspection points have been identified to monitor surface water impacts from the Ashing Area on both the Komati and Geluk Spruit.
- Inadequate groundwater monitoring has been identified at the eastern and north-western sides of the ash dam.

3.4.2 The Coal Stockyard Area

- The sources of contamination of this area include the coal storage yard and the coal stockyard pollution control dam as well as the settling ponds.
- Various sampling and inspection points have been identified to monitor surface water impacts form the Coal Stockyard Area on the Geluk Spruit.
- Inadequate groundwater monitoring has been identified at the eastern and northern sides of the coal stockyard area.

3.4.3 The Power Station and the Coal Stockyard Area

- The sources of contamination of this area include the fuel depot, the oil skimmers, station drain dams and storage yard, the Power Station run-off outlets and the contractor’s area.
- Various sampling and inspection points have been identified to monitor surface water impacts form the Power Station Area on the Komati and Geluk Spruit, as well as at the raw water reservoir for monitoring artificial recharge to the groundwater.
- There is no groundwater monitoring system in place at the fuel depot. Monitoring of hydrocarbon pollution of groundwater from the oil skimmers and power station drain dams is inadequate.
- Inadequate groundwater monitoring has been identified at the eastern and northern sides of the power station area.

3.4.4 The Sewage Plant Area

- This area can impact on the groundwater as well as on the Komati Spruit.
- A monitoring point has been identified at the final effluent point for surface water quality, overflows, discharge volumes and bacteriological sampling.
- Inadequate groundwater monitoring has been identified downstream of the sewage plant.

3.4.5 The Komati Spruit

- This Spruit can be impacted upon by areas of the Power Station, the Ashing Area and the Sewage Plant.
- New sampling points of the spruit have been identified where it originates at **AP02**, along the spruit at **KMR01** as well as where it leaves Eskom property at **KMR07** in order to establish and quantify the influence of the Power Station and Ashing Area on this spruit.

3.4.6 The Geluk Spruit

- This Spruit can be impacted upon by both the Power Station Area, Coal Stockyard Area and the Ashing Area.
- A new sampling point of the spruit has been identified where it enters Eskom property at **GLR03.** This can be used together with **GLR04** in order to establish and quantify the influence of the Power Station on this spruit.

4 PROPERTIES OF THE ASH DAM, GEOLOGY & GEOHYDROLOGY

4.1 Ash Dam

The Power Stations Operations will produce in excess 50 thousand tons of ash per month. From a 3 : 1 water to solids ratio, it is evident that large volumes of water are released onto the ash dams every month. Figures obtained from Eskom are that 70 - 80% of the water dumped onto the tailings will reach the return water dam. The remaining water will either be absorbed by the tailings, reach the ground-water table by infiltration or be evaporated mainly from the pool area.

According to Stanley (1987), fly ash may be described as a rock floor, comprising 0 - 5% fine sand and 0 - 10% clay fraction, with some 80% of the material falling within the silt classification.

According to van Niekerk (1991) up to a depth of ± 2.0 m, there is vertical movement of moisture, after which the moisture has to move horizontally, either to the centre of a ashing facility or to its side, where it can evaporate, explaining the precipitation of sulphates on the ashing facility surface. It furthermore means that there is no vertical flow past the depth of 2.0 m, hence limiting the influx of oxygen for oxidation of heavy minerals. This also correlates well with the work done on residue dump leaching procedures by James and Mrost (1971). The above-mentioned has the implication that water movement below a depth of 2 m is essentially in the horizontal direction, towards the sides of the ash dam (where it evaporates) or towards the saturated central part (pool area) of the ash dam (where it is intercepted by the drainage system).

It should, however, be stressed that the above-mentioned water movement only applies to parts of the ash dam above the phreatic surface, i.e. the unsaturated part of the slimes dam. If the saturated part of the slimes dam (i.e. the part beneath the phreatic surface) is considered, the situation changes significantly. In this region, there always exists a downward flux, due to the hydraulic gradient between the saturated part of the ash dam and the surrounding ground-water regime, as well as the chemical gradient between the two regimes.

Furthermore, van Niekerk (1991) noted that the stratification of finer and coarser layers in a ash dam is enhanced by their water content. Generally fines tend to retain a larger portion of the available moisture than coarser materials.

The above results were used by van Niekerk (1991) to calculate a possible flux of water through the ash dam. According to van Niekerk (1991) this is difficult to achieve, as the soil moisture characteristics of an ash dam can change significantly towards the centre (pool area) of the ash dam. Two locations were therefore used:

(i) Along the side of the ash dam (wall area), representing the measured data.

(ii) In the centre of the ash dam (pool area), representing a totally saturated area.

An average saturated hydraulic conductivity (K_s) valve of 1 x 10^{-7} m/s was obtained by means of laboratory experiments, as well as Cambell's formula. This value also compared favourably with values obtained from Steffen, Robertson and Kirsten (1990), as well as values published by James and Mrost (1965) and Mrost and Lloyd (1971). An estimated flux (q) of 1.7 x 10^{-11} m/s was obtained for the wall area (unsaturated area), while a value of 1 x 10^{-7} m/s was obtained for the pool area.

From the above discussions, it is evident that large quantities of contaminated water, depending on the size of the ash dam can seep into the underlying sediments to eventually reach the ground-water table. The amount of water, as well as the rate of infiltration, will furthermore depend on the under-drainage of the ash dam and the hydraulic properties of the underlying sediments respectively.

4.2 Geology

4.2.1 Regional Geology

The site forms part of the Highveld Coalfield and falls within the Carboniferous to early Jurassic aged Karoo Basin, a geological feature that covers much of South Africa. In the Komati area, shales typically define lower and upper levels of the series, with coal measures and associated detrital sediments present between (Truswell, 1977). Two sedimentary units are of interest in this area; the Dwyka Formation, and the Vryheid Formation. The Dwyka Formation is essentially comprised of a succession of glacial deposits characterized by angular to rounded clasts of basement within a silt and clay matrix that were emplaced from the Late Permian, although varved shales, sandstone, and conglomerates typical of a fluvio-glacial environment also occur (Botha et al., 1998). The formation unconformably overlies an undulating basement surface defined by lithologies associated with the Bushveldt Complex in the area.

The younger Vryheid formation is comprised of a succession of sandstones and minor interbeds of siltstone and mudstone to a thickness of ±180 m. Typically, five seams, numbered 1 (youngest) to 5 (oldest) are represented across the Highveld Coalfield, although Seam 1 is often absent. Seam 4, a flat lying to gently undulating unit with a thickness of about 5 m and regional dip of less than 1^{o} to the southwest, is the seam mostly mined in the area, and typically occurs at a depth of about 30 m in open cut areas. While the entire thickness of the seam is extracted during surface mining, underground operations only exploit the lower two thirds of the unit. The layout of mine operations and subsequent extraction of the coal is influenced by the presence of dolerite sills that tend to displace the coal measures, thereby compartmentalizing the reserves.

The term fracture refers to cracks, fissures, joints and faults, which are caused by geological and environmental processes, such as tectonic activity, secondary stresses, release fractures, shrinkage cracks, weathering, and chemical and thermal influences. Fracturing can also be a function of petrological factors such as mineral composition, internal pressure, and grain size.

From a geohydrological viewpoint, a fractured rock mass can be considered a multi-porous medium, consisting of a matrix intercepted by preferential pathways (i.e. fractures). Fractures can be regarded as conduits of higher hydraulic conductivity within permeable or permeable matrix blocks, most of the storage usually contained within the matrix. It should be appreciated, however, that a rock mass can contain fractures of different scale, and indeed in many cases the hydraulic conductivity of the matrix blocks can be attributed to the presence of micro-fractures. A rock mass comprising only large fractures and some matrix blocks with no micro- fractures can be termed purely fractured rocks. In this case, the domain takes the form of an interconnected network of fractures, and the rock matrix, consisting of fracture-surrounded blocks, is impervious to flow. Where the domain is a porous medium intersected by a network of interconnected fractures, the rock is termed a fractured porous rock, the domain characterized by at least two subsystems, each having a different degree of heterogeneity that is often referred to as the scale effect.

4.2.2 Geophysical Investigations

The geophysical survey was conducted at the western, southern and eastern boundary of the ashing facility. The purpose of the geophysical investigations was to detect and delineate geological features that may be associated with preferential pathways for groundwater migration and contaminant transport. Intrusive magmatic bodies are often associated with baked zones that are usually highly fractured and weathered. Such zones could form preferential pathways along which rapid groundwater flow and contaminant transport can take place. The magnetic method was used during the geophysical survey since this method is often very successful in detecting intrusive magmatic bodies such as dolerite/diabase sills or dykes.

Magnetic data were recorded on 9 traverses. The location of the traverses is as follow:

- Three traverses were recorded west of the Ashing Area.
- One traverses were recorded south of the Ashing Area and
- Five traverses east of the Ashing Area, (Refer to the locality maps in **Appendix A**).

The lengths of the traverses ranged from a few metres to 720 m and the total length of all the traverses was approximately 3.5 km. Data on the traverses were recorded using station spacing of 10 metres, depending on the variability of the data and the detail required. The magnetic profiles are presented in Figure 4 to Figure 12.

The above data could be employed to determine optimal siting positions of boreholes, if necessary. These boreholes could be used as production boreholes to intercept groundwater influx or for grouting of preferred pathways, as well as for monitoring boreholes for future development. These boreholes must be upstream and downstream from the areas under investigations and must be used to conduct permeability tests for the calculation of the hydraulic conductivity of the saturated geological formations. The drilling of additional boreholes is, however, not part of this investigation.

4.2.2.1 Geophysical Survey West of the Ash Dam

Data were recorded on three traverses on the western boundary of the Ash Dam. All three of the traverses have an approximate south/north strike (Traverses 1, 2 and 3).

The anomalies recorded on Traverse 1 and 2 generally had low amplitudes (40 nT) and were observed at only single stations. Most of these anomalies might be due to the presence of metal objects such as poles, pipes and fences. No magnetic anomalies of any significance were recorded on these two traverses.

An anomaly was recorded on Traverse 3 indicating the possible presence of a dolerite sill with a dip in a northwest southeast direction.

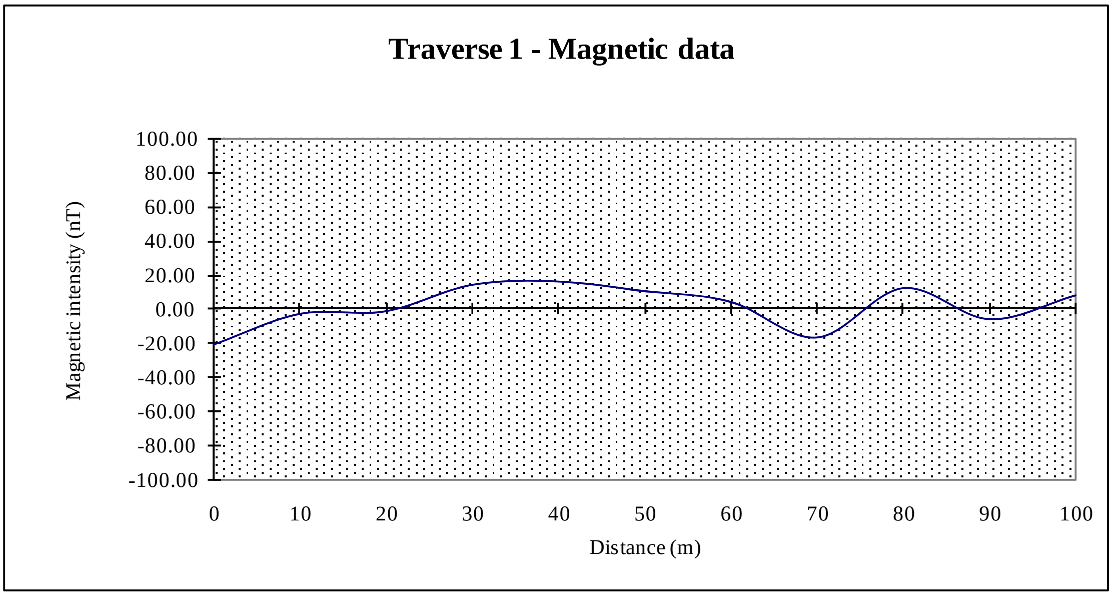


Figure 4. S-N magnetic profile of Traverse 1.

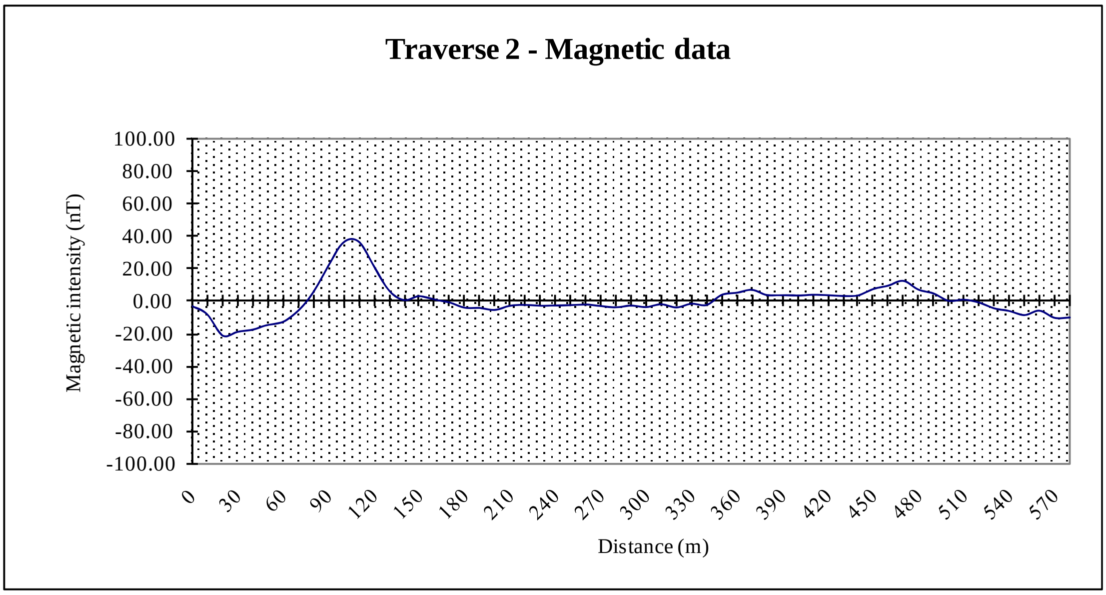


Figure 5. S-N magnetic profile of Traverse 2.

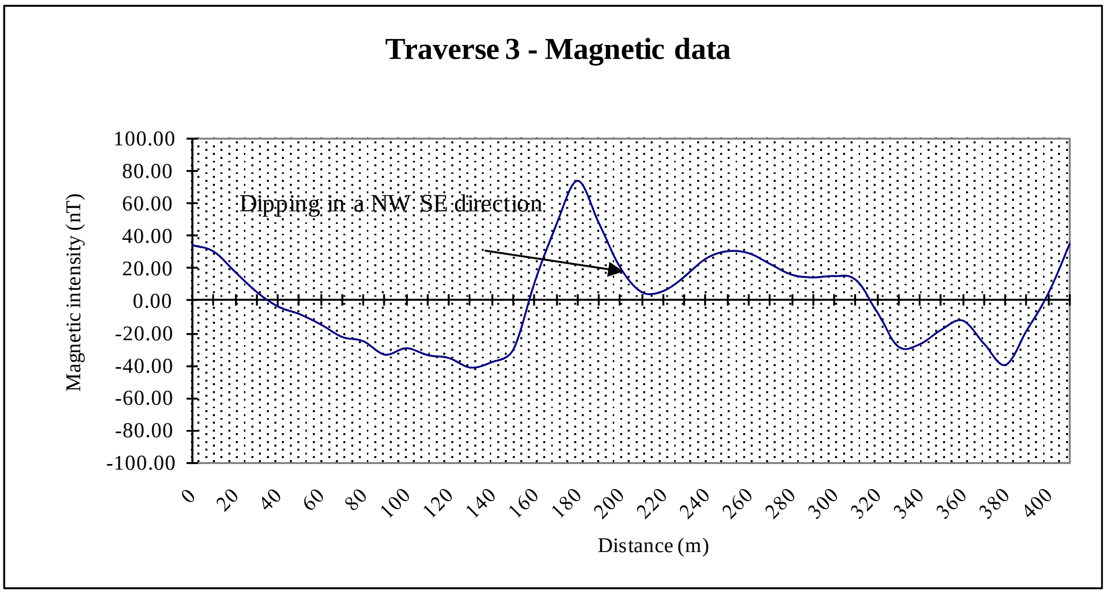


Figure 6. SW-NE magnetic profile of Traverse 3.

4.2.2.2 Geophysical Survey South of the Ash Dam

Data was recorded on one traverses south of the Ash Dam with an approximate west/east strike (Traverses 4). No magnetic anomalies of any significance were recorded on traverse 4.

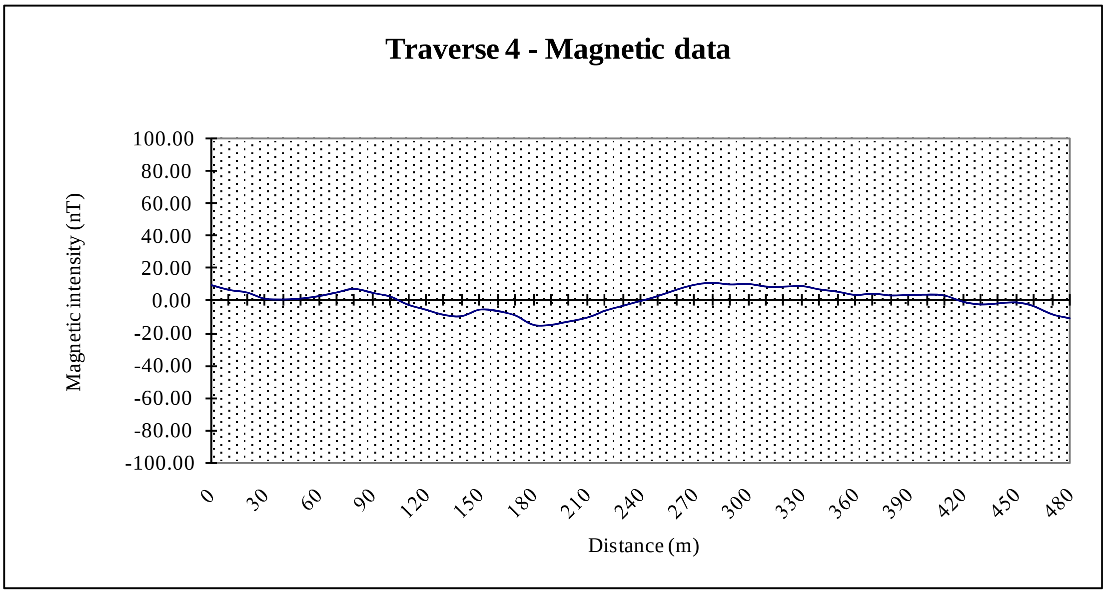


Figure 7. W-E magnetic profile of Traverse 4.

4.2.2.3 Geophysical Survey East of the Ash Dam

Data were recorded on five traverses east of the Ash Dam. Four traverses with an approximate southwest/northeast strike (Traverse 5, 6, 7 and 8) and one with a southeast/northwest strike (Traverse 9).

Anomalies were recorded on two of the traverses namely, Traverses 5 and 9. These anomalies are due to the presence of power lines. No magnetic anomalies of any significance were recorded on the other traverses on the eastern side of the Ash Dam.

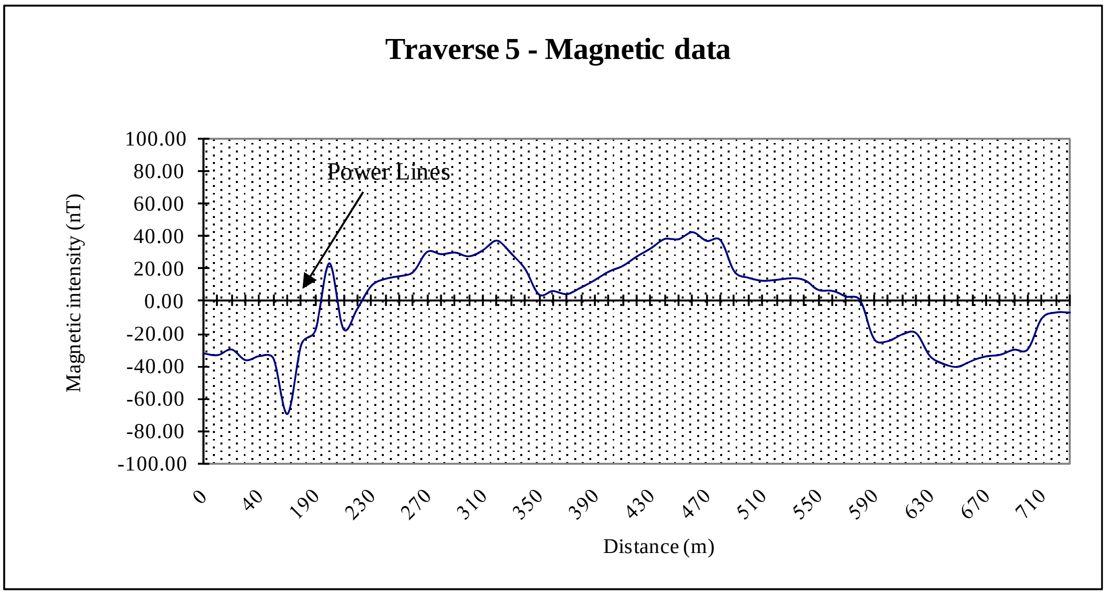


Figure 8. SW-NE magnetic profile of Traverse 5.

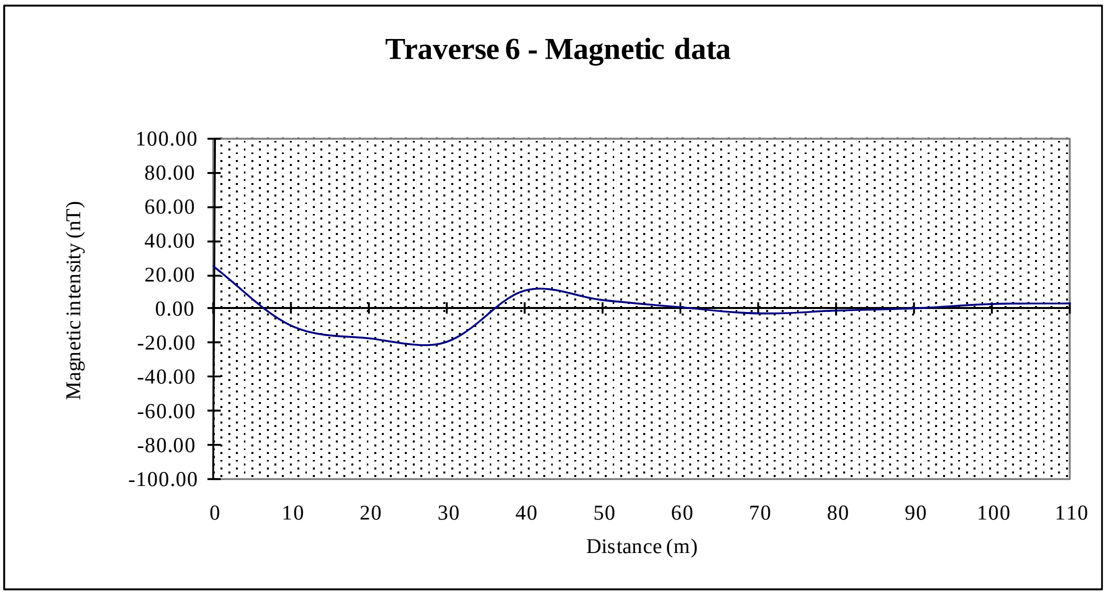


Figure 9.   SW-NE magnetic profile of Traverse 6.

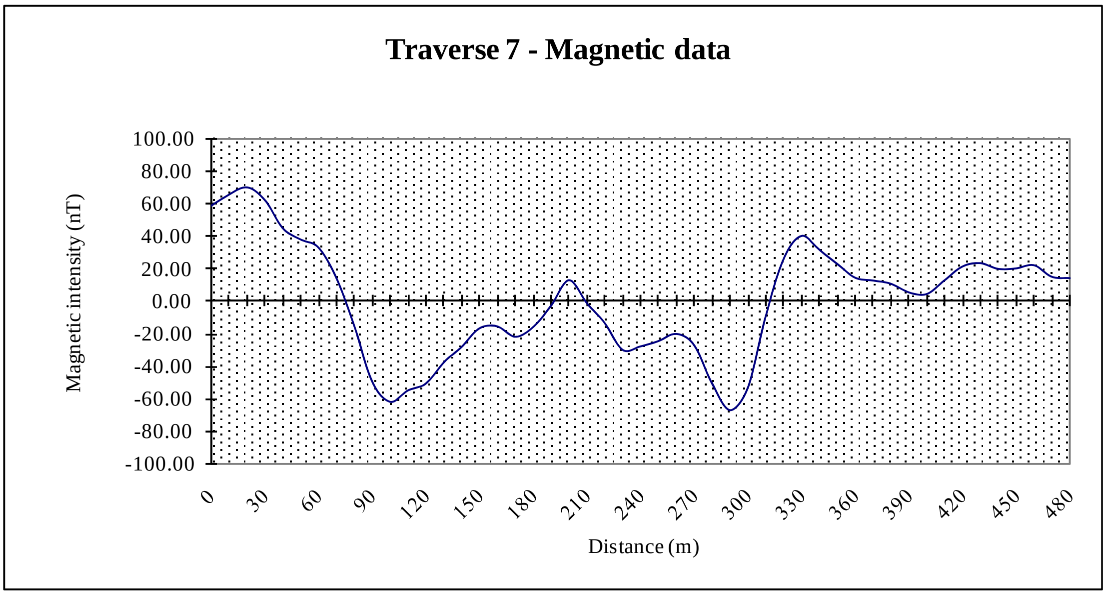


Figure 10. SW-NE magnetic profile of Traverse 7.

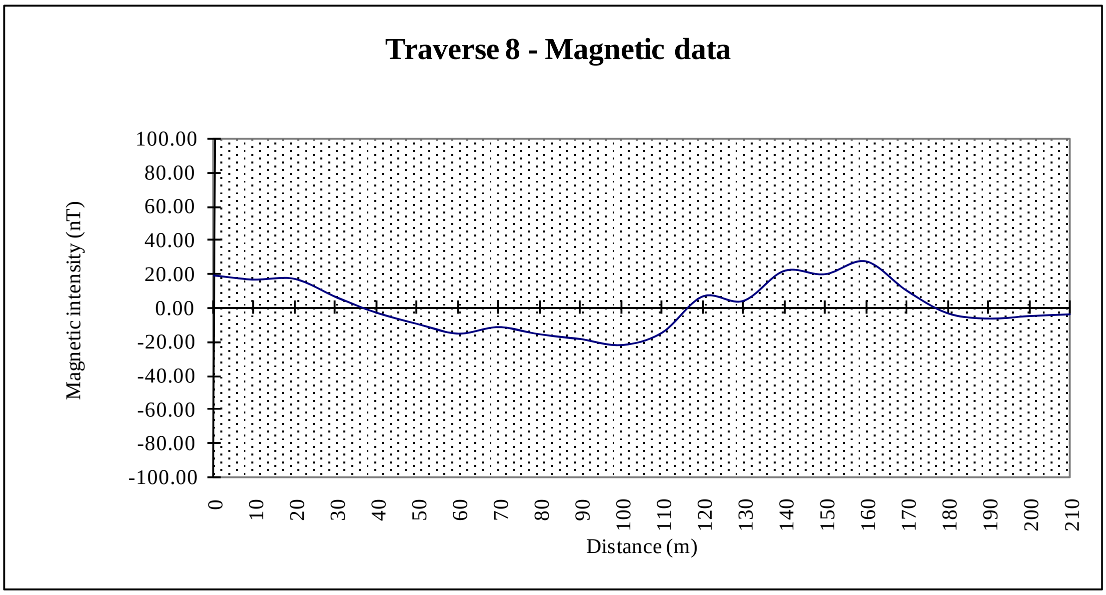


Figure 11. SW-NE magnetic profile of Traverse 8.

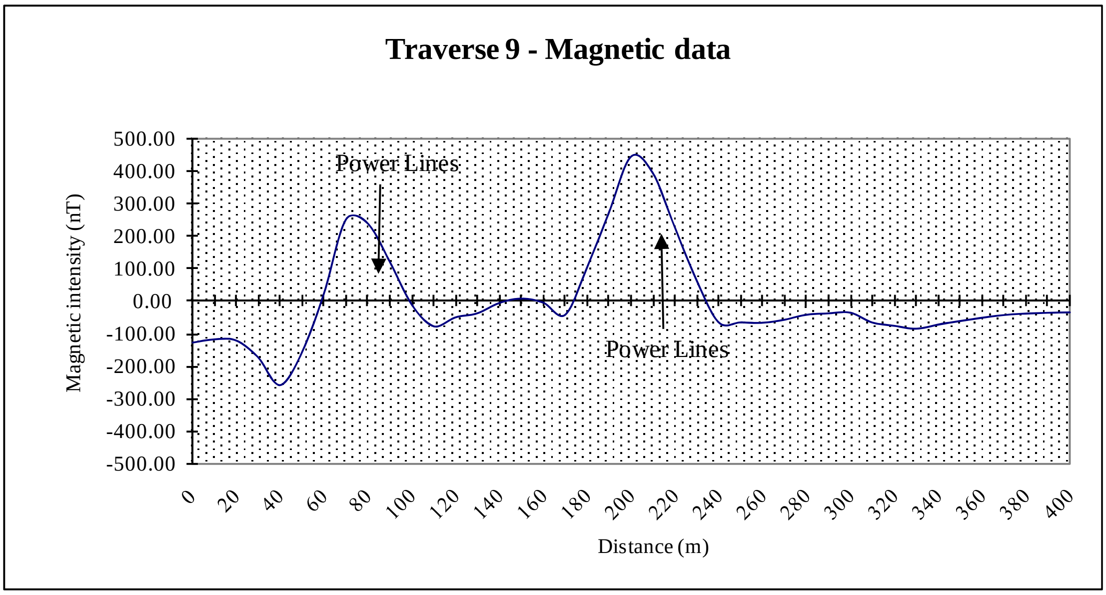


Figure 12. SE-NE magnetic profile of Traverse 9.

4.3 Geohydrology

The main water bearing aquifers in the vicinity of the power station are fractured rock aquifers. The term fracture refers to cracks, fissures, joints and faults, which are caused by (i) geological and environmental processes, e.g. tectonic movement; secondary stresses; release fractures; shrinkage cracks; weathering; chemical action; thermal action and (ii) petrological factors like mineral composition, internal pressure, grain size, etc.

From a hydrogeological point of view, a fractured rock mass can be considered a multi-porous medium, conceptually consisting of two major components: matrix rock blocks and fractures. Fractures serve as higher conductivity conduits for flow if the apertures are large enough, whereas the matrix blocks may be permeable or impermeable, with most of the storage usually contained within the matrix. Actually, a rock mass may contain many fractures of different scales. The permeability of the matrix blocks is in most cases of practical interest a function of the presence of micro-fractures. A rock mass which consists only of large fractures and some matrix blocks with no micro-fissures (or smaller fractures) lead to a term called purely fractured rocks. In this case, the domain takes the form of an interconnected network of fractures and the rock matrix, comprising the blocks surrounded by fractures, is impervious to flow. However, there may still be porosity. In the case where the domain is a porous medium (or a micro-scaled fractured medium) intersected by a network of interconnected fractures, the rock is termed a fractured porous rock and the domain is therefore characterized by at least two subsystems, each having a different scale of inhomogeneity (called scale effect).

4.3.1 Aquifer characteristics

Drilling data and work undertaken during previous investigations suggests that multiple aquifer types are represented at the site. These include:

- Unconfined aquifers present within soil horizons that have developed within colluvial and alluvial environments and the weathered upper levels of Ecca Formation sediments. These aquifers are generally perched on less permeable underlying in situ sediments;
- Unconfined aquifers along the trend of dolerite dykes. These may also act as recharge points for confined aquifers within the Ecca Formation at depth;
- Semi-confined aquifers within the Ecca Formation. These aquifers are commonly confined along essentially horizontal bedding interfaces between different lithologies, but can be locally unconfined along the trend of fractures zones, which allows the aquifers to recharge seasonally. The aquifers can therefore be regarded as a semi-confined, or leaky confined, aquifer on a regional scale if the definition of Fetter (1994) is considered;
- Deeper confined aquifers within basement lithologies.

From a pollution management viewpoint, the presence of a perched shallow aquifer is problematic due to resulting localised decreases in the bearing capacity of site profiles, and the increased potential for pollutant transport. In this instance, shallow aquifers are generally seasonal, which suggests that they either drain quickly (i.e. they are relatively permeable), have a low storage potential, or that stored water can be lost via evapo-transpiration processes. Contaminant movement away from pollution point sources can be reduced, or prevented entirely, through the construction of cut-off trenches and sub-soil drains to the confining layer at the base of the aquifer. This is generally not an option at sites where this layer occurs at significant depths, or when pollutants enter underlying regional aquifers.

While seasonally influenced, the perched aquifer is also artificially recharged by the different structure associated with the power generation activities, the relatively impermeable Karoo sediments which act as aquifer base in some areas of the shallow perched aquifer encouraging lateral migration through the unsaturated zone in these areas. In comparison, recharge to regional aquifers occurs via preferential pathways, such as fractures, dykes, bedding planes and highly weathered bedrock areas. The regional aquifers are therefore classified as fractured rock aquifers. In general, aquifers appear unconfined to semi-confined in character.

The higher water levels observed in the immediate vicinity of the water bearing surface structures are an indication of the artificial recharge from these structures.

The distribution of groundwater levels were inferred from available groundwater level data assuming that the water level is a sub-surface reflection of surface topography using Bayesian interpolation. Subsequently the direction and velocity of groundwater flow were calculated.

Due to the unavailability of pre-operations groundwater data the water levels measured at uninfluenced sites during December 2008 were used for the Bayesian interpolation of groundwater level data for the initial conditions (refer to Figure 13). The same water level data with the exception of the affected areas were used to do Bayesian interpolation for the current ground water level distribution (Figure 14) The elevated topography and groundwater levels associated with the surface structures were incorporated in the current 2008 interpolation.

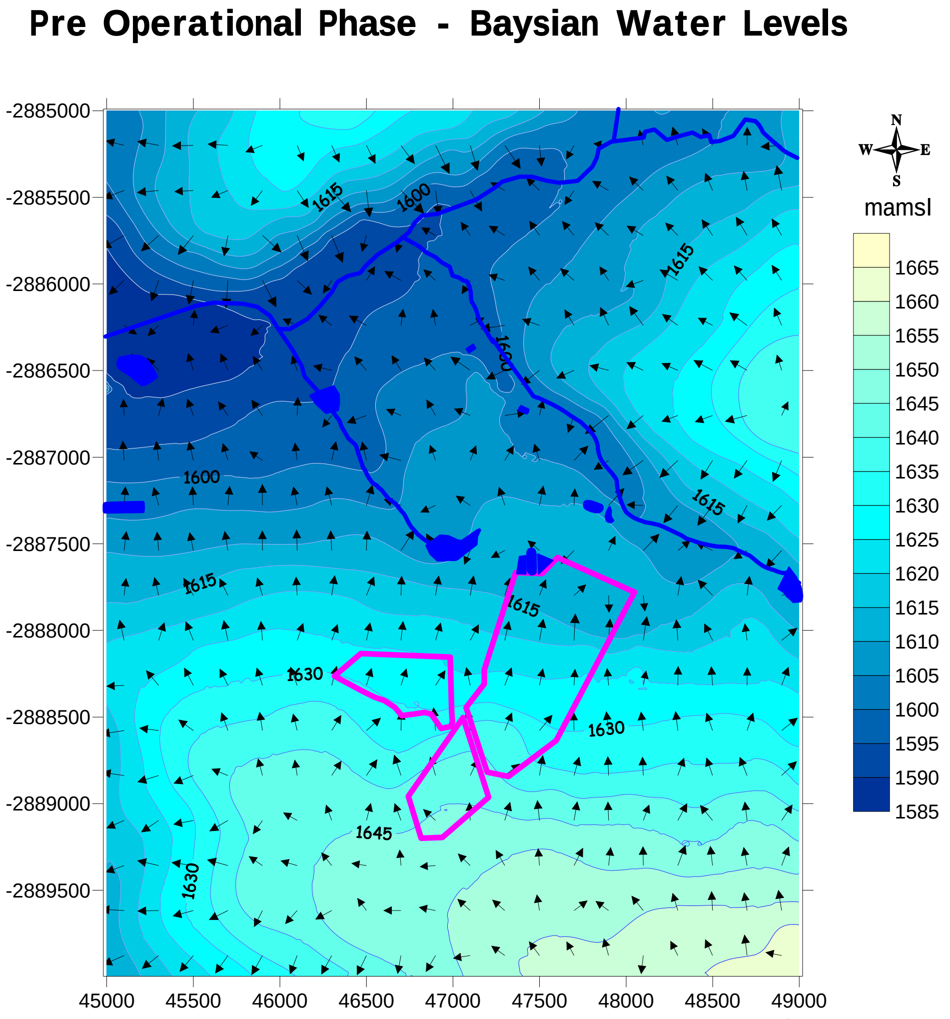


Figure 13. Simulated Pre-Operational Phase groundwater levels and flow directions (Bayesian Interpolation)

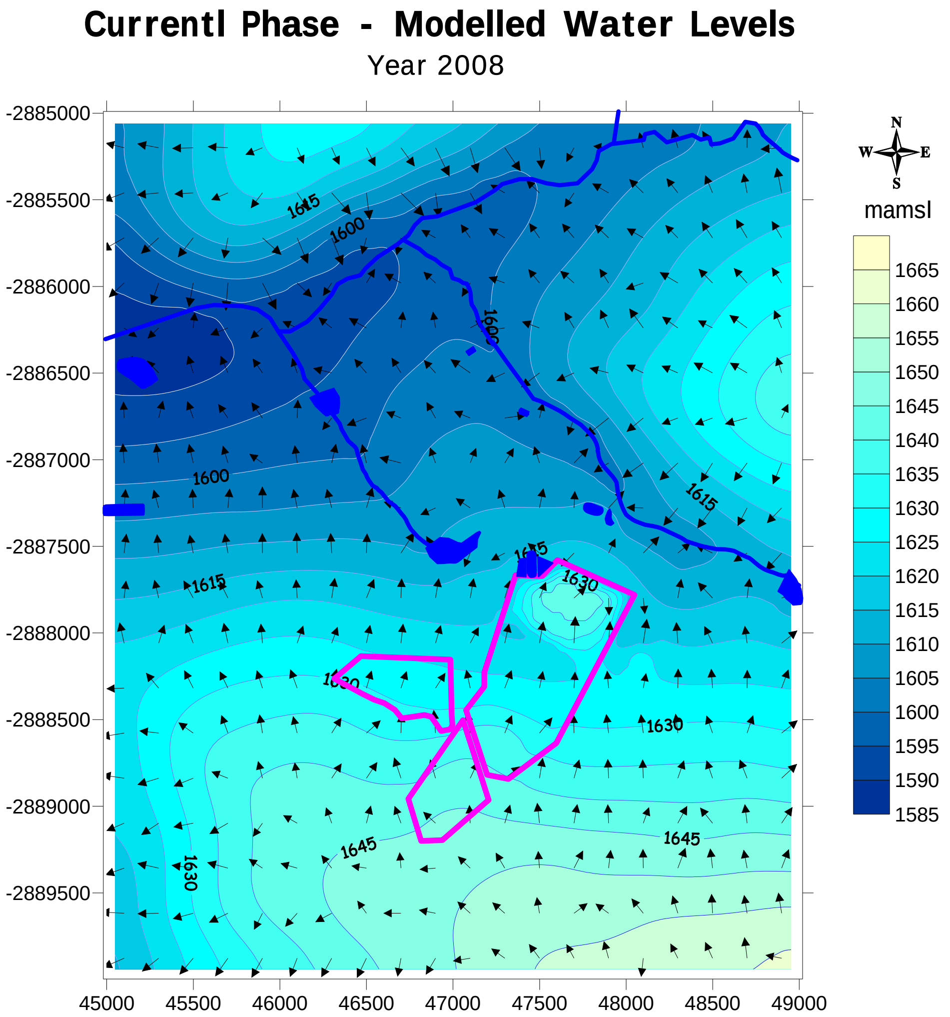


Figure 14. Simulated current (2008) groundwater levels and flow directions (Modelled Water Table))

4.3.2 Factors Controlling Water in Rocks

Permeability of the Aquifer

Permeability is the intrinsic capacity of a rock to transmit fluids. Materials that do not allow water to pass through them are classified as impermeable. Sands and gravel, which have large pore spaces, are highly permeable; clays, on the other hand, are practically impermeable because pore spaces are extremely small and the water contained in them is virtually stationary.

During the execution of permeability tests, also known as "slug tests", a certain volume of water is either added, or removed from, the column water inside the borehole. The rate at which the recovery towards the original rest water level takes place after the addition/removal, is measured. A displacement in the order of 10 cm – 50 cm is considered to be sufficient to enable the investigator to obtain useful results from the exercise. The transmissivity (T) and/or hydraulic conductivity (K) are determined from these measurements. It must, however, be kept in mind that the values obtained from the slug test represent only the aquifer properties in the immediate vicinity around the borehole, since disturbances in the equilibrium conditions are only experienced over small distances from the borehole.

Hydraulic Conductivity (K)

Hydraulic conductivity is defined as the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at a right angle to the direction of flow. Hydraulic conductivity has units of Length/Time.

Transmissivity (KD or T)

Transmissivity is the product of the average hydraulic conductivity (*K*) and the saturated thickness of the aquifer (*D*). Consequently, transmissivity is the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer. Transmissivity has the units of Length^2/Time.

Storativity (S)

The storativity of a saturated confined aquifer of thickness (*D*) is the volume of water released from storage per unit surface area of the aquifer per unit decline in the component of hydraulic head normal to that surface. In a vertical column of unit area extending through the confined aquifer, the storativity *S* equals the volume of water released from the aquifer when the piezometric surface drops over a unit distance. As storativity involves a volume of water per volume of aquifer, it is a dimensionless quantity.

4.3.3 Hydraulic Testing of Monitoring Boreholes

The geological formations permeabilities were determined by conducting falling head tests on eight of the nine current monitoring boreholes. Borehole AB06 were infested by bees and could not be tested. The hydraulic tests on the boreholes were done in order to obtain information on the hydraulic properties of the rock formations in the vicinity of the Ashing Area Power Station Area and the Coal Stockyard Area.

The results of the permeability tests are used to determined fluid/contaminant migration in the rock formations in the vicinity of the boreholes.

The Bouwer-Rice method was used to analyses the permeability tests performed on the Power Station boreholes. The results of the tests are presented in Figure 15 to Figure 22.

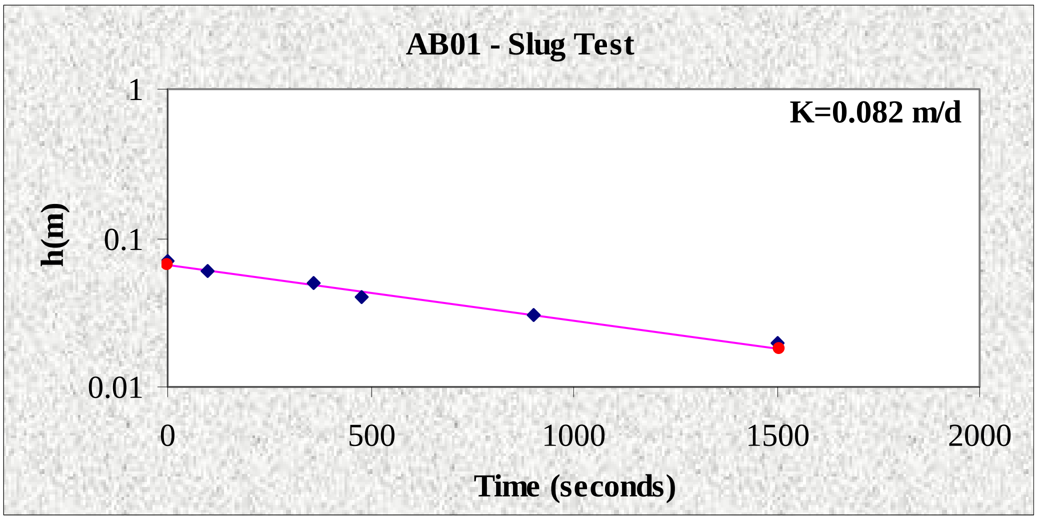


Figure 15. Results of the permeability test performed on AB01.

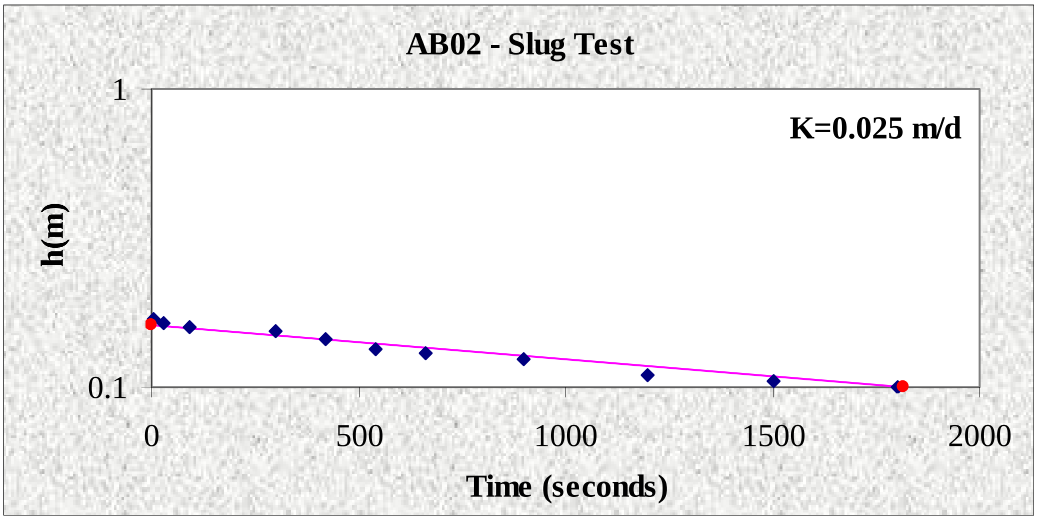


Figure 16. Results of the permeability test performed on AB02.

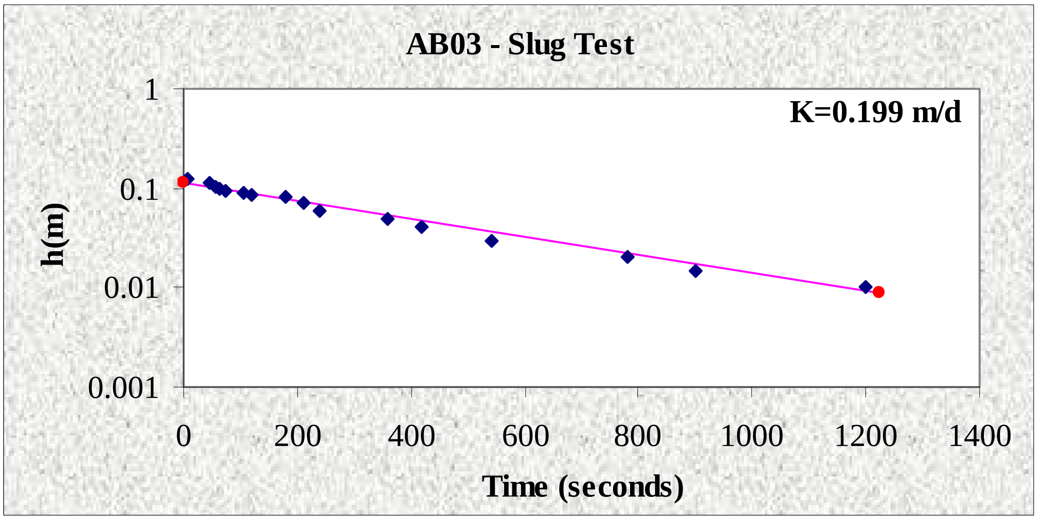


Figure 17. Results of the permeability test performed on AB03

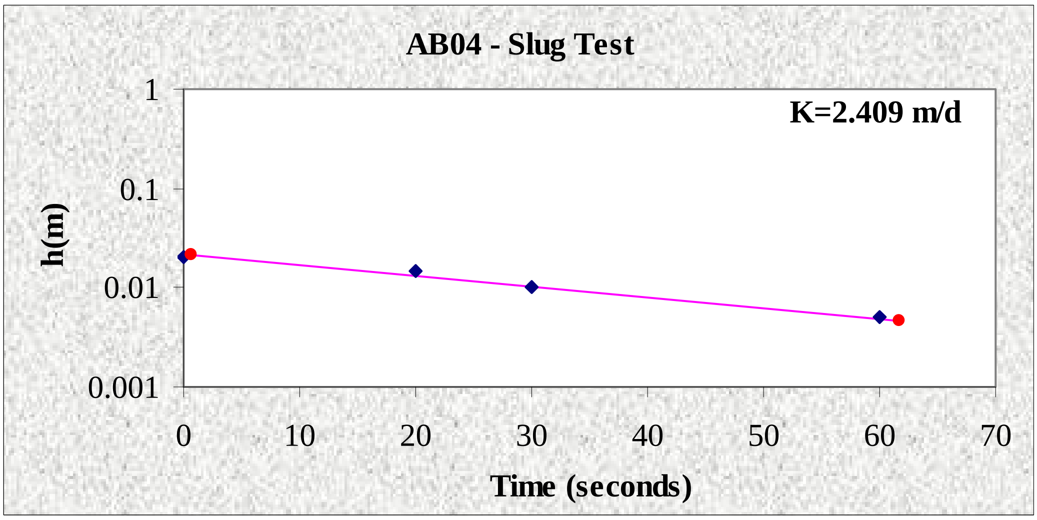


Figure 18. Results of the permeability test performed on AB04.

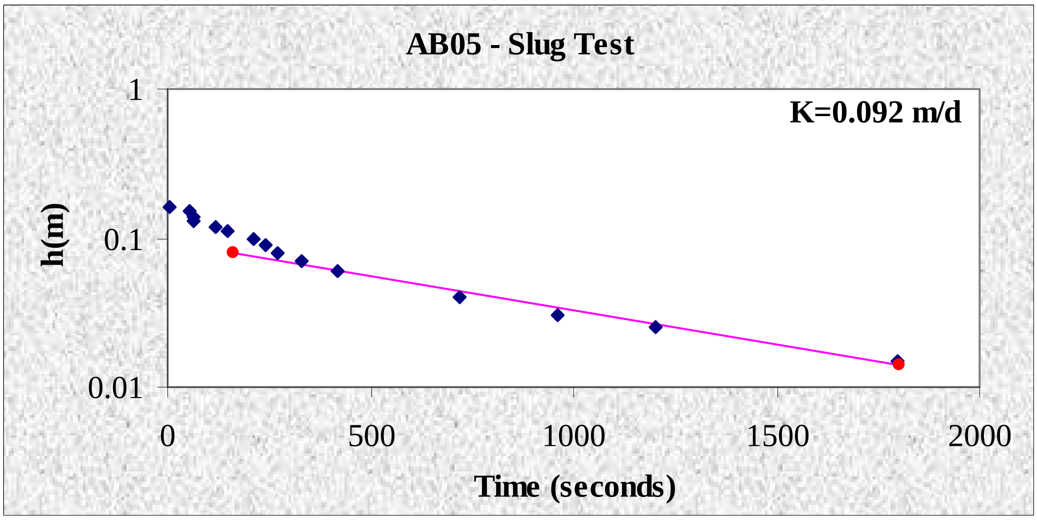


Figure 19. Results of the permeability test performed on AB05.

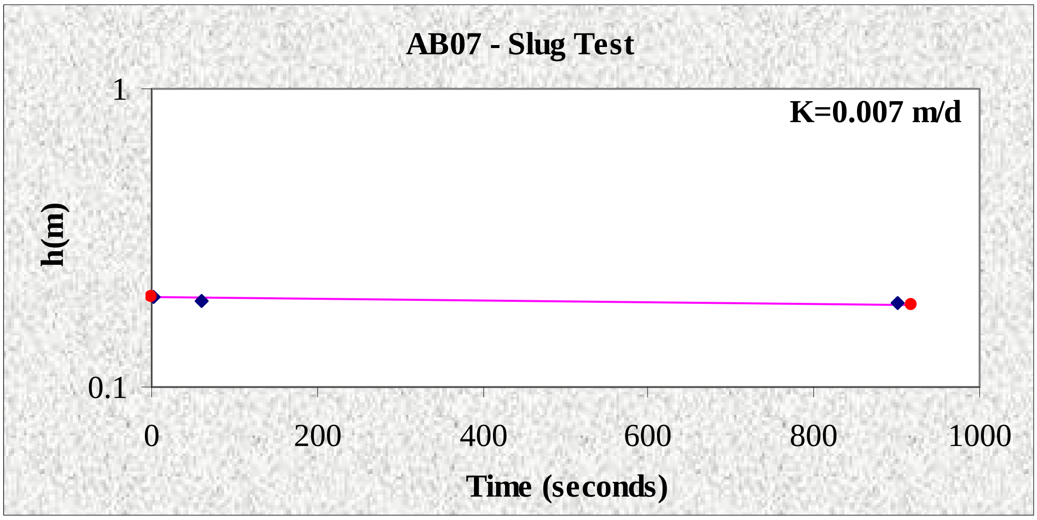


Figure 20. Results of the permeability test performed on AB07.

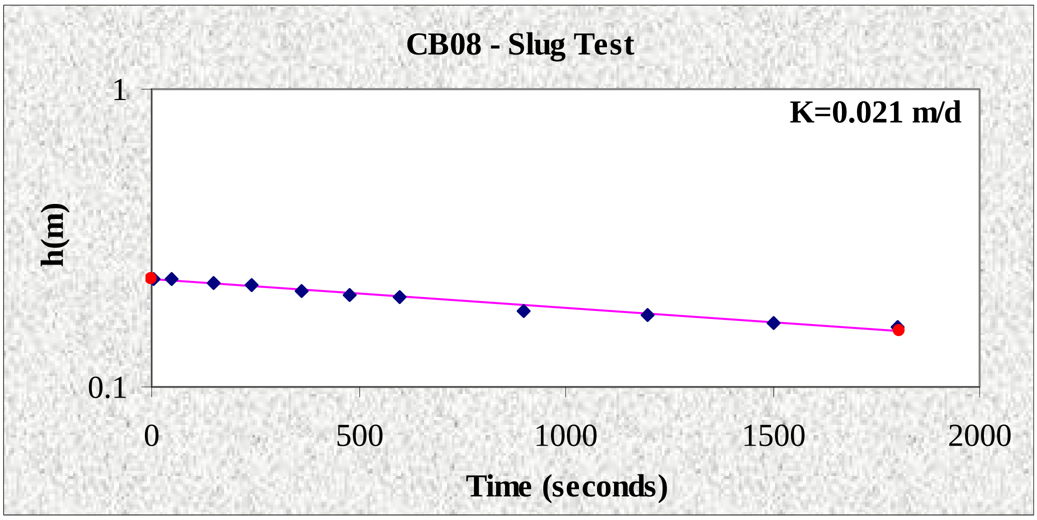


Figure 21. Results of the permeability test performed on CB08.

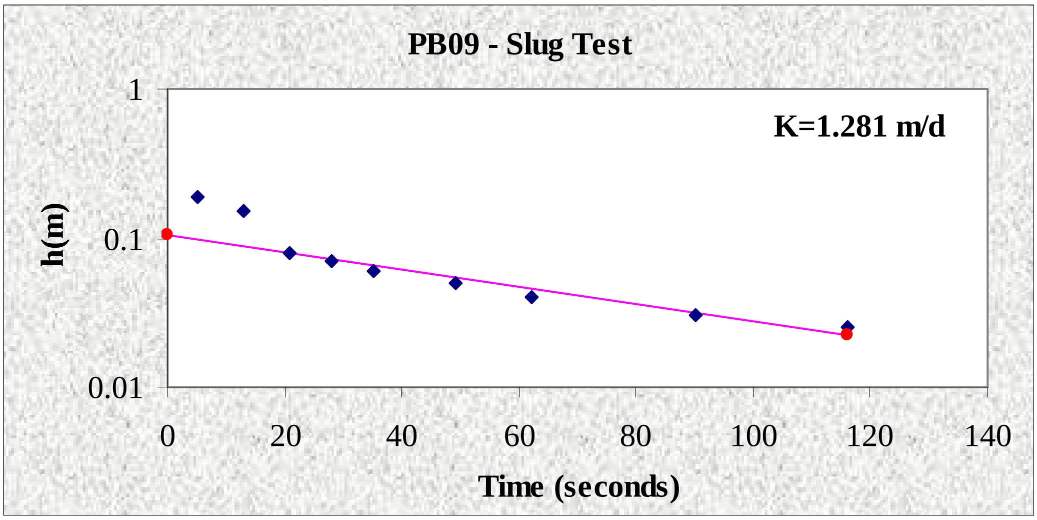


Figure 22. Results of the permeability test performed on PB09.

These observations suggest that the rocks on and in the vicinity of Komati Power Station generally have low permeabilities and hydraulic conductivities. The presence of preferential pathways, such as fractured zones, might be present in the region and may cause marked increases in the hydraulic conductivities. Migration of groundwater and/or contaminants can be expected to be high along such pathways. Permeability tests were not performed during this investigation on boreholes located on the neighbouring farms due to the presence of equipment in the boreholes.

The results of the permeability tests are implemented in the calculation of the flow velocities of the groundwater (which acts as the carrier of pollution [if any] in the geohydrological environment). The calculations are performed as follows:

$$v_s = \frac{K}{n}\frac{\Delta h}{\Delta l}$$

where v_s is Darcy's flow velocity, K is the hydraulic conductivity, $\Delta h/\Delta l$ is the hydraulic gradient, and n is the porosity, assumed to be 30% (0.3). The hydraulic gradient is assumed to equal the local topographic gradient of 0.02 (1:63). The results of the calculations are presented in Table 9.

Table 9. Darcy's flow velocities for the monitoring boreholes

No.	**Hydraulic Conductivity *K* (m/d)**	**n Porosity**	**Hydraulic Gradient**	**Flow Velocity (m/y)**
AB01	0.082	0.3	0.01	1.1972
AB02	0.025	0.3	0.01	0.3650
AB03	0.199	0.3	0.01	2.9054
AB04	2.409	0.3	0.01	35.1714
AB05	0.092	0.3	0.01	1.3432
AB07	0.007	0.3	0.01	0.1022
CB08	0.021	0.3	0.01	0.3066
PB09	1.281	0.3	0.01	18.7026
Average				**0.7811**

The flow velocities listed in Table 9 suggest that fluid/contaminant migration in the rock formations at Komati Power Station will be slow. However, it must be remembered that the results obtained from permeability tests only represent the characteristics of the aquifer in the immediate vicinity of the boreholes tested. In the presence of preferential pathways these flow velocities may be much higher. The velocity will also be much lower as hydraulic gradient become less in the flat areas.

5 SURFACE- AND GROUNDWATER QUALITY – INORGANIC PARAMETERS

The results of the analyses (as obtained from the submitted database) are presented in this section by various graphical means and observations regarding the contamination status of the surface- and groundwater are made.

Although the concentrations of more than 17 inorganic chemical parameters in the water samples were determined during the chemical analyses, only eight parameters are used as indicators of contamination in the monitoring of the pollution potential in this system. These eight parameters are: the **pH**, the electrical conductivity (**EC**), the major ions **Ca, Na**, **Cl**, **SO_4, K** and **Mg**. The suitability of these parameters to act as *indicator elements* in the evaluation of water contamination was determined by GHT during previous investigations and reports. The additional information on the concentrations of the other elements is required to evaluate the accuracy and reliability of the chemical analyses.

5.1 Chemical Analysis Reliability

The most common way to evaluate the reliability of an analysis is to perform an Ion Balance Calculation. For any water analysis, the total cation and anion concentrations should balance. The difference between these concentrations is referred to as the Ion Balance Error. A negative value indicates that anions predominate in the analysis, whereas a positive value shows that cations are more abundant. For the analysis to be considered reliable, the ion balance error should not be greater than 5% of the total ion concentration. A value greater than this figure indicates that some major constituents have not been analysed for or that there is an analytical error. Some trace elements are not included in the ion balance calculation. However, these may still be important as pollution indicators and may be used to identify point sources of pollution.

5.2 Chemical Data Presentation Formats

The results of the inorganic chemical analyses are presented in various formats in this report. These formats include Data Tables, MMAC plots and Time Graphs. The formats used are not exhaustive and any special requirements could be incorporated if suggested by the client or if shown necessary as the monitoring program progresses. The formats of data presentation used in this report are discussed below.

5.2.1 Data Tables and Water Quality Tables

Data Tables

The results of all the inorganic chemical analyses that have been performed on water samples from Komati Power Station during the current and previous phases of the monitoring program are available in an electronic database for review. A summary of the data tables can be seen in Appendix B.

Water Quality Tables

In these tables the water samples from each monitoring site are classified according to the “South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, First Edition 1993” and the “South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, Second Edition 1996”, as well as according to the publication “Quality of Domestic Water Supplies, DWA&F, Second Edition 1998”. A description of the various classes is given in Table 10.

Table 10. Classification system used to evaluate water quality classes.

Quality of Domestic Water Supplies, DWA&F, Second Edition 1998

Class 0	- **Ideal water quality** - Suitable for lifetime use.
Class 1	- **Good water quality** - Suitable for use, rare instances of negative effects.
Class 2	- **Marginal water quality** - Conditionally acceptable. Negative effects may occur in some sensitive groups
Class 3	- **Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.
Class 4	- **Dangerous water quality** - Totally unsuitable for use. Acute effects may occur.

South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, First Edition 1993 & Second Edition 1996

NR	- **Target water quality range** - No risk.
IR	- **Good water quality** - Insignificant risk. Suitable for use, rare instances of negative effects.
LR	- **Marginal water quality** - Allowable low risk. Negative effects may occur in some sensitive groups
HR	- **Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.

5.2.2 MMAC Plots

Monitoring is undertaken so that changes in water quality over time can be identified. Such changes may be particularly evident in areas affected by surface activities, which could enhance water degradation. For this investigation the evaluation of previous and the current monitoring period has again been condensed and plotted in a format referred to as the Maximum, Minimum, Average and Current plot (MMAC). The results from a number of sample sites can be plotted in a single diagram for comparison.

A diagram of an MMAC plot is shown in the Figure 23 and serves to explain the meaning of each element in the presentation. Instead of only an average value, twice the standard deviation, given as one value above and one value below the average is supplied. The standard deviation allows an idea of the usual range of values measured for the particular constituent at the particular site. A small standard deviation indicates a stable sample, while a large value represents a high variation in values. The maximum and minimum values ever recorded at the site are indicated in these plots by horizontal lines.

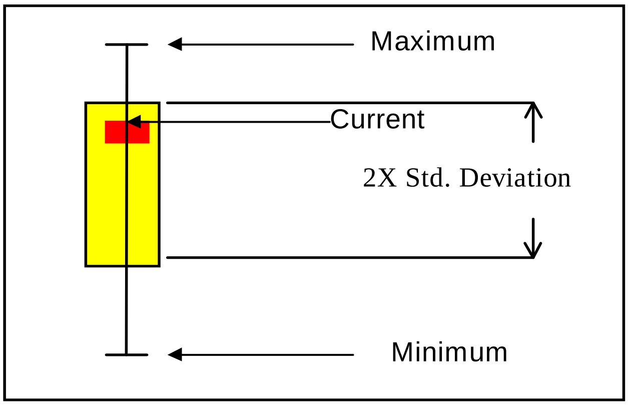


Figure 23. Maximum, Minimum, Average and Current Plot (MMAC)

In this way, a visual comparison may be made between the different sampling points for each monitoring period. At the same time, the history of each sampling point can be assessed. For example, if the red rectangle in the diagram were an actual data point, the current value would be higher than the average. If this is the case for other indicator parameters, and the condition persists through a number of monitoring events, then progressive degradation is indicated.

It must be noted that on the plots included in **Appendix C,** only the sampling sites that were sampled during the last monitoring phase were included. The geohydrological software package 'WISH' *(Institute of Groundwater Studies, UOVS, 1999)* was used to evaluate the data. On each of the plots the Department of Water Affairs and Forestry drinking water standard for human consumption is indicated and can be described as follows:

- The Target Water Quality Range (TR) for a particular constituent is indicated by the lower horizontal line on the figures. Concentrations below this value correspond to levels at which the presence of the particular constituent would have no known adverse or anticipated effects on the fitness of the water assuming long-term continuous use. If the quality is within the TR one can immediately concluded that water quality in that particular case is not an issue to the water use concerned. However, if the water quality falls outside the TR it does not mean that the water is unsuitable for a particular use, but rather that the particular situation must be more thoroughly assessed by referencing the comprehensive guidelines.
- The upper horizontal line of the standard indicates the Maximum Allowable Limit (AL). This is the limit above which remedial action should be implemented. It does not mean that the water is unsuitable for a particular use, but rather that the particular situation must be more thoroughly assessed by referencing the comprehensive guidelines.

5.2.3 Time Graphs

Time graphs (refer **Appendix C**) are constructed for the groundwater samples so that temporal changes in concentrations of the indicator elements may be identified. These changes are interpreted to reflect the contamination levels of the groundwater. The temporal trends as observed in the time graphs are summarized in table format in this report.

5.3 Evaluation of Surface- and Groundwater Quality – Inorganic parameters

In this section the results of the chemical analyses of the water samples taken during the current monitoring phase is discussed and related to the results of previous monitoring phases. At the time of the latest sampling event, most of the streams at Komati Power Station were characterized by stagnant water. It is therefore fair to assume that the dilution effect of continuous stream flow was negligibly small during the months preceding the sampling event.

5.3.1 Water Quality Tables

The water quality of the surface- and groundwater at Komati Power Station is summarised in this section in table format. The data in the are colour-coded according to the “South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, First Edition 1993” and the “South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, Second Edition 1996”, as well as according to the publication “Quality of Domestic Water Supplies, DWA&F, Second Edition 1998” (see Table 10 and refer to Appendix C).

5.3.1.1 The Ashing Area and Domestic Waste Site

Table 11. Water quality – Ashing Area and Domestic Waste Site.

No.	Date	pH	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO_4 mg/L	T.Alk mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	PO_4 mg/L	B mg/L
AB01	20081203	7.1	348	362	242	236	30.5	299	1188	684	0.00		0.00	0	
AB02	20081203	7.1	251	90	281	211	44.9	45	1545	294	0.00		0.00	0	
AB03	20081203	6.6	74	43	42	25	7.3	41	203	121	0.19	0.00	0.00	0	0.01
AB05	20081202	7.2	257	374	121	76	7.2	234	879	327	0.00		2.35	0	
AB07	20081203	6.9	227	145	178	178	10.3	59	1308	158	0.00		0.00	0	
AC02	20081203	3.1	233	143	306	35	25.1	66	1318	0	0.79	0.00	0.00	0	0.59
AC03	20081203	6.8	83	73	38	14	11.9	51	148	203	0.48	0.00	0.00	0	0.14
AC04	20081203	7.4	137	87	133	48	10.8	42	478	285	0.79	0.00	0.00	0	0.09
AC05	20081203	7.3	107	99	78	12	16.4	49	387	121	0.40	0.00	2.68	0	0.26
AP02	20081203	7.3	131	112	104	27	15.5	50	523	215	0.87	0.00	1.34	0	0.24
AP03	20081203	7.1	114	100	86	17	16.6	52	392	142	0.62		0.00	0	

5.3.1.2 Power Station and Coal Stockyard area

Table 12. Water quality – Power Station and Coal Stockyard area.

No.	Date	pH	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO_4 mg/L	T.Alk mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	PO_4 mg/L	B mg/L
PB08	20081203	6.7	107	122	43	27	3.6	68	261	226	0.87		0.00	0	
CB09	20081203	7.5	69	28	64	20	3.5	15	132	212	0.90		0.47	0	
PC08	20081202	7.0	92	25	89	39	3.4	29	263	205	0.44	0.00	0.00	0	0.03
CP06	20081203	7.5	66	56	32	13	5.9	21	171	142	0.50	0.00	3.80	0	0.14

5.3.1.3 Sewage plant area

Table 13. Water quality – Sewage plant area.

No.	Date	pH	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO_4 mg/L	T.Alk mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	PO_4 mg/L	B mg/L
SPE01	20081202	6.6	61	37	21	9	7.4	47	63	147	0.19	30.35	0.77	1.52	0.15

5.3.1.4 Komati Spruit Area

Table 14. Water quality – Komati Spruit area.

No.	Date	pH	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO_4 mg/L	T.Alk mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	PO_4 mg/L	B mg/L
KMR01	20081203	7.2	151	133	122	40	23.2	55	646	224	0.86	0.00	0.00	0	0.42
KMR02	20081203	7.5	79	51	50	18	9.3	30	244	135	0.48	0.00	0.00	0	0.21

5.3.1.5 Geluk Spruit Area

Table 15. Water quality – Geluk Spruit area.

No.	Date	pH	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO_4 mg/L	T.Alk mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	PO_4 mg/L	B mg/L
GR03	20081203	7.5	40	15	22	12	2.8	13	40	147	0.31	0.00	0.00	0	0.11
GR04	20081203	7.1	118	50	118	46	5.0	18	240	481	0.00	0.00	0.00	0	0.16

5.3.1.6 Discussion

The Ashing Area

The waters from the sites of the Ashing Area can be classified as good to poor water quality due to high concentrations of mainly Mg and SO_4. It can be summarised as follows:

- AB01 (monitoring borehole at domestic waste site), AB02 (monitoring borehole east of new ash dams), AB07 (monitoring borehole below seepage recovery dam) and AC02 (north-western side of ash dam) is classified as dangerous due to the concentrations of Mg and SO_4 and is classed as Class 4 water quality totally unsuitable for human use. Acute effects may occur.
- AB05 (monitoring borehole at dam) can be classified as poor due to the concentrations of SO_4.
- AP02 (clean water dam where Komati Spruit originates west of ash dam) and AC04 (north-eastern corner of ash dam where road crosses over pipelines) can be classifies as marginal due to the concentrations SO_4.

- AB03 (monitoring borehole east of old ash dams), AC03 (dirty water canal on eastern side of ash dam), AC05 (north of ash dam where road crosses over pipelines) and AP03 (seepage recovery dam previously labelled D26) can be classified as good water quality.

Power Station and Coal Stockyard Area

The waters from the Power Station and Coal Stockyard area are classified as ideal to good. It can be summarised as follows:

- CP06 (station drain holding dam at north-western corner of Power Station) can be classified as water with an ideal quality.
- PB08 (monitoring borehole below station drains and oil skimmers), PB09 (monitoring borehole at Lake Fin or new coal stockyard pollution control dams) and PC08 (first bridge south of Power Station where road crosses Komati Spruit) can be classified as good water quality.

Sewage Plant Area

- SE01 (sewage PSE outlet) at the sewage plant can be classified as poor due to the concentrations of NO_2.

Komati Spruit Area

- KMR01 (second bridge south of Power Station where road crosses Komati Spruit) can be classified as poor due to the concentrations of SO_4.

Geluk Spruit Area

- The waters from the Geluk Spruit can be classified as ideal to good.

5.3.2 MMAC Plots and Time Graphs

The observations made from the MMAC plots and Time Graphs are presented in table format in this report. The table headings are as follows:

- AV - The current pollution indicator concentration is above the recorded average;
- HR - The current pollution indicator concentration is the highest on record;
- SD - Sites with high standard deviations in the particular indicator element concentration.
- V - Variable – The indicator element concentration is variable over time;
- S - Stable – The indicator element concentration has remained stable over time;
- D - Decreasing – The indicator element concentration has been decreasing over time.
- I - Increasing – The indicator element concentration has been increasing over time;

The MMAC plots of the chemical analyses of water samples from the various monitoring areas are given in Appendix C.

5.3.2.1 The Ashing Area and Domestic Waste Site

The MMAC plots and temporal trends in the indicator element concentrations of the surface- and groundwater of the Ashing Area are summarised in Table 16.

Table 16. MMAC presentation of the indicator element concentrations of the surface- and groundwater of the Ashing Area.

Sites	Trends PH							Trends EC							Trends Ca							Trends Na							Trends Cl							Trends SO$_4$							Trends Mg						
	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I
AB01						Y		Y	Y	Y				Y	Y	Y					Y	Y	Y	Y				Y	Y	Y	Y				Y	Y	Y	Y				Y	Y	Y					Y
AB02							Y	Y	Y					Y	Y	Y					Y	Y						Y	Y				Y			Y	Y	Y				Y	Y	Y					Y
AB03						Y				Y			Y				Y			Y							Y							Y				Y			Y							Y	
~~AB04~~																																																	
AB05							Y	Y	Y	Y				Y	Y						Y	Y	Y	Y				Y	Y	Y					Y	Y	Y	Y				Y	Y	Y					Y
~~AB06~~																																																	
AB07							Y	Y		Y				Y	Y		Y				Y	Y						Y	Y				Y			Y		Y				Y	Y						Y
~~AC01~~																																																	
AC02*																																																	
AC03*																																																	
AC04*																																																	
AC05*																																																	
~~AP01~~																																																	
AP02*																																																	
AP03						Y		Y						Y	Y					Y						Y		Y	Y				Y			Y		Y			Y							Y	

Notes: Sites in strikethrough font not sampled during latest monitoring phase
** Sites that are ssampled for the first time*

5.3.2.2 Power Station and Coal Stockyard Area

The MMAC plots and temporal trends in the indicator element concentrations of the surface- and groundwater of the Power Station, Coal Stockyard and the Sewage Plant are summarised in Table 17.

Table 17. MMAC presentation of the indicator element concentrations of the water of the Power Station, Coal Stockyard Area and the Sewage plant Area.

Sites	Trends PH							Trends EC							Trends Ca							Trends Na							Trends Cl							Trends SO$_4$							Trends Fe						
	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I
PB08					Y		Y			Y		Y	Y						Y	Y						Y		Y					Y	Y		Y				Y	Y							Y	
CB09	Y						Y						Y				Y			Y							Y							Y				Y			Y				Y			Y	
~~PC06~~																																																	
~~CC07~~																																																	
PC08*																																																	
~~PP04~~																																																		
~~PP05~~																																																	
CP06*																																																	
SE01*																																																	

Notes: Sites in strikethrough font not sampled during latest monitoring phase
** Sites that are ssampled for the first time*

5.3.2.3 Komati and Geluk Spruit Area

The MMAC plots and temporal trends in the indicator element concentrations of the surface water of the Komati and Geluk Spruit Area are summarised in Table 18.

Table 18. MMAC presentation of the indicator element concentrations of the water of the Komati and Geluk Spruit Area.

Sites	Trends PH							Trends EC							Trends Ca							Trends Na							Trends Cl							Trends SO$_4$							Trends Fe						
	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I	AV	HR	SD	V	S	D	I
KMR01*																																																	
KMR02*																																																	
GLR03*																																																	
GLR04*			Y			Y		Y						Y	Y						Y					Y		Y						Y				Y		Y			Y					Y	

Notes: Sites in strikethrough font not sampled during latest monitoring phase
** Sites that are ssampled for the first time*

5.3.2.4 Discussion

Degradation in the water quality at a number of sampling sites is evident.

Ashing Area and Domestic Waste Site

Surface water

Although AP03 forms part of the dirty water system, the quality of the water is good.

Groundwater

Impacts upon the groundwater in the vicinity of the Ash dam, is evident by the large standard deviations observed at AB01, AB02, AB03, AB05 and AB07. Evidence of negative impacts upon the groundwater further north at AB07 is also apparent with concentration of SO_4 and Mg which exceed the groundwater drinking standards.

Of concern is the highest on record concentrations recorded at AB01, AB02 and AB05 for EC, Ca, Na, Cl, SO_4 and Mg.

Power Station, Coal Stockyard Area and Sewage plant Area

Surface water

The surface water sites of the Power Station, Coal Stockyard Area and Sewage plant Area were sampled for the first time.

Groundwater

Stable trends for all the indicator elements were observed at PB08. Large standard deviations with sharp decreasing trends are observed for Ca, SO_4 and Mg at CB09.

Komati and Geluk Spruit Area

Surface water

Variable trends are observed for pH, Ca, Na, Cl and SO_4 at GLR04 (Northern Holding Dam overflow at western corner of Power Station) and large standard deviations of ph, EC, Na and SO_4 which is an indication of negative impacts on the Geluk Spruit.

5.4 EC Profiling of Monitoring Boreholes

Electrical conductivity (EC) profiling was performed on eight of the nine current monitoring boreholes. Borehole AB06 were infested by bees and could not be tested. The aim of the EC profiling was as follows:

- To identify horizons along which preferential contaminant migration may be taking place.
- To determine the depth of the boreholes.

Conductivity measurements of the groundwater were taken every half a metre down the length of the borehole. The data obtained during EC profiling were entered into the existing water quality data base of Komati Power Station.

EC profiling was done on the 2 and 3rd December 2008. Conductivity measurements of the groundwater were taken every half a metre down the length of the borehole. The data obtained during EC profiling were entered into the existing water quality data base of Komati Power Station.

The results of the EC profiling investigations are briefly discussed below:

Monitoring borehole AB01

The EC of the groundwater in borehole AB01 display a gradual increase with depth from 186 mS/m to 212 mS/m.

This borehole is currently sampled at a depth of 15 mbgl. The EC values remain within a very narrow range along the length of the borehole. No preferential pathways for groundwater migration and contaminant migration can be identified. It is recommended that sampling be continued at this depth.

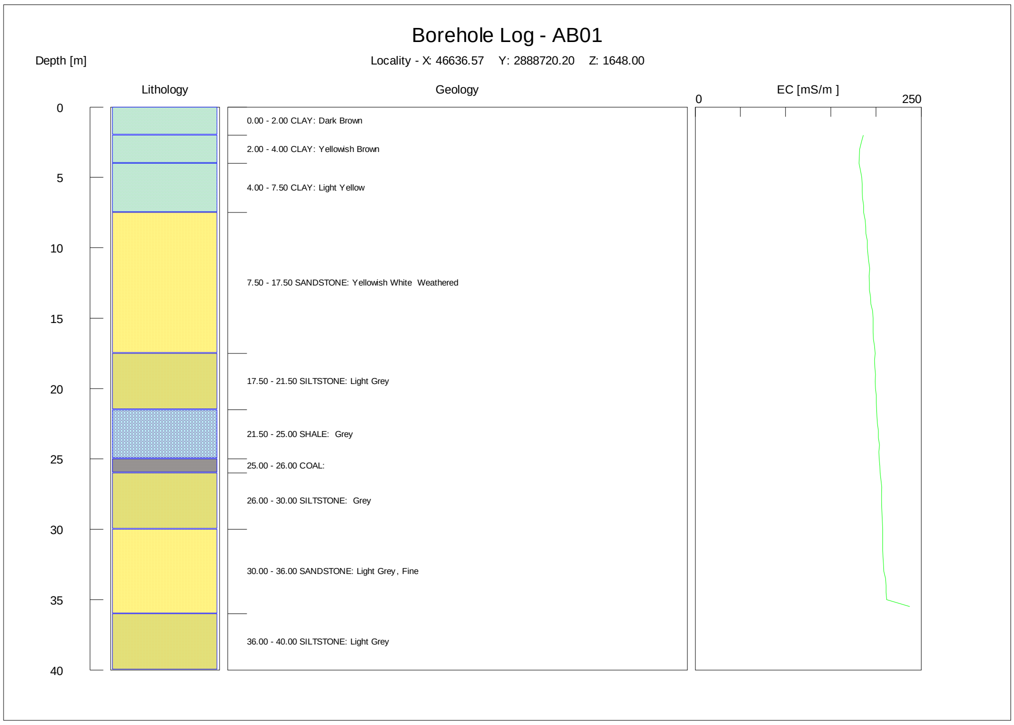


Figure 24. Monitoring borehole AB01.

It should be noted that AB01 was drilled to a depth of 40 metres but has since silted up to a depth of around 35.5 metres.

Monitoring borehole AB02

The EC of the groundwater in borehole AB02 is very constant along the length of the borehole.

This borehole is currently sampled at a depth of 20 mbgl within a sandstone layer. Since the EC values remain within a very narrow range along the length of the borehole and no clear preferential pathways for groundwater migration and contaminant migration can be identified, it is recommended that sampling be continued at this depth.

It should be noted that AB02 was drilled to a depth of 40 metres but has since silted up to a depth of around 32.5 metres.

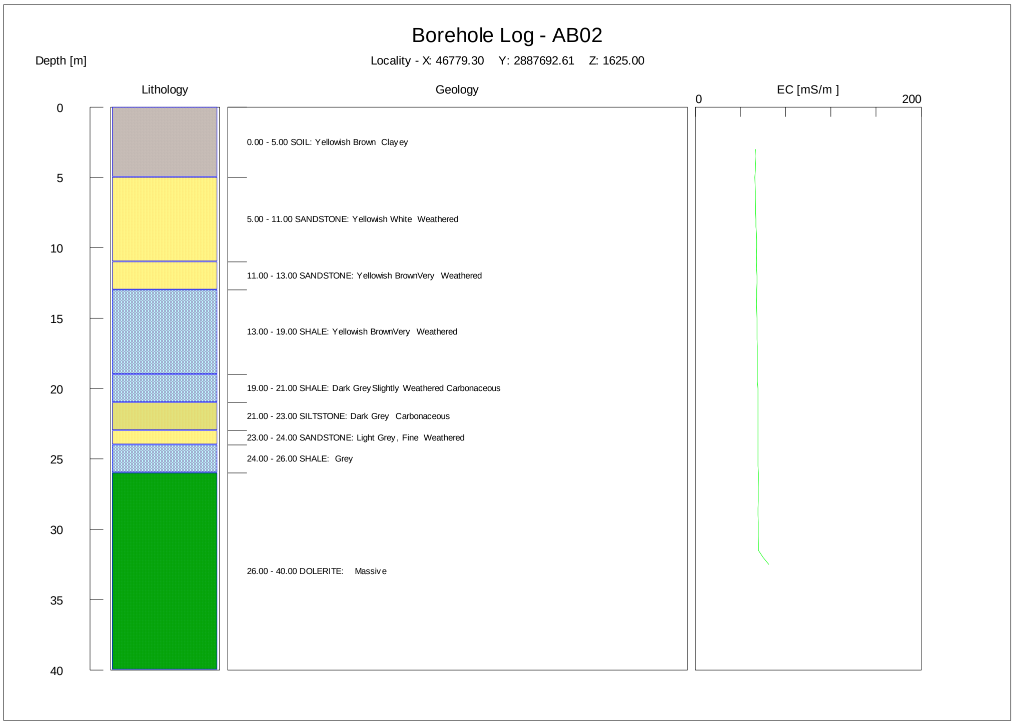


Figure 25. Monitoring borehole AB02.

Monitoring borehole AB03

The EC of the groundwater in borehole AB03 is constant in the borehole.

Borehole AB03 is currently sampled at a depth of 6 mbgl. It is recommended that sampling be continued at this depth.

It should be noted that AB03 was drilled to a depth of 40 metres but has since collapsed or silted up to a depth of around 7.5 metres.

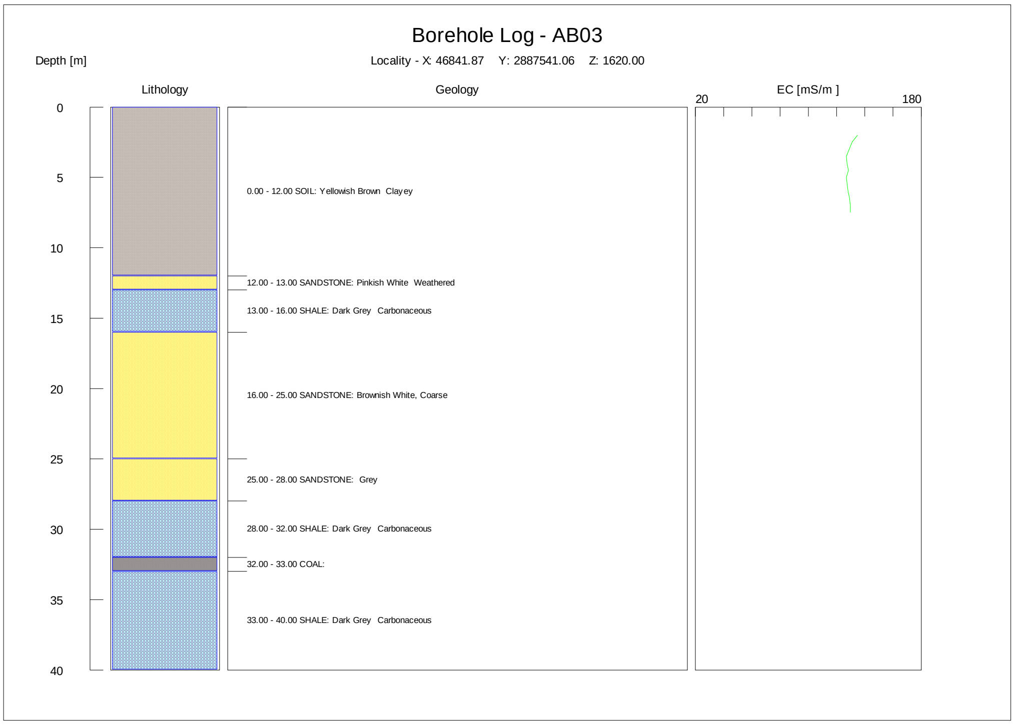


Figure 26. Monitoring borehole AB03.

Monitoring borehole AB04

The EC of the groundwater in borehole AB04 is very constant along the length of the borehole.

This borehole is currently sampled at a depth of 19 mbgl. It is recommended that sampling be continued at this depth.

It should be noted that AB04 was drilled to a depth of 40 metres but has since silted up to a depth of around 38 metres.

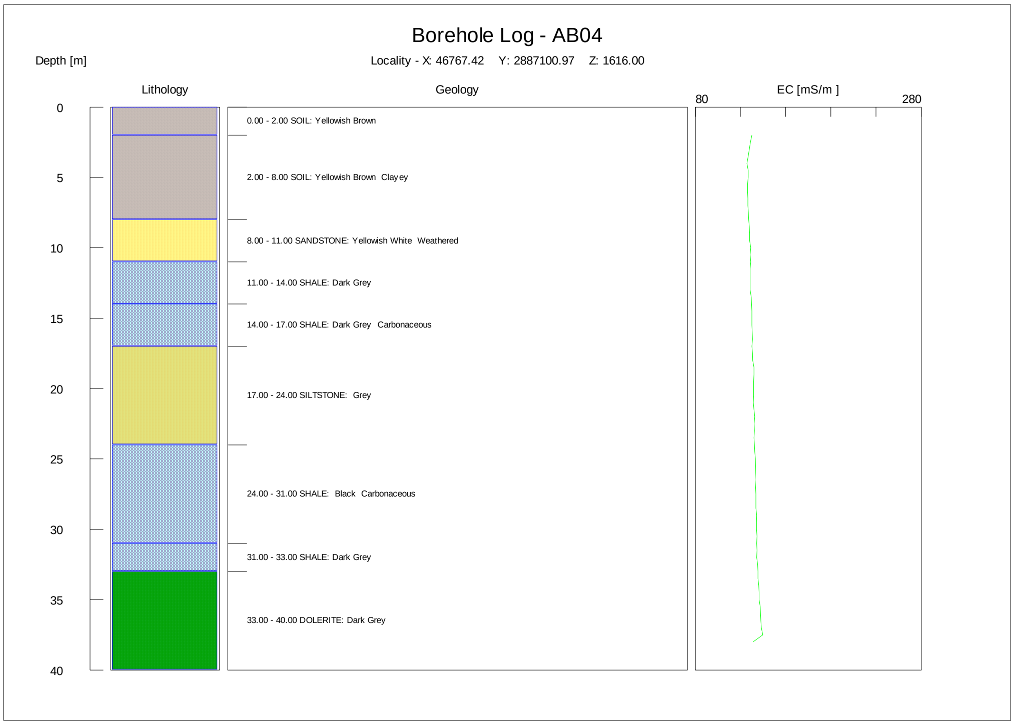


Figure 27. Monitoring borehole AB04.

Monitoring borehole AB05

The EC profiling showed that the groundwater in borehole AB05 displays a gradual increase in the conductivity from a value of around 55.3 mS/m to around 70.9 mS/m at a depth of 3 mbgl. Between 3.5 and 8.5 a further increase in conductivity was measured.

It should be noted that AB05 was drilled to a depth of 40 metres but has since silted up or collapsed to a depth of around 8.5 metres.

This borehole is currently sampled at a depth of 8.5 mbgl within a sandstone layer.

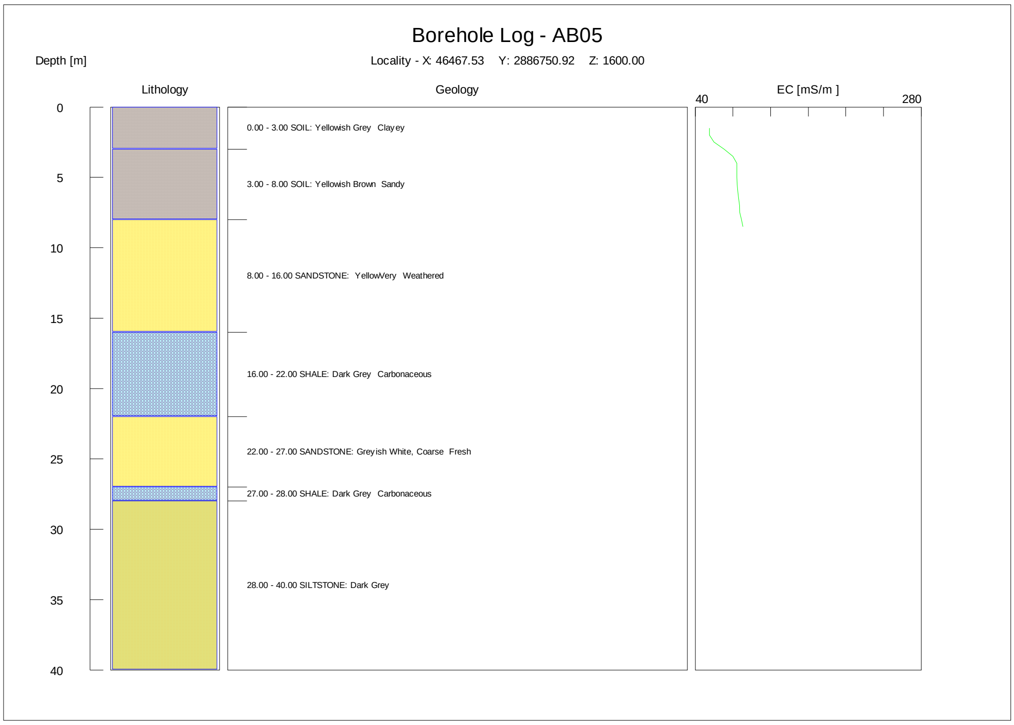


Figure 28. Monitoring borehole AB05.

Monitoring borehole AB07

The EC of the groundwater in borehole AB07 display a gradual increase with depth from 130 mS/m to 138 mS/m.

Since the EC values remain within a very narrow range along the length of the borehole, no clear preferential pathways for groundwater migration and contaminant migration can be identified. This borehole is currently sampled at a depth of 15 mbgl. It is recommended that sampling be continued at this depth.

It should be noted that AB07 was drilled to a depth of 40 metres but has since silted up to a depth of around 37 metres.

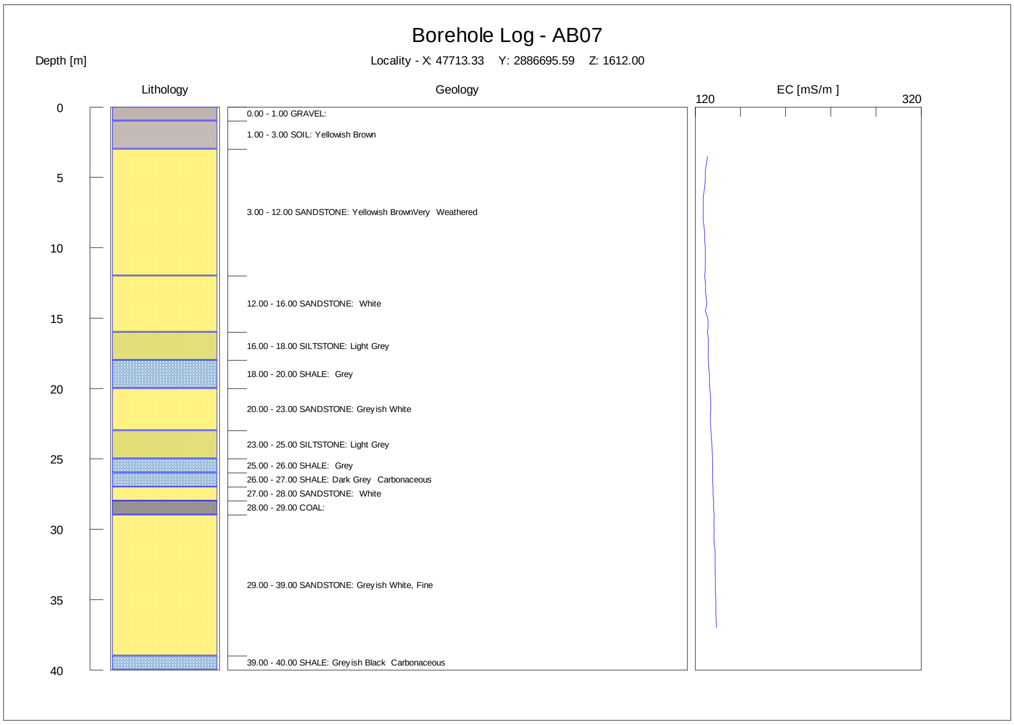


Figure 29. Monitoring borehole AB07.

Monitoring borehole PB08

The EC of the groundwater in borehole PB08 is very constant along the length of the borehole.

This borehole is currently sampled at a depth of 13 mbgl within a sandstone layer. Since the EC values remain within a very narrow range along the length of the borehole and no clear preferential pathways for groundwater migration and contaminant migration can be identified, it is recommended that sampling be continued at this depth.

Borehole PB08 was drilled to a depth of 40 metres but has since silted up to a depth of around 35.5 metres.

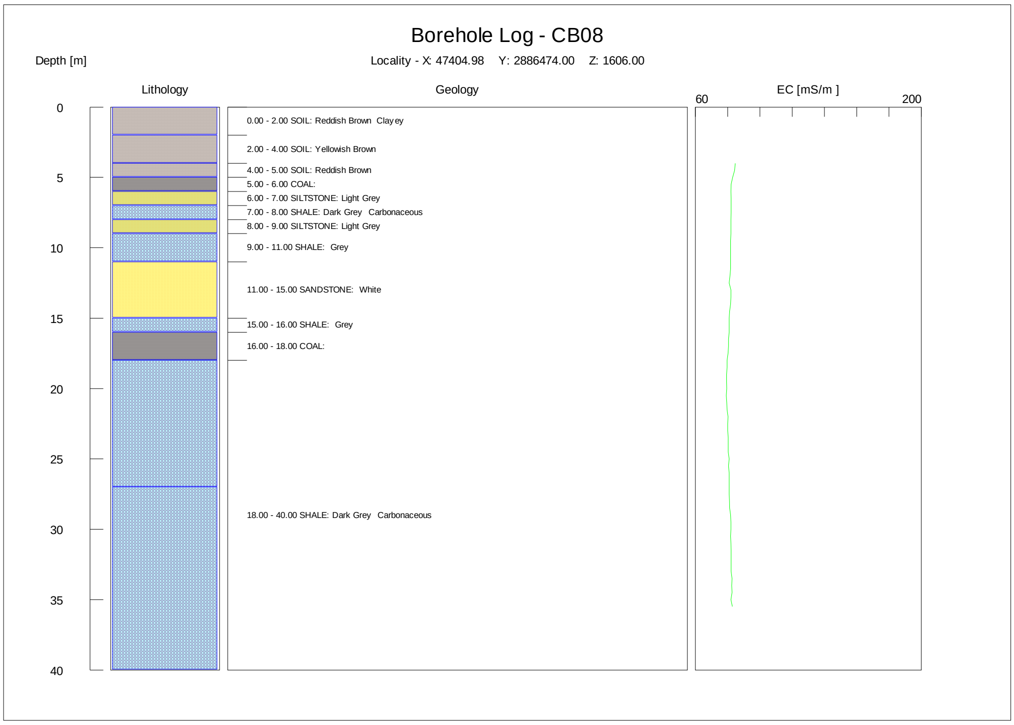


Figure 30. Monitoring borehole PB08.

Monitoring borehole CB09

The EC of the groundwater in borehole CB09 display a gradual increase with depth from 41 mS/m to 55.6 mS/m.

Since the EC values remain within a very narrow range along the length of the borehole, no clear preferential pathways for groundwater migration and contaminant migration can be identified.

This borehole is currently sampled at a depth of 31 mbgl. It is recommended that sampling be continued at this depth.

Borehole CB09 was drilled to a depth of 40 metres but has since silted up to a depth of around 35.5 metres.

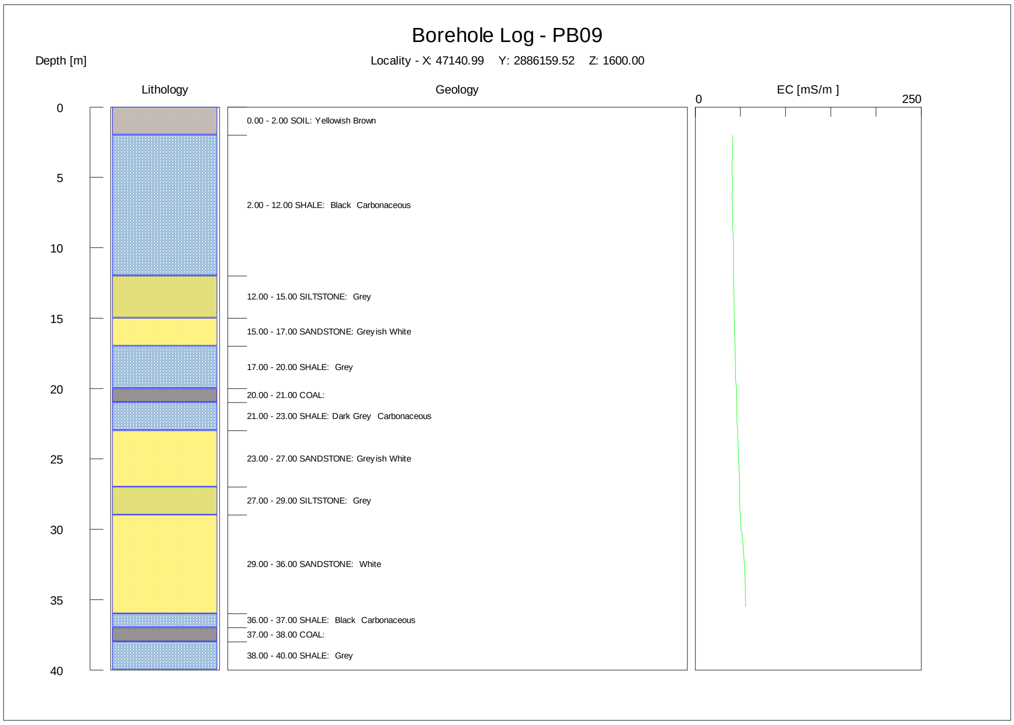


Figure 31. Monitoring borehole CB09.

5.4.1 Discussion

During the latest investigations conducted by GHT Consulting at Komati Power Station, some of the monitoring boreholes of the power station were profiled by means of down-hole electrical conductivity measurements.

During this investigation no preferential pathways were identified in the boreholes along which contaminant transport can take place.

The results of the EC profiling investigations are summarised in Table 19. In Table 19 the drilled and current borehole depths. Also listed are the current and recommended future sampling depths.

Table 19. Results of EC profiling investigations

Borehole #	Drilled depth (m)	Current depth (m)	Current depth of sampling (mbgl)	Recommended depth of sampling (m)
AB01	40	35.5	15	15
AB02	40	32.5	6	6
AB03	40	7.5	19	19
AB04	40	38	8.5	8.5
AB05	40	8.5	20	20
AB07	40	37	15	15
PB08	40	35.5	13	13
CB09	40	36.5	31	31

From Table 19 it can be seen that the current and recommended future sampling depths are identical. It is thus recommended that the boreholes be sampled at the same levels as done in the past.

It is also clear from the data presented in Table 19 that some of the boreholes have been subject to severe silting or have collapsed. Decreased borehole depth is evident at all the boreholes. These boreholes can, however, still serve as monitoring boreholes and it is not deemed necessary to replace them at present.

6 NUMERICAL POLLUTION PLUME MODEL

6.1.1 Groundwater Numerical Model

A groundwater numerical model was also constructed on the limited data currently available. In order to develop a Comprehensive Groundwater Model (CGM), field data is commonly inputted into a predictive model to allow simulations to be developed for given field conditions, the outcomes of this simulations used as a guide during the decision making process. The reliability of these models and consequent understanding of site hydrological behaviour is, however, influenced by the quality and quantity of data available for consideration. Thus, in an ideal case, data should be available for all variations in site conditions, be they geological, chemical, hydrological, or physical. In reality, though, it is either not possible, or cost-effective, to account for all possible variations, particularly where there has been a significant disruption to the natural environment from human activities on a large scale.

Firstly a Conceptual Model was constructed using historical data as well as data gathered during this investigation. The following shortcomings and data gaps were identified during the construction of the conceptual model:

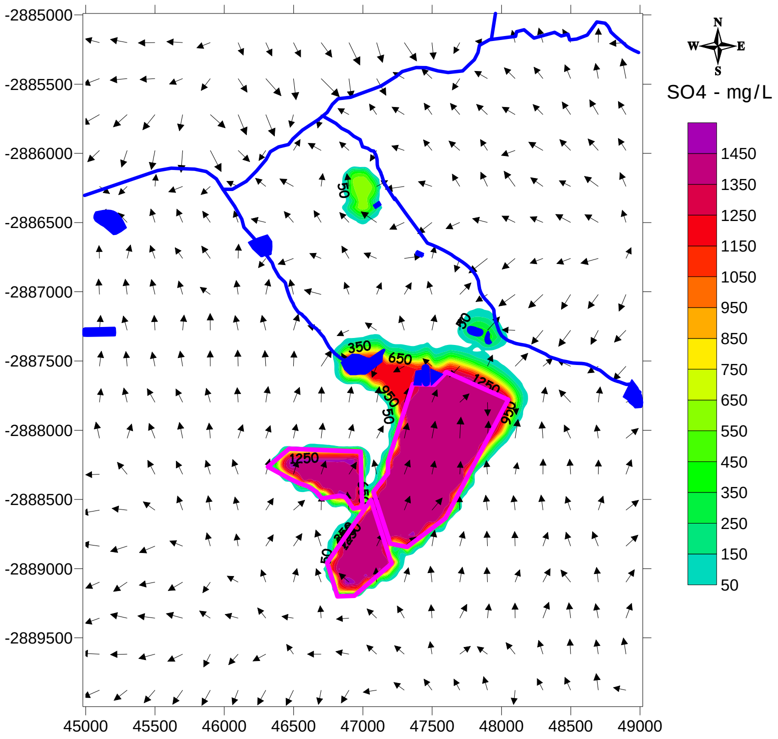
- Geology, permeabilities and yields from nine boreholes is not enough to construct a representative concept of the area under investigation.
- No historical water level data exist for any boreholes of the area under investigation. Although sufficient chemical data exist for the monitoring boreholes no water levels were recorded in the past. Water levels are more important in the construction of conceptual and numerical models than chemical data. Water levels determined the hydraulic gradient and therefore the flow and spreading of contaminants. Water levels are also used to calibrate and test the integrity of numerical models over time.
- During the drilling of the current monitoring boreholes only certain parameters were recorded and/or entered into the data base.

After the construction of the conceptual model a VISUAL MODFLOW numerical model was developed relevant to the aquifer systems at the site and surrounding areas. The groundwater modelling code accommodate the interaction between the two aquifers underlying the site, rainfall recharge and the groundwater influx into surface water systems and pollution sources. Given that model calibration will be done with historical data and during future monitoring phases, MODFLOW, which was developed by the United States Geological Survey, will be used for the modelling exercise.

VISUAL MODFLOW considers 3 dimensional flows for the aquifer system and calibration during future exercises could transfer the current model into fully 3 dimensional simulations.

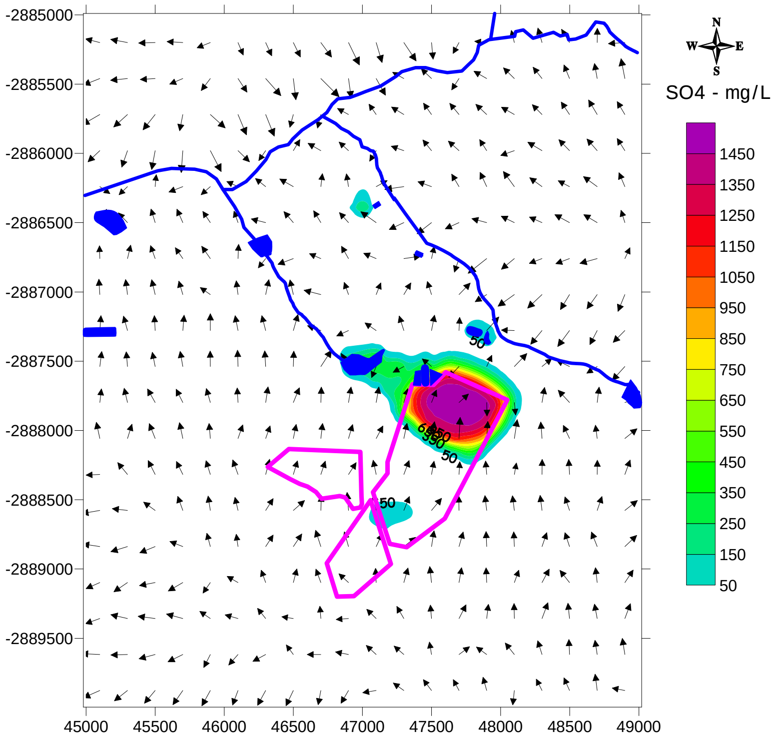
Top Layer Soil & Ash Dump - SO4 Cocentrations

Year 2008



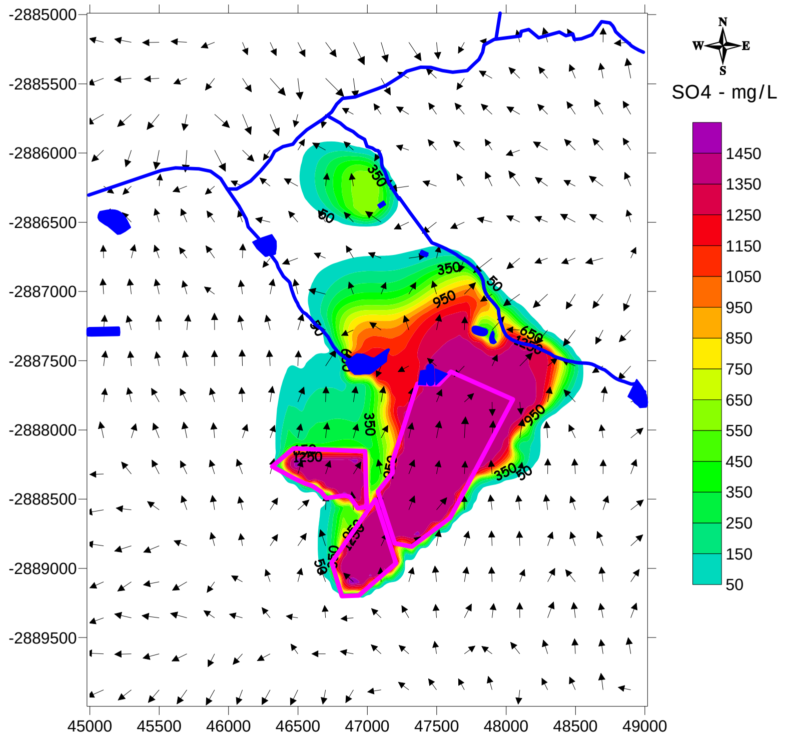
Second Layer Underlying Geology - SO4 Cocentrations

Year 2008



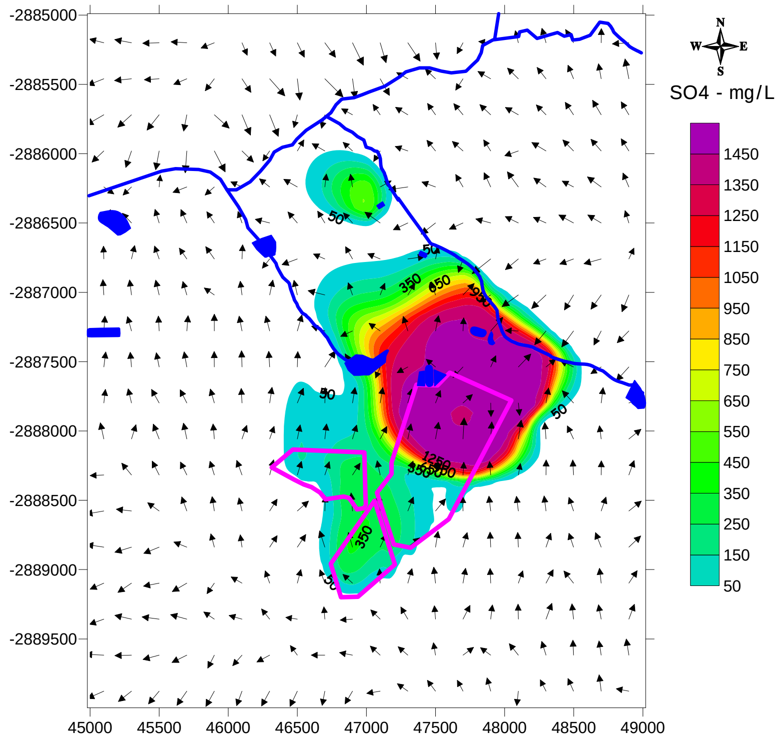
Top Layer Soil & Ash Dump - SO4 Cocentrations

Year 2033

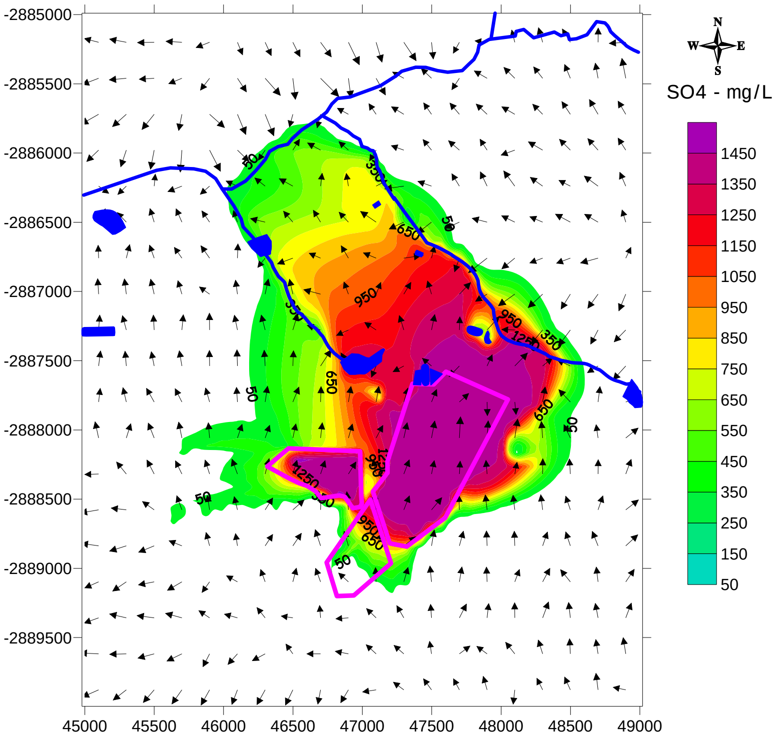


Second Layer Underlying Geology - SO4 Cocentrations

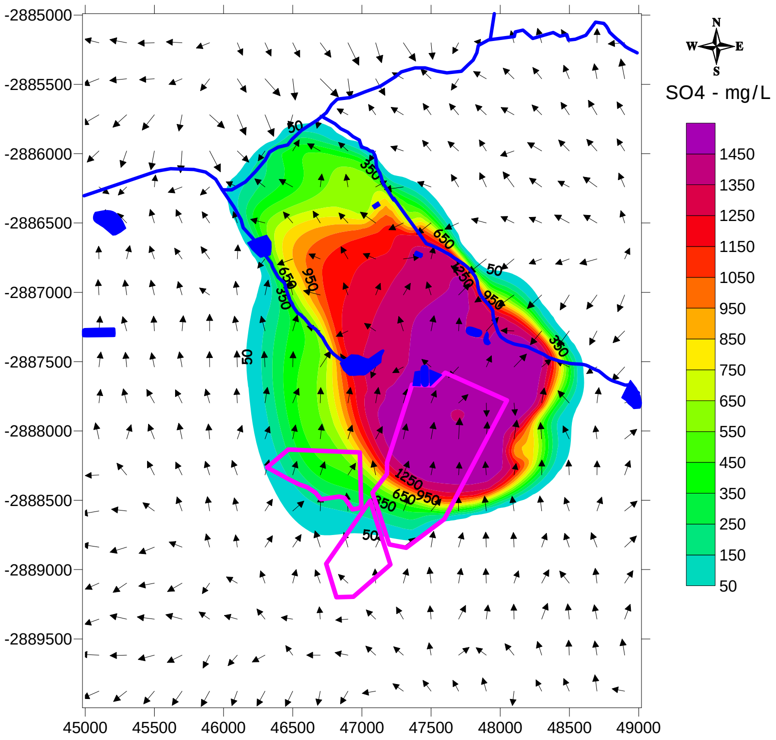
Year 2033



Top Layer Soil & Ash Dump - SO4 Cocentrations
Year 2108



Second Layer Underlying Geology - SO4 Cocentrations
Year 2108



7 CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes findings made during the baseline study undertaken at Eskom Komati Power Station by GHT Consulting Scientists in December 2008. The following conclusions are made on the basis of site observations, monitoring measurements and analyses of laboratory test results as supplied by Komati Power Station:

7.1 Current state and description

The information supplied in the current state and description in the preceding sections is summarised in this section. Additional comments are made about identified problems.

General

- The overall condition of the monitoring boreholes is very good, with a concrete plinth and a well protected frame around the borehole. However, the protected frame around borehole AB06 (monitoring borehole north of old ash dam) needs to be repaired. There is also no cap or locking mechanisms in place at all the boreholes to prevent someone from tampering with the boreholes, or marker posts to be able to easily locate the boreholes.

Ashing Area and Domestic Waste Site

- Sources of contaminants include the ash dam and return water canals and pipelines.
- Seepage problems are evident towards the west of the ash dam.
- Monitoring of surface runoff is inadequate.
- Groundwater monitoring towards the east and north-eastern side of the ash dam is inadequate.
- Various new trenches, canals and pollution control dams are currently been constructed in and around the ashing area.

Power Station Area and Coal Stockyard

- Sources of contaminants include the fuel depot, the oil skimmers and storage area, the power Station outlets and the station drain dams.
- Hydrocarbon pollution of groundwater from the oil skimmers might be inadequate.
- Monitoring of groundwater pollution from the fuel depot is inadequate.
- Monitoring of surface runoff is inadequate.
- Maintenance work is done in the vicinity of PC06. Maintenance work must be finished and the area must be rehabilitated.
- The coal settling ponds must be cleaned and coal and rubbish must be removed.
- The oil skimmers are currently in the process of building. Skimmers are not yet operational. Oils skimmers must be brought up to standard and in a working condition.
- The new CP06 (coal stockyard dam at north-western corner of Power Station) is currently in a satisfactory condition.
- Standing water was detected close to CP06. Water is also seeping from the old part of CP06. This area must be inspected and monitored on a regular basis.
- Old coal settling pond must be cleaned.
- The oil containers are left to stand on open soil in the contractor’s area. The drums should be put on bunded hard stands or in the oil sump.

Sewage Plant Area

- The area is clean and neat and seems to be operated properly.
- Monitoring bacteriological pollution of the ground- and surface water is inadequate.

Komati Spruit

- A detailed monitoring system which includes all the inadequacies of the system is discussed in detail in Appendix D of this document.

Geluk Spruit

- A detailed monitoring system which includes all the inadequacies of the system is discussed in detail in Appendix D of this document.

7.2 Surface- and Groundwater Quality – Inorganic parameters

Ashing Area and Domestic Waste Site

- Groundwater from this area is classified as marginal to poor and dangerously poor due to high concentrations of Mg, Fe, SO_4 and high EC values indicating detrimental impacts on the groundwater.
- AB01 (monitoring borehole at domestic waste site), AB02 (monitoring borehole east of new ash dams), AB07 (monitoring borehole below seepage recovery dam) and AC02 (north-western side of ash dam) is classified as dangerous due to the concentrations of Mg and SO_4 and is classed as Class 4 water quality totally unsuitable for human use. Acute effects may occur.
- AB05 (monitoring borehole at dam) can be classified as poor due to the concentrations of SO_4.
- AB03 (monitoring borehole east of old ash dams), AC03 (dirty water canal on eastern side of ash dam), AC05 (north of ash dam where road crosses over pipelines) and AP03 can be classified as good water quality.
- The surface water is expected to be contaminated as it is part of the dirty water system and is classified as poor due to high SO_4 and Fe concentrations at the seepage recovery dam **AP03**.
- AP02 (clean water dam where Komati Spruit originates west of ash dam) and AC04 (north-eastern corner of ash dam where road crosses over pipelines) can be classifies as marginal due to the concentrations SO_4.

Power Station and Coal Stockyard Area

The waters from the Power Station and Coal Stockyard area are classified as ideal to good. It can be summarised as follows:

- CP06 (coal stockyard dam at north-western corner of Power Station) can be classified as water with an ideal quality.
- PB08 (monitoring borehole below station drain dams and oil skimmers), CB09 (monitoring borehole at coal stockyard dam) and PC08 (first bridge south of Power Station where road crosses Komati Spruit) can be classified as good water quality.

Sewage Plant Area

- SE01 (sewage PSE outlet) at the sewage plant can be classified as poor due to the concentrations of NO_2.

<u>Komati Spruit Area</u>

- KMR01 (second bridge south of Power Station where road crosses Komati Spruit) can be classified as poor due to the concentrations of SO_4.

<u>Geluk Spruit Area</u>

- The waters from the Geluk Spruit can be classified as ideal to good.

7.3 MMAC Plots and Time Graphs

Interpretation of MMAC plots and time graphs suggests that water quality has deteriorated at a number of sites across Komati Power Station. Water quality deterioration is particularly evident at sites AB01, AB02, AB05 and AB07. These sites have the highest on record concentrations for some of the indicator elements. This observation indicates that ashing facility and power station are still contributing to groundwater contamination.

Variability in some chemical parameter concentrations is observed at most sites. This may reflect the influence of climatic factors on the groundwater quality. During and after heavy rains it is possible that leaching of contaminants into the groundwater may be more pronounced, thereby causing increases in the concentrations of the contaminants. In addition, groundwater level increases during the rainy seasons may cause the water to be exposed to contaminants that would otherwise be too shallow to have a direct impact on the groundwater quality. To obtain more insight in this regard, groundwater level data are required so that these data can be related to the observed chemical parameter concentrations.

Increasing trends in the parameter concentrations show the cumulative effects of contaminant impacts on the surface- and groundwater quality. Water quality degradation over time is especially apparent at sites AB01, AB02, AB05 and AB07.

7.4 EC Profiling

During this investigation no preferential pathways were identified in the boreholes along which contaminant transport can take place. It is recommended that sampling be continued at the depths indicated in Table 19.

The EC profiling investigation showed that some of the boreholes have been subject to severe silting or have collapsed. Decreased borehole depth is evident at all the boreholes. These boreholes can, however, still serve as monitoring boreholes and it is not deemed necessary to replace them at present.

7.5 Recommendations

<u>Ashing Area and Domestic Waste Site</u>

- The seepage towards the west of the ash dam must be contained as it enters the Komati Spruit and eventually ends up in the Koring Spruit towards the north-west of the Power Station.
- A detailed monitoring system which includes all the inadequacies of the system is discussed in detail in Appendix D of this document.

<u>Power Station Area and Coal Stockyard</u>

- An investigation should be launched at the oil skimmers to determine if groundwater monitoring at P**B08** is adequate for hydrocarbon pollution monitoring from the oil skimmers. An additional borehole should be installed if **B08** is found to be inadequate for this purpose.

- A detailed monitoring system which includes all the inadequacies of the system is discussed in detail in Appendix D of this document.

Sewage Plant Area

- A monitoring borehole should be installed to monitor bacteriological contamination of groundwater at this area.
- A detailed monitoring system which includes all the inadequacies of the system is discussed in detail in Appendix D of this document.

Komati Spruit

- Seepage from the ash dam should be intercepted and prevented from entering this spruit.
- A detailed monitoring system which includes all the inadequacies of the system is discussed in detail in Appendix D of this document.

Geluk Spruit

- Provisions should be made to intercept spillages that may arise from leaking pipes at the eastern side of the Power Station in order to prevent it from entering this spruit.
- A detailed monitoring system which includes all the inadequacies of the system is discussed in detail in Appendix D of this document.

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