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Tutuka Power Station

Proposed Continuation of Ash Disposal: Hydrogeological Screening Report

SLR Ref.: 721.23003.00014

Doc. no. 1

October 2012

Lidwala
THE SPECIALIST ENGINEERS

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PROPOSED CONTINUATION OF ASH DISPOSAL: HYDROGEOLOGICAL SCREENING REPORT

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ACRONYMS AND ABBREVIATIONS

Below a list of acronyms and abbreviations used in this report.

Acronyms / Abbreviations	**Definition**
DWA	Department of Water Affairs
GRAI	Groundwater Resource Assessment Phase I Project
GRAII	Groundwater Resource Assessment Phase II Project
L/s	Litres per second
NGDB	National Groundwater Database
WMS	Water Management System

EXECUTIVE SUMMARY

SLR Consulting (South Africa) (Pty) Limited ("SLR") has been commissioned by Lidwala Consulting Engineering ("Lidwala") to conduct a desk-top review of available report(s) and data on the groundwater resources for a Screening Report being completed for an Environmental Impact Assessment for the proposed extension of ash disposal facilities at Eskom's Tutuka Power Station.

The desk-top study has been used to identify, through a risk-based process, areas within an 8km radius of the site that are 'high risk' to groundwater and those that are 'low risk'.

Risk to groundwater has be assessed using a simple risk-based model developed in GIS using available geology, hydrogeology data and proximity to surface water course.

The output of the assessment is a 'groundwater vulnerability plan' which identifies 'preferred' and 'less preferred' areas associated with the possible location of the proposed extension and the risk to groundwater.

PROPOSED CONTINUATION OF ASH DISPOSAL: HYDROGEOLOGICAL SCREENING REPORT

1 INTRODUCTION

SLR Consulting (South Africa) (Pty) Limited ("SLR") has been commissioned by Lidwala Consulting Engineering ("Lidwala") to conduct a desk-top review of available report(s) and data on the groundwater resources for a Screening Report being completed for an Environmental Impact Assessment for the continuation of ash disposal at Eskom's Tutuka Power Station, located approximately 25 km from Standerton, in Mpumalanga Province of South Africa.

1.1 BACKGROUND

Tutuka Power Station is a 3,654 MW installed capacity base load coal fired power station, consisting of 6 units. Ash is generated as a by-product through the combustion of coal from the power station and is currently disposed of by means of 'dry ashing' within the premises of the Tutuka Power Station, on Eskom owned land. In order to continue with operation of the power station, Eskom envisages the continuation of ash disposal at the site. In terms of the National Environmental Management Waste Act (NEMWA), Act no 59 of 2008, this activity requires licencing of such ash disposal facilities which is undertaken through an Environmental Impact Assessment.

It is proposed that the footprint of the existing ash disposal facilities would be extended by 759 Ha so that the ashing requirements of the power station are accommodated for the next 44 years from 2012 to 2055. It is proposed that the new portion of the ash disposal facility will be placed on the South Eastern portion of the Eskom, Tutuka Power Station ash disposal facility site boundary. The new portion of ash disposal facility will continue from the existing ash disposal facility, all on Eskom's land within the originally planned ashing area.

1.2 OBJECTIVES

The main objectives of the Screening Report are to:

- Conceptualise the groundwater regime based on the available geological report(s) and data;
- Identify, through a risk-based process, areas within an 8km radius of the power station that are 'high risk' to groundwater and those that are 'low risk'. Risk to groundwater will be assessed using a simple risk-based model developed in GIS using available data.

In addition the Screening report would allow the preparation of more detailed terms of reference for the EIA study phase.

2 SCOPE LIMITATIONS

This study considers only groundwater in the vicinity of Tutuka Power Station and is based predominantly on available published information about the geology and hydrogeology of the area. A reconnaissance site visit to inspect the area and identify potential receiving environments (e.g. wetlands, water sources) was undertaken by SLR in September 2012; however no groundwater monitoring was undertaken.

Limited groundwater quality data has been provided by the client. It is assumed that the available data is correct in its representation of the groundwater conditions in the area.

3 METHODOLOGY

3.1 SOURCES OF INFORMATION

Limited hydrogeological information was gathered during the reconnaissance site visit undertaken by SLR in September 2012. The following sources of information have been consulted in order to investigate the hydrogeology of the area in the vicinity of the ash disposal facilities:

- 1:500 000 scale hydrogeology map (Johannesburg 2526);
- National Groundwater Database (NGDB);
- Groundwater Harvest Potential Map of South Africa;
- Water Management System (WMS) database;
- Maps published for the Groundwater Resource Assessment Phase I (GRA I) project;
- Groundwater Resource Assessment Phase II (GRA II) project;
- The Department of Water Affairs (DWA) Best Practice Guideline – Water Management for Mine Residue Deposits (DWA, 2008);
- Monitoring reports for the site – GHT Consulting.

3.2 DESCRIPTION OF METHODOLOGIES

The Department of Water Affairs (DWA) Best Practice Guideline – Water Management for Mine Residue Deposits (DWA, 2008) suggests that the groundwater impacts of a mine residue deposit (similar to an ash disposal facility) should be identified before a final site is chosen. Suggested criteria (DWA, 2008) include:

- Impacts on downstream water users;
- Impacts on sensitive or protected areas;
- Impacts on any open-cast or underground workings, shafts or occupied premises; the stability of the underground/excavated workings can be affected by possible seepage and the mass of the mine residue deposits;
- Effects of seepage on dump stability; and/or
- Groundwater quality impacts.

A review of all available information has been undertaken as presented in Section 4 and a basic screening has been undertaken to identify areas that are ‘high’ or ‘low’ risk as described below. The results of which are presented in Section 5.

3.3 CRITERIA USED TO RANK SITES

At this stage of the project there is little site specific data available, therefore the ability to 'rank' sites is limited. As part of this assessment, sites have been ranked based on a basic consideration of groundwater 'vulnerability'. The following criteria have been considered:

- **The proximity to a water course** – depth to groundwater is often assumed to be a subdued reflection of the topography in the absence of other information, and surface water features tend to occupy the lowest-lying areas in the site. Surface water features have therefore been buffered by 250m (conservative). Areas that fall within 250m of a water course are assumed to be 'more vulnerable / high risk';
- **Aquifer classification** (based on hydrogeology map classes) - areas that are underlain by higher-yielding aquifers are assumed to be 'more vulnerable / high risk'; and
- **Geology** – areas that are underlain by Quaternary sediment are assumed to be 'more vulnerable / high risk'.

Those sites that are 'more vulnerable / high risk' have been classified as ***"less preferred"*** at this stage.

4 REGIONAL OVERVIEW

4.1 GEOLOGICAL CHARACTERISTICS

The hydrogeological map for the area suggests the Tutuka Power Station and surrounding area (8km radius) is underlain by rocks of Permian to Jurassic age. More specifically:

- **Permian Ecca Group - Vryheid Formation;**
- **Karoo Supergroup – Karoo Dolerite.**

4.1.1 VRYHEID FORMATION

The Vryheid Formation is made up of various lithofacies arranged in up-ward coarsening cycles which are essentially deltaic in origin. The formation can generally be divided into a lower fluvial dominated deltaic interval, a middle fluvial interval and an upper fluvial-dominated deltaic interval which are associated with 'lower sandstone unit, 'coal zone' and 'upper sandstone unit' (Johnson *et al*, 2006).

In the vicinity of Tutuka the geology is mainly arenaceous sandstone.

4.1.2 KAROO DOLERITE

The area in the vicinity of Tutuka (and on a wider scale) is intruded by a network of dykes, sills and discordant sheets that are well developed in the sedimentary sequences (Johnson *et al*, 2006).

The intrusions predominately consist of ultramafic / mafic rocks consisting of dolerite, diabase, gabbro, norite, carbonatite, anorthosite and pyroxenite.

4.2 AQUIFER CHARACTERISTICS

The Department of Water Affairs (DWA) have produced a series of 1:500 000 scale hydrogeology maps (General Hydrogeology Map Series), that cover the whole of South Africa. Analysis of median borehole yields and aquifer types has allowed DWA to classify the aquifers of the country according to an alphanumeric code incorporating aquifer type and borehole yield, as presented in Table 4-1 below.

TABLE 4-1 GENERAL HYDROGEOLOGY MAP CLASSIFICATION OF SOUTH AFRICA

Aquifer Type	Borehole Yield Class (L/s)				
	Class "1" 0 - 0.1	Class "2" 0.1 - 0.5	Class "3" 0.5 - 2.0	Class "4" 2.0 - 5.0	Class "5" >5.0
Type "a": Inter-granular	A1	A2	A3	A4	A5
Type "b": Fractured	B1	B2	B3	B4	B5
Type "c": Karst	C1	C2	C3	C4	C5
Type "d": Inter-granular and fractured	D1	D2	D3	D4	D5

The DWA 1:500 000 scale hydrogeology map of the area (Sheet 2526 Johannesburg) shows that the area within an 8 km radius of the Tutuka site is entirely classified as "D2", suggesting the underlying aquifer is inter-granular and fractured and the average borehole yield is reasonably low ranging between 0.1 and 0.5 litres per second (L/s). There are no major groundwater abstractions shown on the hydrogeological map within 8km of the site.

An extract of the hydrogeological map is presented in Figure 4.1.

4.3 QUATERNARY CATCHMENT AREA

The area within an 8km radius of the Tutuka site is located in quaternary catchment C11K (GRA2), within the Upper Vaal Water Management Area. The GRA2 data for the quaternary catchment C11K is summarized in Table 4.2 below.

TABLE 4.2: SUMMARY OF THE GRA2 DATA

QUATERNARY CATCHMENT	C11K
Area (km^2)	340
Average water level (meters below ground level)	7.61
Volume of water in aquifer storage (Mm^3/km^2)	258.96
Specific Yield	0.003
Harvest Potential (Mm^3/a)	7.41
Contribution to river base flow (Mm^3/a)	1.82
Utilizable groundwater exploitation potential in a wet season (Mm^3/a)	2.44
Utilizable groundwater exploitation potential in a dry season (Mm^3/a)	1.58

The Groundwater Harvest Potential Map of South Africa (Baron et al, 1998) classifies the study area as having an estimated groundwater harvest potential of 15 000 to 25 000 m^3/km^2/year (i.e. relatively low). It also suggests that the average borehole yield is > 0.4 litres per second (L/s), and the total dissolved solids concentration of the (unpolluted) groundwater is between 200 and 300 mg/l (i.e. relatively fresh).

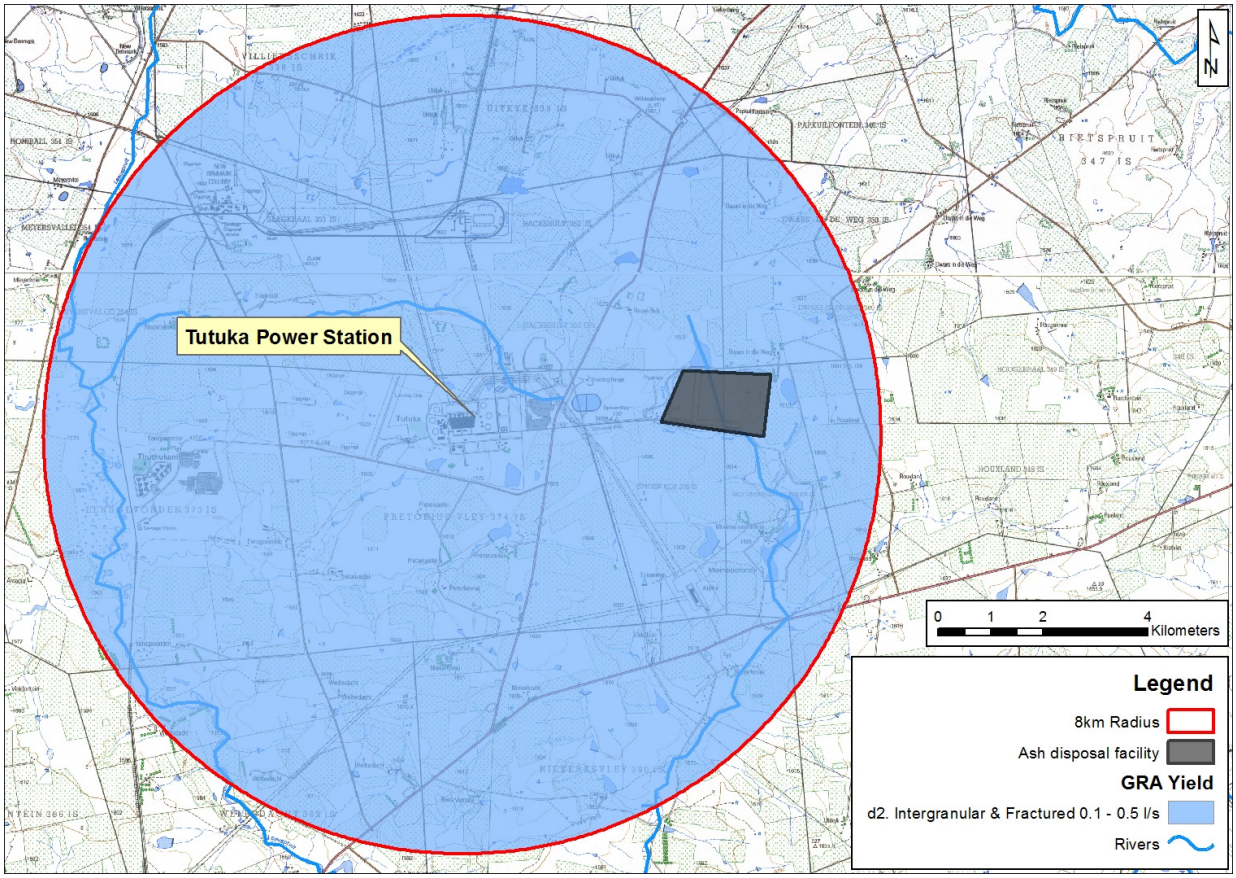

FIGURE 4.1: EXTRACT OF THE HYDROGEOLOGICAL MAP FOR THE AREA IN THE VICINITY OF TUTUKA POWER STATION

5 SITE SPECIFIC RESULTS

5.1 GEOLOGICAL CHARACTERISTICS

No site specific geological information was made available for this review, i.e. borehole logs.

Quaternary deposits are shown on the 1:250 000 geology map published by the Council for Geoscience within an 8 km radius of Tutuka Power Station, predominately associated with the Leeuspruit River which flows to the west of the power Station.

5.2 GROUNDWATER LEVELS AND FLOW

Routine monitoring reports completed by GHT Consulting were provided to SLR as part of this review and discuss groundwater levels in the vicinity of the Power Station. The groundwater monitoring network at Tutuka is divided into specific areas according to their location relative to the infrastructure. Four different monitoring areas are identified at the Power station in relation to groundwater monitoring:

- Ashing Area;
- Power Station Area;
- Domestic Waste Area; and
- Coal Stockyard Area.

The most recent report made available as part of this study (36th routine monitoring investigations) details measurement collected on 11th and 12th April 2011. Results are compared to data collected since 1993 and trends observed as presented in the GHT report are summarized below.

5.2.1 ASHING AREA

- Water levels recorded in boreholes located in or on the ash stack during the April 2011 monitoring round range between 11.63mbgl (AMB25S) and 28.25mbgl (AMB24D). Long term trends show water levels are stable in all boreholes;
- Water levels recorded in boreholes located within 100m of the ash stack during the April 2011 monitoring round range between 1.12mbgl (AMB90A) and 12.67mbgl (AMB31). Long term records show stable and decreasing trends with seasonal fluctuations in the majority of these boreholes;
- Water levels recorded in boreholes located more than 100m away from the ash stack during the April 2011 monitoring round range between 0.5mbgl (AMB63) and 2.8mbgl (AMB6D). Boreholes AMB02 and AMB77S are both artesian. Mostly stable long-term trends are observed in these boreholes, although some seasonal fluctuations are observed.

5.2.2 POWER STATION AREA

- Water levels recorded in boreholes located in the Power Station Area during the April 2011 monitoring round range between 0.5mbgl (PMB06) and 6.15mbgl (PMB76);
- Seasonal variations are generally observed in most of the boreholes of the Power Station Area with decreasing long-term trends;
- Activities at the power station do not seem to affect the groundwater levels (except at PMB75), although some of the fluctuations observed in boreholes located close to dams could possibly by attributed to water level changes in these dams. The decreasing trend observed at PMB75 is a clear indications that artificial recharge is occurring south of the conveyor.

5.2.3 DOMESTIC WASTE SITE AREA

- Water levels recorded in boreholes located in the Domestic Waste Site Area during the April 2011 monitoring round range between 1.38mbgl (DMB34) and 3.85mbgl (DMB25);
- A relatively stable decreasing long-term trend with some seasonal fluctuation in the groundwater level is observed.

5.2.4 COAL STOCKYARD AREA

- Water levels recorded in boreholes located in Coal Stockyard Area during the April 2011 monitoring round range between 0.19bgl (CMB12) and 6.55mbgl (CMB10);
- Stable water levels with some seasonal fluctuations are generally observed in long term data whihc suggests activities in and around the coal stockyard have minimal influence on the groundwater table.

5.3 GROUNDWATER QUALITY

Routine monitoring reports completed by GHT Consulting were provided to SLR as part of this review which discusses groundwater quality in the vicinity of the Power Station. As previously discussed, the groundwater monitoring network at Tutuka is divided into 4 specific areas according to their location relative to the infrastructure.

The most recent report made available as part of this study (36th routine monitoring investigations) details measurement collected on 11th and 12th April 2011.

Although the concentrations of more than 20 inorganic chemical parameters in the water samples were determined during the chemical analyses, GCT Consultants used only five parameters as indicators of contamination in the monitoring of the pollution potential in this system. These five parameters are: electrical conductivity (EC) and the major ions, sodium (Na), calcium (Ca), chloride (Cl) and sulphate (SO4). Concentrations were compared to the following water quality standards:

- Quality of Domestic Water Supplies Volume 1: Assessment Guide, Second Edition, (1998); and
- South African Water Quality Guidelines – Volume 1 Domestic Use (1993 and 1996).

The results for the April 2011 monitoring round are summarized below.

5.3.1 ASHING AREA

- The groundwater recorded in boreholes on the ash stack show signs of contamination, in particular AMB24A, AMB24D and AMB25S;
- The groundwater recorded in boreholes AMB90 and AMB92, located within 100m of the Ash stack show signs of severe contaminant impacts;
- Data suggest that contaminant migration has occurred away from the ask stack and detrimental impacts on the groundwater quality have resulted primarily towards the west and south-east.

5.3.2 POWER STATION AREA

- The groundwater quality in the Power Station area can be classified as good to marginal quality.

5.3.3 DOMESTIC WASTE SITE AREA

- The groundwater of the Domestic Waste Site Area is generally of an ideal to marginal quality.

5.3.4 COAL STOCKYARD AREA

- The groundwater from most of the borehole sites in the Coal Stockyard Area is of a good quality;
- Elevated concentrations of EC, Ca and SO4 were recorded in borehole CMB32, therefore water quality has been classified as marginal. Elevated sulphate values are possibly due to oxidation processes of the stored coal at the stockyard.

6 RISK ASSESSMENT

The Risk Assessment / Screening Assessment has predominantly been based on published data. The following sections present the potential risk associated to groundwater based on the geology, aquifer characteristics and proximity to surface water courses.

6.1 GEOLOGY

The geological map for the area, as presented in Figure 6.1 shows that the site is underlain predominantly by intrusive Karoo Dolerite and the sandstones of the Vryheid Formation.

The Karoo dolerite is likely to exhibit low primary porosity and permeability which would suggest a low risk to groundwater; however the dolerite is likely to exhibit fractures and fissures, with higher permeabilities often associated with the contact between an intrusion and the host rock. These features could increase the risk to groundwater.

Quaternary deposits are present in areas within 8 km of the power station (yellow on Figure 6.1 and Figure 6.2) and are associated with the main water courses. Due to the assumed higher permeability of such deposits, these areas are considered to be 'higher risk' and 'less preferable'.

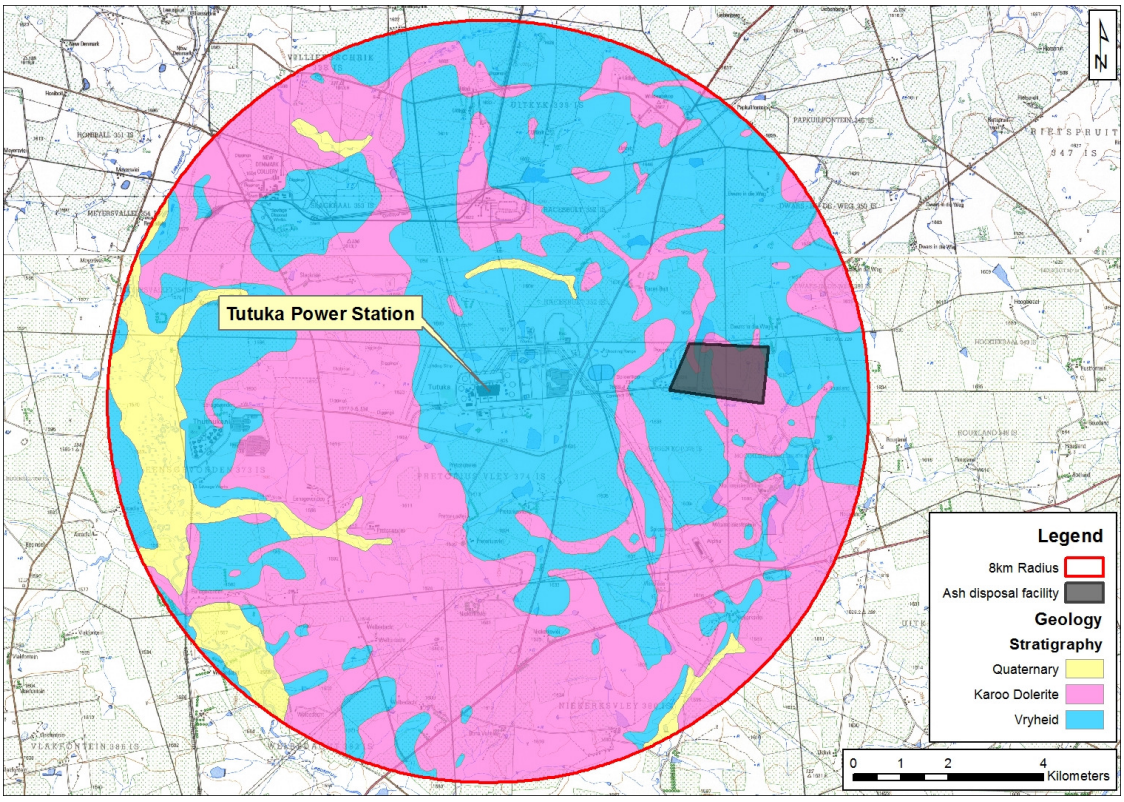

FIGURE 6.1: PLAN ILLUSTRATING THE UNDERLYING GEOLOGY WITHIN AN 8KM RADIUS OF THE TUTUKA POWER STATION

6.2 AQUIFER CHARACTERISTICS

The Hydrogeological Map for the area suggests the entire 8 km area is underlain by a 'd2' type aquifer which is an inter-granular and fractured aquifer with borehole yields in the range of 0.1 to 0.5L/s.

Fractures within the underlying geology can increase the vulnerability to the aquifer as they act as significant pathways for contaminants to travel. However anticipated borehole yields are reasonably low and the porosity and / or permeability of the aquifer (i.e. the ability to transport contaminants) may be low. Figure 6.3 below presents a plan illustrating the aquifer classification.

6.3 PROXIMITY TO SURFACE WATER COURSES

Perennial and ephemeral surface water courses derived from the 1:50 000 topography maps were buffered by 250 m using ARC-GIS software since these zones were assumed to have shallower (and therefore more vulnerable) groundwater. In some cases it is possible that shallow groundwater is in hydraulic continuity with surface water features. Figure 6.3 presents a plan illustrating the location of all surface water courses within an 8 km radius of the power station with the 250 m buffer zones. It also shows how the Quaternary sediment is associated with the water courses.

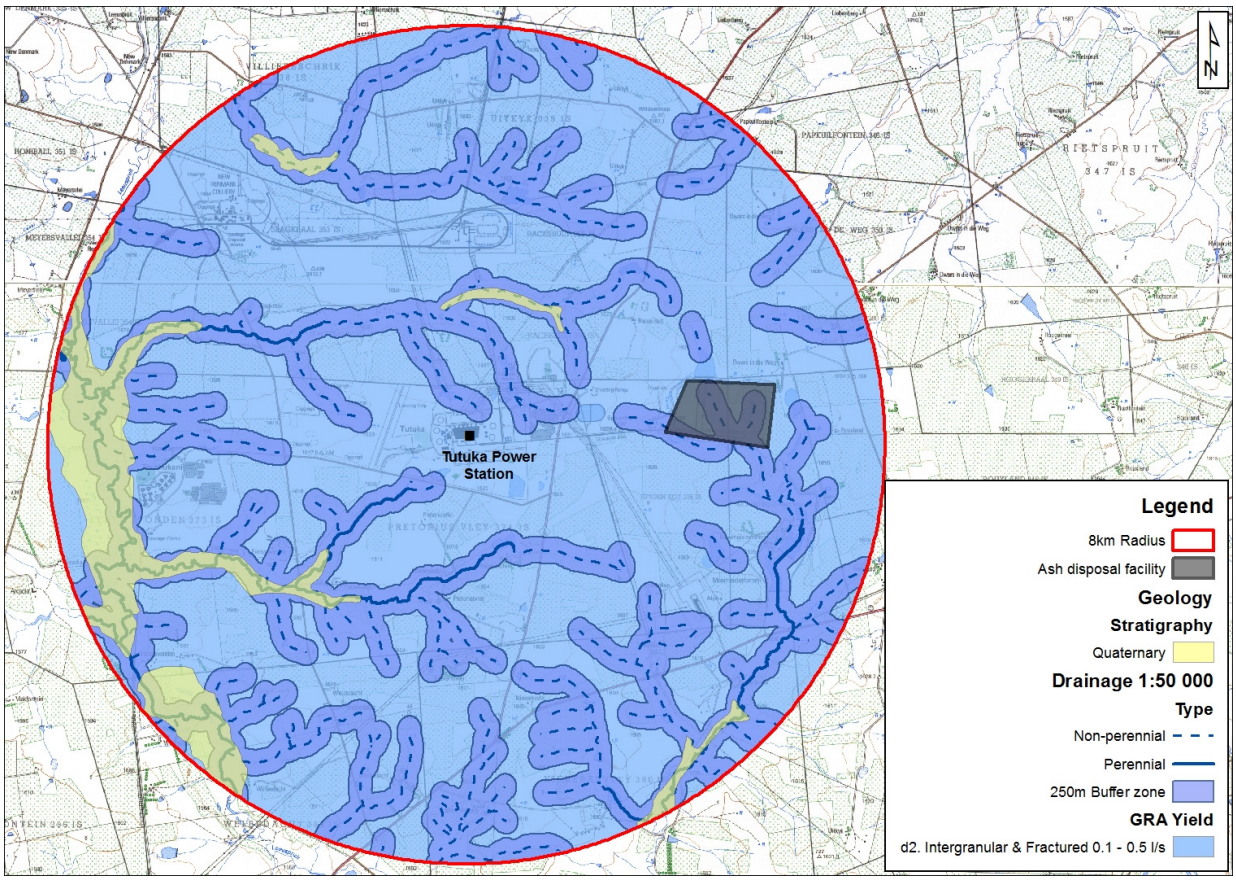

FIGURE 6.2: PLAN ILLUSTRATING THE AQUIFER CLASSIFICATION, SURFACE WATER COURSES AND QUATERNARY GEOLOGY WITHIN AN 8KM RADIUS OF THE TUTUKA POWER STATION

6.4 SUMMARY

An area within an 8 km radius of the Tutuka power station was assessed in terms of the potential risk to groundwater from the proposed continuation of ash disposal at Tutuka Power Station.

It is noted that this assessment has been based on limited data and a simple system based on the geology, hydrogeology map classification and buffer zones around surface water courses has been used to provide a preliminary classification into “less preferred” and “preferred” areas. The outcome of the assessment is presented in Figure 6.3.

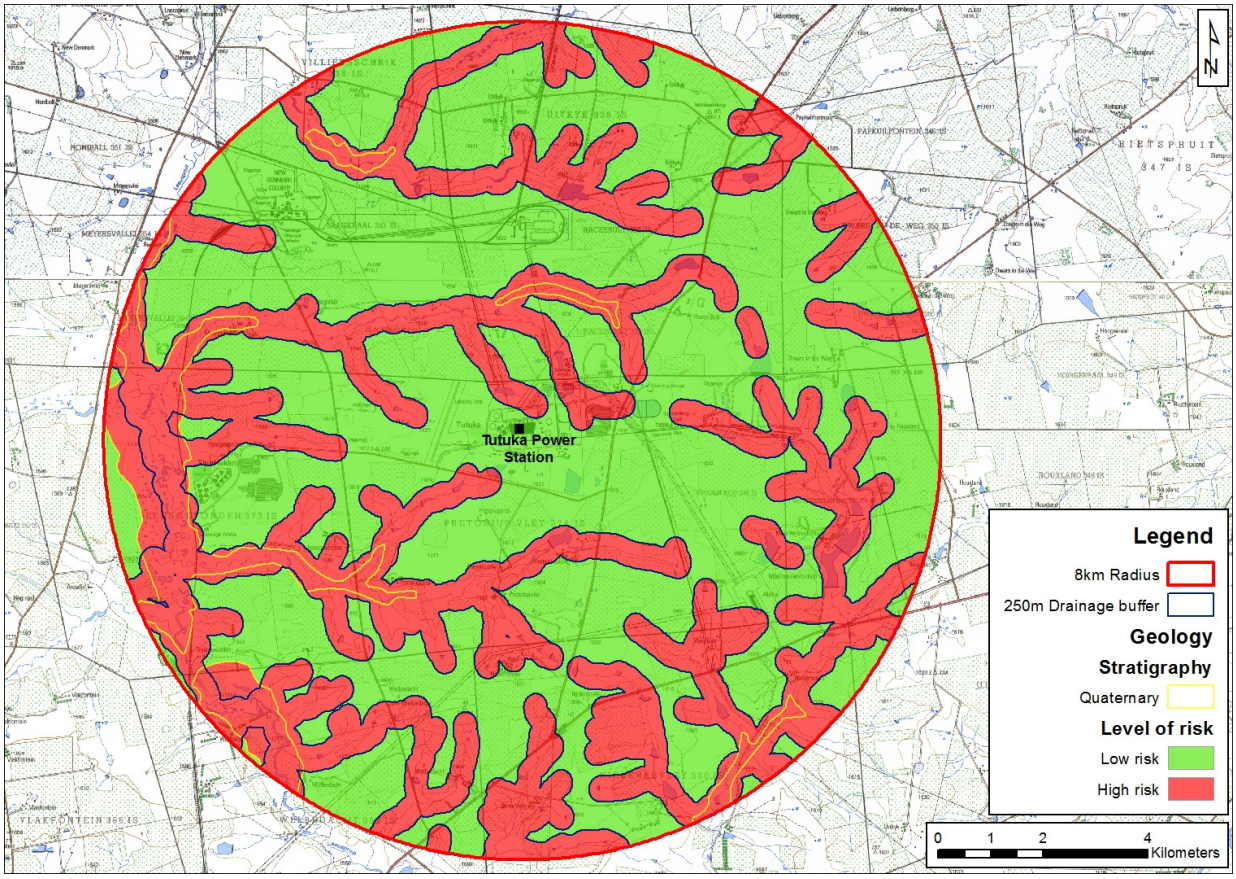

FIGURE 6.3: PLAN IDENTIFYING LESS PREFERRED AND PREFERRED AREAS FOR THE PROPOSED EXTENSION TO THE ASH DISPOSAL FACILITIES AT TUTUKA POWER STATION

7 CONCLUSION

SLR Consulting (South Africa) (Pty) Limited ("SLR") has been commission by Lidwala Consulting Engineering ("Lidwala") to conduct a desk-top review of available report(s) and data on the groundwater resources for a Screening Report being completed for an Environmental Impact Assessment for the proposed extension of ash disposal facilities at Eskom's Tutuka Power Station.

Based on the data review and a basic consideration of groundwater vulnerability (assessment of proximity to surface water courses, geology and aquifer classifications), a distinction between areas of 'low' and 'high' risk have been identified. Those areas identified as 'low risk' are considered a 'preferred' area for the location of the proposed extension of the ash dump.

In order to better assess the risk to groundwater, it is recommended that further site specific work, including a field investigation, be undertaken. This work is scheduled to take place as part of the EIA investigation.

7.1 TERM OF REFERENCE FOR ENVIRONMENTAL IMPACT ASSESSMENT

7.1.1 OBJECTIVES OF THE EIA

- Document baseline groundwater conditions of the study area;
- Assess in detail the impacts on the groundwater environment that would result from the project;

7.1.2 INFORMATION REQUIRED

Further site specific data would be required to enable a comprehensive conceptual site model (CSM) to be developed and to ensure the objectives of the EIA are met. The information required would include:

- Up-to-date groundwater elevations data;
- Current groundwater quality data;

A site visit would therefore be undertaken by SLR personnel to collect appropriate data; groundwater levels and samples from accessible boreholes and submitted to an accredited laboratory for for major and minor ion analysis. The site visit would also allow for a visual inspection of the area for any hydrogeological important features.

8 REFERENCES

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9 CLOSURE

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