Appendix E – Groundwater Report submitted with the Motivation Report and Application for Exemption Amendment

Leopard Court Building, 1st Floor, South Wing
56 Jerome Street, Lynnwood Glen, Pretoria, South Africa
Tel: +27 (0) 12 348 1114 **Fax:** +27 (0) 12 348 1180 **Web:** www.gcs-sa.biz

Tutuka Power Station Ash Disposal Facility – Hydrogeological Assessment

Final Report

Version - 1

29 July 2019

Eskom Holdings SOC Ltd

GCS Project Number: 19-0217

Client Reference: GCS

Final Report
Version - 1

29 July 2019

Eskom Holdings SOC Ltd

19-0217

DOCUMENT ISSUE STATUS

Report Issue	Final Version - 1		
GCS Reference Number	GCS Ref - 19-0217		
Client Reference	GCS		
Title	Tutuka Power Station Ash Disposal Facility – Hydrogeological Assessment		
	Name	**Signature**	**Date**
Author	Raymond Minnaar		29 July 2019
Document Reviewer	Alkie Marais		29 July 2019
Director	Alkie Marais		29 July 2019

CONTENTS PAGE

List of Figures

LIST OF TABLES

LIST OF APPENDICES

1 INTRODUCTION

GCS Water and Environment (Pty) Ltd (GCS) was appointed by Eskom Holdings SOC Ltd to undertake a hydrogeological assessment for the Tutuka Power Station Ash Disposal Facility required for the extension of the exemption granted by the Department of Environmental Affairs (DEA) for the continuous Ash Disposal Facility (ADF), located north of Standerton, in the Mpumalanga Province of South Africa.

1.1 Background

Tutuka Power Station applied for an environmental authorisation for the continuous Ash Disposal Facility (ADF), which was approved by the Department of Environmental Affairs (DEA) on 19 October 2015. Subsequent to this, the station applied for a 4-year exemption from installing the required liner (a Class-C liner) on an immediate ashing area since the approval. The equivalent footprint for the 4-year exemption was estimated to be 54ha, and was assessed and motivated by an independent environmental consultant. The DEA granted the 4-year exemption on 5 May 2016. The exemption period lapses on 4 May 2020 (4 years after the date of issue). Parallel to ashing on the area under the exemption, developmental work was executed for the Class C liner for the rest of the ADF, starting at the boundaries of the area under Exemption.

In 2018, the project realised that the 54ha approved under the exemption would not be fully utilised at the end of the 4-year exemption period, and Eskom undertook to evaluate alternatives that could be followed to manage this remaining area. From evaluation process of the alternatives a decision was made to apply for an extension of the exemption period, without extending the area under the exemption. The inability for full utilisation of the area under exemption was triggered by a reduction in the station's Generation Load Factor (GLF), which happened after the exemption was approved. A meeting was held Eskom and the DEA to explain the challenge, and get guidance from the DEA on the most appropriate process to follow for extending the exemption period. Following this engagement a Part 1 amendment application was submitted to the DEA on 7 December 2018.

The DEA responded on 9 January 2019, with a requirement for the project to undertake a Part 2 amendment process; required all specialists that conducted the studies to confirm that the required extension would not have additional impacts on the environment; required a public participation process; and required results of all monitoring programmes that were requested to be developed in the exemption approval.

1.2 Terms of reference

The scope of work required by Eskom Holdings SOC Ltd is the verification of potential impacts determined from previous specialists' studies of the requested extension, developing a report of these investigations, undertaking public participation process, and reflecting on the status of compliance with the conditions of the exemption approval.

Environmental consultants are required to undertake the following:

- Respond to the DEA's requirement, which states, "Confirmation from all specialists that conducted the studies that the proposed amendment will not have additional impacts on the environment." This means the specialist in these respective specialist fields must assess the specialist reports produced during the exemption application, and confirm if their findings will change due to additional time used to ash over the same footprint (54ha) under the exemption approval;
- Provide results of monitoring programmes requested in the exemption approval; and
- Undertake public participation process for a Part 2 amendment process.

2 SCOPE OF WORK

GCS will conduct a desktop study level hydrogeological assessment in order to verify the potential impacts determined from the previous hydrogeological study. The scope of work consisted of the following tasks:

- A review of the previous specialist hydrogeological study;
- Review of available site monitoring and received data (incl. groundwater levels and quality);
- Verify the potential impacts from the ash disposal facility; and
- Recommendation to address identified potential gaps.

2.1 Limitations, assumptions and exclusions

The following limitations, assumptions and exclusions apply based on the scope of work:

- No site visit was conducted by GCS, i.e. no reconnaissance site visit, hydrocensus (incl. groundwater level measurements and quality sampling);
- Limited groundwater monitoring quality results were made available. Only data from July 2015 to December 2016 were made available;
- No intrusive studies were conducted during the GCS study, i.e. no drilling of boreholes;
- No aquifer hydraulic tests were conducted, i.e. no slug tests and pump tests;
- No geochemical assessment was conducted by GCS on the ash material;
- No geochemical or waste classification data from the site were received;

- No groundwater numerical model was compiled for the site by GCS. GCS will only review the previous modelled groundwater impacts made by SLR;
- This assessment does not evaluate the existing groundwater monitoring and management programme at Tutuka Power Station and the ash disposal facility; and
- This assessment does not include the appraisal of modelling results or in-depth review of the model constructed for a separate numerical groundwater model for the site (GHT Consulting Scientists – Ash Stack Pollution Plume Model 2015).

3 METHODOLOGY

3.1 Review of previous hydrogeological study

The previous hydrogeological study was conducted by SLR Consulting (Africa) (Pty) Ltd):

- Tutuka Power Station Proposed Continuous Ash Disposal at Tutuka Power Station: Groundwater Specialist Study – SLR Project No.: 721.23003.00014 – July 2014.

  The objectives of this report were:

  - To develop a hydrogeological conceptual site model (CSM) for Tutuka Power Station and document baseline groundwater conditions of the study area.
  - To assess in detail the impacts on the groundwater resources that may result from the continued ash disposal at Tutuka Power Station, considering construction, operation and decommissioning phases of the project.

- Tutuka Power Station Proposed Continuation of Ash Disposal: Hydrogeological Screening Report – SLR Project Ref.: 721.23003.00014 – October 2012.

  The objectives of this report were:

  - 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.

3.2 Site data review

Data that was reviewed includes:

- Published 1:250 000 scale geological data and map (CGS,1986);
- Published hydrogeological data and map;
- Public domain climatic and topographic data for the site;
- Eskom Holdings (Pty) Ltd: Tutuka Power Station Water Use License (08/C11K/ABCFGI/1016);

- Groundwater monitoring reports:
  - GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 3rd Quarter 2016 (December 2016)
  - GHT Consulting Scientists – Annual Report Phase 52 – Final Report (December 2016)
  - GHT Consulting Scientists – Annual Report Phase 51 – Final Report (July 2016)
  - GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 2nd Quarter 2016 (July 2016)
  - GHT Consulting Scientists – Annual Report Phase 50 – Final Report (March 2016)
  - GHT Consulting Scientists – Farmers' Background Boreholes Annual Report March 2016 (March 2016)
  - GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 1st Quarter 2016 (March 2016)
  - GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 3rd Quarter 2015 Final Report (October 2015)
  - GHT Consulting Scientists – Monitoring Report Phase 48 – Final Report (October 2015)
  - GHT Consulting Scientists – Hazardous Waste Site 1st Quarter 2015 Annual Monitoring Site Assessment Report (July 2015)
  - GHT Consulting Scientists – Monitoring Report Phase 47 – May 2015 Final Report (July 2015)
- Groundwater investigation reports:
  - GHT Consulting Scientists – Drilling report for the installation of monitoring boreholes 2018 (March 2018)
  - GHT Consulting Scientists – Hydrocensus April 2017 (June 2017)
  - GHT Consulting Scientists – Ash Stack Pollution Plume Model 2015 (March 2016)

3.3 Verify potential impacts

The previous hydrogeological studies conducted during the original exemption application will be reviewed together with the site information received (as listed in Section 3.2). Findings will be made to determine if SLR's previously predicted groundwater impacts will change or not due to additional time used to ash over the same footprint (54ha) under the exemption approval area.

4 GENERAL PHYSIOGRAPHICAL AND GEOLOGICAL DESCRIPTION

4.1 Locality

Tutuka Power Station is located approximately 25 km north-east of Standerton, Mpumalanga Province, South Africa. Figure 4.1 illustrates the locality of the Tutuka ash disposal facility and power station.

4.2 Climate

The climate can be described as typical Highveld conditions with moderate and wet summers and cold dry winters. The mean annual precipitation is approximately 580mm/year with rain experienced predominantly in the summer months (October to April) (SLR, 2014).

4.3 Topography and drainage

The area is characterised by a strong undulating topography with low ridges east of the study area. The natural topography however has been disturbed as a result of various agricultural and power generation activities. Topography ranges approximately from a low of 1 613 meters above mean sea level (mamsl) on the southern site boundary, to a high of 1 640 mamsl on the northern site boundary. The topography of the Tutuka site and surrounding area is illustrated in Figure 4.2.

Several streams and rivers are present in the area surrounding the project site, with the Leeuspruit River and the Vaal River being the two main surface water features. The Leeuspruit River is approximately 12 km west of the site and flows south into the Grootdraai Dam. The Vaal River is approximately 12 km south of the site and flows west into the Grootdraai Dam. Local drainage is in a general southerly direction towards the Vaal River. The Grootdraai Dam is located approximately 15 km to the south of the ash disposal facility site.

The project area falls in the C11K quaternary catchment in the Upper Vaal Water Management Area.

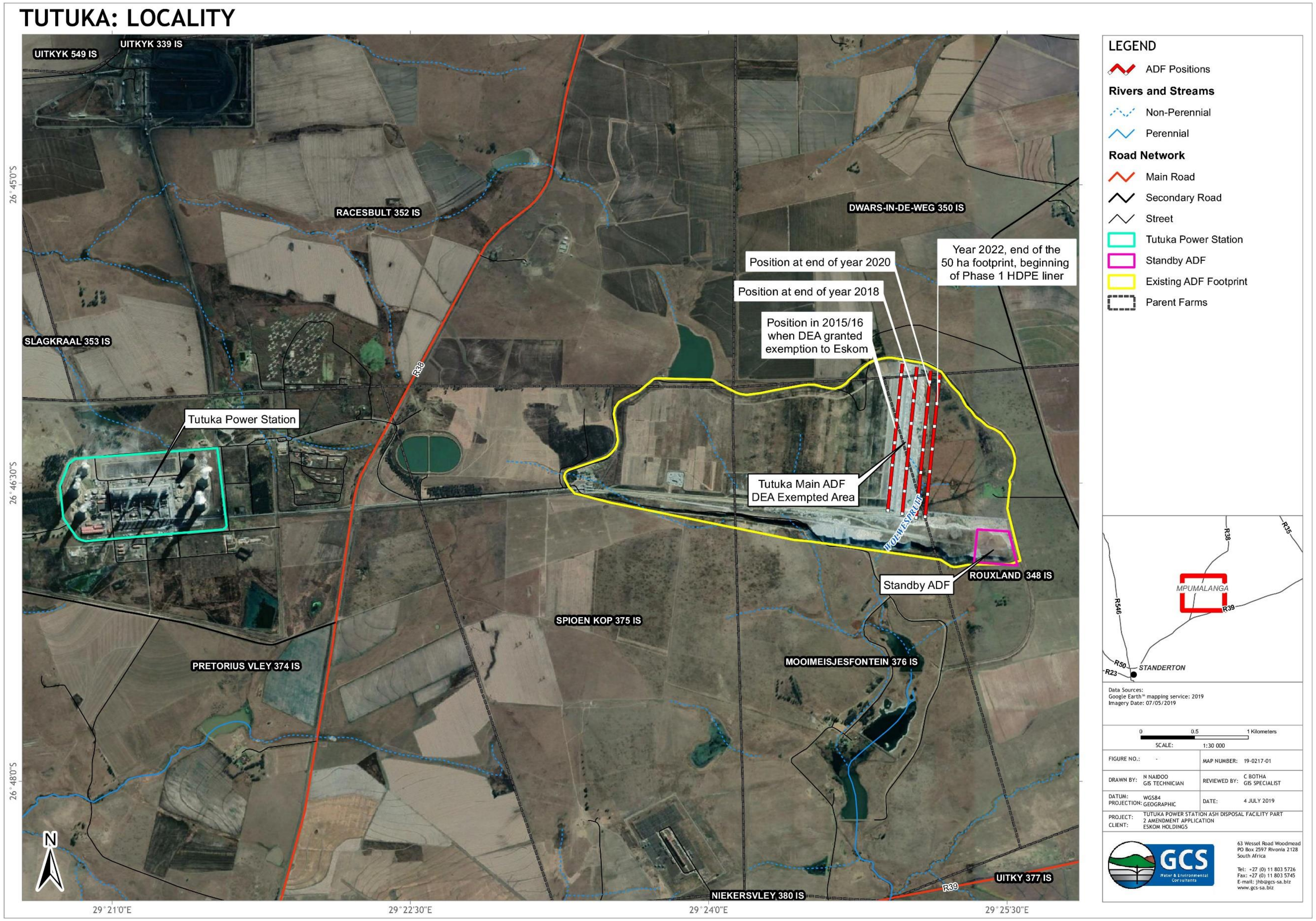


Figure 4.1: Locality of the Tutuka power station and ash disposal facility site.

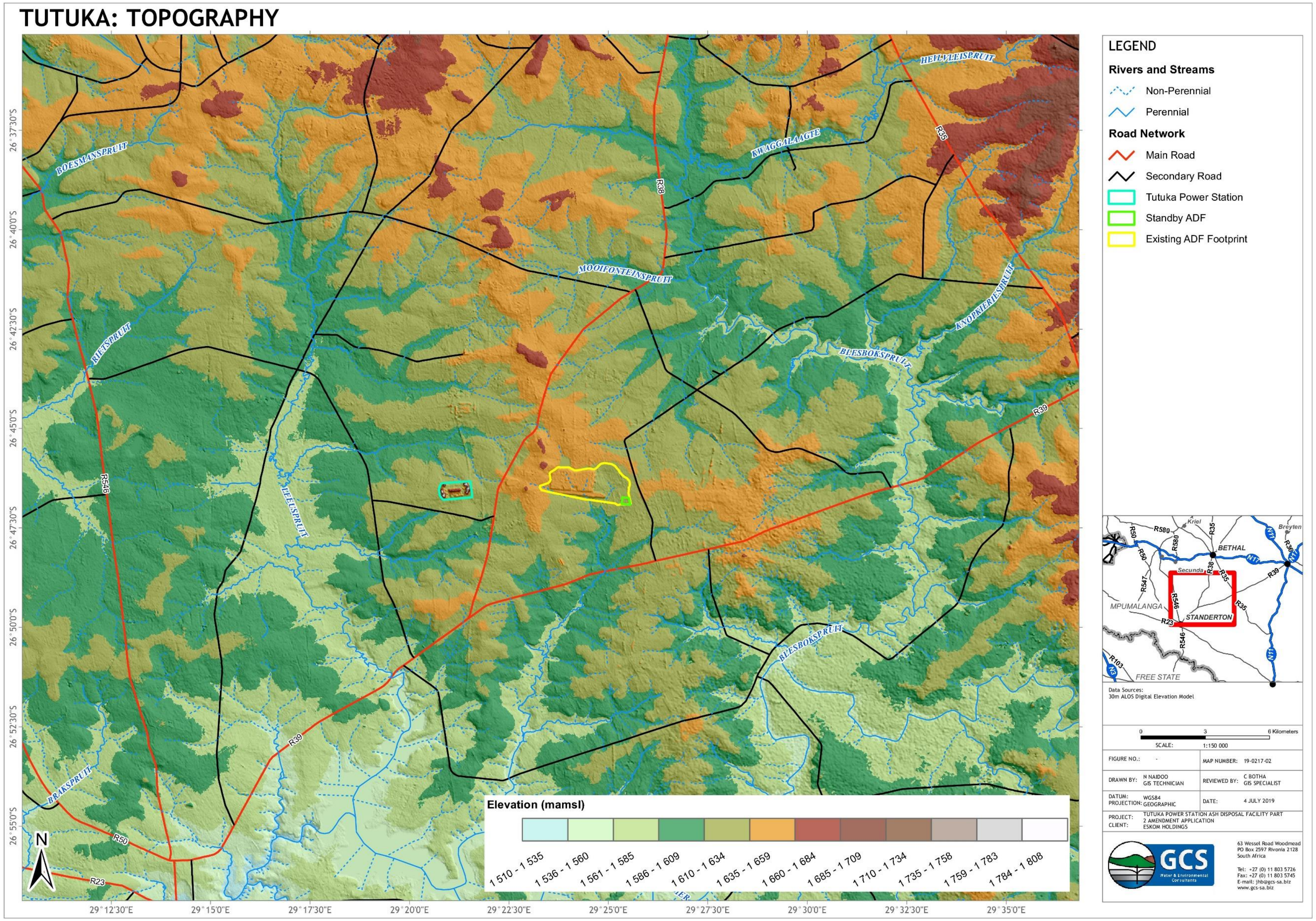


Figure 4.2: **Topography and major rivers/streams of Tutuka site and surrounding area.**

4.4 Geological Setting

The baseline geological information was sourced from previous studies (SLR, 2014) and available literature.

4.4.1 Regional geology

The Tutuka Power Station and the surrounding area are underlain by Karoo Supergroup lithology of Permian to Jurassic age and predominantly consists of the Permian Ecca Group (Vryheid Formation) and dolerite intrusions. All of the known coal deposits in South Africa are hosted in sedimentary rocks of the Karoo Basin, a large foreland basin which developed on the Kaapvaal Craton and filled between the Late Carboniferous and Middle Jurassic periods. The Karoo Supergroup is lithostratigraphically subdivided into the Dwyka, Ecca and Beaufort groups and succeeded by the Molteno, Elliot, Clarens, and Drakensburg formations. The coal ranges in age from early Permian (Ecca Group) through to Late Triassic (Molteno Formation) and is predominantly bituminous to anthracite in rank, which is classified in terms of metamorphism under influence of temperature and pressure.

The coal seams are usually separated by coarse to fine-grained sandstone, siltstone and/or shale at the top. Glauconitic sandstones, indicative of transgressive marine periods, are present above the No.4 and No.5 Seams. The coal zone is overlain by another deltaic sequence, which consists of sandstone and sandy micaceous shale and siltstone with varying thickness (approximately 60 to 100m thick).

The Karoo sediments are practically undisturbed and geological structures (e.g. faults, shears, associated fracturing) are rare. However, fractures are common in rocks such as sandstone and coal. Dolerite intrusions, in the form of sills or dykes cause in some locations various mining problems (i.e. devolatised coal, weakened roof strata and/or displaced coal seams), where near vertical dykes have very little displacement associated transgression through the seam.

Sill transgressions, on the other hand, generally results in displacement of the coal seams and strata. The magnitude of these displacement being dependent on a number of factors, including sill thickness and presence / orientation of pre-existing zones of weakness. These intrusions introduce local structural complexity by displacing seams relative to one another and isolating blocks of coal.

4.4.2 Local geology

As seen in Figure 4.3 the Tutuka site area is underlain by the Vryheid Formation and dolerite intrusions.

The Vryheid Formation is made up of various lithofacies arranged in upward 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’. It was noted that in the vicinity of Tutuka the geology is mainly arenaceous sandstone (SLR, 2014).

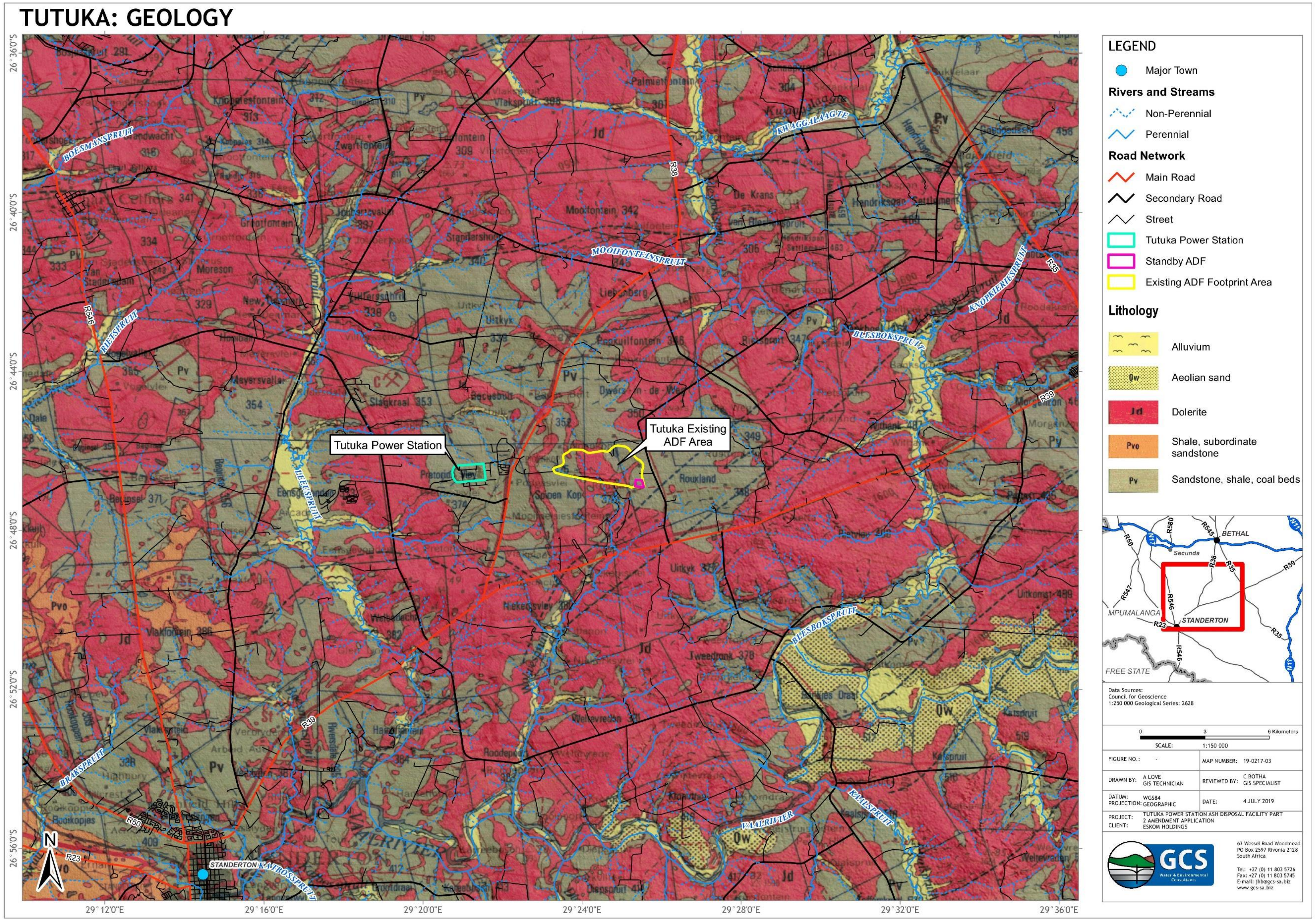


Figure 4.3: Regional geology of Tutuka site and surrounding area.

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. The intrusions predominately consist of ultramafic / mafic rocks consisting of dolerite, diabase, gabbro, norite, carbonatite, anorthosite and pyroxenite (SLR, 2014).

5.2 Groundwater Levels

5.2.1 Previous SLR groundwater study recorded groundwater levels

Routine monitoring reports completed by GHT Consulting were provided to discuss groundwater levels in the vicinity of the Power Station. Results have been compared to data collected since 1993 and trends observed as presented in the GHT Consulting monitoring data that SLR reviewed are summarised below for the 'Wolwe Spruit Drainage System'. Boreholes in this area included those installed within the current ash disposal facility, up-gradient of the current ash disposal facility and down-gradient of the current ash disposal facility. In addition the drainage area includes boreholes located in the vicinity of dirty / clean water dams associated with the ashing area.

The results are summarised below:

- Groundwater levels recorded in boreholes located within the current ash disposal facility during the April 2012 monitoring round range between 6.60mbgl (AMB53) and 28.64mbgl (AMB24D). Long term trends show water levels are stable in the majority of boreholes. Increasing trends are observed in boreholes AMB52 and AMB53.
- Groundwater levels recorded in boreholes down-gradient of the current ash disposal facility during the April 2012 monitoring round range between 1.33mbgl (AMB90A) and 8.85mbgl (AMB55). It is noted that AMB02 is artesian. Long term records show stable trends with seasonal fluctuations in the majority of these boreholes.
- Groundwater levels recorded in boreholes located down-gradient of dirty / clean water dams in the vicinity of the Ashing Area during the April 2012 monitoring round range between 0.76mbgl (AMB63) and 6.13mbgl (AMB21). Borehole AMB77S is artesian. Mostly stable long-term trends are observed in these boreholes, although some seasonal fluctuations are observed.

SLR undertook a hydrocensus of accessible boreholes on the 18th of October 2012. Groundwater levels were measured at eight boreholes. The groundwater levels recorded during the SLR hydrocensus is summarised below in Table 5.1.

Table 5.1: Summary of SLR (2014) groundwater study groundwater levels.

BH ID	Location	Water level (mbgl) SLR Hydrocensus 18 October 2012	Water level (mbgl) GHT Report 2 April 2012
AMB55	100m from current ash disposal facility	8.47	8.85
AMB93	100m from current ash disposal facility	1.89	2.66
AMB67	South of current ash disposal facility	1.98	2.8
AMB64	South of current ash disposal facility	2.11	2.4
AMB25S	In current ash disposal facility	10.69	11.55
AMB25D	In current ash disposal facility	12.19	12.82

5 HYDROGEOLOGICAL SETTING

5.1 General Aquifer Description

Regional hydrogeological data was sourced from the published 1:500 000 Hydrogeological Map Series of the Republic of South Africa – Sheet 2526 (Johannesburg) and previous studies for the site.

The Tutuka site is underlain by Karoo sedimentary rocks and dolerite intrusions (Section 4.4) and the hydrogeological characteristics of the study are a function of the geological formations. The aquifers of the Karoo Supergroup display characteristics of intergranular and fractured rock. The borehole yielding potential of the aquifer is classified as d2, which implies an average borehole yield varying between 0.1 and 0.5 l/s. There are typically six different modes of groundwater occurrence associated with these formations (Barnard, 2000). According to Barnard (2000) the six different modes are:

- Weathered and fractured sedimentary rocks not associated with dolerite intrusions;
- Indurated and jointed sedimentary rocks alongside dykes;
- Narrow weathered and fractured dolerite dykes;
- Basins of weathering in dolerite sills and highly jointed sedimentary rocks enclosed by dolerite;
- Weathered and fractured upper contact-zones of dolerite sills; and
- Weathered and fractured lower contact-zones of dolerite sills.

Barnard (2000) found that the groundwater yield potential is classed as low since 83% of the boreholes on record (at that time) produce less than 2 L/s. The static groundwater level is generally encountered between 5 and 25 mbgl. Numerous springs occur at lithological contacts such as where sandstone overlies an impervious shale horizon, along fault zones and along impermeable dolerite dykes. Groundwater seepage in lower lying areas contributes substantially to sustaining the dry season flow in the stream systems that drain these landscapes.

According to SLR (2014) the aquifer units at the Tutuka site can then be divided into 2 main units:

- A shallow, weathered rock aquifer, referred to as the ‘shallow aquifer’; and
- A deeper, hard rock fractured aquifer, referred as the ‘deeper aquifer’.

Groundwater storage and transport in the unweathered (deeper aquifer) Vryheid Formation and in the Karoo dolerites is likely to be mainly via fractures, bedding planes, joints and other secondary discontinuities. To some extent, increased groundwater storage in the upper weathered zone will provide a resource of groundwater for the underlying fractured aquifer along with relatively thin local accumulations of alluvium. In general the rocks in the study area are together considered to constitute a minor aquifer (SLR, 2014).

BH ID	Location	Water level (mbgl) SLR Hydrocensus 18 October 2012	Water level (mbgl) GHT Report 2 April 2012
AMB24S	In current ash disposal facility	25.42	25.85
AMB24D	In current ash disposal facility	27.14	28.64

Take note that the coordinates of the hydrocensus boreholes were not available.

5.2.2 Groundwater level monitoring

Tutuka monitors several boreholes within and surrounding the site as part of its groundwater monitoring programme. The water level results from July 2015 to December 2016 were made available. No monitoring borehole coordinates were present in the monitoring reports.

The GHT Consulting groundwater level monitoring results for the ash disposal facility monitoring area are summarised below:

GHT Consulting Scientists – Monitoring Report Phase 47 – May 2015 Final Report (July 2015)

Groundwater levels for 27 boreholes varied between artesian conditions and 28.65 mbgl. Artesian conditions were recorded at AMB02 and AMB63 and relatively deep groundwater level was recorded at AMB24D (28.65 mbgl).

GHT Consulting Scientists – Hazardous Waste Site 1st Quarter 2015 Annual Monitoring Site Assessment Report (July 2015)

Groundwater levels for 6 monitoring boreholes for the hazardous waste site varied between 12.09 mbgl and 19.84 mbgl. Relatively shallow water levels were recorded at AMB31 (12.09 mbgl) and relatively deep groundwater level was recorded at AMB54 (19.34 mbgl).

GHT Consulting Scientists – Monitoring Report Phase 48 – Final Report (October 2015)

Groundwater levels for 27 boreholes varied between artesian conditions and 28.84 mbgl. Artesian conditions were recorded at AMB02 and relatively deep groundwater level was recorded at AMB24D (28.84 mbgl).

GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 3rd Quarter 2015 Final Report (October 2015)

Groundwater levels for 6 monitoring boreholes for the hazardous waste site varied between 12.59 mbgl and 19.59 mbgl. Relatively shallow water levels were recorded at AMB31 (12.59 mbgl) and relatively deep groundwater level was recorded at AMB54 (19.59 mbgl).

GHT Consulting Scientists – Farmers' Background Boreholes Annual Report March 2016 (March 2016)

Only two groundwater levels were recorded in this study. The groundwater levels ranged between dry and 7.28 mbgl for boreholes FBB132 and AMB21, respectively.

GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 1st Quarter 2016 (March 2016)

Groundwater levels for 6 monitoring boreholes for the hazardous waste site varied between 12.59 mbgl and 19.59 mbgl. Relatively shallow water levels were recorded at AMB31 (12.59 mbgl) and relatively deep groundwater level was recorded at AMB54 (19.59 mbgl).

GHT Consulting Scientists – Annual Report Phase 50 – Final Report (March 2016)

Groundwater levels for 25 boreholes varied between 0.1 mbgl and 28.97 mbgl. Relatively shallow groundwater level was recorded at AMB02 (0.1 mbgl) and relatively deep groundwater level was recorded at AMB24D (28.84 mbgl).

GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 2nd Quarter 2016 (July 2016)

Groundwater levels for 5 monitoring boreholes for the hazardous waste site varied between 11.36 mbgl and 19.68 mbgl. Relatively shallow water levels were recorded at AMB25 (11.36 mbgl) and relatively deep groundwater level was recorded at AMB54 (19.68 mbgl).

GHT Consulting Scientists – Annual Report Phase 51 – Final Report (July 2016)

Groundwater levels for 25 boreholes varied between 0.1 mbgl and 29.04 mbgl. Relatively shallow groundwater level was recorded at AMB02 (0.1 mbgl) and relatively deep groundwater level was recorded at AMB24D (29.04 mbgl).

GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 3rd Quarter 2016 (December 2016)

Groundwater levels for 6 monitoring boreholes for the hazardous waste site varied between 11.68 mbgl and 19.76 mbgl. Relatively shallow water levels were recorded at AMB25 (11.68 mbgl) and relatively deep groundwater level was recorded at AMB54 (19.76 mbgl).

GHT Consulting Scientists – Annual Report Phase 52 – Final Report (December 2016)

Groundwater levels for 29 boreholes varied between 0.25 mbgl and 28.08 mbgl. Relatively shallow groundwater level was recorded at AMB02 (0.25 mbgl) and relatively deep groundwater level was recorded at AMB24D (28.08 mbgl). A slight rise in water table depth were noted and were determined to be potentially due to historic influences of brine water irrigation or recharge occurring through the top. Although the rise in water levels were extremely slow, it was recommended to further investigate as this could potentially be as a result of the ash disposal facility slowly becoming more saturated.

5.2.3 Other groundwater studies

GHT Consulting Scientists – Ash Stack Pollution Plume Model 2015 (March 2016)

The 'ash stack pollution plume model' study evaluated groundwater levels and stated that the groundwater level within the western part of the ash stack becomes lower as the brine irrigation progressed to the east.

GHT Consulting Scientists also noted that time and progress at which this lowering occurs was not well documented due to the limited number of boreholes in the ash stack. For the same reason, GHT Consulting Scientists stated that the influence of the streams on the natural water table below the ash stack is also not recorded. GHT Consulting Scientists noted from groundwater level monitoring that the water table is at the bottom or below the ash stack and that very little water exists in the ash stack itself where the brine irrigation has stopped.

GHT Consulting Scientists – Hydrocensus April 2017 (June 2017)

During the hydrocensus of 2017 a total number of 33 sites were sampled (29 boreholes/groundwater sites and 4 surface water sites). However, no groundwater levels were measured.

GHT Consulting Scientists – Drilling report for the installation of monitoring boreholes 2018 (March 2018)

The drilling report for ten additional monitoring boreholes did not include any water level measurements recorded after drilling.

5.2.4 Conclusions

Based on the results from the previous SLR groundwater study and historic on-site monitoring the following can be concluded related to groundwater levels:

- Monitoring data indicated groundwater levels that varied between artesian conditions and 29.04 mbgl;
- The artesian conditions and shallow groundwater levels were recorded in borehole AMB02, located approximately 800 metres south of the existing ash disposal facility;
- The relatively deep groundwater levels recorded was measured in borehole AMB24D, which is located within the current ash disposal facility. The shallow borehole pair AMB24S also had relatively deep groundwater level measurements of approximately ~26 mbgl;
- There were no indication of the final monitoring borehole depths, especially where dry boreholes were mentioned in the monitoring reports;
- The majority of the water levels measured during monitoring were less than 20 meters below surface.

- A slight rise in water table depth were noted by GHT Consulting Scientists and were determined to be potentially due to historic influences of brine water irrigation or recharge occurring through the top (dust suppression). Although the rise in water levels were extremely slow, it was recommended to further investigate as this could potentially be as a result of the ash disposal facility slowly becoming more saturated.

5.3 Aquifer Parameters

5.3.1 Recharge

Two recharge zones were first considered by SLR in the 2014 study across the groundwater model domain, based on the two rock types identified in the hydrogeological map (i.e. Karoo dolerite and arenaceous sandstone). However, due to limited information with regards to different recharge characteristics, a uniform recharge rate of 0.00008 metres per day (m/d) was chosen by SLR for the entire model domain. This rate is approximate to the GRA2 recharge rate for quaternary catchment C11K (i.e. 28 mm per year) and approximately 5% of the rainfall rate (mean annual rainfall of 580mm/year). A value of 0.00016 metres per day (10% of mean annual precipitation) (i.e. double the ambient recharge) was used by SLR in the 2014 study for the ash disposal facility and alternative sites.

The GHT Consulting Scientists 'Ash Stack Pollution Plume Model 2015' study reported precipitation in the region of Tutuka Power Station was in the order of 700 mm/annum with a natural recharge to groundwater ranging between approximately 2 – 3% of MAP. Recharge rate/seepage of the ADF was not specified.

5.3.2 Aquifer parameters

Transmissivity

SLR (2014) reported from model calibration that the site transmissivity ranged from 3.0 m^2/d to 10 m^2/day. SLR (2014) used a vertical anisotropy set to a Kh/Kv ratio of 3:1 for layer 1 and layer 2 of the model. No site aquifer hydraulic tests were performed during the SLR (2014) study.

The GHT Consulting Scientists 'Ash Stack Pollution Plume Model 2015' study reported from various aquifer test results transmissivity ranging between 0.06 m^2/day and 95 m^2/day. GHT Consulting Scientists stated that the relatively higher transmissivity was found in perched aquifers within the weathered zone, and deeper regional aquifers associated with fractured and 'baked' zones. However, this report poorly describes the aquifer parameters applied to each aquifer unit in the model and final calibrated parameters that were used.

The aquifer transmissivity values used in both studies differ vastly from each other and while the GHT Consulting Scientists model refers to perched conditions, this is not mentioned or evident from Kh/Kv values used in the SLR model.

Porosity

Porosity values of the different aquifer units are required for the transport model and influence the predicted migration of the simulated contamination plume, but do not influence the outcome of the steady-state flow model.

SLR (2014) used effective porosity values sourced from literature and were 'conservatively' specified as 0.27 (sandstone - medium) for the weathered zone, 0.18 for the deeper sandstone and mudstone aquifers (Layer II) and 0.1 fractured Karoo dolerite (layer II).

The GHT Consulting Scientists 'Ash Stack Pollution Plume Model 2015' study only referred to the weathered zone porosity and assigned a value of 0.01 to the model. Porosity of the other aquifer units were not described.

5.4 Groundwater Quality

5.4.1 Previous SLR groundwater study groundwater quality

SLR (2014) found from previous monitoring data that the groundwater quality of the sites on the current ash disposal facility shows signs of severe contamination. The deteriorating qualities of the deep piezometers from the existing ash disposal facility was reported to be impacting on the shallow aquifer directly below the current ash disposal facility. Severe contamination reported downstream of the current ash disposal facility was also reported by SLR (2014) to indicate that contaminant migration has occurred away from the current ADF and detrimental impacts on the groundwater quality have resulted primarily towards the east and south-east.

The hydrocensus conducted by SLR included the sampling of three groundwater samples and the results indicated:

- A number of elements were observed at concentrations above the SANS 241 (2011) limits and included:
    - Chromium – elevated above chronic health limit of 0.05mg/L in sample AMB93 (0.26mg/L);
    - Iron - elevated above aesthetic limit of 0.3mg/L in sample AMB64 (1.02mg/L) and above chronic health limit of 2mg/L in sample AMB55 (23mg/L);
    - Manganese – elevated above the chronic health limit of 0.76mg/L in sample AMB55 (0.76mg/L);
    - Selenium – elevated above the chronic health limit of 0.01mg/L in sample AMB93 (0.065mg/L);
- The electrical conductivity, total dissolved solids, chloride and sulphate concentrations were all significantly elevated above the most stringent water quality limits in sample AMB93.

5.4.2 Groundwater quality monitoring

Tutuka monitors several boreholes within and surrounding the site as part of its groundwater monitoring programme. The water quality results from July 2015 to December 2016 were made available.

The water quality results that were made available were classified by GHT Consulting Scientist according to:

- South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, First Edition 1993 and Edition 1996.
- Quality of Domestic Water Supplies, DWA&F, Second Edition 1998.
- SABS South African National Standard: Drinking water SANS 241-2:2011 Edition 1 and SANS 241:2006 Edition 6.1.
- Tutuka Power Station Water Use License (08/C11K/ABCFGI/1016).

The GHT Consulting groundwater quality monitoring results for the ADF monitoring area are summarised below:

GHT Consulting Scientists – Monitoring Report Phase 47 – May 2015 Final Report (July 2015)

The majority groundwater sites on the ash stack shows signs of severe contamination. The deteriorating qualities of the deep piezometers indicated that the ash stack is impacting on the shallow aquifer directly below the ash stack.

The severe contamination was found and results indicated that contaminant migration has occurred away from the ash stack and detrimental impacts on the groundwater quality have resulted primarily towards the east and south-east, approximately 30 to 800 metres downstream of the ash stack.

It was concluded that the impact on the groundwater sites downstream from the ash stack were likely attributed to the dams and channels transferring dirty water from the ash stack than seepage from the ash stack. Contaminations were reported for monitoring boreholes located approximately one kilometre downstream from the dirty/clean water dams.

Contaminants of concern reported included fluoride, magnesium, sodium, chloride, and sulphate. Elevated electrical conductivity was also noted.

Sulphate concentrations from borehole samples ranged between 0.3 mg/L and 2 187.0 mg/L and electrical conductivity ranged between 62.2 mS/m and 689.0 mS/m.

GHT Consulting Scientists – Hazardous Waste Site 1st Quarter 2015 Annual Monitoring Site Assessment Report (July 2015)

A severe impact from the ash stack was reported with contaminants of concern listed as sodium, chloride, chromium and sulphate. Elevated electrical conductivity was also noted.

The study found that leachate from the ashing area is at present of greater concern to the groundwater quality than leachate from the hazardous waste site.

GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 1st Quarter 2016 (March 2016)

A severe impact from the ash stack was reported with contaminants of concern listed as sodium, chloride, chromium and sulphate. Elevated electrical conductivity was also noted.

The study found that leachate from the ashing area is at present of greater concern to the groundwater quality than leachate from the hazardous waste site.

Sulphate concentrations from borehole samples ranged between 56.3 mg/L and 1 393.0 mg/L and electrical conductivity ranged between 62 mS/m and 551 mS/m.

GHT Consulting Scientists – Annual Report Phase 50 – Final Report (March 2016)

The majority groundwater sites on the ash stack shows signs of severe contamination and the same conclusions were made as reported in Monitoring Report Phase 47 – May 2015 Final Report (July 2015).

Contaminants of concern reported included fluoride, magnesium, sodium, chloride, chromium and sulphate. Elevated electrical conductivity was also noted.

Sulphate concentrations from borehole samples ranged between below detection limit and 1 736 mg/L and electrical conductivity ranged between 78 mS/m and 691 mS/m.

GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 2nd Quarter 2016 (July 2016)

A severe impact from the ash stack was reported with contaminants of concern listed as sodium, chloride, chromium and sulphate. Elevated electrical conductivity was also noted.

The study found that leachate from the ashing area is at present of greater concern to the groundwater quality than leachate from the hazardous waste site.

Sulphate concentrations from borehole samples ranged between 18.6 mg/L and 1 574.0 mg/L and electrical conductivity ranged between 58 mS/m and 510 mS/m.

GHT Consulting Scientists – Annual Report Phase 51 – Final Report (July 2016)

Water quality was not described in the report, but laboratory results were attached in Appendix B of the report.

Contaminants of concern from groundwater samples were sodium, chloride, chromium and sulphate. Elevated electrical conductivity was also observed. Sulphate concentrations ranged between below detection limit and 3 221.7 mg/L and electrical conductivity ranged between 91 mS/m and 940 mS/m.

GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 3rd Quarter 2016 (December 2016)

Sulphate concentrations from borehole samples ranged between 16 mg/L and 3 507.0 mg/L and electrical conductivity ranged between 49 mS/m and 955 mS/m.

GHT Consulting Scientists – Monitoring Report Phase 48 – Final Report (October 2015)

The majority of groundwater sites on the ash stack showed signs of severe contamination and the same conclusions were made as reported in Monitoring Report Phase 47 – May 2015 Final Report (July 2015).

Contaminants of concern reported included fluoride, magnesium, sodium, chloride, and sulphate. Elevated electrical conductivity was also noted.

Sulphate concentrations from borehole samples ranged between 0.3 mg/L and 2 285.0 mg/L and electrical conductivity ranged between 62.2 mS/m and 686.0 mS/m.

GHT Consulting Scientists – Hazardous Waste Site Monitoring Report 3rd Quarter 2015 Final Report (October 2015)

A severe impact from the ash stack was reported with contaminants of concern listed as sodium, chloride, chromium and sulphate. Elevated electrical conductivity was also noted.

The study found that leachate from the ashing area is, at present, of greater concern to the groundwater quality than leachate from the hazardous waste site.

Sulphate concentrations from borehole samples ranged between 4 mg/L and 3 461.0 mg/L and electrical conductivity ranged between 47 mS/m and 923 mS/m.

GHT Consulting Scientists – Farmers' Background Boreholes Annual Report March 2016 (March 2016)

A total of 13 private land owners' boreholes were visited and seven groundwater samples were taken during this study. These boreholes were located approximately 1 – 5 kilometres to the north-east and east of the ash disposal facility.

The groundwater quality at the borehole located approximately 1 kilometre downstream from the Dirty/Clean Water Dams (AMB21) showed signs of severe contamination due to fluoride concentrations. The origin of fluoride was unknown and might have been attributed to the geology of the area according to GHT Consulting Scientists. The quality of the water at borehole AMB21 is above the recommended standard limit and above the maximum allowable limit for the electrical conductivity, magnesium and chloride which is unsuitable for human consumption.

The groundwater quality at boreholes FBB129, FBB134 and FBB901 depicted high nitrate concentrations and was above the recommended standard limit which is unsuitable for human consumption. The high nitrate concentration was attributed to agricultural activities, as fertilizers are the most common source of dissolved nitrate levels in groundwater.

A severe impact from the ash stack was reported with contaminants of concern listed as sodium, chloride, chromium and sulphate. Elevated electrical conductivity was also noted.

Sulphate concentrations from borehole samples ranged between 23.5 mg/L and 1 637.0 mg/L and electrical conductivity ranged between 59.9 mS/m and 565 mS/m.

GHT Consulting Scientists – Annual Report Phase 52 – Final Report (December 2016)

The majority groundwater sites on the ash stack shows signs of severe contamination and the same conclusions were made as reported in Monitoring Report Phase 47 – May 2015 Final Report (July 2015).

Contaminants of concern reported included calcium, magnesium, sodium, chloride, and sulphate. Elevated electrical conductivity was also noted.

Sulphate concentrations from borehole samples ranged between 0.352 mg/L and 1 835 mg/L and electrical conductivity ranged between 77.1 mS/m and 630 mS/m.

5.4.3 Surface water monitoring

Data for a number of surface water monitoring points for the ash disposal facility were evaluated and included:

- The stream approximately 600 metres to the south of the ash stack (AMS68);
- Two dirty water dams (AMD08 & AMD09) that receive direct surface water runoff;
- The 'clean' water dam water quality data (AMD07) located downstream of the dirty water dams; and
- Stream leaving the ashing area (WSS06) to the south of the clean water dam.

Coordinates for the surface water monitoring points were not available from the received data.

Stream south of ash disposal facility

Sulphate concentrations from AMS68 ranged between 5 412 mg/L and 10 315 mg/L and electrical conductivity ranged between 1 626 mS/m and 2 588 mS/m. GHT Consulting Scientists stated that surface runoff from the ash stack is directly flowing into this stream. Recommendations were made to consider installing a dirty water trench at the south-eastern side of the ash stack.

Dirty water dams

Sulphate concentrations from the dirty water dams ranged between 3 119 mg/L and 11 083.0 mg/L and electrical conductivity ranged between 1 173 mS/m and 4 222 mS/m.

Clean water dam

The clean water dam is situated downstream of the two dirty water dams. Sulphate concentrations from the 'clean' water dam ranged between 621 mg/L and 808 mg/L and electrical conductivity ranged between 299 mS/m and 413 mS/m. GHT Consulting Scientists stated that surface water impacts were evident from water quality data at this dam. This was due to overflows from the upstream dirty water dams as well as the previous overflows from the silted southern dirty water trenches (which has been cleaned) into the clean water streams, as well as the absence of south-eastern clean/dirty water separation at the stream south of the ash disposal facility (AMS68).

Stream south of clean water dam

Sulphate concentrations from the local stream ranged between 35.7 mg/L and 97.4 mg/L and electrical conductivity ranged between 64 mS/m and 131 mS/m. GHT Scientific Consultants noted that the upstream samples WSS61 coming from the overflow of dam AMD07, as well as the eastern tributary WSS32 were consistently dry.

5.4.4 Other groundwater studies

GHT Consulting Scientists – Ash Stack Pollution Plume Model 2015 (March 2016)

GHT Consulting Scientists updated and re-calibrated the previous numerical pollution plume model created in 2013 by GHT Consulting Scientists of the ash stack at Tutuka Power Station. The purpose was to simulate the completed ash stack (expected round 2055) and to compare the difference between lined and unlined scenarios (assuming seizing of excessive brine irrigation from 2015 onwards).

Constant sulphate concentration of 1500 mg/l was assigned as input parameter for the area covered by ash. Constant concentrations of 1000 mg/l on dirty water dams AMD09 and AMD08 and 100mg/l on the clean water dam AMD07. These concentrations were derived from monitoring quality data according to GHT Consulting Scientists. However, the sulphate concentrations from the monitoring results are much higher, which can underestimate the modelled groundwater impact predictions.

The simulated periods between 2015 and 2055 and up to 2105 the model results indicated that the pollution plume will most likely be localised.

GHT Consulting Scientists – Hydrocensus April 2017 (June 2017)

This report summarised the findings of hydrocensus that was conducted during April 2017 and in order to identify the water users and usage within the possible impact zone of the power station. These boreholes were located between approximately 1 – 8 kilometres from the Tutuka ash disposal facility. Coordinates of the hydrocensus boreholes were not available.

Boreholes FBB015, FBB132, FBB133, FBB135, FBB292, FBB293, FBB295, FBB301, FBB309, FBB310, FBB312, FBB314, FBB315 and FBB319 are classified as above recommended standard. The groundwater quality of borehole FBB015 was above recommended standard due to sodium and fluoride which were mainly attributed to the geology or natural occurrence.

The groundwater quality of boreholes FBB132, FBB133, FBB292, FBB293, FBB295, FBB301, FBB309, FBB310, FBB314, FBB315 and FBB319 were above drinking water standard due to exceeded nitrate, which is mainly attributed to fertilizers and agricultural activities.

The groundwater quality of borehole FBB135 was above drinking water standard due to fluoride and arsenic. These parameters are naturally occurring in groundwater and sometimes attributed to agricultural activities in the area.

The groundwater quality of borehole FBB312 was above drinking water standard due to exceeded chloride which was attributed to agricultural activities such as irrigation as well as industrial effluents which might be transported by surface run-off.

5.4.5 Conclusions

Based on the results from the previous SLR (2014) study and on-site monitoring the following can be concluded related to groundwater quality:

- SLR (2014) found from previous monitoring data that the groundwater quality of the sites on the current ash disposal facility showed signs of severe contamination.
- SLR (2014) noted that the deteriorating qualities of the deep piezometers from the current ash disposal facility was reported to be impacting on the shallow aquifer directly below the current ash disposal facility.
- Severe contamination reported downstream of the current ash disposal facility were reported by SLR (2014) to indicate that contaminant migration has occurred away from the current ash disposal facility and detrimental impacts on the groundwater quality have resulted primarily towards the east and south-east.
- The hydrocensus conducted by SLR (2014) included the sampling of three groundwater samples and the results indicated that chromium, iron, manganese and selenium were observed at concentrations above the SANS 241 (2011) limits. The electrical conductivity, total dissolved solids, chloride and sulphate concentrations were all significantly elevated above the most stringent water quality limits in one sample.
- The majority of groundwater monitoring sites on the ash stack shows signs of severe contamination.

- The deteriorating groundwater qualities of the deep piezometers was concluded by GHT Consulting Scientists to indicate that the ash stack has impacted the shallow aquifer directly below the ash stack. The contamination of groundwater quality away from the ADF indicated that contaminants have migrated away from the ash stack and detrimental impacts on the groundwater quality have resulted primarily towards the east and south-east, approximately 30 to 800 metres downstream of the ash stack at that point in time (2015).
- It was concluded by GHT Scientific Consultants that the impact on the groundwater sites downstream from the ash stack were likely attributed to the dams and channels transferring dirty water from the ash stack than solely seepage from the ash stack. Contaminations were reported for monitoring boreholes located approximately one kilometre downstream from the dirty/clean water dams.
- Contaminants of concern reported from monitoring and hydrocensus data were arsenic, fluoride, magnesium, sodium, chloride, and sulphate. Elevated electrical conductivity were also noted.
- Surface water samples of the stream south of the ash disposal facility, the dirty water dams and the clean water dams showed severe signs of contaminations with sulphate concentrations from the dirty water dams ranged between 621 mg/L and 11 083.0 mg/L and electrical conductivity ranged between 299 mS/m and 4 222 mS/m.

6 CONSTITUENTS OF CONCERN FROM COAL FLY ASH

Several case studies publicly available relating to typical contaminants of concern potentially emanating from coal ash and coal combustion residues were evaluated. The main findings are summarised below for each case study.

Kendal Power Station (Zitholele Consulting, 2018)

The waste classification of Kendal Power Station's ash was undertaken in 2014 by Jones and Wagener. The contaminants of concern (COCs) were compared to the total concentration thresholds and leachable concentration thresholds detailed in the GN R. 635 of 2013 (National Norms and Standards for the assessment of waste for Landfill Disposal), and included, amongst others, aluminium, antimony, arsenic, barium, boron, cadmium, chlorine, chromium (total), chromium VI, cobalt, copper, fluoride, lead, manganese, mercury, molybdenum, nickel, selenium, vanadium, zinc, polycyclic aromatic hydrocarbons, sulphate and nitrate.

Matla Power Station (Dalton et al., 2018)

A site assessment was conducted at Matla coal fired power plant to determine whether surrounding soils were being enriched with trace metals resulting from activities at the power plant. It was found that deposition of fly ash from the flue stacks and the ash dump along with deposition of coal dust from the coal stock yard were the activities most likely to lead to such enrichment. Eighty (80) topsoil samples were gathered and analysed for total metal content. Results were interpreted within the context of background values. It was found that concentrations of arsenic, copper, manganese, nickel and lead exceeded local screening levels, but only arsenic and lead could be confidently attributed to anthropogenic intervention and actual enrichment.

Thabametsi Power Station (Geo Pollution Technologies, 2014)

Geo Pollution Technologies (Pty) Ltd (GPT) conducted a hydrogeological impact study for the proposed Thabametsi Coal Fired Power Station Project at the Grootgeluk coal mine in 2014. Potential contaminants of concern identified by GPT potentially emanating from an ash dump included calcium, sulphate, chloride, sodium, and mercury. Sulphate was identified as the most significant solute in drainage from the ash dump. A starting concentration of 2 000 mg/L was used in numerical transport modelling by GPT. GPT recommended that the ash material should be summited for geochemical analysis to determine the leachability, acid generation capacity and contamination potential.

Thabametsi Power Station (Downstream Strategies, 2018)

Downstream Strategies focused on the potential risks to water resources from the coal ash dump, including its pollution control dams (PCDs). A full set of Coal Combustion Residues (CCR)-related pollutants were recommended to be included in the groundwater monitoring programme. The following CCR-related pollutants were identified: antimony, arsenic, barium, beryllium, boron, cadmium, cobalt, lead, lithium, molybdenum, radium-226 and radium-228 combined, selenium, and thallium.

Kriel Power Station (Aurecon, 2016)

Aurecon undertook a geohydrological evaluation as part of an environmental impact assessment for the proposed expansion of the ash dam facility at Kriel Power Station. The study found high pH values due to the influence of the ash disposal facility. Elevated sulphate and sodium were also listed as contaminants of concern in the study. The main source of sulphate in fly ash water was found to be from the demineralisation effluent. Sulphate concentrations were stated to range between 200 – 1000 mg\L.

Tutuka Power Station (Akinyemi, 2011)

The study aimed to provide a comprehensive characterisation of weathered dry disposed ash cores, to reveal mobility patterns of chemical species as a function of depth and age of ash, with a view to assessing the potential environmental impacts. Fifty-nine samples were taken from 3 drilled cores obtained respectively from the 1 year, 8 year and 20-year-old sections of sequentially dumped, weathered, dry disposed ash in an ash dump site at Tutuka Power Station. Results showed older ash cores are enriched in arsenic, boron, chromium, molybdenum and lead were enriched in the residual fraction of older ash cores.

Georgia State - United States of America (EIP, 2018)

The Environmental Integrity Project (EIP) and Earthjustice examined state-wide monitoring data and determined that 92 percent (11 of 12) of Georgia's coal-fired power plants have contaminated groundwater with one or more toxic pollutants. Ten of the 11 plants had unsafe levels of one or more of the following pollutants:

- Antimony, which causes developmental toxicity (reduced fetal growth) and metabolic toxicity (reduced blood glucose levels). Antimony can also irritate the skin.
- Arsenic, which causes multiple types of cancer, neurological damage, and other health effects.
- Boron, which poses developmental risks to humans, such as low birth weight, and can result in stunted growth and plant toxicity in aquatic ecosystems.
- Cobalt, which harms the heart, blood, thyroid, and other parts of the body.
- Lithium, which presents multiple health risks including neurological impacts.
- Molybdenum, which damages the kidney and liver at high concentrations.
- Radium, which causes cancer and is a radioactive element.
- Selenium, which harms fish and other aquatic organisms at very low concentrations and is bioaccumulative. Selenium can also be toxic to humans.
- Sulphate, which causes diarrhea, and can be very dangerous to young children.

7 POTENTIAL IMPACTS FROM ASH DISPOSAL FACILITY

7.1 Previous predicted groundwater impacts

7.1.1 Groundwater levels

SLR (2014) noted that even though a dry ashing technique will be used during the operational phase from 2015 onward for the ash disposal facility, precipitation will collect on top of the ash disposal facility and eventually infiltrate through the ash and liner to the underlying aquifer. SLR stated that water will likely be stored within the ash disposal facility over time and subsequently increase the 'recharge' within the footprint of the facility which may cause mounding of groundwater. However, this ultimately depends of the volume of water that falls on the facility and the relative permeability of the ash, which were only estimated in the study. This may have the potential to cause a rise in the water table beneath the ash disposal facility and may impact local groundwater flow directions. Notwithstanding, it was considered by SLR unlikely that a significant rise in the water table beneath the ash disposal facility will occur as a direct result of the ash itself. SLR also noted that the use of toe drains, stormwater dams and other surface water impoundments close to the proposed ash disposal facility may lead to local water table rise.

7.1.2 Groundwater quality

The SLR numerical model predictions results suggested that the movement of leachate away from the ash disposal facility as a groundwater plume should take place relatively slowly, with predicted plume extents being generally less than 1 km from the ash disposal facility after 100 years. However, the input concentration for the model was only made as 100 % and the ash material was never characterised by means of geochemical analyses. Geochemical modelling to determine potential contaminants of concern and the final expected water quality emanating from the ash disposal facility has not been undertaken to date.

SLR (2014) concluded that the quality of groundwater beneath the site will most likely deteriorate, since natural groundwater will be mixing with the poorer quality ash leachate (either directly draining from the ash disposal facility, or leaking from surface water impoundments). Geochemical data for the ash at Tutuka was not made available for the SLR (2014) assessment, but typical constituents of concern (elements that are elevated above water quality standards) listed by SLR included: arsenic, boron, chromium, molybdenum, antimony, selenium, vanadium and wolfram. In addition, the pH of water was also mentioned to be impacted upon. It was noted however that groundwater quality data indicated that groundwater quality has already been impacted by the existing ash disposal facility.

SLR stated that if contaminated water was impounded at the surface in unlined ponds, there was a risk to both groundwater and surface water resources. SLR reviewed monitoring data and there were an indication that boreholes located near ponds were adversely impacted both in terms of groundwater levels and quality.

7.1.3 Impact summary

The cumulative impacts from the ash disposal facility of all three phases (construction, operation and decommissioning) determined by SLR (2014) were summarised as:

- A rise in water table in the vicinity of the site due to increased recharge from stored water within the ash disposal facility and any associated surface water impoundments.
- Deterioration in groundwater quality.

The potential impacts of the proposed ash disposal facility on the local groundwater were also qualitatively assessed by SLR and the nature of the impacts were assessed using a standard significance rating scale. The significance rating for the cumulative impacts from the ash disposal facility with and without mitigation measures were determined by SLR as medium to low respectively in terms of deterioration of groundwater quality due to leachate from ash disposal facility.

7.2 Verification of previous groundwater impacts

The previous hydrogeological study conducted by SLR (2014) during the original exemption application was reviewed together with the site information received (as listed in Section 3.2) in order to determine if SLR's previously predicted groundwater impacts will change or not due to additional time used to ash over the same footprint (54ha) under the exemption approval area.

Regarding groundwater levels, SLR concluded that there was a risk that a rise in water table in the vicinity of the site due to increased recharge from stored water within the ash disposal facility and any associated surface water impoundments could occur. A slight rise in water table depth were noted from monitoring data around the ash disposal facility and were determined by GHT Consulting Scientists to be potentially due to historic influences of brine water irrigation and/or recharge occurring through the top. Although the rise in water levels were extremely slow, it was recommended by GHT Consulting Scientists to further investigate as this could potentially be as a result of the ash disposal facility slowly becoming more saturated.

During the operational, decommissioning and post closure phases the main impact on groundwater that may result from the additional time used to ash over the same footprint under the exemption approval area is the contamination of the groundwater as a result of seepage from the ash disposal facility. Based on the results from the previous SLR (2014) study and on-site monitoring the following can be concluded related to groundwater quality:

- SLR (2014) found from previous monitoring data that the groundwater of the sites on the current ash disposal facility shows signs of severe contamination.
- SLR (2014) noted that the deteriorating qualities of the deep piezometers from the current ash disposal facility was reported to be impacting on the shallow aquifer directly below the current ash disposal facility.

- Severe contamination reported downstream of the current ash disposal facility were reported by SLR (2014) to indicate that contaminant migration has occurred away from the current ash disposal facility and detrimental impacts on the groundwater quality have resulted primarily towards the east and south-east.
- The hydrocensus conducted by SLR (2014) included the sampling of three groundwater samples and the results indicated that chromium, iron, manganese and selenium were observed at concentrations above the SANS 241 (2011) limits. The electrical conductivity, total dissolved solids, chloride and sulphate concentrations were all significantly elevated above the most stringent water quality limits in one sample.
- The majority of groundwater monitoring sites on the ash stack shows signs of severe contamination.
- The deteriorating qualities of the deep piezometers indicated, according to GHT Consulting Scientists, that the ash stack is impacting on the shallow aquifer directly below the ash stack. The water quality monitoring results indicated that contaminant migration has occurred away from the ash stack and detrimental impacts on the groundwater quality have resulted primarily towards the east and south-east, approximately 30 to 800 metres downstream of the ash stack at that period of time.
- It was concluded by GHT Scientific Consultants that the impact on the groundwater sites downstream from the ash stack were likely attributed to the dams and channels transferring dirty water from the ash stack than solely the seepage from the ash stack. Contaminations were reported for monitoring boreholes located approximately one kilometre downstream from the dirty/clean water dams.
- Contaminants of concern reported from monitoring data were fluoride, magnesium, sodium, chloride, and sulphate. Elevated electrical conductivity was also noted.
- Surface water samples of the stream south of the ash disposal facility, the dirty water dams and the clean water dams showed severe signs of contaminations with sulphate concentrations from the dirty water dams ranging between 621 mg/L and 11 083.0 mg/L and electrical conductivity ranging between 299 mS/m and 4 222 mS/m.
- Chemical constituents analysed during site monitoring do not include all contaminants of concern identified from groundwater case studies, conducted in South Africa as well as internationally, that may potentially be present in leachate emanating from similar ash disposal facilities.
- No geochemical assessment has been conducted during the SLR (2014) assessment and no geochemical data were received from the client in order to identify all the contaminants of concern that may have an impact on groundwater quality.

The available data in the previous hydrogeological study conducted by SLR (2014) during the original exemption application together with the site information received (as listed in Section 3.2) are not sufficient to enable GCS to quantify the groundwater impacts that may result from the additional time used to ash over the same footprint (54ha) under the exemption approval area. Additional geochemical and hydrogeological work is recommended to be performed before GCS can determine the final changes in potential groundwater impacts due to the additional time used to ash. The additional work is described in Section 8.

8 RECOMMENDATIONS

Although the groundwater impacts determined by SLR (2014) will still remain in terms of groundwater levels and quality, to quantify the changes to groundwater quality that may results from the additional time used to ash over the same footprint (54ha) under the exemption approval area, GCS recommends that the site consider conducting additional hydrological and hydrogeological work. The additional work will enable the site to better characterise and predict the changes to groundwater quality due to the use of the current ash dump facility and the extension area. Additional geochemical, hydrogeological, and hydrological work is recommended to be performed and is discussed in more detail below.

8.1 Groundwater monitoring

Continuous groundwater monitoring is recommended in order to quantify ongoing impacts and provide early warning of any potential contamination. Chemical constituents analysed during site monitoring by GHT Consulting Scientists did not include all contaminants of concern identified from other groundwater case studies, conducted in South Africa as well as internationally, that may potentially be present in leachate emanating from similar ash disposal facilities.

The quarterly water quality parameters should include: pH, EC, total alkalinity, chloride, sulphate, nitrate, ammonium, orthophosphate, fluoride, calcium, magnesium, sodium, potassium, aluminium, iron, manganese, cobalt, nickel, and total hardness. Parameters should include any metals identified future geochemical assessments that may potentially leach out from the ash material. The annual analysis should include the proposed quarterly parameters as well as the following parameters: antimony, arsenic, barium, boron, cadmium, chromium (total), chromium VI, cobalt, copper, lead, lithium, mercury, molybdenum, nickel, radium, selenium, vanadium, zinc.

Historically the following constituents have not been previously included in the site monitoring or only a very small number of samples were analysed for: antimony (Sb), barium (Ba), boron (B), cadmium (Cd), chromium VI (Cr VI), cobalt (Co), lead (Pb), lithium (Li), mercury (Hg), molybdenum (Mo), nickel (Ni), radium (Ra), selenium (Se), vanadium (V), zinc (Zn), and polycyclic aromatic hydrocarbons (PAH). Additionally, arsenic and selenium has been detected at elevated concentrations from the GHT Consulting Scientists and SLR (2014) hydrocensus studies, respectively.

A groundwater monitoring database should be created and updated with all available historic data and as new information becomes available. It is recommended that the data is stored in a dedicated database and that quarterly and annual reports are generated for the site's environmental management.

8.2 Geochemical assessment

A total of at least 10 (ten) geochemical samples will be required of the ash samples. The samples should be submitted to a SANAS accredited laboratory. For the geochemical characterisation of the ash material the following tests should be performed to characterise the ash material and determine the expected elements that may pose a risk to groundwater quality:

- Whole rock/sample analyses;
    - X-ray diffraction (XRD);
    - X-ray fluorescence (XRF) of major oxides;
    - Acid digestion with ICP on trace elements;
- Acid-mine drainage potential;
    - Acid-base accounting - paste pH, total %S and neutralisation potential (ASTM E1915-11);
    - Sulphur speciation (ASTM E1915-11);
    - Net acid generation (NAG) test (ASTM E1915-11);
- Leach tests;
    - Peroxide water extraction 1:4 and 1:20 ratio (250g sample 1L water; 18h) * (similar to ASTM D3987-06); and

  **The following analyses should be performed on the leachate: pH, EC, Total Alkalinity, Cl, NO3, NH4, SO4, F as well as ICP which should include at least the following: 1) Ca, Mg, Na, K, Si, 2) Al, Fe, Mn, As, Ba, Be, Bi, Cd, Co, Cr, Cu, Li, Mo, Ni, Pb, Sb, Se, Sn, Sr, Ti, U, V, W, Zn.*

- Ten (10) week humidity cell leach test (ASTM D5744-07) will be conducted and will be used to calibrate the geochemical models. Kinetic column leaching tests indicate the chemicals that will leach out from the rock material over time as well as the oxidation rate of the sulphide minerals in the material if no interference is present from secondary sulphate minerals.

The test results should be screened in order to determine the long-term acid generation potential of the samples, the expected elements that may be present at elevated concentrations in the ADF seepage, and to prepare input for the geochemical model.

Laboratory test work should be followed by geochemical modelling to provide a quantitative estimate of the expected mine water quality. Laboratory test data cannot be used directly to represent field conditions. The actual water-rock ratio, oxidation rate and chemical residence times can only be incorporated into a numerical geochemical model. Several of these factors depend also on the geometry of the ADF, its interaction with the atmosphere (oxidation) and the ADF water balance.

The following should be evaluated during geochemical modelling:

- The oxygen diffusion into the residue waste should be modelled.
- Geochemical reaction modelling should be performed in order to determine the actual ADF seepage water that will be expected.
- Equilibrium and mineral kinetic modelling should be performed.

Contaminants of concern identified from the geochemical assessment should be included into the groundwater monitoring network.

8.3 Site stormwater management plan

A conceptual SWMP design for the ash disposal facility (ADF) site should be undertaken including determination of existing clean and dirty water areas and size the required berms, channels and Pollution Control Dams (PCDs) to be sufficient. Concept design layouts should be provided for proposed stormwater infrastructure.

The SWMP management practices should include:

- Minimise dirty areas and divert clean water around potential contaminant sources;
- Limiting the exposure of sediment producing materials to erosive forces;
- Taking reasonable measures to limit or prevent offsite sediment transport; and
- Water conveying structures should be protected from erosion.

The storm water management plan should also incorporate best practice guidelines in terms of protecting the environment and minimising discharge of poor water quality. The SWMP should be devised in accordance with the South African Department of Water and Sanitation (DWS) (formerly the department of Water Affairs – DWA) Best Practice Guidelines G1: Storm Water Management (DWA, 2006) and should be adopted as these are strict guidelines that pave the way for responsible site water management.

8.4 Site water balance

Updated site climate data should be obtained from the South African Weather Service (SAWS) and/or databases of WR2012 to update the data used in the surface water specialist study.

A water balance modelling process is recommended and should provide hydrological inputs; these include obtaining recent information on meteorology, runoff and catchments. The water balance should include all components to be modelled such as water sources and losses to the system, and the following must be discussed with the site environmental management team:

- Documentation of operational philosophies;
- Documentation of User Requirements and Assumptions of relevant operations;
- Planned or projected volumes of water to be used within each component, and
- Linkages and routes between components.

These studies should be undertaken with adherence to the relevant South African Best Practice Guidelines and Acts. The Water Balance must be undertaken according to the South African Department of Water and Sanitation (DWS) (formerly the department of Water Affairs – DWA) Best Practice Guidelines (BPG) G2: Water and Salt Balances.

8.5 Updated conceptual and numerical groundwater flow and transport modelling

A high-level desktop study should be completed for the site prior to the conceptual and numerical model update, during which previous consultant reports as supplied by the client, as well as public domain data that is available for the site area will be analysed. Based on all compiled and reviewed data a gap analysis should be carried out to identify critical gaps in the available information. Based on the gap analysis recommendations for additional data collection and analysis should be provided, including any fieldwork and laboratory analyses that may need to be performed.

Updated site and monitoring data should be reviewed and integrated to construct an updated conceptual and numerical groundwater model for the ADF and whole site that describe and quantify aquifers, groundwater flow, boundary conditions and contaminant transport.

Groundwater modelling tools will also be employed in quantifying potential impacts. Risks to be investigated include:

- Groundwater contamination risk posed by the ADF seepage;
- Influence of the position of the site infrastructure (including dirty and clean water dams) on contaminant risk; and
- Post-closure groundwater scenarios.

8.6 Updated groundwater impact assessment

The potential groundwater impacts for the additional time used to ash should be quantified based on the results of updated site information, geochemical assessment, and the numerical groundwater flow and contaminant transport modelling. A significance rating should be used to class the impacts.

Groundwater management measures should be formulated based on the results of the above impact assessment. Such management measures should be discussed with the environmental project team and client. The Tutuka groundwater monitoring programme should be reviewed and recommendations to potential changes should be formulated as part of a site water management plan.

9 CONCLUSIONS

The Department of Environmental Affairs required the site to undertake a Part 2 amendment process and required all specialists that conducted the studies to confirm that the required extension would not have additional impacts on the environment. This required that GCS assess the specialist reports produced during the exemption application, and confirm if the findings will change due to additional time used to ash over the same footprint (54ha) under the exemption approval.

GCS conducted a desktop study level hydrogeological assessment in order to verify the potential impacts determined from the previous hydrogeological study.

The cumulative impacts from the ash disposal facility of all three phases (construction, operation and decommissioning) determined by SLR (2014) were summarised as:

- A rise in water table in the vicinity of the site due to increased recharge from stored water within the ash disposal facility and any associated surface water impoundments.
- Deterioration in groundwater quality.

It can be concluded that, an extension in the duration of ashing within the residual Exemption period to cover the residual area of 11 ha will not change the groundwater impacts determined by SLR (2014), the 2014 identified impacts will still remain in terms of groundwater levels and quality.

10 REFERENCES

Barnard, 2000. Department of Water Affairs and Forestry, South Africa, 2000: An Explanation of the 1:500 000 General Hydrogeological Map – Johannesburg 2526. Government Printers Pretoria.

SLR, 2012. SLR Consulting (Africa) (Pty) Tutuka Power Station Proposed Continuation of Ash Disposal: Hydrogeological Screening Report – SLR Project Ref.: 721.23003.00014 – October 2012.

SLR, 2014. SLR Consulting (Africa) (Pty) Tutuka Power Station Proposed Continuous Ash Disposal at Tutuka Power Station: Groundwater Specialist Study – SLR Project No.: 721.23003.00014 – July 2014.

Appendix F – Wetland Summary Report submitted with the Motivation Report and Application for the Exemption Amendment

P.O.Box 84, Florida
Roodepoort, 1710
contact@ecotone-sa.co.za
www.ecotone-sa.co.za

M +27 84 585 7479
+27 82 422 2793
T +27 11 672 1375
F 088 011 672 1375

Ecotone Freshwater
Consultants CC
CK/2008/027022/23
Vat No: 4090245574

ecotone
Freshwater Consultants

17 July 2019

To:

Fatima Matlou

GCS Water and Environmental Consultants

63 Wessel Road

Rivonia

Tel: +27 (0) 11 803 5726

Email: fatima@gcs-sa.co.za

www.gcs-sa.co.za

TUTUKA ASH DISPOSAL FACILITY EXEMPTION AREA: SPECIALIST WETLAND IMPACT ASSESSMENT REVIEW

Tutuka ashing operations will not utilise the full 54 ha of the Exemption area within the authorised four-year period due to an underestimation of the Generation Load Factor (GLF). An approximate extent of 11 ha will remain unused after the four-year period which ends in May 2020. Eskom, through GCS Water and Environmental Consultants (GCS) requested Ecotone freshwater Consultants (Ecotone) to review the aquatic (and wetland) specialist impact assessment associated with the Tutuka Ash Disposal Facility Exemption area, as was undertaken by Ecotone in 2014 (Proposed Continuous Ash Disposal Facility at the Tutuka Power Station, Aquatic Specialist Study, Environmental Impact Assessment, May 2014).

The residual wetlands associated with the Exemption area include parts of a channelled and unchanneled valley bottom system characterised by seasonal and temporary wetness. The wetlands are Seriously modified with little residual functionality or conservation significance.

During construction (preparation activity prior to ashing) impacts will be isolated to the residual wetlands within the Exemption footprint (approximately 5 ha). Impacts will relate to water quality, hydrology, habitat loss and encroachment of alien and invasive species. During the ashing (operational phase) impacts will relate to a loss in downstream flow augmentation and potential surface water pollution. In all instances the residual significance of impacts have been assessed as ‘Low’ after the implementation of mitigation measures.

An extension of the duration of Exemption period to cover the residual area of 11 ha does not influence the residual significance of any of the anticipated impacts identified during the 2014 assessment. The affected wetlands drain a portion of the Wolwespruit catchment that is entirely intercepted by the pollution control of the existing facility. Residual functions such as water purification, flood attenuation and erosion control are thus represented within the pollution control system. Conversely, a net loss in downstream flow augmentation and biodiversity functions have already occurred.

The net loss in flow augmentation may be mitigated through the removal of woody alien vegetation around the facility. This will contribute positively to the local water budget. Similarly, the net loss in biodiversity functions may be compensated for by improving functional integrity of degraded wetlands in close proximity to the Ash Facility through rehabilitation.

Authorised Representative

Michiel-Nell Jonker (Partner)

(MSc. Aquatic Health)
(MSc. Environmental Management)
Sacnasp Registrations 400275/12

Appendix G – Exemption Motivation Report (2016) including a summary of the supporting Specialist Studies.

ESKOM Holdings SOC Ltd

FINAL S24M EXEMPTION APPLICATION MOTIVATION REPORT:

12013KNK

Tutuka Continuous Ash Disposal Facility

October 2015

SUBMITTED BY:
Lidwala Consulting Engineers (SA) (PTY) Ltd
PO Box 2930
Nelspruit
1200
Tel: 0861 543 9252

TABLE OF CONTENTS

TABLES

FIGURES

ABREVIATIONS

ADF	Ash Disposal Facility
ARLP	Acid Rain Leach Procedure
DEA	Department of Environmental Affairs
DPE	Department of Public Enterprises
DWS	Department of Water and Sanitation
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMPr	Environmental Management Programme
ERA	Execution Release Approval
PES	Present Ecological Status
PFMA	Public Finance Management Act
SIA	Social Impact Assessment
WUL	Water Use Licence
XRD	X-Ray Diffraction

LIST OF APPENDICES

DOCUMENT CONTROL

Date	Revision	Name	Role	Signature
2015-08-10	0	Danie Brummer	Author	
2015-08-25	1	Frank vd Kooy	Reviewer	

DOCUMENT CHANGE HISTORY

Date	From Version	To Version	Paragraph Reference	Change Description

EXECUTIVE SUMMARY

Introduction

Lidwala Consulting Engineers (SA) (Pty) Ltd (Lidwala) was appointed by Eskom Holdings SOC Limited to identify, investigate and undertake the licensing process for the continuation of its ash disposal facilities at Tutuka Power Station, in the Mpumalanga Province.

It is envisaged that the total area to be covered by the Ash Disposal Facility (ADF) will be in the order of 2 500 hectares for the life of the station. Since commencement of the ashing operations, Tutuka has utilised approximately 1800ha, and in order to provide adequate ashing facilities for the life of the station an additional footprint of approximately 759 is still required. Such a footprint was the subject of the "Environmental Impact Assessment for the Proposed Continuous Ashing at the Tutuka Power Station, Mpumalanga Province – (DEA Ref. 14/12/16/3/3/3/52").

Eskom pro-actively aligned its continued ashing activities with the requirements of the waste licensing processes in line with the environmental laws such as the National Environmental Management Waste Act, Act 59 of 2008 and the National Environmental Management Act, Act 107 of 1998. Classification of the ash according to the 2013 Norms and Standards for waste disposal to landfill resulted in a Type 3 Category. The Type 3 waste requires protection by a Class C liner.

The planning and developmental processes, which also ensure good quality projects, for installing the Class C liner will take a period of approximately four (4) years, post-acquisition of the Integrated Environmental Authorisation (IEA). The duration to get the lined surface ready for ashing may result in challenges with achieving immediate compliance with respect to the lining. Eskom is thus applying for exemption for the said duration (up to 4 years) from the required Class C liner. Eskom anticipates full installation of the Class C liner after four (4) years from acquisition of Integrated Environmental Authorisation. The estimated footprint required for this 4-year exemption period is only 54ha.

Scope of the exemption submission

Lidwala identified the potential environmental impacts of continuing with ashing on an unlined, but prepared surface as per current operations, for the next four years and assessed the implications of granting such an exemption. The intention was to incorporate the potential impacts and the associated mitigation strategy as part of an Eskom (S24M) motivation to DEA for exemption from lining the (ADF) for the 4-year period.

From an environmental perspective, this motivation is based on the surface water and groundwater reports as well as the ash classification results that formed part of the EIA process. The intention of these studies and models were to illustrate a worst case scenario (i.e. ashing without lining) and therefor did not include any mitigation measures in the formulation of predictions. The result of this is that the identified impacts and their significance ratings sketch the unmitigated state. The impacts as identified in these reports will therefore be the impacts experienced during the transitional period (prior to lining).

Although Eskom is committed to be compliant with all environmental legislation in connection with its ashing activities for Tutuka Power station the lining of the future ashing area can only be provided after 4 years from receipt of the IEA. This duration is due to consideration of project planning lead times within the internal and external governance processes (e.g. Public Finance Management Act, PFMA, application to the Department of Public Enterprises).

Summary of Findings

It is predicted that mostly localised impacts on surface and groundwater currently experienced will continue for the 4-year period, a duration in which ash disposal would occur on an unlined surface. Wetland functionality will be lost for the wetlands at Alternative A, irrespective of the lining regime, because the ash facility footprint traverses these wetlands.

The groundwater model in the EIA Groundwater specialist report did not account for a liner as this study was conducted with the objective to describe the worst case pollution potential scenario. The model is therefore a good reflection of the plume migration in the unlined state. According to this model, if unlined disposal continues, the plume will migrate for a distance of 1km from the edge of disposal (distance to the closest privately owned borehole from the new facility) in 100 years.

Current monitoring results indicate that the existing ash disposal facility has impacted upon the water quality of both the shallow and deeper aquifer system. However, the plume is localised underneath and is surrounding the current ash disposal facility and the existing surface water dams which contain water from the ash disposal facility.

While there may not be environmental benefits in granting this exemption, the social and economic advantages of approving the exemption are deemed to outweigh the environmental cost. If Tutuka does not have ashing capacity, the station may have to reduce its load at some of its generating units and may have to close down the station, resulting in no-assurance of power supply to the country. In practice the current status quo and level of deterioration of groundwater quality, on the site will be maintained until such time that the liner can be integrated in the operations. The additional 54 hectares of unlined ash disposal area is seen as a small percentage in relation to the benefits to the country’s development initiatives.

The EMPr for the EIA process considered the possibility of an exemption application for a temporary period of up to 4 years. The EMPr, the remainder of the IEA and the WUL conditions should be followed t by the Eskom Engineers and the contractor responsible for construction and operation. The onsite surface and groundwater monitoring plan and system should be revised and updated to cater for the new unlined ashing area, due to the exemption.

1. APPLICANT'S DETAILS

Table 1:1 Details of the applicant

Name of Applicant:	**Eskom Holding SOC Limited** Eskom
Contact person:	Deidre Herbst
Postal Address:	PO Box 1091, Johannesburg, 2000
Tel:	011 800 3501
Fax:	086 660 6092
E-mail:	deidre.herbst@eskom.co.za

Table 1:2 Details of the applicant

Name of Power Station:	**Tutuka Power Station**
Contact person:	Mr Ryno Lacock (Power Station Manager)
Postal Address:	Private Bag X2016, Standerton, 2430
Tel:	017 749-5700
Fax:	017 749-5736
E-mail:	LacockR@eskom.co.za

2. INTRODUCTION

Background

Lidwala Consulting Engineers (SA) (Pty) Ltd (Lidwala) was appointed by Eskom to identify, investigate and license a continuation of the existing disposal facility at Tutuka Power Station located close to Standerton in Mpumalanga, South Africa.

It is envisaged that the total area to be covered by the Ash Disposal Facility (ADF) will be in the order of 2 500 hectares for the life of the station. Since commencement of the ashing operations, Tutuka has utilised approximately 1800ha, and in order to provide adequate ashing facilities for the life of the station an additional footprint of approximately 759 is still required. Such a footprint was the subject of the “Environmental Impact Assessment for the Proposed Continuous Ashing at the Tutuka Power Station, Mpumalanga Province – (DEA Ref. 14/12/16/3/3/3/52”).

The Tutuka Power Station employs a dry ash disposal method, i.e., the ash has a 20 % moisture content. Classification of the ash according to the 2013 Norms and Standards resulted in a Class C liner now being required for future ashing operations at Tutuka power station.

With the promulgation of the environmental laws such as the National Environmental Management Waste Act, Act 59 of 2008, in particular, Eskom is planning to pro-actively align its continued ashing activities with the requirements of the waste licensing processes.

Eskom is experiencing some operational challenges (details section 4.4) in achieving immediate compliance and is therefore applying for exemption from the provisions of the Department of Environmental Affairs (DEA) Norms and Standards (2013), (and in specific the required Class C liner) on a temporary basis for a period of four years, after acquisition of the Integrated Environmental Authorisation (IEA). Lidwala assessed the environmental implications of granting such an exemption.

From an environmental perspective, this motivation is based on the surface water and groundwater reports as well as the ash classification results that formed part of the EIA process. The intention of these studies and models were to illustrate a worst case scenario (i.e. ashing without lining) and therefor did not include any mitigation measures in the formulation of predictions. The result of this is that the identified impacts and their significance ratings sketch the unmitigated state. The impacts as identified in these reports will therefore be the impacts experienced during the transitional period (prior to lining).

Figure 1. Tutuka Ash Disposal Facility at the back of figure 1.

3. OBJECTIVES OF THE REPORT

Eskom approached Lidwala to apply for exemption from the liner requirements for a period of 4 years from acquisition of the IEA. The process being undertaken includes identifying the potential environmental impacts of continuing with ashing on unlined surface of the Ash Disposal Facility for the next four years (post acquisition of the IEA). The approach followed was to incorporate the potential impacts and the associated mitigation strategy as part of application to DEA for exemption from lining the Ash Disposal Facility (ADF) for the said temporary duration.

4. ACTIVITY DESCRIPTION

4.1 Location of the affected area (this application)

To make this report comprehensive a short summary of the impacts that were identified during the Environmental Impact Assessment (EIA) are provided below, with a specific focus on the 54 hectare area where Eskom proposes to dispose of the ash without the liner installation. Current disposal (faces visible on the photo) occurs just before the newly proposed alternative (blue outline in figure 2). The ashing philosophy and strategy is such that the disposal continues in an easterly direction. The Google image below indicates the area for which the exemption application is being made (white outline, Figure 2).

Figure 2. Google image of the area that forms part of this exemption application.

4.2 Description of activity

The operation of the ash disposal facility is such that the facility expands in the eastern direction, where the main stacker system is shifted to the next position every 6 months. The last shift was in January 2015. This process is repeated twice a year. The main disposal facility is expanding by 80 meters (horizontally) annually, where the shift distance is 40 meters at a time. Through these shiftings Eskom covers the remaining landscape in front of the ash disposal facility at a rate of 80 meters per year. The face width of this main disposal facility is about 1300 meters and the front face height is about 32 meters. The main disposal facility is in operation for about 85% of the time every year.

The standby ash disposal facility is also expanding in the eastern direction at a rate of 240 meters and its face width is about 100 meters. The height of this face is about 35 meters. This standby ash disposal facility is covering the front landscape at a rate of 240 meters every year. The standby ash disposal facility is in operation for the remaining 15% of the time when the main ash disposal facility system is not available. The standby ash disposal facility's remaining volume is much smaller than the main ash disposal facility.

4.3 Eskom motivation for this exemption application

Eskom is a state owned utility and as such, the use of public funds goes through stringent investment and procurement governance processes. To minimize on unnecessary expenditure in order not to contravene the Public Finance Management Act (PFMA) on any project, thorough front-end planning goes into the project during its development. The planning phase together with the investment and procurement process, in any Eskom ash disposal project, could amount to 4 to 6 years before the project could be executed. This planning included, but is not limited to, the application for environmental authorisations, licenses and permits from DEA, Department of Water and Sanitation (DWS) and Department of Public Enterprises (DPE). The application of the environmental licences/permits could take anything from 12 to 24 months. Once the EIA is approved the project will finalise its basic design and obtain Execution Release Approval (ERA). This whole process of finalising the designs and obtaining investment approval will take approximately 12 months. Besides the internal investment approval, Eskom will have to apply for the PFMA approval which will take approximately 8 months. Eskom’s procurement processes takes 18 months from the day of the PFMA approval to contract award. Once the contract has been awarded, construction time for the pollution control measures is planned for 8 months. These approval processes, post acquisition of the IEA, have a total lead time of approximately 48 months from the day Eskom receives the Environmental Authorisation to the day the pollution control measures are implemented and the ashing facility is ready for the disposal of ash. It is worth noting that these timelines does not include any variances due to unforeseen events, although the project will always seek opportunities to optimise the development and shorten the times.

Although Eskom is committed to alignment with the all environmental legislation in the ashing activities for Tutuka Power station the lining of the future ashing area can only be provided by the first quarter of 2020. This is when all the above is taken into account.

4.4 Proposed timelines and milestones for installation of the Class C liner

- The ash disposal facility stability study and design should be complete by 28/02/2017;
- The scope of design work should be complete in 30/08/2017;
- The construction for the new ash disposal facility on the southern area should start at about 01/07/2019 after the tender process and the tender adjudication process; and
- The new ash disposal facility should be in operation from December 2020.

5. LEGAL FRAMEWORK

5.1 Legal requirements

This section of the report highlights the relevant national legislation and regulations, which are applicable to (or have implications for) the proposed exemption application.

The Exemption application is made in terms of Regulation 3 of the National Exemption Regulations (R.994), Section 24M of the National Environmental Management Act, 1998 (Act No. 107 of 1998) and section 74 of the National Environmental Management Waste Act, 2008 (Act No. 59 of 2008) . The application is compiled in accordance with Regulation 4 of the National Exemption Regulations (R.994).

The following environmental Acts are applicable to this project:

- National Environmental Management Act No 107 of 1998 (with reference Section 24M);
- The National Environmental Management Waste Act No 59 of 2008;
- National Water Act No 36 of 1998.

5.2 Ash Classification

The ash was classified in terms of the DEA's waste assessment regulations for disposal to landfill, the ash assessed as a Type 3 waste (low risk waste), which requires disposal on a landfill of which the performance of the barrier system complies with that of a Class C. The outcome of the assessment was the result of the leachable concentrations of boron and chromium VI, and the total concentrations of barium and copper in the ash.

6. DESCRIPTION OF THE RECEIVING ENVIRONMENT

6.1 Surface water

Ecotone Freshwater Consultants were appointed to undertake the freshwater ecology specialist component for the Environmental Impact Assessment (EIA) of the proposed continuous dry ashing at the Tutuka Power Station. This study included a desktop and fieldwork component. Please refer to the {Environmental Impact Assessment for the Proposed Continuous Ashing at the Tutuka Power Station, Mpumalanga Province – (DEA Ref. 14/12/16/3/3/3/52") (2014)}, for a description of the detailed methodology.

The report was consulted again to focus on the proposed area identified for unlined ashing in the compilation of this report. In the following sections a short description of the affected environmental, potential impacts and proposed mitigation is provided.

Figure 3 below shows the proposed area identified and recommended for continued ashing throughout the EIA process (within the Green boundary). The figure also indicates the identified wetlands and seeps and the proposed areas for unlined ashing as part of this application (the Blue shaded areas).

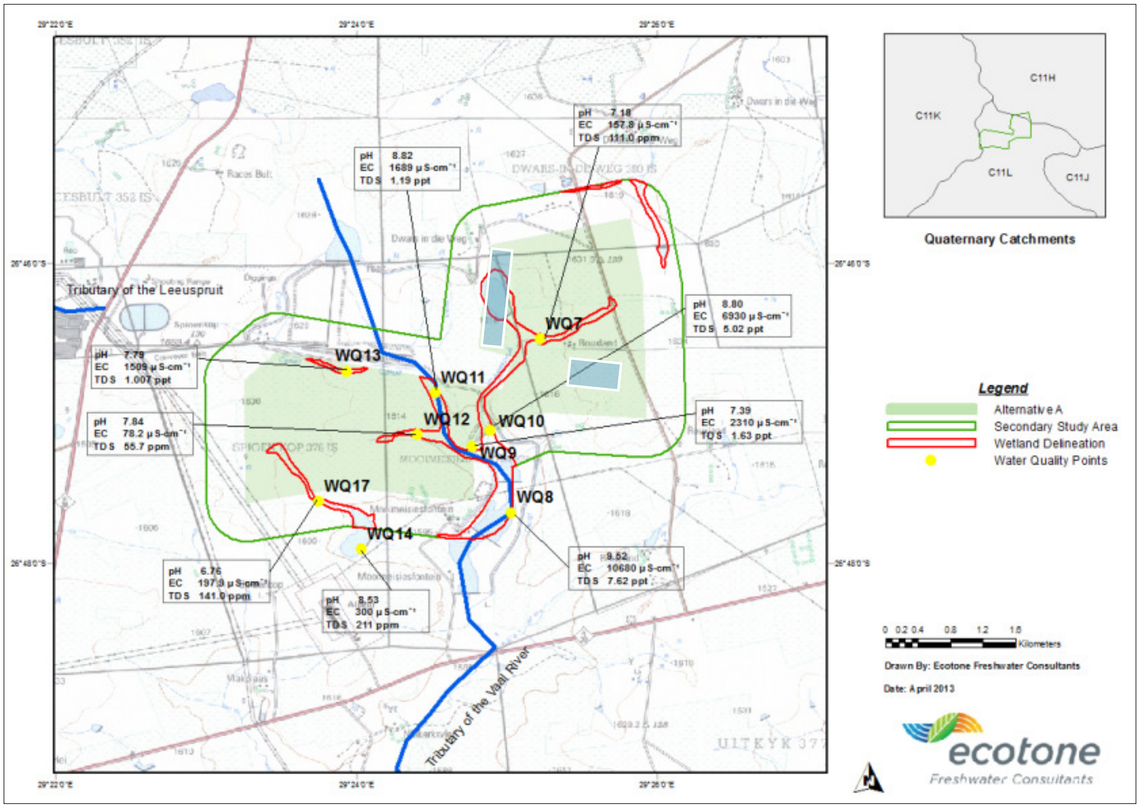


Figure 3. Alternative A that has been identified as the preferred alternative for continuous ashing Tutuka ADF EIA (2014). The figure indicate the approximate areas for the proposed unlined ashing (shaded in blue).

6.1.1 PES (Present Ecological State)

The Present Ecological Status (PES) assessment for Alternative A shows a C-category for wetland 5 and 10, while Wetland 6 fell into an E-category (Table 6.1). The former translates into a Moderately Modified state and the latter implies a **Seriously Modified state** with a substantial departure from natural hydrological state.

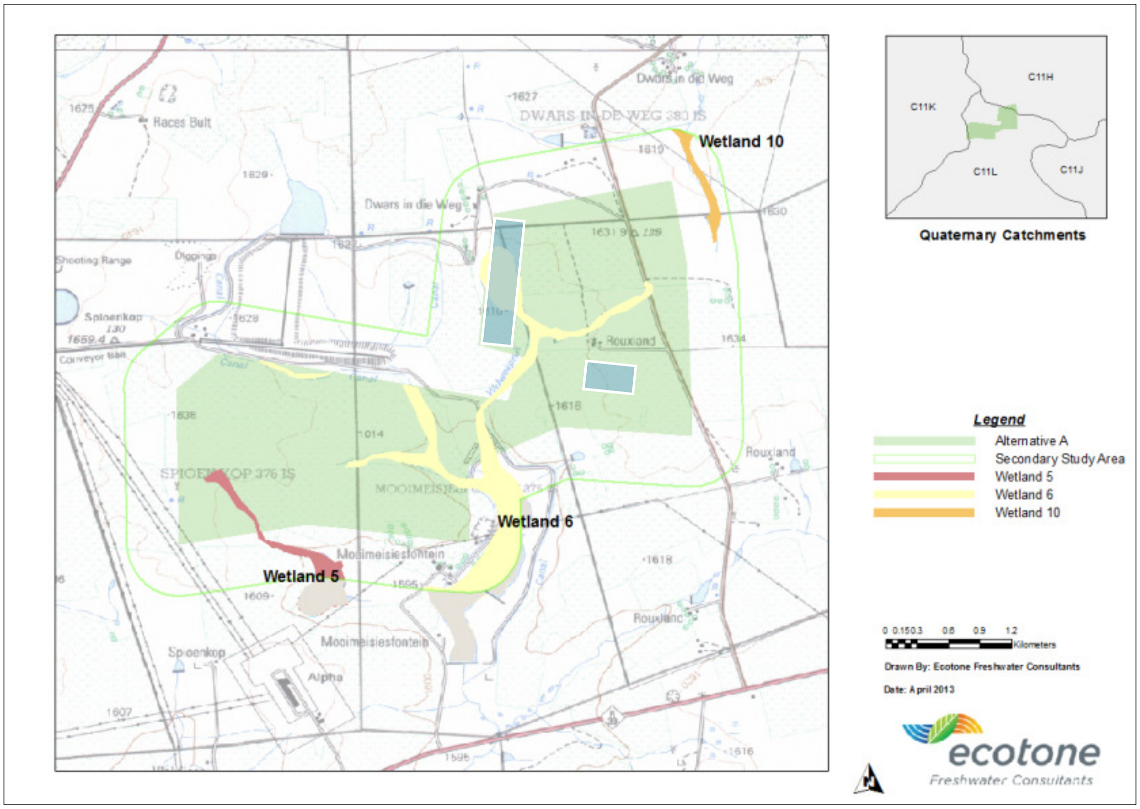


Figure 4. Footprint of Alternative A indicating the extent and location of wetlands 5 and 6, which is the only wetlands that will be affected by the unlined ashing shaded in blue.

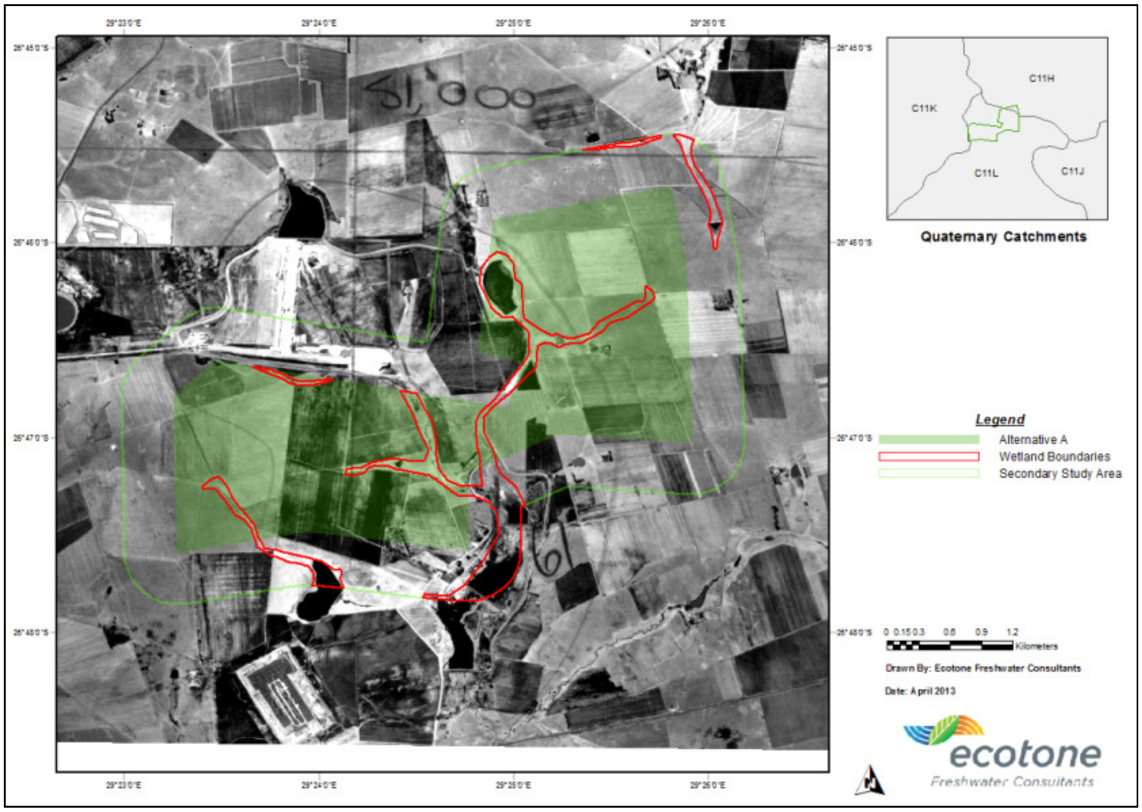


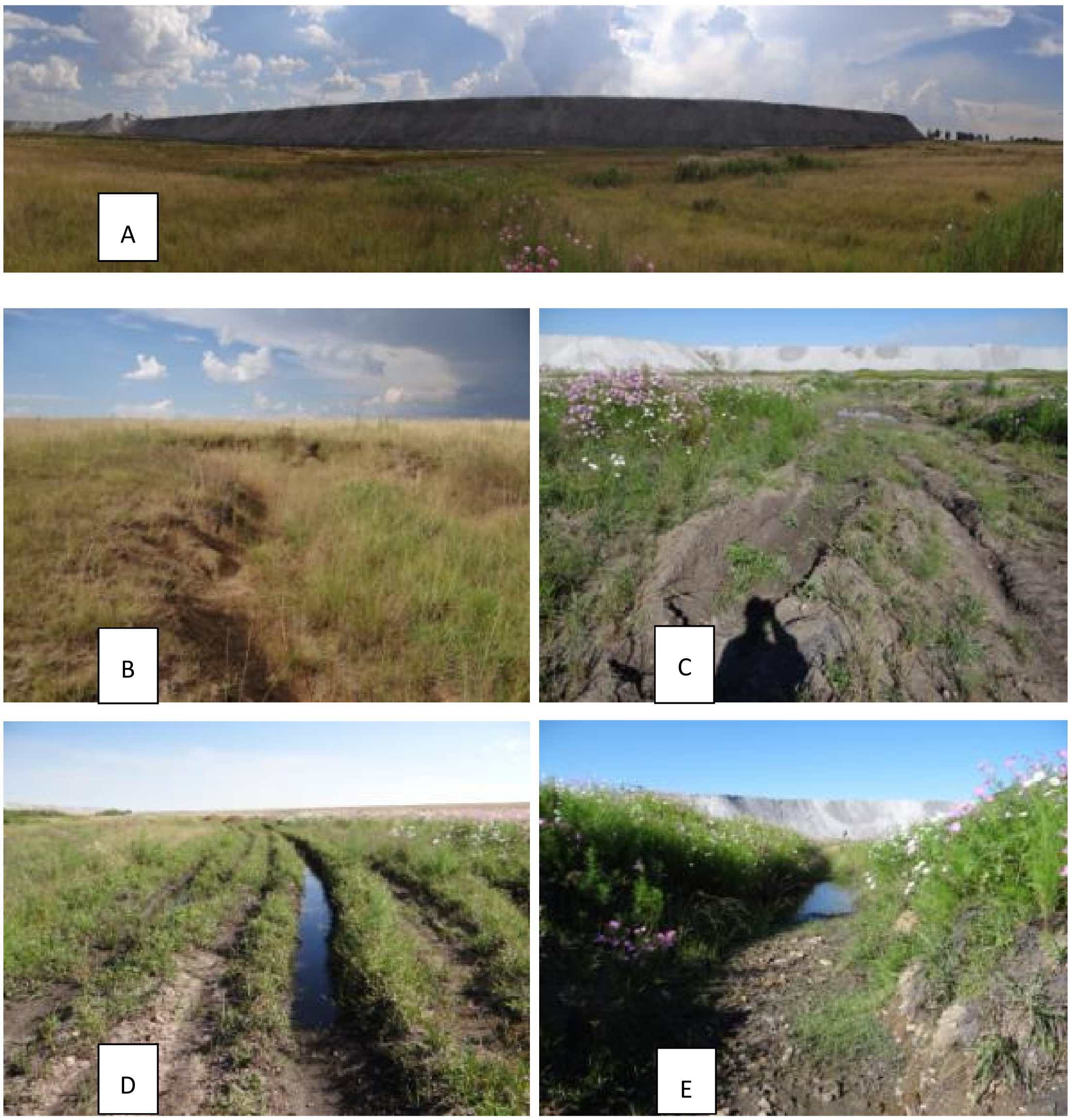
Figure 5. Arial image of the Tutuka ADF and surrounds (1991).

Historical aerial images reflect substantial agricultural activity before 1968. Most of the existing dams and ploughed fields were already visible in the 1968 image. The 1991 image (Figure 5) shows the footprint of the ash disposal facility and its infringement on Wetland 6. Two of its south east tributaries have already been sterilised. A comparison with 2010 aerial image shows an infringement in the upper parts of the same wetland. This infringement along with the following factors resulted in the PES measured:

- Possible increase in flow volumes - large dams located in the lower parts of Wetland 6 were not in existence in 1968. The capacity of these dams in relation to the local catchment yield suggests increased flows.
- An increase in hardened surfaces and subsequent increase in surface runoff characteristics.
- A decrease in surface runoff within the catchment, mostly due to monoculture and chronic soil disturbances of agricultural practices.
- Deep and shallow flooding by dams within highly seasonal systems.
- Impeding features such as inappropriate road crossings and infilling for roads and dam walls resulting in alteration of the horizontal movement of water.
- Decrease in surface roughness within the catchment and within the wetland units.
- Recent deposition of ash within wetland boundaries.
- Recent excavation and infilling, particularly in the northern parts of Wetland 6.

- Large canal structures and a number of drain features, dividing the catchment of Wetland 6.
- Cattle grazing within wetland units further resulted in soil compaction and preferential flow paths, contributing to erosion features.
- Catchment utilisation resulted in poor water quality associated with Wetland 6.

Figures 6 below show some images of Alternative A (Photos A, F and G includes areas under this application).



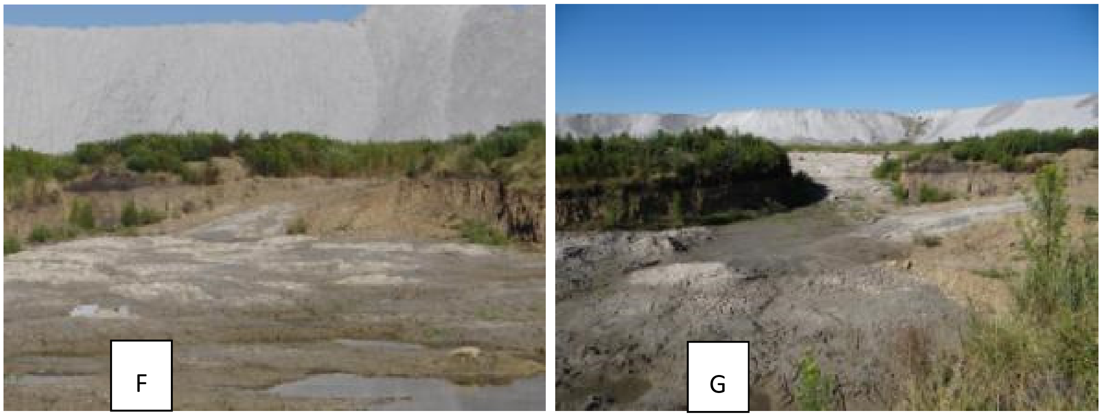


Figure 6: Site Wetland 6 upstream of the Ash Disposal Facility within Alternative A showing (A) panoramic view of the area, (B-E) extensive trenching and (F-G) clearing activities

6.1.2 Vulnerability

As part of the health assessment of wetland units the inherent vulnerability of wetlands should be assessed (Macfarlane, et al., 2009). Erosion and the rate of head-cut erosion are dependent upon many factors (such as soil type, vegetation cover and type, rainfall events etc.) but one of the most critical factors is slope. For any given discharge the steeper the slope the greater the erosion risk. It follows that the slope of a wetland unit in relation to its size provides a measure of its vulnerability (Figure 7). The following section illustrates this relationship for the wetlands at Alternative A, which includes wetlands 5 and 6 as the subject of this application. Wetland 10 is included as a local control. Wetland 6 scored the highest, and its vulnerability state is expressed through its low PES.

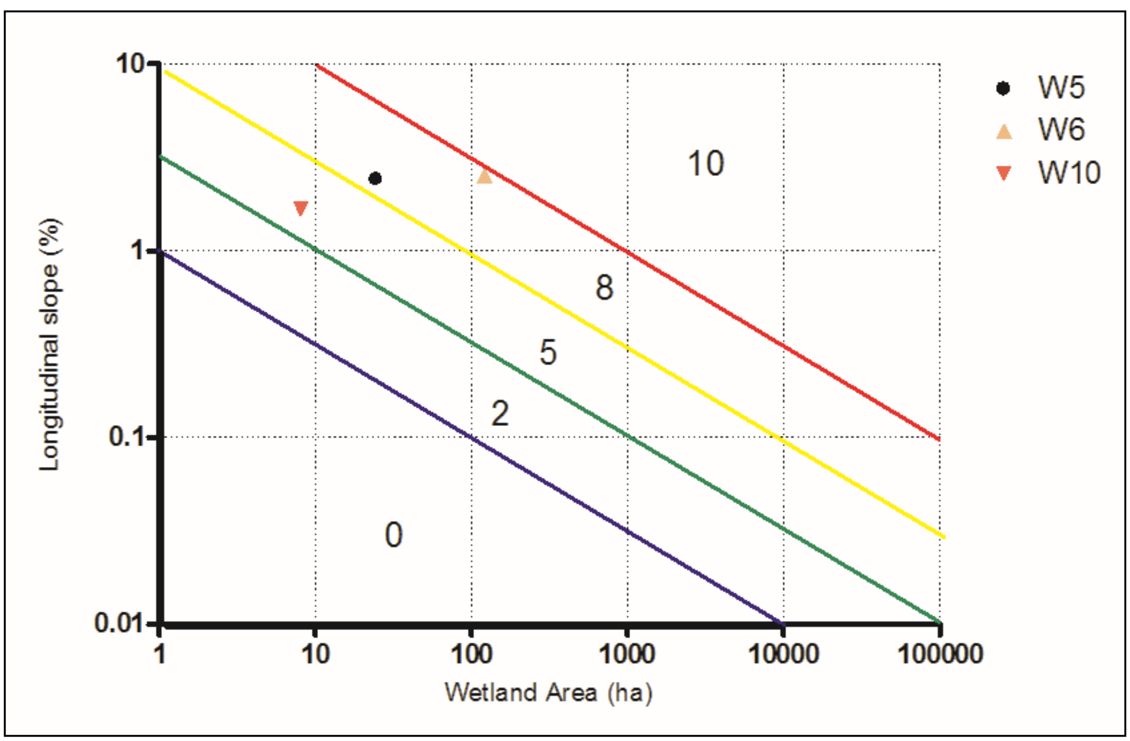


Figure 7. Vulnerability as a function of slope for the affected wetlands at Alternative A.

6.1.3 WET EcoServices: Functional Assessment

These functions would include amongst others functions such as:

- Streamflow regulation
- Water quality maintenance and improvement
- Flood attenuation
- Erosion control and sediment trapping
- Maintenance of biodiversity

Figure 8 indicates the current functional assessment scores for the wetlands on site. This score refers to the number and variety of ecosystem functions (bullet points above) at each wetland. It is clear that Wetland 6 (the proposed area for unlined ashing) are at the lower end of wetland functionality in comparison to the other wetlands.

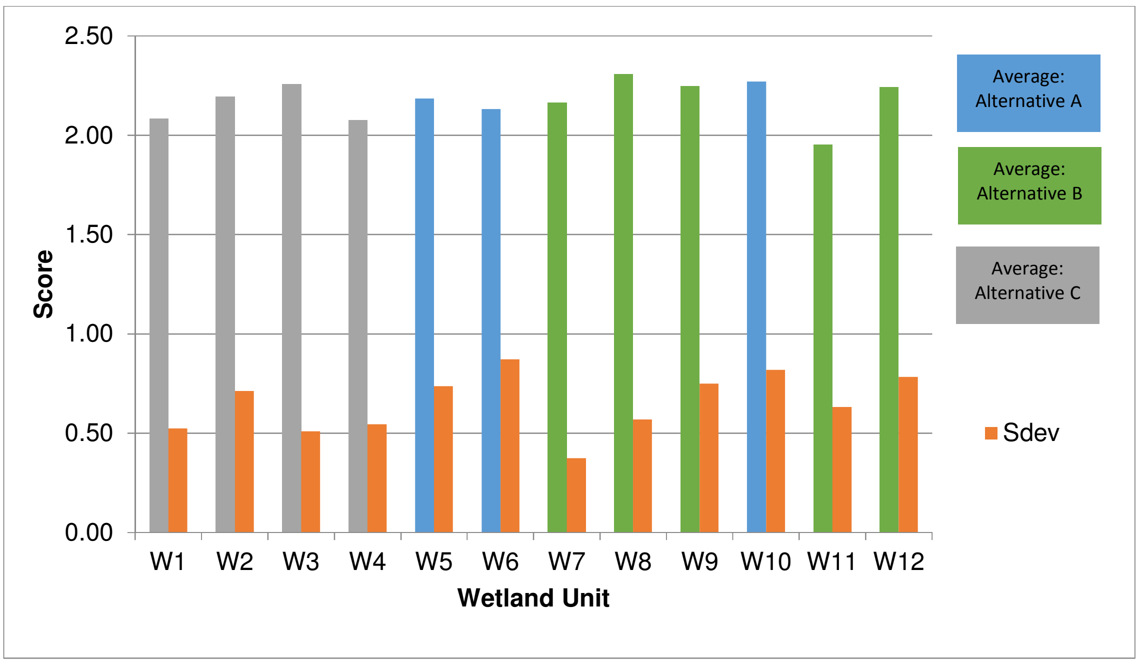


Figure 8. Average overall Ecosystem Service scores per wetland unit

Wetland 6 retains little hydrological integrity and mainly functions as a pollution control facility at the moment (Figure 8).

6.1.4 Cumulative Impacts

Receiving watercourses linked to Alternative A include the Blesbokspruit and the Groot Draai Dam. Wetland 5 drains into the same tributary as Wetland 6 (a tributary of Groot Draai Dam), which reflects a desktop PES of an E-ecological category. The PES for this wetland itself retains a Medium integrity. Wetland 10 eventually drains into the Blesbokspruit which has a desktop PES of C. It follows that a possible commutative risk is greater for the receiving environment of Wetland 10, which retains more integrity and functionality, than it will be for Wetland 5 and 6.

Table 6:1: Provides a summary of the assessment scores for the various wetlands at alternative A.

Alternative A	Wetland 5	Wetland 6	Wetland 10
Total wetland size	24.4	121.55	8.03
% wetland on Alternative		8 %	
Hectare Equivalents		62.92 (ha)	
PES of wetlands	**C**	**E**	**C**
PES of receiving watercourses	**E**	**E**	**C**
Water Quality	Good	Poor	Good
Service Score	2.21	2.16	2.35
EIS		Medium	

The most significant impacts from a wetland perspective are considered to be the loss of wetland habitat that falls within the footprints of the proposed ash disposal facility and the risk of water quality deterioration due to seepage and leakage of pollutants from the facility.

Wetland 6 has been identified as being part of the direct ADF footprint during the EIA and recommended as the preferred site for disposal. The wetland aspects described above will therefore be sacrificed in totality during the life of the power station regardless if it is lined at this stage or not. Wetland 6 also forms part of the area affected by this application. The only remaining significant impact identified during the EIA is the impact to Groundwater, and is described below.

6.2 Groundwater

The geological map for the area, as presented in Figure 9 shows that the site is underlain predominantly by intrusive Karoo Dolerite and the sandstones of the Vryheid Formation.

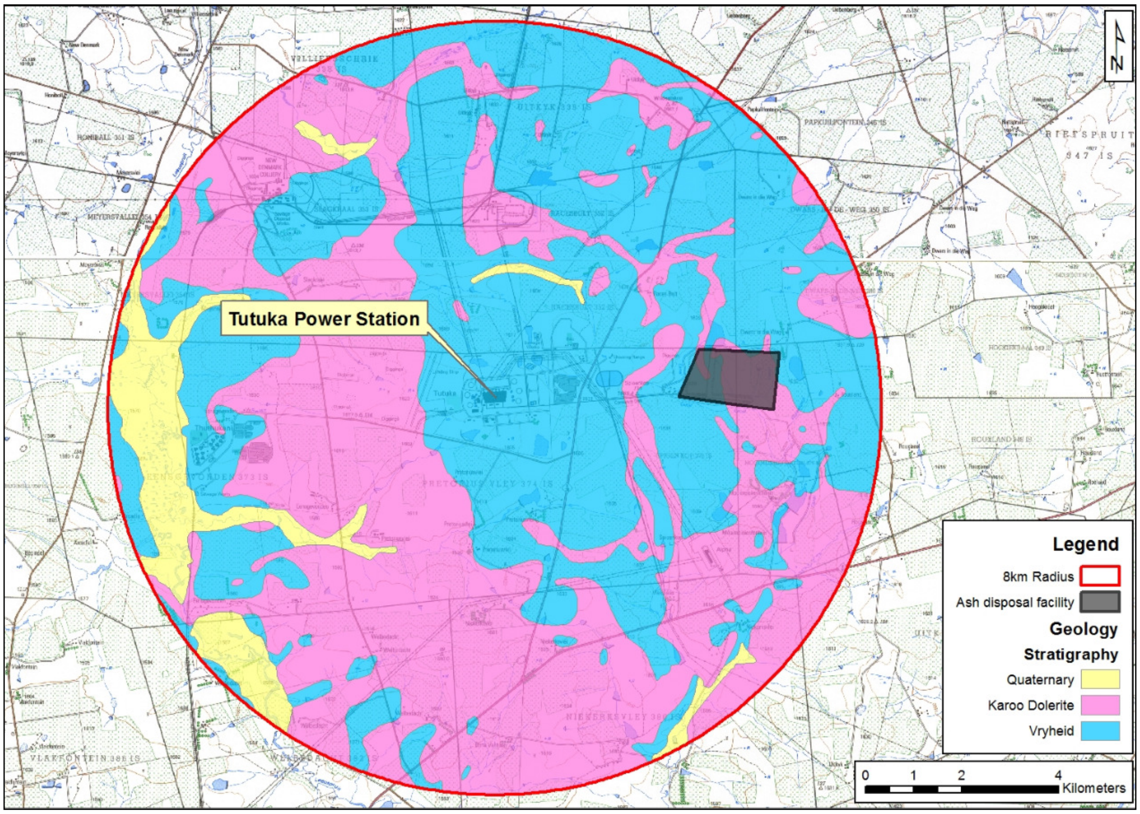


Figure 9. Geological extract of the geological map for the area in the vicinity of Tutuka power station showing the existing ash disposal facility

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 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.

The main impacts on groundwater of the proposed unlined ash disposal facility (which has also been confirmed by evaluating current impacts of the existing facility) are likely to be:

- Deterioration in groundwater quality; and
- Rise in groundwater levels in the immediate vicinity of the ash disposal facility due to additional recharge and groundwater mounding, which may alter the local groundwater flow direction.

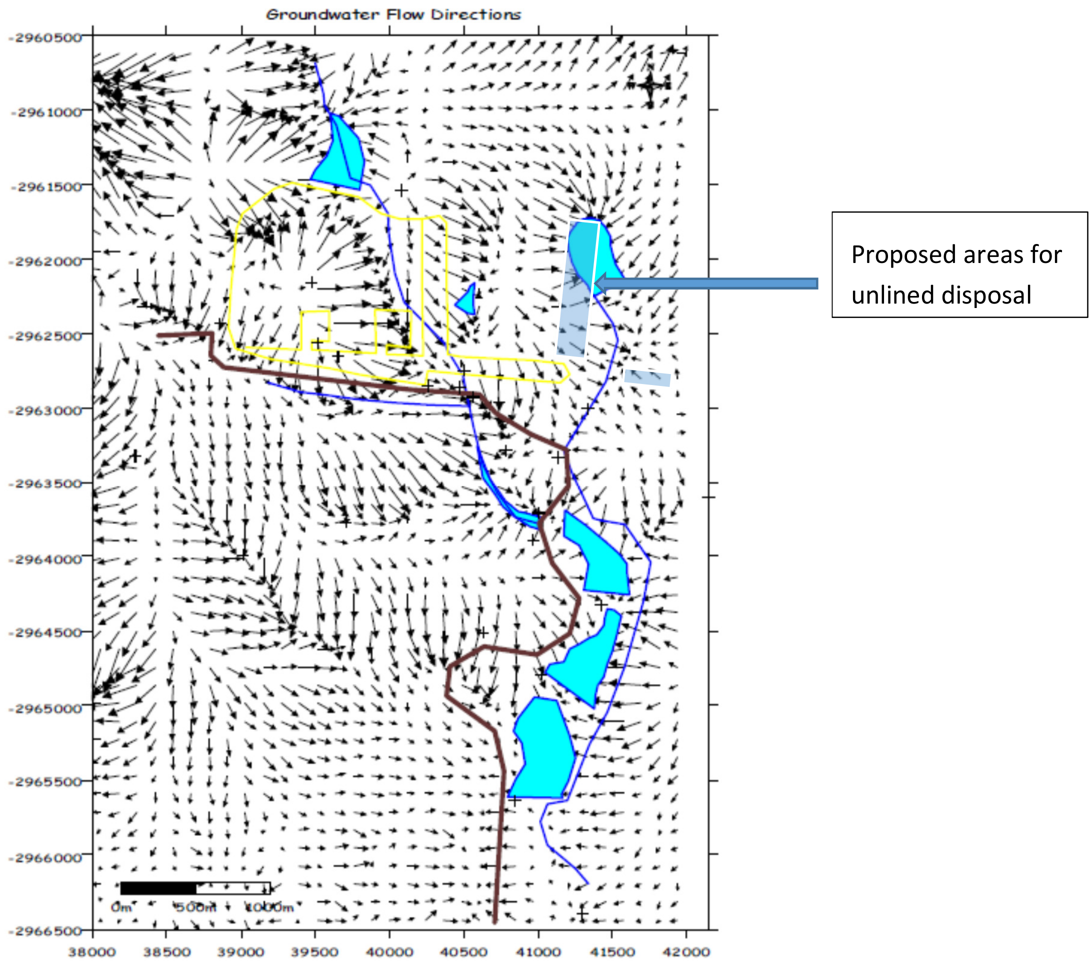


Figure 10. Indicates the directional flow of groundwater underneath the Tutuka ADF (GHT Pollution Plume Model Report, 2007). The highlighted rectangle is next to the current phase where Eskom propose to continue disposal under this application.

From Figure 10 it is evident that the flow at the existing disposal point is towards the seep/wetland area. This might lead to a reduced spread of the pollution plume. Natural attenuation whereby the groundwater quality starts to recover due to recharge as well as due to influx of fresh water is suggested by the movement of the pollution plume underneath the ash stack. Groundwater underneath the older rehabilitated areas seems to improve in the upper aquifer system (GHT Pollution Plume Model Report, 2007).

Figure 11. Modelled impact on groundwater plume five years after deposition starts. Assuming impact on the entire footprint without lining (SLR, 2013).

The numerical model results suggest that the movement of leachate away from the ash disposal facility as a groundwater plume should take place relatively slowly, with plume extents being generally less than 1 km from the ash disposal facility after 100 years.

The reasoning behind the inclusion of the above model as part of this application, is to emphasise the velocity of migration in the aquifers below the facility and not to predict a pollution footprint after 100 years. The above model were based on a full footprint of the total facility (ie. pollution source upon closure), across the site assessed during the EIA phase. The impact of the applied 54 hectares under this application would be much less.

The primary mitigation for this impact is to maintain the ash disposal facility in good condition (especially the drainage system).

Table 6:2. Summary of impacts on groundwater by disposing on Alternative A as identified during the EIA phase with and without the proposed mitigation. Lining has not been considered as mitigation during this assessment.

GROUNDWATER		
Rise in local (area within a 1 km radius of the ADF) water table due to additional recharge caused by ash deposition and possible concentration of recharge	Without	**Medium**
	With	**Low**
Change in local groundwater flow directions due to possible rise in local water table	Without	**Medium**
	With	**Low**
Deterioration of groundwater quality due to leachate from ash disposal facility	Without	**Low**
	With	**Low**
Groundwater contamination in local area due to infiltration from surface water polluted by the ash disposal facility.	Without	**Low**
	With	**Low**
Deterioration of groundwater quality due to spillages of hydrocarbons	Without	**Low**
	With	**Low**

It is clear that the most significant impacts identified by the groundwater studies during the operational phase of the facility, were mostly rated as Low (before and after mitigation) except for the first two. Future lining of the facility will reduce the significance of these impacts even further.

6.3 Social Assessment

A Social Impact Assessment (SIA) was undertaken for the proposed continuous ADF EIA, at Tutuka Power Station. A SIA can be described as the systematic appraisal, before the project commences, of the potential impacts on the day-to-day quality of life of persons and communities when the environment is affected by a development.

Social impacts include all the significant changes in the social environment that take place because of the actions of a development or project, which would not otherwise have occurred. The SIA serves to identify issues that will need to be addressed by avoidance or mitigation, as well as social impacts that cannot be resolved.

The Tutuka power station employs 929 permanent Eskom workers. The majority (95%) of workers reside in Standerton, with the remaining 5% living in Secunda, Bethal and Morgenzon.

Social Impacts identified for the project include:

- Dust;
- Health Impacts as a result of exposure to ash
- Stable jobs; and
- More reliable supply of electricity;

In the case of this application, no large communities are affected in a different way than they already are affected by the existing ADF over many years. This in essence means that no measurable change or social impact is expected when Eskom continues its proposed ash disposal operations as normal to accommodate for ash disposal for the 4-year period.

Although there are not many potential social impacts that can occur as a result of ashing on unlined surface for the 4-year period (as this is a proposed continuation of an already existing waste facility, that is not lined), the impacts, if they do occur, will not be severe. It is, however, still imperative that mitigation measures are implemented to prevent any negative impacts from occurring.

The following mitigation measures are recommended:

- Because any health and/or social impacts that occur will be as a result of negative environmental impacts (water pollution and/or air pollution), all potential environmental impacts need to be mitigated to prevent any of these environmental impacts from occurring.
- Measures to prevent risks to people, animals and land must be put in place and adhered to.
- Water quality from boreholes is important to adjacent farmers and precautions should be taken to keep the quality to an acceptable standard.
- A zero liquid effluent discharge policy, in place, must be complied with.
- Adequate safeguards must be in place to prevent air pollution.
- Low nuisance dust levels must be maintained by means of dust suppression.
- The ash disposal facility should not be within 1.5km of any people living downwind of the area.
- Employees must use appropriate protective clothing and/or equipment.

7. PROPOSED MITIGATION AND MANAGEMENT MEASURES

For surface water pollution control, the existing east and south perimeter canals will be extended to allow the dirty storm water from the open ash areas and surroundings to flow back to the existing pollution control dams in the south. New drainage systems will be installed to allow for storm water drainage via the existing drainage pipes under the current standby ash dump to lead the water flows to the south dirty water dam.

For ground water pollution control, while it will only be possible to provide the Class C plastic/clay composite liner from the point where the ash dump will be in 4-years from IEA, in the period from IEA acquisition and liner installation, the ground will be compacted after stripping of the topsoil in order to reduce its permeability.

The EMPr for the EIA process considered the possibility of an exemption application for a temporary period up to 4 years from acquisition of IEA. The EMPr, remaining IEA and the IWUL conditions should be followed. The onsite monitoring plan should be revised and updated to accommodate the new requirements.

Other measures that will be implemented include:

- Topsoil will be recovered from in front of the advancing ash face before it is covered by ash. Once stripped the topsoil shall be utilised for rehabilitation purposes.
- Ensuring that any systems for the draining of leachates and / or supernatant water from the ash disposal facility are installed correctly.
- Under-drain systems should be checked for integrity once they have been completed.
- Systems for removing or preventing blockages (e.g. rodding eyes, water traps) must be installed correctly as blocked under-drains can cause leaks, and lead to additional groundwater pollution.
- Intensive groundwater and surface water monitoring regimes;
- All work should be supervised by a suitably qualified professional.

8. CONCLUSION

It is predicted that the mostly localised impacts on surface water and groundwater currently experienced will continue for the duration in which ash disposal occurs on an unlined facility (54ha). Wetland functionality will be lost for the wetlands at Alternative A, irrespective of the proposed lining regime.

The groundwater model referred to in this report did not account for a liner in an attempt to illustrate a worst case scenario. The model is therefore a good reflection of the plume migration in the unlined state. According to this model the plume will migrate 1km (distance of the closest privately owned borehole from the boundary of the facility) in 100 years, should unlined disposal continue. Table 2 shows that the groundwater specialist consider the (current/unlined) impacts mostly insignificant during the operational phase (considered the phase with the highest level of impacts).

Current monitoring results indicate that the existing ash disposal facility has impacted upon the water quality of both the shallow and deeper aquifer system, however, the plume is localised in the vicinity below the current ash disposal facility, and the existing surface water dams which contain water from the ADF. It has also been shown that the infiltration is assumed to be low as a result of the geology of the area. All of the above are physical factors that might reduce the expected environmental impacts during the concession period.

In practice the current status quo and level of deterioration on the site will be maintained until such time that the liner can be integrated in the operations. For the interim it is crucial that all possible mitigation measures (Section 7 & EMPr) are implemented and maintained to their full extent, at least until the liner is in place.

It is important to emphasise that there are no environmental benefits in granting this exemption. The predicted environmental costs described above will be in line with the existing status quo for the exemption period. **In the absence of a more acceptable triple bottom line alternative it is the opinion of the EAP that the Social and Economical advantage of allowing unlined ashing for the next four years outweigh the Environmental cost described above**.

The continuous running of Tutuka Power Station ensures that workers at the Tutuka power station will keep their jobs. This in essence means that there will not be any negative impacts on the local economy or society.

The granting of this application will also ensure that Eskom (Tutuka Power station) continue to supply electricity to the national grid. This is of high importance especially with the national grid currently being under tremendous pressure. This application will therefore prevent any additional negative impacts on the national economy. No social or economic costs are predicted on the local, regional or national population as a result of the projected environmental impacts discussed in this report.

9. REFERENCES

Lidwala Consulting Engineers (SA) (Pty) Ltd (2014) Environmental Impact Assessment for the proposed continuous ashing at the Tutuka Power Station, EIA Report

SLR Global Environmental Solutions (2014) Proposed Continuous Ash Disposal at Tutuka Power Station, Groundwater Specialist Study, SLR Project No.: 721.23003.00014, Report No.: 2, Revision No. 1

Ecotone Freshwater Consultants (2014) Proposed Continuous Ash Disposal Facility at the Tutuka Power Station, Aquatic Specialist Study, Environmental Impact Assessment, Final