# ESKOM

# GEOLOGICAL DESK STUDY REPORT FOR THE EIA FOR THE PROPOSED WITBANK AREA POWER STATION AND RELATED INFRASTRUCTURE

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**Report No: 4225/401281**
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## DOCUMENT CONTROL SHEET

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## Synopsis

Two sites, designated Site "X" and Site "Y" were identified at the end of a screening process held in July 2006 as those to be taken forward to the Scoping stage of the Environmental Impact Assessment.

Both sites are situated broadly in the area that is bounded by the N4 Highway in the north, the N12 Highway to the south, the R545 Road to the east and various farm boundaries to the west. Site "X" (about 5000 ha), lies just north east of Site "Y" (about 2500 ha).

The geotechnical study has been based on a desk study review of all known available reports and mapping and the collation of the data therein. The objectives were to identify the significance of potential geotechnical constraints, if any, to the proposed power station and infrastructure at each site, propose mitigation measures that could reduce or eliminate identified constraints and offer an opinion on which of the two sites would be preferable from a geological / geotechnical perspective.

The area wherein the sites are situated occurs in the more humid eastern part of the country, with a predominantly chemical weathering mode. Rainfall occurs during the hot summer months, the winter months are cold / mild and dry.

The regional geology comprises several geological sequences. These include, from oldest to youngest, the Transvaal Supergroup sedimentary quartzites / shales, the Loskop Formation, tholitic lavas, sedimentary rocks of the Karoo Supergroup and the Transvaal diabase which is intruded into all horizons of the Transvaal Supergroup. Rocks of the Bushveld Complex also occur.

The detailed geology of Site X is discussed. This has fairly uniform geology, with the Rayton Formation shales (Vr) outcroping at surface in places in the central portion of the site as well as to the north. There is little or no rock visible on surface to the south, but the soils are likely to be clayey and occur to some depth. There are no recorded major faults or lineations crossing the site. From published Seismic-Hazard Maps the site lies in a region with a peak ground acceleration (g) of about 0.13 with a 10% probability of being exceeded on a 50 year period.

Site Y has more complex geology. The Loskop Formation lavas appear in the southern area, together with igneous rocks of the Bushveld Igneous Complex. Generally these sequences do not exhibit rock outcrops at surface. Quartzites of the Silverton Formation are very hard and resistant to weathering, and a number of outcrops were noted. The northern part of the site is dominated by extensive diabase sills that have been intruded into the Silverton Formation shales. There are no recorded major faults or lineations crossing the site. It has a seismic hazard rating similar to that of Site X.

The main conclusion was reached that there are no known obvious geological constraints to the development of a power station and infrastructure on either of the sites.

The recommendation is made that the Site X would be preferable from a geological / geotechnical perspective, and the fact that it is in closer proximity to coal supplies.

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APPENDICES

# 1. INTRODUCTION

## 1.1 Terms of Reference

Ninham Shand was appointed by Eskom to carry out an Environmental Impact Assessment (EIA) for the site for the proposed coal-fired power station and the related infrastructure in the Witbank geographical area.

Initially the two sites that had been identified by Eskom were the subject of a reconnaissance site visit on 09 March 2006. Subsequent to this there was a further site screening inspection visit and workshop held on 10 and 11 July 2006. The outcome from the screening process was the identification of the current Sites “X” and Site “Y” to be taken forward to the Scoping stage.

## 1.2 Objectives

The objectives of the specialist geotechnical input are:

a) Undertake a desktop study of existing geological and geotechnical information, including published maps, data and aerial photography,

b) Identify and assess the significance of potential geotechnical constraints to the proposed power station and infrastructure at each of the two alternative sites,

c) Propose mitigation measures that could reduce or eliminate identified constraints,

d) Describe how the existing geological conditions at each site could benefit the proposed project e.g. with respect to ash dump sites and groundwater contamination etc.

e) Offer an opinion on which of the two sites would be preferable from a geological / geotechnical perspective.

f) Prepare this report of findings, conclusions and recommendations

Liaison with Eskom personnel to gather data, and with groundwater specialist, Mr Mark Stewart of GCS took place during the execution of the work to supplement the study.

## 1.3 Scope of Work

The report summarises a review of available geotechnical literature for the two areas under consideration.

- A desk study of all known available reports and mapping and the collation of the data therein
- Utilisation of the Ninham Shand knowledge of the area
- Acquisition of known published geological / engineering geological data of the areas of interest, including topocadastral and geological survey maps
- Discussions with Ms Estelle Grobler of the Map Library at the Council for Geoscience, Pretoria and a data search to obtain relevant maps and reports.
- Discussion with Mr Peter Roberts of Anglo Coal regarding updated information on probable mining areas.

- Telephonic discussions with Mr Suren Rajaruthnam of Eskom regarding any available information on ground conditions and the as built foundations at the old Wilge Power Station
- Discussions with Mr Mark Stewart of GCS on positions of existing boreholes etc in the area of interest.
- Telephonic discussion with Mr Martin Brand of the Seismology Unit of the Council for Geoscience, Pretoria
- A site walkover visit on 08 September 2006 and discussions with farmers / landowners.

### 1.4 Sources of Information

#### 1.4.1 Mapping and Aerial Photography

- Probabilistic Seismic-Hazard Maps for South Africa, Version 1, dated 2003. Council for Geoscience.
- Two 1:50 000 topographical maps, namely 2528DD BALMORAL and 2628BB KENDAL
- Unpublished geological mapping Field-sheet of the Council for Geoscience 2528DD BALMORAL completed by PG Schutte, dated 18-12-1990.
- Unpublished geological mapping Field-sheet of the Council for Geoscience 2628BB KENDAL completed by PG Schutte, dated 18-12-1990.
- Published Geological Series map 2628 EAST RAND and 2528 PRETORIA

  at 1:250 000 scale

#### 1.4.2 Reports

- No reports on the previous foundation conditions of the demolished Wilge Power Station could be sourced.
- The Section 5: Geology, taken from the AngloCoal New Largo Report to Eskom, dated May 2006.

## 2. REGIONAL GEOLOGY OF THE AREA OF BOTH SITES

The lithology of the area comprises several geological sequences. The oldest rocks are the sedimentary rocks comprising the Transvaal Supergroup, Pretoria Group, Silverton (shales), Magaliesberg (quartzites) and Rayton (quartzites, shales and subgreywacke) Formations.

The Loskop Formation, comprises tholitic lavas and other igneous or altered sedimentary rocks, including quartz porphyry, rhyolite, dacite, quartzite and tholitic lava.

Overlying the Transvaal Supergroup are the sedimentary rocks of the Karoo Supergroup, Dwyka Group (tillites, shale), the Ecca Group (shales, sandstones, conglomerates and coal beds in places near the base and the top).

The other dominant rock type is the rocks collectively referred to as the Transvaal diabase. These are probably related to an early intrusive phase of the Bushveld Complex. They are intrusive into all horizons of the Transvaal Supergroup, and are particularly prolific in the strata of the Pretoria Group. The diabase sills can vary in thickness from 1m to >300m, occurring characteristically at the contact between the shales and quartzites. Because chemical decomposition is relatively far advanced in these warm humid areas, relatively deep residual soils can be expected.

The rocks of the Bushveld Complex - the Rustenburg Layered Suite (the anorthosites, gabbros and norites of the Critical, Main and Upper Zones), the Rashoop Granophyre Suite (granophyres and pseudogranophyres) and the Lebowa Granite Suite (medium to coarse grained, pink or grey granite and porphritic granite) also occur.

## 3. THE SITE DESIGNATED "X"

### 3.1 Location

The area under consideration is located on 10 farms. It extends for about 5 km in an east-west direction, and 10 km in a north-south direction and covers about 5000 hectares.

The site is bounded on the north (virtually) by the N4 Highway and to the south by certain farm boundaries. The eastern boundary runs approximately 2 km from, but parallel to, the R545 Road. The western boundary is delineated by various Eskom power lines. See Locality Plan Figure 1.

### 3.2 Land Ownership

Detailed research into land ownership forms the basis of a separate study. However, from discussion with the project team and information provided, it was established that the area comprises solely privately owned land, namely individuals or Anglo Coal.

### 3.3 Present Land Use

#### 3.3.1 Mining and undermining

From information supplied by Anglo Coal it can be seen that the western edge of the closest coal field (to be developed to supply coal to the proposed power station) co-incides approximately with the site's eastern boundary. The extent of Anglo Coal's coal rights is shown on Drawing No 401281 GE 01 in Appendix B. It was ascertained from the Environmentalist of Anglo Coal, Mr P Roberts, that the site area is not undermined.

#### 3.3.2 Developed areas (residential and other)

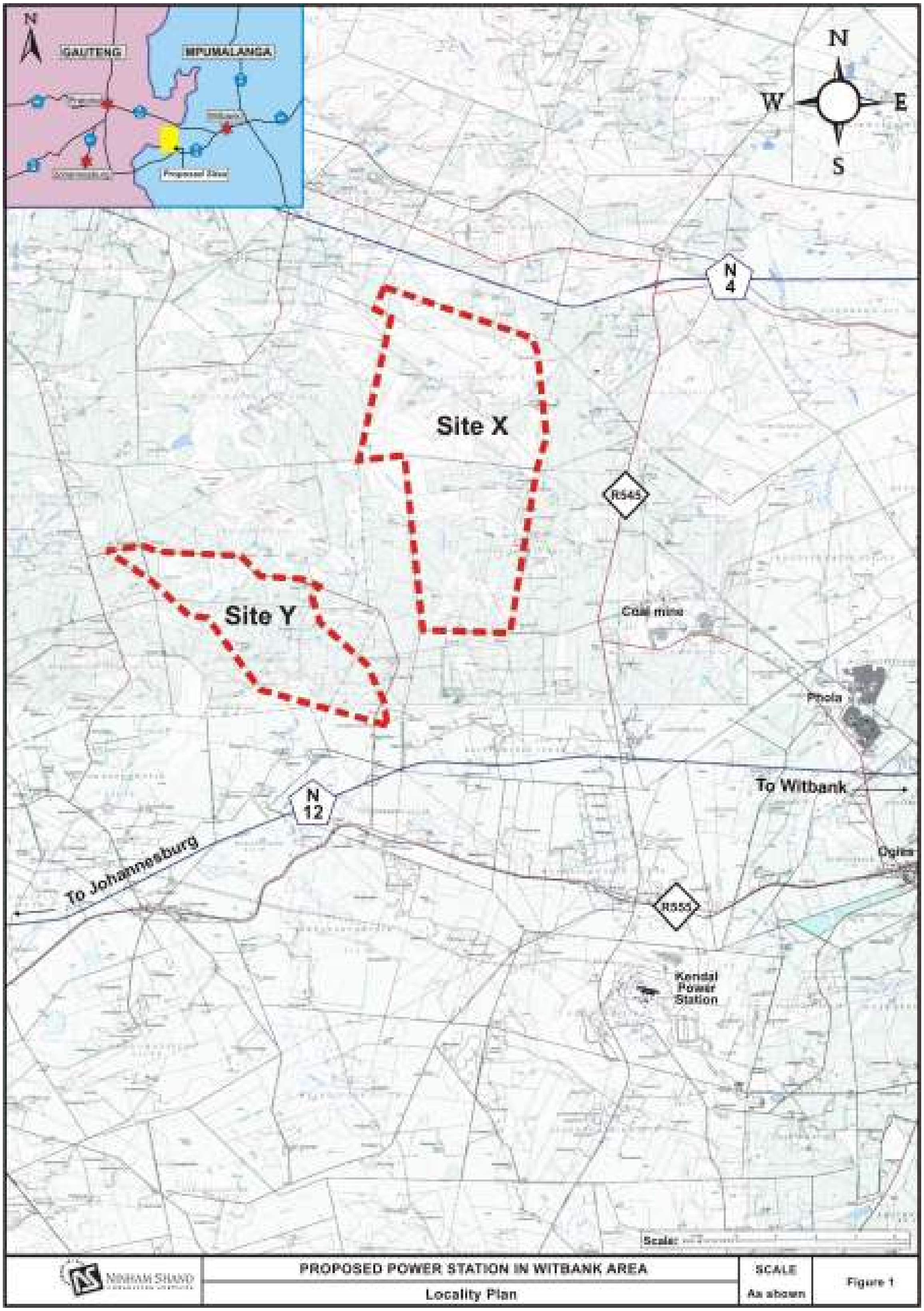
The only developments are individual farmhouses and labourers' accommodation etc related to farming activities.

#### 3.3.3 Agriculture

The site area comprises agricultural land, predominantly grasslands and some cattle farming.

#### 3.3.4 Marshy areas and pans

There are some marshy area, but generally associated with the recognized defined water courses. No pans were identified as part of this study.


GAUTENG
MPUMALANGA
Proposed Sites
N
W
E
S
N 4
Site X
R545
Site Y
Coal mine
Phola
To Witbank
N 12
To Johannesburg
Ogies
R555
Kendal Power Station
Scale:
NINHAM SHAND
PROPOSED POWER STATION IN WITBANK AREA
Locality Plan
SCALE
As shown
Figure 1

## 3.4 Climate and Topography

The area occurs in the more humid eastern part of the country within the zone with a Weinert's N-value <5. (ref. No 5).

This Weinerts climatic N-value is calculated from climatic data, namely E= Evaporation during January and Pa =annual precipitation, using the formula $N = \frac{12.E_j}{P_a}$

It has been demonstrated that mechanical disintegration is the predominant mode of rock weathering in areas where climatic N-value is greater than 5, whereas chemical decomposition predominates where the N-value is less than 5. The climatic N-value equal to 5 has been plotted for southern Africa, and is used as the reference.

From this very broad generalizations can be made about the chemical weathering mode and the soil profile. The residual soils can be more deeply developed, transported soils shallow and pedocretes, where present, are likely to be in the form of ferricretes. Rainfall occurs during the hot summer months. The winter months are cold / mild and dry.

The area is fairly flat and generally lies at an altitude of between 1500m in the east and 1440m in the west.

## 3.5 Geology of the Site

### 3.5.1 Subsurface Geological Conditions

A geological plan of the region has been compiled, based on mapping completed by the Council for Geoscience (see Drawing No 401281 GE 01 in ***Appendix B)***. A site walkover was conducted on 08 September 2006. Some photographs illustrating portions of the site are found in ***Appendix A***.

A simplified plan (Figure 2) shows what the basic layout of the main elements of the power station (PS), the coal stockpile (CS) and the ash dump (AD) might be, though this is in no way fixed at this stage.

Without conducting any on site investigation (borehole drilling, test pitting, laboratory testing of soils etc) at this stage, the following ground conditions are expected:

1. Very little or no rock outcrop is expected on the Dwyka shales (C-pd) in the southern and western portions. The soils here will tend to be clayey, with rock at some depth.
2. The Rayton Formation shales (Vr) outcrop at surface in places in the central portion of the site as well as to the north. It has been recorded that bedding planes in these shales can be very smooth and even. Depending on the angle of dip in relation to the excavations, this can cause instability with slip occurring along the direction of dip.
3. The intrusive diabase sills (di) are expected to be weathered to greater depth than the shales.
4. There are no recorded major faults or lineations crossing the site.

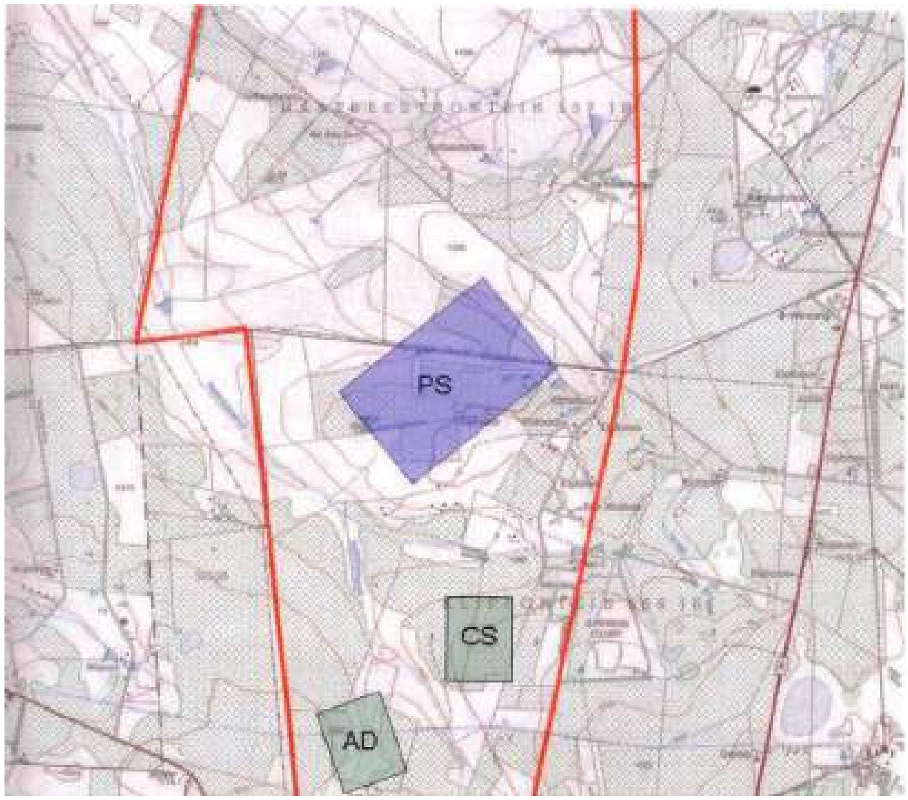



Figure 2

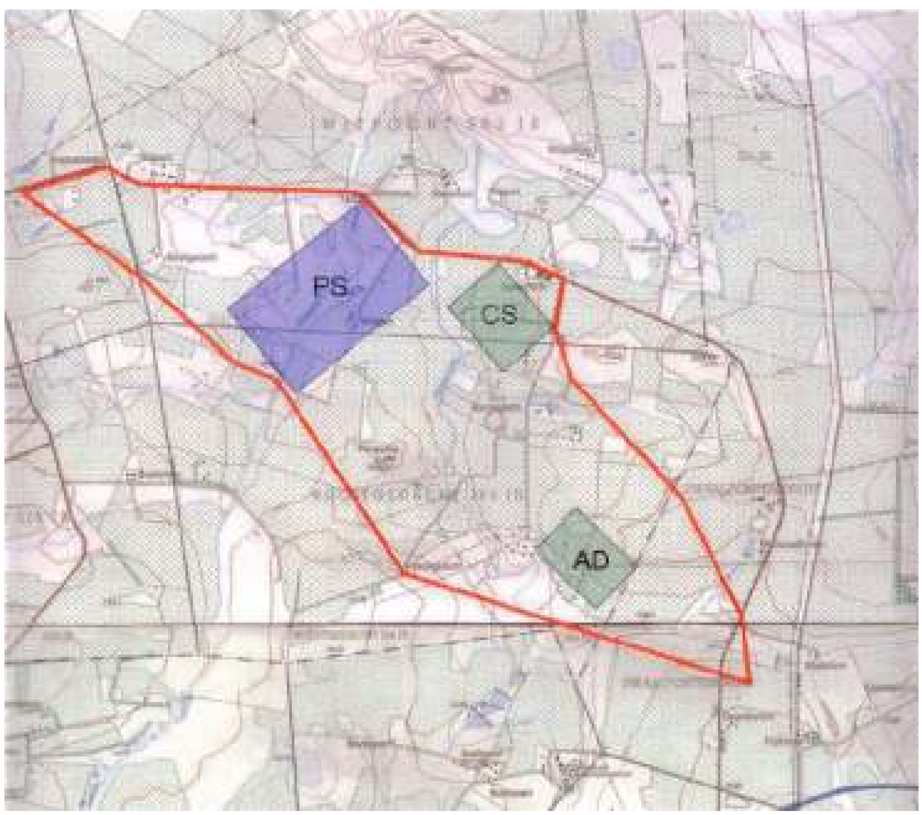



Figure 3

### 3.5.2 Geohydrology

The geohydrological study is the subject of a separate report. However, a few summary points are made here, after consultation with Mr Mark Stewart of Groundwater Consulting Services.

(a) The predominant drainage waterways in the south are:

The Klipfonteinspruit that flows in a roughly east to west direction. It has two dams situated on it. This is joined by the small Holfonteinspruit that flows in a northerly direction.

(b) In the north there are tributaries and streams which flow in a westerly direction to join the Wilge river. A total of six or more dams / weirs are situated on these.

There is groundwater use in this area, and also spring capture for domestic use. From discussions with a few farmers it appears it is of an acceptable quality.

### 3.5.3 Seismic Hazard

(a) Background

By way of definition, seismic hazard can be described as being the physical effects of an earthquake. Such phenomena include surface faulting, ground shaking and liquefaction. In the southern African region it has been shown that two types of seismic events occur, both in space and time, namely natural earthquakes and mine tremors (associated with local mining activity). The seismic hazard maps referenced here have been compiled for southern Africa, and give an overview of seismic hazard for a particular region.

(b) From the Probabilistic Seismic-Hazard Maps the site lies in a region with a peak ground acceleration (g) of about 0.13 with a 10% probability of being exceeded a 50 year period.

The seismic activity occurring in the greater area of interest for the proposed power station would mostly be associated with local mining activity (e.g. stope closure underground). There is no severe probability of such activity on the site. However, at design stage, the appropriate “earthquake” base factors are used in structural design calculations.

## 3.6 Geotechnical Suitability / Constraints

The indicative positions of elements of the power station development in Figure 2 are used as reference in the discussion points below. However, should these positions move, (as they most likely will if considerations other than purely geology are taken into account) the mapping does cover the entire site and reasonable assumptions can be made for alternative positions.

1. There are no known obvious geological constraints to the development of a power station and infrastructure on this site.
2. The potential siting of the main power station in the middle of the area under review is fairly optimal as it would be over an area where rock would be found at shallow depth dipping gently to the centre of the area at about 10 to 20 degrees.
3. The areas to the south, where the ash dump and coal stockpile might be positioned, has a uniform geology (shales/tillite). More clayey impervious soils are to be encountered at surface. This would be a positive mitigating factor against groundwater contamination etc.

4. The most northern section also has favourable geology for foundations (shallow rock etc, but streams dissect the area, and the topography is not so uniform.
5. It can be seen that this site is in immediate proximity (but just to the west) of the coalfields that would be developed to feed the power station. It is planned to mine the north of the coalfield first, from west to east as an open strip mine. There would be no sterilization of coal resources by this power station development.
6. Some grassland areas would be taken up by this development.

## 4. THE SITE DESIGNATED "Y"

### 4.1 Location

The elongated area under consideration lies south west of Site "X", and is located on 7 farms. It extends for about 10 m in a north east- south west direction, and for 3 km on its short axis, covering about 2500 hectares.

The roads N12 to the south and the Arbor/Dwarsfontein road form very rough identifying boundary features to the south, east and north respectively. See Locality Plan Figure 1.

### 4.2 Land Ownership

Detailed research into land ownership forms the basis of a separate study. However, from discussion with the project team and information provided, it was established that the area comprises solely privately owned land.

### 4.3 Present Land Use

#### 4.3.1 Mining and undermining

There is an indication of some small scale mining of economic minerals (e.g lead-zinc veins) to the south and west of the site. However no signs of mining were picked up during the site walkover. The area is not underlain by any of the coal-bearing geological strata.

#### 4.3.2 Developed areas (residential and other)

The obvious developments are individual farmhouses and labourers' accommodation etc related to farming activities. On the most north easterly boundary is situated the Sterley Farms, which appear to be chicken rearing / broiler type structures.

#### 4.3.3 Agriculture

The site area comprises agricultural land, predominantly grasslands and some cattle farming.

#### 4.3.4 Marshy areas and pans

The Wilge river runs through the site in a northerly direction. No real pans or marshes were noted.

### 4.4 Climate and Topography

As for Site "X" the area occurs in the more humid eastern part of the country within the zone with a Weinert's N-value <5. (Ref. No 5). Similar broad generalizations can be made about weathering and the soil profile, namely that the residual soils can be more deeply developed, transported soils shallow and pedocretes, where present, are likely to be in the form of ferricretes. Rainfall occurs during the hot summer months. The winter months are cold / mild and dry.

The area is fairly undulating, but generally lies at an altitude of about 1500m. In the central portion the Wilge river lies at about 1440m. The Perskekop is a prominent koppie, with an altitude of 1496m.

### 4.5 Geology of the Site

4.5.1 <u>Subsurface Geological Conditions</u>

A geological plan, of the region has been compiled, based on mapping completed by the Council for Geoscience (see Drawing No 401281 GE 01 in ***Appendix B)***. It can be seen that the area is underlain by several geological sequences. A site walkover was conducted on 08 September 2006. Some photographs illustrating portions of the site are found in ***Appendix A***.

A simplified plan (Figure 3) shows what the basic layout of the main elements of the power station (PS), the coal stockpile (CS) and the ash dump (AD) might be, though this is in no way fixed at this stage.

Without conducting any on-site investigation (borehole drilling, test pitting, laboratory testing of soils etc) at this stage, the following ground conditions are expected:

1. The geology of this site is more complex than that of Site X. The Loskop Formation lavas (Vl) appear in the southern area, together with igneous rocks of the Bushveld Igneous Complex Upper (Vu) and Main Zone (Vg) of the Rustenburg Layered Suite. These comprise gabbros, diorite, quartz gabbro and pyroxenite with magnetite bands and norites.
2. There is little evidence of rock outcrop of these igneous rocks on the site. However, they can exhibit the development of hard rock corestones in an otherwise possibly fairly deeply weathered residual soil profile (see photo for example and section 4.4).
3. The quartzites of the Silverton Formation (Vsik) are very hard and resistant to weathering. Quite a number of outcrops were noted in the fields.
4. Quite a broad band through the middle of the site has been mapped as "surface deposits" (Q2). Where inspected these appeared to be rich brown soils, possible some of alluvial and colluvial origin.
5. The northern part of the site is dominated by extensive diabase sills (di) that have been intruded into the Silverton Formation shales. This portion of the site is more flat and appears more high-lying and without rock at surface. Because of advanced chemical decomposition, relatively deep residual soils can be expected.
6. An exposure of these shales was visible in a road cutting just west of the Wilge river bridge on the north edge of the site. It is a medium weathered, closely joined soft rock.
7. As one approaches the southern edge of the diabase from the north, the area become quite rocky, with numerous outcrops visible (see photos).

8. Diabase and quartzite rock, if fairly unweathered, could be utilized as construction materials.
9. There are no recorded major faults or lineations crossing the site.

#### 4.5.2 Geohydrology

The geohydrological study is the subject of a separate report. However, a few summary points are made here, after consultation with Mr Mark Stewart of Groundwater Consulting Services.

(a) The predominant drainage waterway is the Wilge river which flows from south to north. It is obvious from the number of boreholes on farms that groundwater is utilised quite a lot by the farmers.

(b) A spruit was crossed in the most southerly part of the site, flowing from east to west. It is used for irrigation of lands just off the area under review.

(c) From discussion with a few farmers, groundwater is being used for farming / potable consumption and is of an acceptable quality.

#### 4.5.3 Seismic Hazard

From the Probabilistic Seismic-Hazard Maps the site lies in the same region as site X, namely the site lies in a region with a peak ground acceleration (g) of about 0.13 with a 10% probability of being exceeded once in a 50 year period. The significance is the same as for Site X (see section 3.5.3 (b)).

### 4.6 Geotechnical Suitability / Constraints

1. There are no known obvious geological constraints to the development of a power station and infrastructure on this site.
2. The power station would be situated on diabase sills, with a combination of both deep weathering and rock outcropping.
3. The coal stockpile would be on similar rock, but possibly occurring at greater depth, with more clayey overburden soils at surface. This would be a positive mitigating factor against groundwater contamination etc.
4. To the south, where the ash dump might be positioned, it can be said that the soils will probably be fairly deep on the igneous rocks, but shallow with hard quartzitic bands over the Silverton Formation i.e. rather mixed and variable geological conditions.
5. It can be seen that this site is further away to the west than Site X from the coalfields that would be developed to feed the power station. This would mean transporting the coal further. However, there would be no sterilization of coal resources by this development.
6. Some grassland areas would be taken up by this development.

## 5. CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Conclusions

1. A desk study and site walkover has been undertaken. From this a geological map has been prepared that covers both Site X and Site Y, as well as extending to show the general geological setting of both sites.

2. The sites do differ in their geology. The extent of visible rock outcrop is limited, but generalizations are possible on the type of founding conditions that might be encountered.
3. Neither site has any known obvious geological constraints to the development of a power station and infrastructure
4. The very preliminary guide as to where various elements of the plant might be positioned was considered. In general, these match fairly well with current geological / geotechnical knowledge about the sites and could be utilized to explore further.
5. Neither site sterilizes any coal-bearing or other economically viable geological strata.
6. The seismic hazard rating for both sites is the same, namely the site lies in a region with a peak ground acceleration (g) of about 0.13 with a 10% probability of being exceeded on a 50 year period.
7. Site Y is further from the anticipated coal mine source than Site X, necessitating longer transportation lines (e.g. conveyors).
8. On both sites it would appear that groundwater is being used for farming / potable consumption and is of an acceptable quality. Care will have to be taken in the engineering of the plant, and the various dumps, to ensure that there is no contamination of the groundwater.

## 5.2 Recommendations

It is not easy to make a definite recommendation of one site over the other. However, with current information, it is felt that probably Site X would be the more favourable.

- The geology is somewhat more uniform;
- Suitable founding with adequate bearing capacity for heavy equipment would probably be found on the shales / diabase in the central part of the site;
- Extensive blasting of very hard rock can be avoided;
- The soils will be clayey and more impervious in the sections on the Dwyka Formation, assisting with the protection of groundwater from pollution;
- The site is in better situated closer to the coal supply.

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# APPENDIX A – PHOTOGRAPHS

**Photo 1**

**Photo 2**

**Photo 3**

**Photo 4**

Photo 5

**Photo 6**

**Photo 7**

**Photo 8**

**Photo 9**

**Photo 10**

Photo 11

Photo 12

Photo 13

Photo 14

**Photo 15**

**Photo 16**

Photo 17

Photo 18


**Photo 19**

**Photo 20**

**Photo 21**

**Photo 22**

## Captions of Photos for Site "X"

**Photo 01** – Looking west along the power line that dissects the site. In the distance is the possible power station site. The ground slopes in a westerly direction. Short grasslands with no visible rock outcrops.

**Photo 02 -** Looking west; potential power station site south of the small dam and clump of trees in the centre of the photo. Geology is Dwyka Formation (C-pd) and Pretoria Group shales (Vr)

**Photo 03** – A spring being captured and utilised for domestic purposes.

**Photo 04** – Another view, as for Photo 02.

**Photos 5 and 6** – Outcrops of Rayton Formation (Vr) shales.

**Photo 7** – Looking east. A small dry dam on the most easterly central portion of the site. Geology is Dwyka Formation shales (C-pd).

**Photos 8 and 9** – Looking in a north easterly direction, further illustration of (Vr) shales and grasslands, northern portion of the site.

## Captions of Photos for Site "Y"

**Photo 10** – An example of large hard rock corestones that develop in the soil profile of the Loskop Formation tholitic lavas (Vl). The photo was taken just south of the south east corner of the site.

**Photo 11** – A general views looking north westward from the most SE point of the site. Grasslands and mielie fields. Geology is tholitic lava (Vl). This area is a possible ash dump position.

**Photo 12** – View of stream running westward at the south end of the site.

**Photos 13 and 14** – General views looking west over the potential coal stockpile position. Geology is diabase sills (di) with brown silty soil at surface – some maize cultivation.

**Photos 15 and 16** – Pretoria Group, Silverton Formation (Vsik) hard rock quartzite outcrop in the east central part of the site on the farm Nooitgedagt.

**Photo 17** – View of Perskekop (elev. 1496m) at western edge of site. Rock is Silverton quartzites.

**Photo 18** – Looking west to the Wilge River (tree line) with rich brown soil surface deposits (Q2).

**Photo 19** – Wilge River crossing on northern boundary of site.

**Photo 20** – Wilge River, which flows northwards, looking upstream.

**Photo 21** – Wilge River looking downstream (N). The river dissects the area with the potential power station position to the west, and the coal stockpile to the east.

**Photos 22 and 23** – Potential power station position – diabase (di) outcrop looking westwards, on the farm Witpoort.

**Photo 24** – Silverton Formation shale (Vsi) exposed in a road cutting just west of the Wilge River bridge on the northern side of the site.

# APPENDIX B – DRAWINGS