PROPOSED ESKOM WIND ENERGY FACILITY ON THE CAPE WEST COAST

ENVIRONMENTAL SCOPING STUDY OF THE GROUNDWATER ENVIRONMENT

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ABBREVIATIONS, ACRONYMS and SYMBOLS

°C	degree(s) Celsius
CSIR	Council for Scientific and Industrial Research
%ile	percentile
DWAF	Department of Water Affairs and Forestry
EC	electrical conductivity
L/s	litre(s) per second
m	metre(s)
Max	maximum
mbs	metre(s) below surface
mg/L	milligram(s) per litre
Min	minimum
mm/yr	millimetre(s) per year
mS/m	milliSiemens per metre
NGA	National Groundwater Archive
NGDB	National Groundwater Data Base
NRE	Natural Resources and the Environment
n.s.	not specified
NW	northwest
ROL	recommended operational limit
SABS	South African Bureau of Standards
SACNASP	South African Council for Natural Scientific Professions
SANS	South African National Standard
SE	southeast
TDS	total dissolved salts
WMA	Water Management Area

1 INTRODUCTION

The proposed wind energy facility site is located within quaternary catchment F60A of the Olifants/Doorn Water Management Area (WMA). Together with rainwater collected in tanks and water harvested from mist, groundwater represents an important resource in this relatively arid part on the West Coast of South Africa west of the towns of Lutzville and Koekenaap.

The groundwater resource is obtained primarily from boreholes that draw water from a combination of strata, including the near-surface unconsolidated to weakly consolidated sand deposits and calcareous soils, and the underlying basement rocks. Comparatively shallow dug wells represent a secondary source of groundwater. Despite their relatively poor yield, these sources provide a viable source of water to farms, small communities and other users located more than a few kilometres away from the Olifants River. The scoping assessment follows the approach of a groundwater vulnerability assessment to address concerns regarding the potential impact of the proposed land use on local groundwater resources.

2 METHODOLOGY

This is a scoping-level evaluation. No site visit was made to the area of interest, precluding the in situ sourcing of field data from landowners and abstraction facilities such as boreholes. Rather, the assessment has made use of available information sourced from the DWAF's National Groundwater Data Base/National Groundwater Archive (NGDB/NGA). This database holds information on depth to groundwater, groundwater quality, borehole yield and borehole construction, amongst other aspects. This information was supplemented with an evaluation of published geological and hydrogeological maps.

Under circumstances where the coordinate accuracy of most of the boreholes enumerated in the NGDB/NGA is not better than 10 000 m, their positions are at least constrained to the boundaries of the topocadastral farms on which they are located. The associated hydrogeological data and information therefore provides only a broad overview of groundwater conditions rather than site-specific information. This does not favour the use of a standard vulnerability assessment method such as DRASTIC (Aller *et al*., 1987) which requires more detailed data such as groundwater recharge, soil media and vadose zone composition. Information on aquifer hydraulic properties (e.g. transmissivity and storativity) and the mode of groundwater occurrence in the aquifer was taken into account by the DWAF when compiling the published 1:500 000 scale hydrogeological map 3117 Calvinia that covers the study area.

In this assessment, the DWAF groundwater characterisation has been used together with available quantitative hydrogeologic data and information in order to undertake a groundwater vulnerability assessment and consideration of environmental risk associated with the proposed land use.

3 GEOLOGY

The area of interest is described in two published geological maps, viz. map 3118C-Doringbaai/3218A-Lambert's Bay at scale 1:125 000 dated 1969, and the later map 3118 Calvinia at scale 1:250 000 dated 2001. The older map provides more detail than the latter, but only extends as far north as 31°30'S. The combination of these two maps provides sufficient information to describe the geology of the area of interest. This is illustrated in Figure 1.

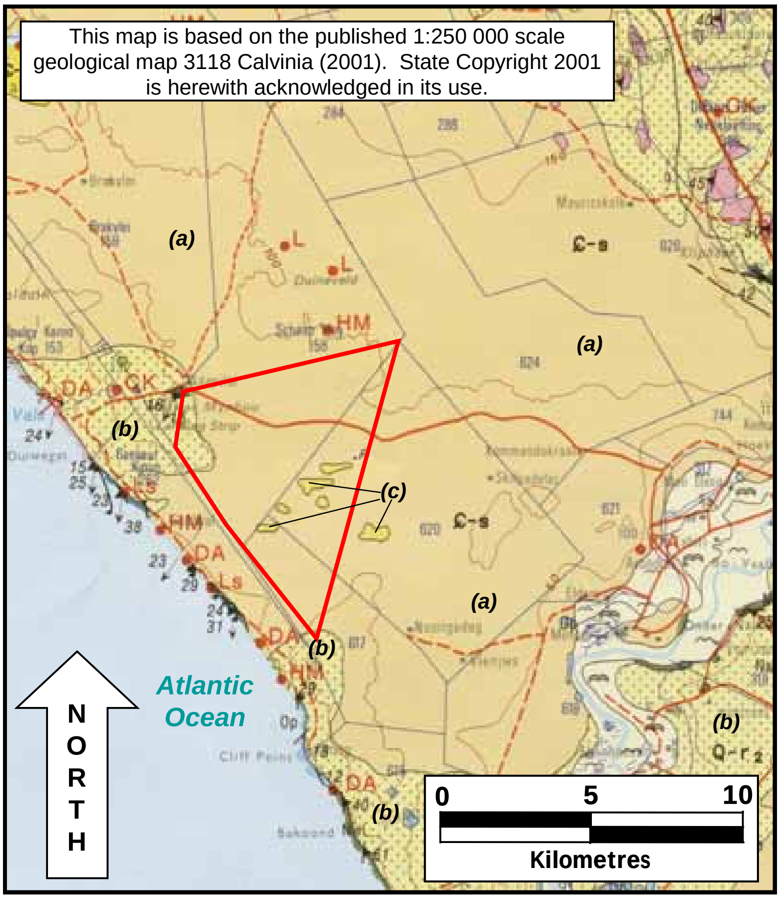

Figure 1. Geological map of the study area [*(a) red aeolian sand, (b) calcareous and gypsiferous soil, (c) calcrete*]

The region is characterised by a surface cover comprising primarily of red aeolian sand of Tertiary to Quaternary age. These unconsolidated to weakly consolidated sediments underlie almost the entire area of interest. A small portion in the Skaapvlei vicinity is underlain by calcareous and gypsiferous soil (Figure 1). Isolated calcrete deposits also occur in the area of interest, and represent the precipitation of calcium carbonate carried in solution in rainwater under conditions of sparse precipitation (20 to 60 mm/yr) and a mean annual temperature of about 18°C (Allaby and Allaby, 1991).

The surficial deposits rest on basement rocks that comprise mainly phyllite and greywacke associated either with the (Neo-proterozoic) Malmesbury Group or the slightly younger (Palaeozoic) Nama Goup. The relationship between these two lithostratigraphic units is still being investigated (Visser, 1989). The basement rocks are most extensively exposed in a narrow strip along the coast. Their occurrence as small isolated outcrops further inland suggests that the sand cover is of moderate depth. The older and larger scale geological map indicates the presence of NW−SE quartz veins in the basement rocks.

4 HYDROGEOLOGY

The phyllitic bedrock strata are fine-grained, low-grade metamorphic rocks with a well-developed schistosity. Greywacke is a texturally and mineralogically immature sandstone containing >15 % clay minerals. These circumstances are not conducive to the development of productive or high-yielding aquifers and, in fact, combine to render the basement strata in the area of interest a minor aquifer at best. The quartz veins are likely to represent more favourable water-bearing features in this geological environment. These observations find support in the "*d2*" characterisation of the groundwater environment that underlies most of the area of interest (Figure 2).

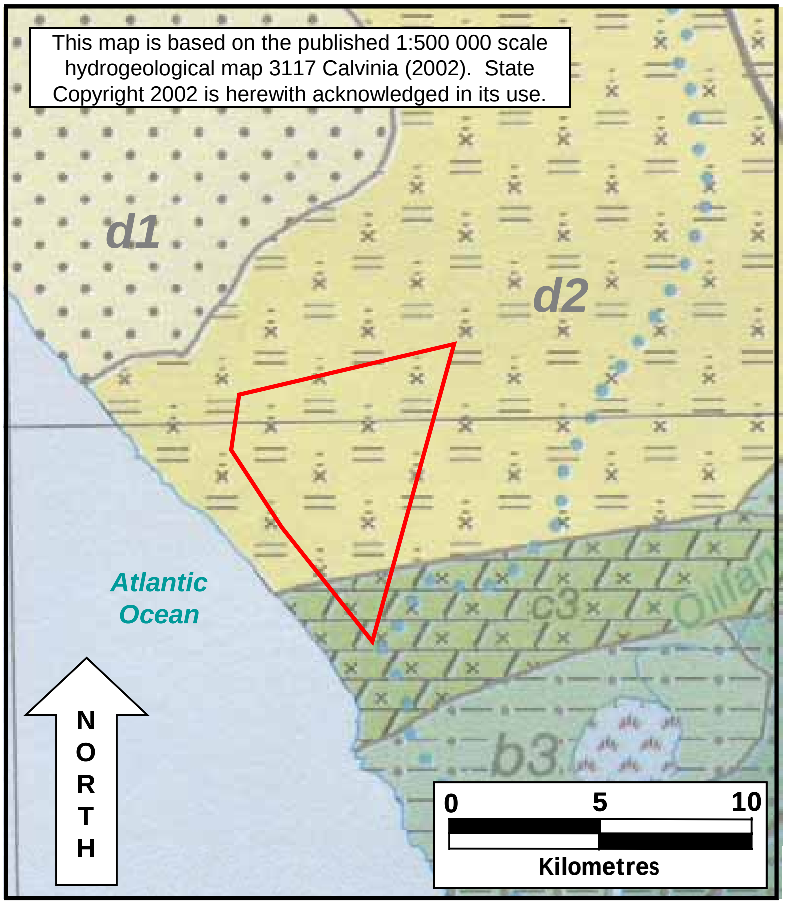

Figure 2. Hydrogeological map of the study area

Based on the published hydrogeological map 3117 Calvinia at scale 1:500 000, this characterisation signifies an intergranular and fractured aquifer supporting a median borehole yield (excluding dry boreholes) in the range 0.1 to 0.5 L/s. This aquifer type is hosted by the meta-arenaceous strata (including greywacke) described on the hydrogeological map. Figure 2 also shows that a small portion in the southern corner of the area of interest lies within a "*c3*" groundwater environment. This environment describes a karst aquifer characterised by a median borehole yield in the range 0.5 to 2.0 L/s. The karst aquifer classification derives from the presence of limestone formations as part of the meta-calcareous strata described on the hydrogeological map.

Salient statistics in regard to the basic borehole parameters of drilled depth, depth to groundwater rest level and yield are presented in Table 1. These derive from an analysis of the DWAF's NGDB/NGA data. A similar analysis of groundwater quality data obtained from the same source is presented in Table 2.

Table 1. Statistical summary of basic borehole parameters

BOREHOLE PARAMETER	STATISTICAL PARAMETER						
	Count	Min	5 %ile	Mean	Median	95 %ile	Max
Depth (m)	55	36.0	51.4	101.8	101.6	151.0	159.0
Water rest level (mbs)	42	1.0	15.5	68.4	70.1	117.1	127.0
Yield (L/s)	49	0.01	0.02	0.73	0.39	2.52	3.79

Table 2. Statistical summary of groundwater chemistry parameters

BOREHOLE PARAMETER	STATISTICAL PARAMETER (for a sample population of 6)						SABS (2005)
	Min	5 %ile	Mean	Median	95 %ile	Max	
pH	7.27	7.27	7.54	7.53	7.89	7.97	5 – 9.5
EC (Ms/m)	143	187	1031	885	2373	2770	<150
TDS (mg/L)	814	1084	6821	5275	16894	19955	<1000
Ca (mg/L)	23.5	31.8	163.6	140.1	332.4	354.0	<150
Mg (mg/L)	32.9	42.6	252.9	193.0	636.4	759.4	<70
Na (mg/L)	207.9	284.8	1967.2	1425.6	4963.6	5813.1	<200
K (mg/L)	9.8	12.7	63.9	39.8	163.5	190.7	<50
Cl (mg/L)	389.2	531.1	3689.2	2794.2	9351.7	11103.0	<200
SO_4 (mg/L)	16.5	34.8	467.4	373.8	1195.1	1414.7	<400
T. Alk. (mg/L $CaCO_3$)	110.0	119.6	175.3	173.3	238.1	252.7	n.s.
NO_3 + NO_2 (mg/L N)	0.02	0.02	0.50	0.02	1.93	2.41	<10
NH_4 (mg/L N)	0.02	0.05	0.22	0.21	0.44	0.50	<1
F (mg/L)	0.20	0.22	0.60	0.39	1.20	1.22	<1
Si (mg/L)	4.82	5.11	8.09	7.02	13.92	15.98	n.s.

The borehole parameter information (Table 1) indicates that boreholes in the subregion that encompasses the area of interest are typically deep (~100 m), exhibit a substantial median depth to groundwater rest level (~60 m), and support a comparatively low median yield (~0.4 L/s).

Although based on a comparatively small sample population of only six, the groundwater chemistry information (Table 2) indicates the rather poor overall quality of groundwater in the subregion. Most notable is the measure of non-compliance with the SANS 241:2005 (SABS, 2005) recommended operational limit (ROL) for a Class 1 drinking water quality that is associated with the median values for EC (ROL <150 mS/m), TDS (ROL <1000 mg/L), Mg (ROL <70 mg/L), Na (ROL <200 mg/L) and Cl (ROL <200 mg/L). In keeping with its characteristic sodium-chloride (NaCl) chemical composition, the groundwater is generally classified as brackish to brack.

5 GROUNDWATER VULNERABILITY ASSESSMENT

This is based on consideration of the following hydrogeological aspects:

- depth to groundwater rest level,
- aquifer type,
- borehole yield,
- groundwater quality,
- aquifer importance.

5.1 Depth to Groundwater Rest Level

In general, the greater the depth to groundwater rest level beneath the surface, the less vulnerable the aquifer will be to surface pollution. The statistics reported for this parameter (Table 1) indicate mean and median values of 68.4 m and 70.1 m respectively for a sample population of 42 stations. This agrees with the mean depth to groundwater level range of 50 m to 75 m assigned to the subregion by Vegter (1995). Groundwater rest level depths of this magnitude are considered as deep, and the host groundwater environment as a consequence significantly less vulnerable to surface pollution.

5.2 Aquifer Type

The DWAF hydrogeology maps define various aquifer types depending on how groundwater is stored and transmitted by the strata. The vulnerability of these aquifer types to surface pollution, based on the possible rate of movement of contaminants through the aquifer and the degree of attenuation provided by the strata, may be characterised as follows:

VULNERABILITY	Most			Least
AQUIFER TYPE	Karst ⇨	Fractured ⇨	Intergranular & fractured ⇨	Interganular

The information provided in section 4 indicates that most of the area of interest is characterised by an intergranular and fractured type aquifer. In fact, the intergranular component is represented by the surficial sand cover that overlies the bedrock, with the latter representing the fractured component. These circumstances similarly suggest a groundwater environment that is less vulnerable to surface pollution. The mapped occurrence of a (pseudo)karst aquifer ("c3" zone in Figure 2) in the region, and especially the observation that this aquifer intersects the southern corner of the area of interest (Figure 2), prompts the following caution. This portion of the site should not be considered for the placement or development of infrastructure that poses a contamination risk to the groundwater resource unless site-specific groundwater studies indicate otherwise.

5.3 Borehole Yield

The yield of boreholes tapping a groundwater resource provides an indication of the water supply potential of such resource. The higher the yield, the more productive the aquifer, since greater volumes can be abstracted. The statistics reported for this parameter in Table 1 (section 4) indicate average and median values of 0.73 L/s and 0.39 L/s respectively for a sample population of 49 stations. The latter value is in agreement with the DWAF's median borehole yield (excluding dry boreholes) range of 0.1 L/s to 0.5 L/s (section 4). It also reflects to some degree the very low mean annual recharge of <1 mm that Vegter (1995) assigns to the subregion. Again, these circumstances are indicative of a groundwater environment that is less vulnerable to surface pollution.

5.4 Groundwater Quality

As described in section 4, the NaCl character of the brackish to brack groundwater is also characterised by elevated electrical conductivity, total dissolved salts and magnesium values that exceed the limits of a Class 1 drinking water (SABS, 2005). These circumstances obviate the need to augment groundwater supplies with much fresher sources such as rainwater (section 1). Nevertheless, they do represent the natural groundwater quality in the subregion. As such, the "poor" quality of ambient groundwater cannot be put forward as a mitigating factor in a groundwater vulnerability assessment. It does, however, represent a less sensitive receiving environment in regard to water quality.

5.5 Aquifer Importance

Many low yielding aquifers of moderate or poor natural groundwater quality are relied on by local populations who may not have another viable source of water for human needs. The importance of an aquifer therefore depends on its context and the people who use it, and not just on its physical properties. Aquifers that represent the sole viable source of water to a range of users must rank as more important than where some alternative sources of water are available to most users or where groundwater is easily replaceable by other sources. This assigns a high level of importance to the aquifer in the study area.

6 ENVIRONMENTAL RISK CONSIDERATIONS

The vulnerability of the groundwater resource to the proposed land use activity is mitigated by factors such as the substantial depth to groundwater level (section 5.1), the intergranular and fractured type of aquifer (section 5.2) that underlies most of the site, and the rather poor yield of boreholes (section 5.3). Site-specific threats relate to the use of petrochemical products (e.g. transformer oils) in the operation of the electricity substation that will be constructed on the site. Similar threats are associated with the transport of these products to the site. Accidental spills from these sources may infiltrate into the groundwater environment at the site of the spill. The assessment of associated environmental risk addresses these concerns in terms of the contaminants they may introduce into the environment, and the nature, extent, duration, intensity/magnitude, probability and significance of the potential impacts such introduction may have on the groundwater environment. These assessment criteria are as defined by Saayman (2005).

6.2 Construction Phase

- Construction of bitumen-based hard surfaces and roads
  Nature: Phenol contamination; negative.
  Extent: Local.
  Duration: Short term risk of contamination (during construction phase).
  Long term risk of reduction in natural recharge.
  Intensity: Low. Limited flushing of phenolic compounds from wet bitumen during a rainfall event.
  Probability: Improbable.
  Significance: Low.
  Mitigation: No laying of bitumen in the rain.

- Storage of diesel fuel for construction equipment
  Nature: Volatile organic compound contamination; negative.
  Extent: Local.
  Duration: Short term risk of contamination (during construction phase).
  Intensity: Low.
  Probability: Improbable.
  Significance: Low.
  Mitigation: Surface storage tanks contained in a paved and bunded area.

- On-site sanitation facilities for construction personnel
  Nature: Bacteriological contamination; negative.
  Extent: Local.
  Duration: Short term risk of contamination (during construction phase).
  Intensity: Low.
  Probability: Improbable.
  Significance: Low.

Mitigation: Provision of chemical toilets for construction personnel.

6.2 Operational Phase

- Electricity substation transformer oils
  Nature: Volatile organic compound contamination; negative.
  Extent: Site and immediate surroundings.
  Duration: Long term.
  Intensity: Low.
  Probability: Improbable.
  Significance: Medium.
  Mitigation: Infrastructure and storage area paved and bunded.

- Landscaping
  Nature: Pesticide and nitrate contamination; negative.
  Extent: Site.
  Duration: Long term.
  Intensity: Low to medium.
  Probability: Improbable.
  Significance: Low.
  Mitigation: Establishment of indigenous vegetation.

7 CONCLUSION

Potentially impacting activities have been identified and assigned a significance depending on the nature, extent, duration, intensity and probability of impact. These are summarised as follows:

High significance/importance:
No activities associated with the proposed wind energy facility are considered to have a high significance for the groundwater environment.

Medium significance/importance:
Transformer oils associated with the electricity substation.

Low significance/importance:
Landscaping.

During the construction phase, the following additional potential impacts, all with a **low significance**, are identified:

- Construction of bitumen based hard surfaces and roads.
- Storage of diesel fuel for construction equipment.
- On-site sanitation facilities for construction personnel.

The area identified for the proposed wind energy facility supports a groundwater environment that is sufficiently robust and able to accommodate the possible impacts associated with the intended land use without undue risk of negative impact. It is concluded, therefore, that there will be no significant impact on the groundwater environment during the construction and/or operation phases of the project.

8 RECOMMENDATION

It is recommended that the southern corner of the proposed wind energy facility site should not be considered for the placement or development of infrastructure that poses a *contamination risk* to the groundwater resource, unless detailed site-specific groundwater studies indicate otherwise. This recommendation recognises the presence of a (pseudo)karst aquifer associated with limestone formations that intersect the southern corner of the site. Provided that this recommendation is followed, no further hydrogeological studies of the site are considered necessary as part of this EIA.

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The author is registered (no. 400020/93) as an Earth Scientist with the South African Council for Natural Scientific Professions (SACNASP). He is currently employed by the CSIR in the Water Resources Competence Area of the Natural Resources and Environment (NRE) Operational Unit in the position of Research Hydrogeologist. Experience in this discipline covers a wide range of groundwater studies across a broad spectrum of geological and hydrogeological environments in a career that spans 28 years in the public and private sectors. The studies include the exploration and development of groundwater resources for water supply purposes at local (domestic) and municipal (bulk) scale, the evaluation and assessment of land use activities such as waste disposal, industrial, mining and residential development on the groundwater environment, and the mapping of groundwater resources at regional scale. The spectrum of geological and geohydrological environments include Archaean granite and Bushveld Complex rocks, much of the Transvaal Supergroup (including the dolomites) and Karoo Supergroup strata, and Tertiary and Quaternary sediments comprising alluvial sediments and coastal limestone and aeolian deposits.

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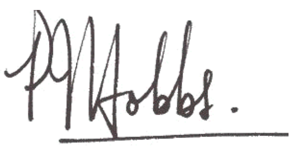

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