6. WATER RESOURCES

6.1. Scope of Work

The project aimed at assessing the surface and groundwater resources within an area of ± 245 km^2 study area, based on the location of the eight candidate sites and the existing Matimba Power Station and infrastructure. The scope of work for the Environmental Scoping Study included:

- A status quo study, regarding quality and quantity of water resources.
- A site suitability assessment from a groundwater and surface water perspective.
- An evaluation of all monitoring data, hydrochemical trend identification, and contamination assessment (coal stockyard, ash dams, etc.).
- Consideration of stormwater controls.
- Surface water availability and supply,
- Groundwater resources.

6.2. Methodology

A desktop study and limited fieldwork were undertaken in order to collate sufficient information to compile the water resources and candidate site assessments report.

These data were assessed in order to address the hydrogeological and surface water aspects of the proposed project.

6.2.1. Desktop Study and Data Sources

All available geological, surface water, and hydrogeological data for the study area was compiled from various sources and analysed.

All relevant hydrogeological data, such as water levels, abstraction, hydrochemistry, and drilling records, was available from either Eskom or the Grootegeluk mine.

The following data sources were used during the study:

- du Toit, W.H., 2003. The hydrogeological map Polokwane 2326. Department of Water Affairs and Forestry
- Geological Survey, 1993. 1:250 000 Geological series 2326 Ellisras geological map.
- Johnstone, A. C., 1989; A hydrogeological investigation of the Grootegeluk Mine, Unpublished M.Sc thesis, Rhodes University.

- Hodgson, F. and Vermeulen, D. 2004. Extension of the groundwater monitoring system at Matimba Power Station. Unpublished report no. 2004/12/FDIH, Institute for Groundwater Studies (IGS), University of the Free State
- The Internal Strategic Perspective (ISP) of the Limpopo Water Management Area, Department of Water Affairs and Forestry (Ref No. P WMA 01/000/00/0101, July 200)
- Roux L., 2001. Grootegeluk Coal Mine Geohydrological perspective. Unpublished report, Grootegeluk Coal Mine Geology Department
- Roux L., 2003. Revised numerical groundwater modelling at Grootegeluk Coal Mine. Unpublished report, Grootegeluk Geohydrology Kumba Resources
- Steenkamp, G., 2001. Numerical groundwater modelling at Grootegeluk Coal Mine. Internal report, Kumba Resources
- The groundwater harvest potential of the Republic of South Africa. Department of Water Affairs and Forestry, 1996
- The groundwater resources of the Republic of South Africa, sheets 1 and 2. Water Research Commission and Department of Water Affairs and Forestry, 1995
- The national groundwater database, Department of Water Affairs and Forestry, Pretoria

Discussions, regarding the geology and hydrogeology, with the Grootegeluk mine’s geologist, Mr. Leon Roux, were also conducted.

6.2.2. Fieldwork

The fieldwork conducted during the study included a site visit to the power station and the Grootegeluk colliery.

A visit to each of the four initial candidate sites was conducted. The scope of work was expanded to include an additional four candidate sites, however, due to the abundance of geological and hydrogeological data, no additional fieldwork was conducted.

6.3. Overview of the Geology of the Area

Sediments and volcanics of the Waterberg Group and Karoo Supergroup underlie the study area. Table 6.1 presents the lithostratigraphy of the area.

Table 6.1: Lithostratigraphy

Age	Supergroup / Group	Formation	Alternative Name	Lithology
Jurassic	Karoo	Letaba	Letaba Formation	Basalt
Triassic		Clarens	Clarens Formation	Fine-grained cream-coloured sandstone
Triassic		Lisbon*	Elliot Formation	Red mudstone and siltstone
Triassic		Greenwich*	Molteno Formation	Red sandstone and conglomerate
Triassic		Eendragtpan*	Beaufort Group	Variegated shale
Permian		Grootegeluk*	Upper Ecca Group	Mudstone, carbonaceous shale, coal
Permian		Goedgedacht*	Middle Ecca Group	Gritty mudstone, mudstone, sandstone, coal
Permian		Swartrant*	Lower Ecca Group	Sandstone, gritstone, mudstone, coal
Permian / Carboniferous	Karoo / Dwyka	Wellington*	Dwyka Group	Mudstone, siltstone, minor grit
Carboniferous		Waterkloof*	Dwyka Group	Diamictite, mudstone
Mokolian	Waterberg	Mogalakwena	Mogalakwena Fm	Coarse-grained purplish brown sandstone

*Not yet approved by the South African Committee on Stratigraphy (SACS)

A veneer of quaternary (2 Ma) sandy soil covers the Waterberg Group sediments to the south of the study area.

Figure 6.1, a portion of the 1:250 000 geological map 2326 Ellisras, illustrates the study area geology. Figure 6.2 presents the structural geology within the study area, as provided by Mr. Leon Roux, Grootegeluk Coal Mine.

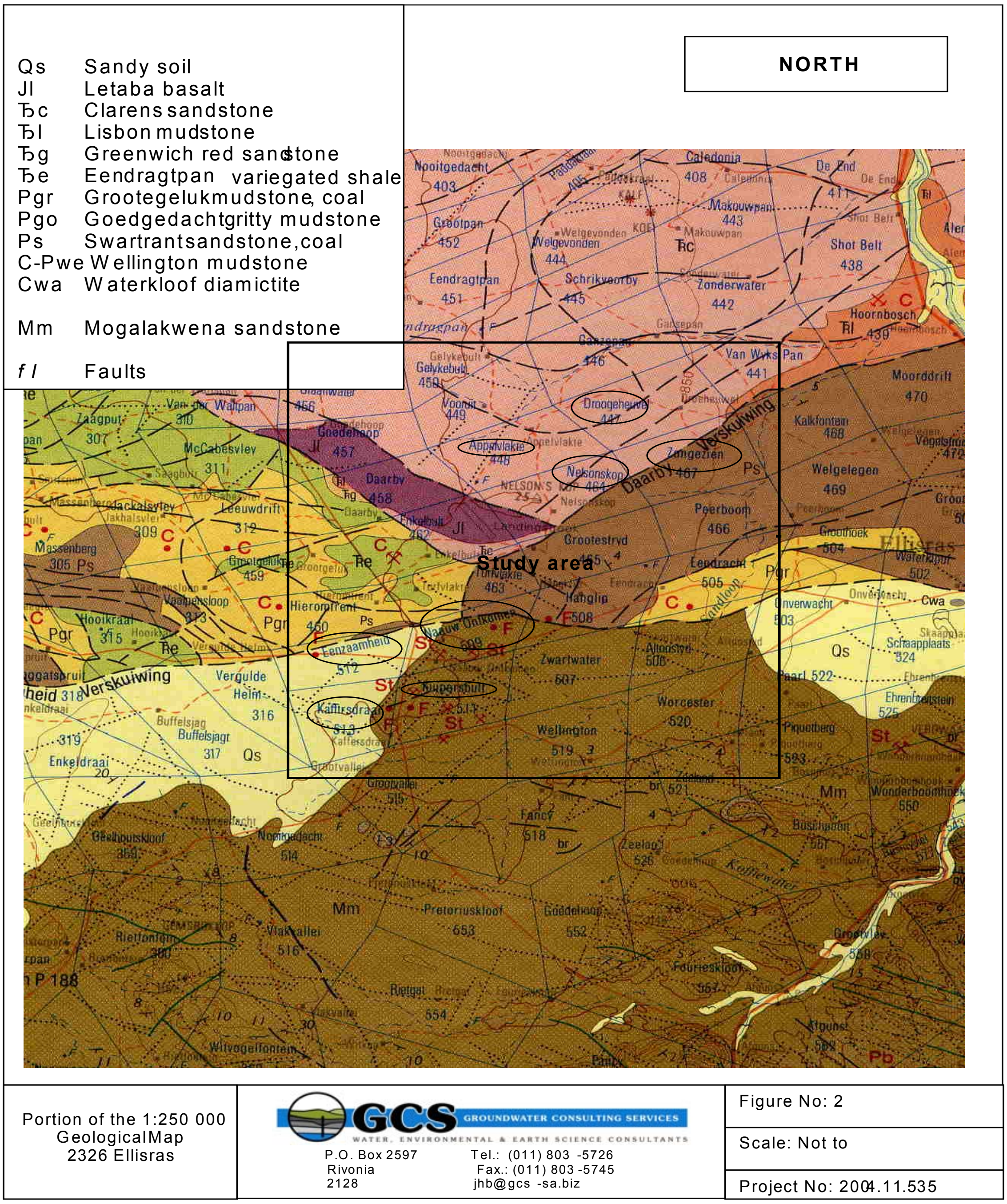
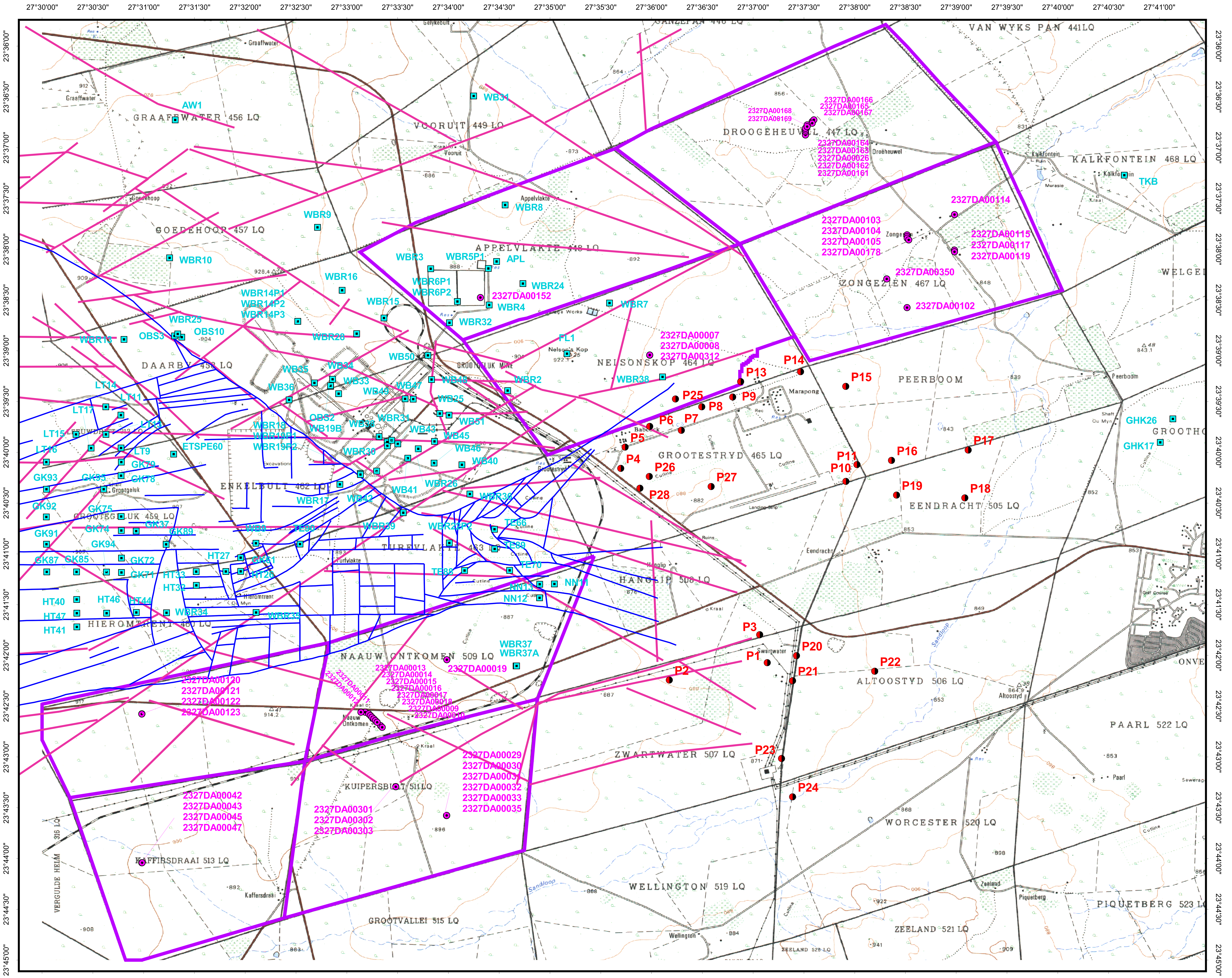


Figure 6.1: A portion of the 1:250 000 geological map 2326 Ellisras, illustrating the study area geology

Figure 6.2 – Structural geology within the study area

STRUCTURAL GEOLOGY WITHIN STUDY AREA



LEGEND:

- Grootegeluk boreholes
- Matimba boreholes
- NGDB boreholes on 8 farms
- Faults derived from boreholes
- Aeromagnetics Lineaments
- Farm boundaries (SG)
- Image: Wgs2327da_1981.tif

0.5 0 0.5 1 1.5 2 2.5 Kilometers

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Figure 3

6.3.1. Structural Geology

The study area falls within the Waterberg Coalfield, which comprises a graben structure with the Eenzaamheid fault forming the southern boundary and the northern boundary is delineated by the Zoetfontein fault. Archaean granite rocks outcrop to the north of the Zoetfontein fault and sediments of the Waterberg Group outcrop to the south of the Eenzaamheid fault.

The study area is further subdivided by the Daarby fault, a major northeast then northwest trending fault. The Daarby fault has a down throw of 360 m to the north, at an angle of 50° to 60°.

Figure 6.3 is a north-south cross-section across the study area, indicating the faults, throws, and lithological contacts.

Associated minor faulting within the graben structure has been interpreted. Figures 6.4 and 6.5 present the identified and interpreted macros structures within the study area (Roux, 2001).

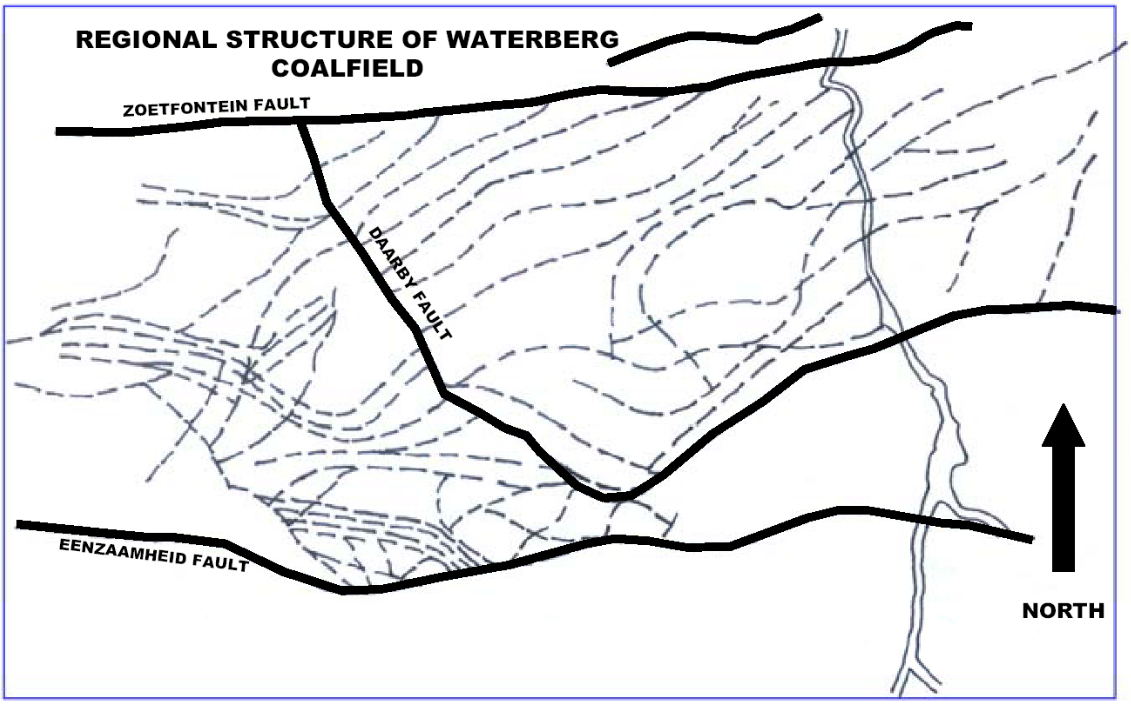


Figure 6.4: Faults and macro structures within the study area.

The geological structures can enhance the groundwater potential in the area by increasing the permeability and transmissivity of the host rock. Secondary processes, such as faulting and fracturing, can create secondary fractured rock aquifers.

Figure 6.3: Cross Section

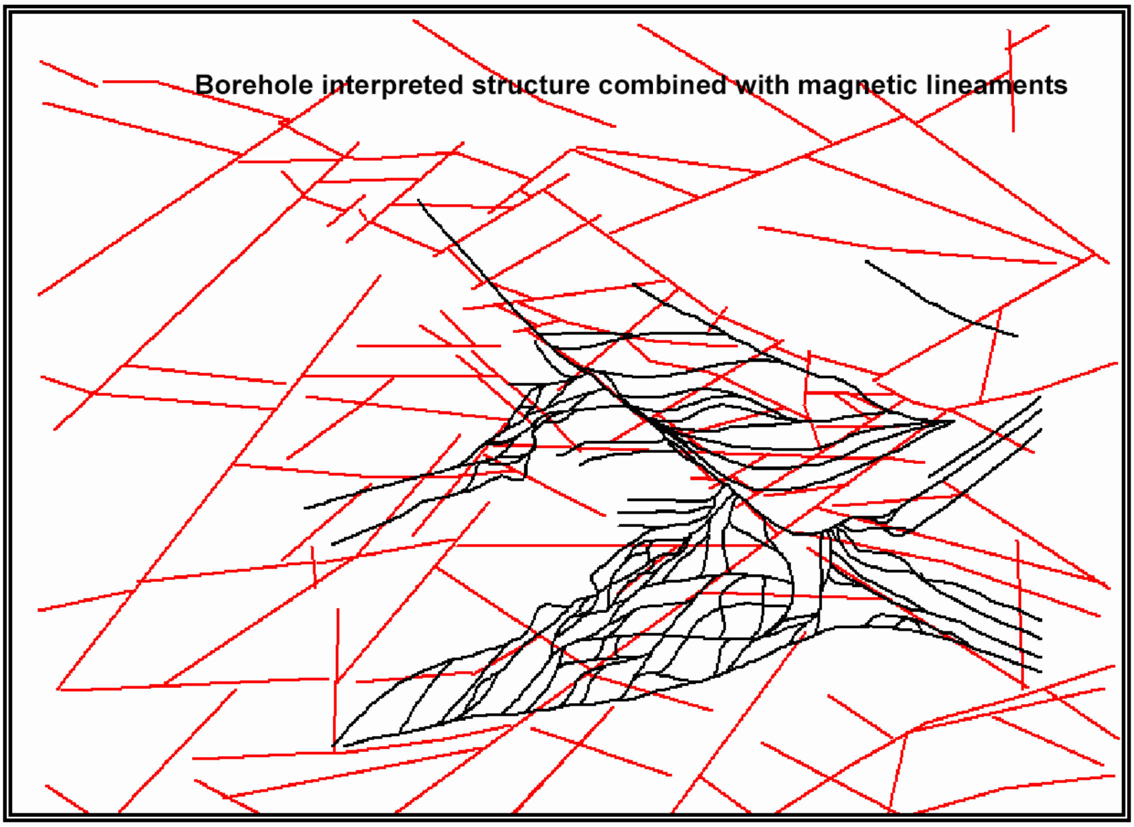


Figure 6.5: Macro structures and lineations interpreted from aerial magnetic data.

- *The Daarby Fault*

  The Daarby Fault is a major northeast then northwest trending fault, assumed to be a combination of two faults that have the same throw and throw directions.

  The down throw of 360 m to the north serves to bring the Grootegeluk Formation rocks to the south in contact with the younger Clarens Formation sandstone and Letaba Formation basalts in the north. Thus the fault divides the coalfield into a shallow (opencast) coal area to the south of the Daarby Fault, and a deep north coal area.

  Packer testing of a borehole drilled through the fault zone has shown the Daarby fault to be impermeable.

- *The Eenzaamheid Fault*

  The Eenzaamheid fault has a throw of 250 m to the north and the fault is near vertical (Figure 6.2). The fault brings the upthrown Waterberg Group sediments on the south side of the fault in contact with shallow coal on the northern side of the fault.

The permeability of the Eenzaamheid fault is not clear, initial groundwater contours indicate that the fault was impermeable (Johnstone, 1989) and that dewatering at the mine did not impact on the Waterberg Group sediments to the south of the fault.

Subsequent groundwater modelling (Roux, 2003) indicates that plume migration will occur along the fault, indicating an increased transmissivity along the fault between the two geological units (Figure 6.6).

The groundwater model indicates that the Eenzaamheid fault has enhanced groundwater potential and could be targeted for groundwater resource development in the future. The fault can also act as a preferential flow path for groundwater and potential contamination. Any possible contaminant sources should not be constructed on the fault as the fault would facilitate the migration of contaminants off site, which could possibly impact on surrounding groundwater users.

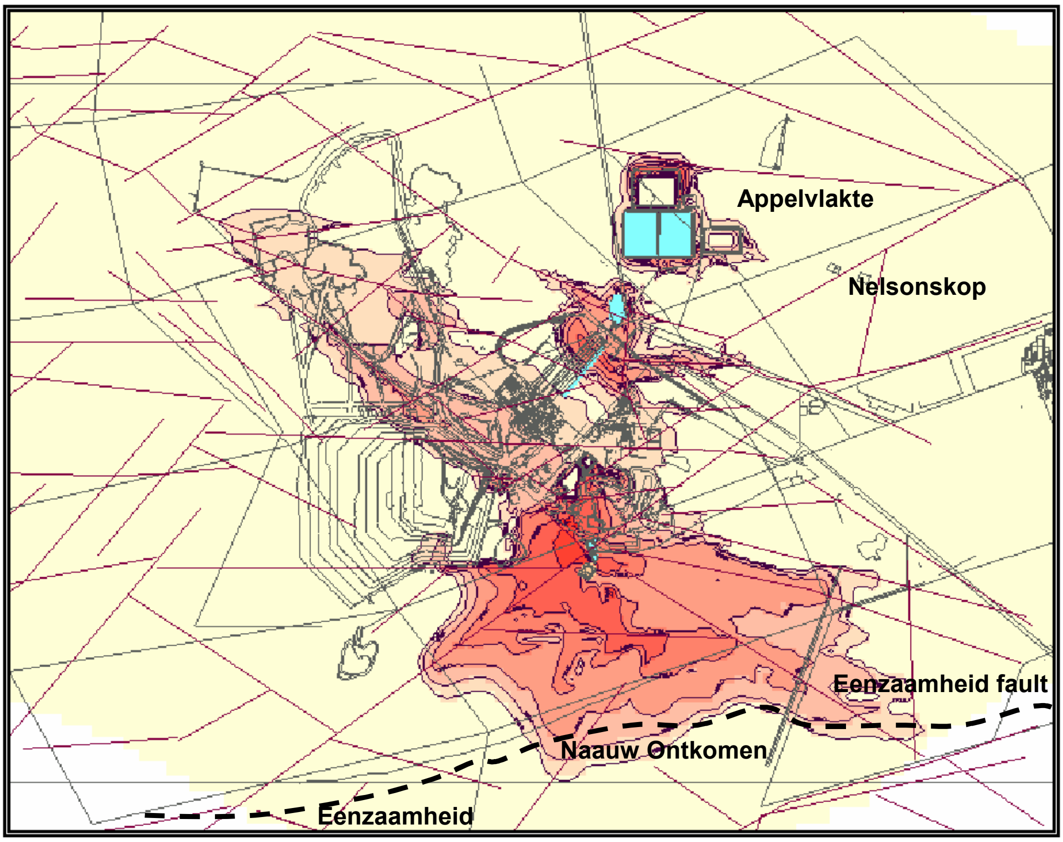


Figure 6.6: Plume migration along the Eenzaamheid Fault

- *Minor faulting*

  Associated step faults are identified within the area, especially where the Eenzaamheid and Daarby faults are in the closest proximity (± 2 km). The associated faults have varying strikes, throws, and throw direction (Figures

6.4 and 6.5). These faults have increased the in situ permeability of these rocks and influence the groundwater flow patterns.

Indications from exploration drilling are that the Daarby and Eenzaamheid faults are linked (on the farm Turfvlakte 463 LQ). This area also acts as a groundwater flow barrier as dewatering occurs within the Grootegeluk and Eendragtpan Formations, but not in the Swartrant Formation, as recognised from the groundwater modelling.

6.3.2. The Grootegeluk Coal Deposits

The Grootegeluk coal mine produces coking coal and middlings from the Grootegeluk and Goedgedacht Formations (Upper and Middle Ecca Group). The Grootegeluk Formation comprises intercalated shale and bright coal, with an average depth of 60 m. Coking and middlings grade coal are obtained from this formation. This coal is suitable for power generation, direct reduction, and formcoke.

Opencast mining occurs within the shallow coal, south of the Daarby Fault. Dewatering occurs which has led to the decline of the groundwater levels around the workings.

The construction of a power station and infrastructure on these coal deposits may have economic implications, as these coal deposits will become sterilised.

6.4. Regional Hydrogeology

The groundwater potential of the formations located in the study area are limited in their pristine state due to low permeability, storage, and transmissivity. Secondary processes, such as weathering, fracturing, etc., are required to enhance the groundwater potential.

Based on regional data, as compiled on the 1:500 000 hydrogeological map 2326 Polokwane, the following hydrogeological information is available for the formations on site:

Letaba Formation	-	Basic extrusive rocks (basalt)
	-	Intergranular and fractured aquifers
	-	Borehole yields 0,1 to 0,5 l/s
Clarens Formation	-	Argillaceous and arenaceous rocks
	-	Intergranular and fractured aquifers
	-	Borehole yields 0,1 to 0,5 l/s

Ecca Group	-	Upper and middle Ecca
(Grootegeluk)	-	Fractured aquifers
	-	Borehole yields 0,5 to 2,0 l/s
Ecca Group	-	Lower Ecca
(Swartrant)	-	Intergranular and fractured aquifers
	-	Borehole yields 0,5 to 2,0 l/s
Dwyka Group	-	Predominately arenaceous rocks
	-	Fractured aquifers
	-	Borehole yields 0,5 to 2,0 l/s
Waterberg Group	-	Predominantly arenaceous rocks
	-	Fractured aquifers
	-	Borehole yields 0,5 to 2,0 l/s

There are no artesian boreholes located within the study area. No large-scale groundwater abstraction occurs in the study area, even along the numerous faults.

The majority of the study area has electrical conductivity concentrations of between 70 and 300 mS/m. Incidents of groundwater with elevated fluoride concentrations (> 1,5 mg/l F) have been recorded.

6.4.1. Regional groundwater occurrence and aquifers

Based on the geology within the study area, the structural geology, and the geomorphology the following conditions can arise to enhance aquifer development within the study area:

- The fractured transition zone between weathered and fresh bedrock
- Fractures along contact zones between dykes and the host rocks due to heating and cooling of rocks involved with the intrusions
- Contact zones between sedimentary rocks of different types
- Contacts which may be open, enlarged, and loosened by weathering
- Openings on discontinuities formed by fracturing
- Faulting due to tectonic forces
- Stratigraphic unconformities
- Zones of deeper weathering
- Fractures related to tensional and decompressional stresses due to off-loading of overlying material
- Fault zones within the Karoo rocks

The sandstone of the Clarens Formation is characteristically massive and dense and has limited permeability and storage. It thus offers only moderate groundwater yield, especially in the absence of dolerite intrusions. 70% of boreholes drilled into the sandstone have yields < 3 l/s.

The groundwater potential of the fractured transitional zones between weathered and unweathered crystalline Letaba basalt rocks is good. Deeper fractures within the basalt, associated with faulting, have good groundwater potential.

Fractured fault zone, especially if related to tensional stresses, are potentially rich targets for groundwater development. The graben structures are associated with tensional stresses, thus the Eenzaamheid fault could be an area of increased groundwater potential. The Daarby thrust fault is impermeable.

Contacts between different rock lithologies and bedding planes within the sediments often yield groundwater. The contact zone between the basalt and the Clarens Formation sandstone can be high yielding.

Groundwater occurs within the joints, bedding planes, and along dolerite contacts within the Waterberg Group sediments. Groundwater potential is generally low in these rocks, with 87% of borehole yields < 3 l/s.

6.4.2 Candidate site hydrogeology

Borehole information derived from the Department of Water Affairs and Forestry's (DWAF) national groundwater database (NGDB) and the monitoring data from the power station and Grootegeluk coal mine allowed for an assessment of the hydrogeology, aquifers, and water levels on each of the eight candidate sites.

Figure 6.7 shows the location of the boreholes. Unfortunately the NGDB borehole co-ordinates are not very accurate, and hence some of the boreholes plot in close proximity to one another. Each borehole record, however, provides individual geological and hydrogeological information.

The borehole information is presented in Table 6.2. Figures 6.8 and 6.9 present the borehole yields and static water level data, respectively.

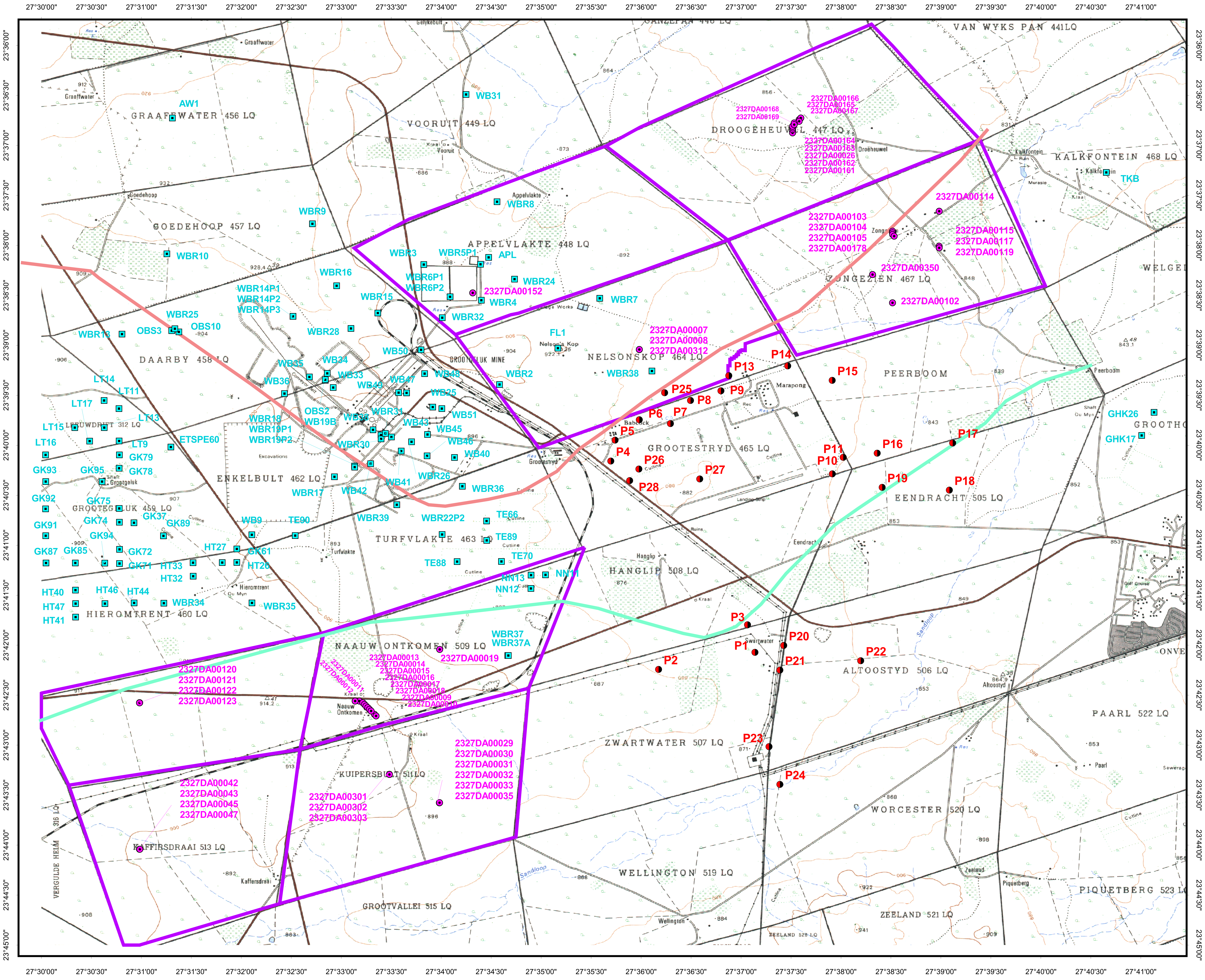
A summary of the borehole (drilling) records is as follows: -

- The majority of boreholes drilled on the candidate sites have very low sustainable yields.
- Only one borehole (41 records) has a yield > 1 l/s. This enhanced groundwater potential is as a result of secondary processes, possibly the faulting recognised on the farm Kuipersbult.

- Borehole depths are very variable. Deep drilling has occurred due to exploration (for coal) rather than for groundwater.
- Groundwater levels are variable due to the different piezometeric pressures associated with the units intersected during drilling
- Groundwater levels do not mimic the topography (which is very flat) as very shallow and very deep groundwater levels have been recorded on site. This is as a result of piezometeric differences, confined aquifers, artificial recharge, and geological structures.
- The average depth to groundwater within the Mogalakwena Formation sandstone is 25,6 m.
- The average depth to groundwater north of the Daarby fault (Clarens Fm) is 16,7 m.

Figure 6.7: All Boreholes

BOREHOLE POSITIONS



LEGEND:

- Grootegeluk boreholes
- Matimba boreholes
- NGDB boreholes on 8 farms

Faults_manual_wgsdd.shp

- Daarby
- Eenzaamheid
- –
- Farm boundaries (SG)

Image Wgs2327da_1981.tif

0.5 0 0.5 1 1.5 2 2.5 Kilometers

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Figure 8

Table 6.2: Borehole information for the candidate sites

Borehole ID	Farm	Depth	Yield	Water level	Comment
2327DA00120	Eenzaamheid	75 m	0.25 l/s	-	
2327DA00121	(Privately owned)	154 m	0.03 l/s	112.78 mbgl	
2327DA00122		400 m	0.06 l/s	77.42 mbgl	
2327DA00123		151 m	Dry	-	
2327DA00042	Kromdraai	7 m	Dry	-	
2327DA00043	(Privately owned)	82 m	0.02 l/s	35.05 mbgl	
2327DA00045		400 m	0.85 l/s	1.83 mbgl	Confined piezometeric level
2327DA00042		152 m	0.07 l/s	32.92 mbgl	
2327DA00029	Kuipersbult	153 m	0.01 l/s	22.86 mbgl	
2327DA00030	(Privately owned)	86 m	0.01 l/s	22.86 mbgl	
2327DA00031		137 m	0.07 l/s	48.77 mbgl	
2327DA00032		121 m	0.33 l/s	22.25 mbgl	
2327DA00033		77 m	0.01 l/s	18.29 mbgl	
2327DA00035		94 m	0.01 l/s	22.86 mbgl	
2327DA00301		79 m	3.2 l/s	-	Fault?
2327DA00302		15 m	0.05 l/s	3.35 mbgl	
2327DA00303		92 m	0.26 l/s	1.83 mbgl	
2327DA00009	Naauwontkomen	7 m	0.06 l/s	1.16 mbgl	
2327DA00010	(Ferroland / Kumba)	4 m	0.15 l/s	1.62 mbgl	
2327DA00011		40 m	0.06 l/s	30.48 mbgl	
2327DA00012		34 m	0.63 l/s	21.34 mbgl	
2327DA00013		22 m	0.25 l/s	9.14 mbgl	
2327DA00014		100 m	0.98 l/s	10.36 mbgl	
2327DA00019		32 m	0.25 l/s	13.72 mbgl	
WBR37		-	-	14.2 mbgl	Grootegeluk monitoring hole
WBR37A		-	-	13.37 mbgl	Grootegeluk monitoring hole
NN12		-	-	49.96 mbgl	Grootegeluk monitoring hole

Table 6.2 cont.: Borehole information for the candidate sites (Page 2)

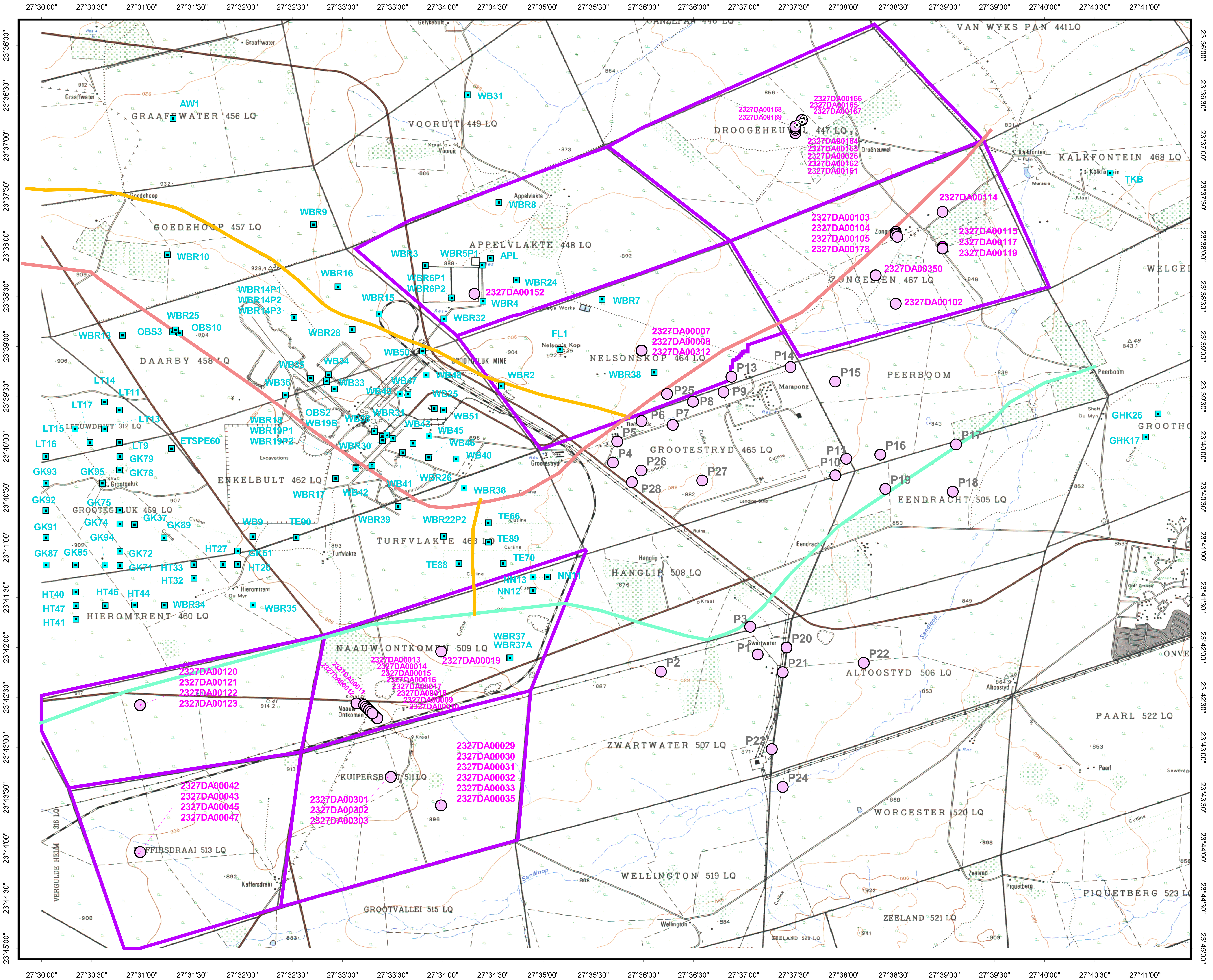
Borehole ID	Farm	Depth	Yield	Water level	Comment
2327DA00102	Zongezien (Eskom land)	80 m	0.05 l/s	-	
2327DA00103		70 m	Dry	-	
2327DA00104		64 m	0.54 l/s	33.53 mbgl	
2327DA00105		600 m	0.79 l/s	30.48 mbgl	
2327DA00178		120 m	0.53 l/s	24.00 mbgl	
2327DA00350		186 m	0.06 l/s	-	
2327DA00007	Nelsonskop (Ferroland / Kumba)	76 m	0.32 l/s	18.9 mbgl	
2327DA00008		500 m	0.85 l/s	27.43 mbgl	
2327DA00312		77 m	0.34 l/s	28.04 mbgl	
WBR38		-	-	13.35 mbgl	Grootegeluk monitoring hole
FL1		-	-	-	Grootegeluk sample point
WBR2		-	-	8.40 mbgl	Grootegeluk monitoring hole
P13					Matimba monitoring hole
P14					Matimba monitoring hole
2327DA00150	Appelvlakte (Ferroland / Kumba)	61 m	0.37 l/s	27.43 mbgl	
2327DA00151		77 m	0.27 l/s	21.03 mbgl	
2327DA00152		52 m	0.57 l/s	21.34 mbgl	
WBR32		-	-	5.4 mbgl	Grootegeluk monitoring hole
WBR6P2		-	-	6.74 mbgl	Grootegeluk monitoring hole
WBR4		-	-	2.88 mbgl	Grootegeluk monitoring hole
WBR5P1		-	-	2.34 mbgl	Grootegeluk monitoring hole
APL		-	-	-	Grootegeluk sample point
WBR24		-	-	11.35 mbgl	Grootegeluk monitoring hole
WBR7		-	-	22.99 mbgl	Grootegeluk monitoring hole
WBR3		-	-	3 .00 mbgl	Grootegeluk monitoring hole
WBR28		-	-	16.71 mbgl	Grootegeluk monitoring hole

Table 6.2 cont.: Borehole information for the candidate sites (Page 3)

Borehole ID	Farm	Depth	Yield	Water level	Comment
2327DA00026	Droogeheuvel (Eskom land)	77 m	0.21 l/s	21.34 mbgl	
2327DA00161		66 m	-	24.38 mbgl	
2327DA00162		49 m	0.44 l/s	22.56 mbgl	
2327DA00163		69 m	0.23 l/s	27.43 mbgl	
2327DA00164		400 m	0.21 l/s	23.77 mbgl	
2327DA00165		108 m	0.64 l/s	23.00 mbgl	
2327DA00166		300 m	-	-	
2327DA00168		204 m	-	-	
2327DA00169		210 m	-	-	

Figure 6.8: Borehole Yields

BOREHOLE YIELDS



LEGEND:

Only 2327DA00301 on Kuipersbult Yield>3 l/s

- Grootegeluk Boreholes
- < 1 l/s (Matimba boreholes)

Ngdb_8farms_boreholes_wgsdd.shp
- No Data
- < 1 l/s
- 1 - 2 l/s
- > 2 l/s

Faults_manual_wgsdd.shp
- Daarby
- Eenzaamheid
- Minor Faults
- Farm boundaries (SG)

0.5 0 0.5 1 1.5 Kilometers

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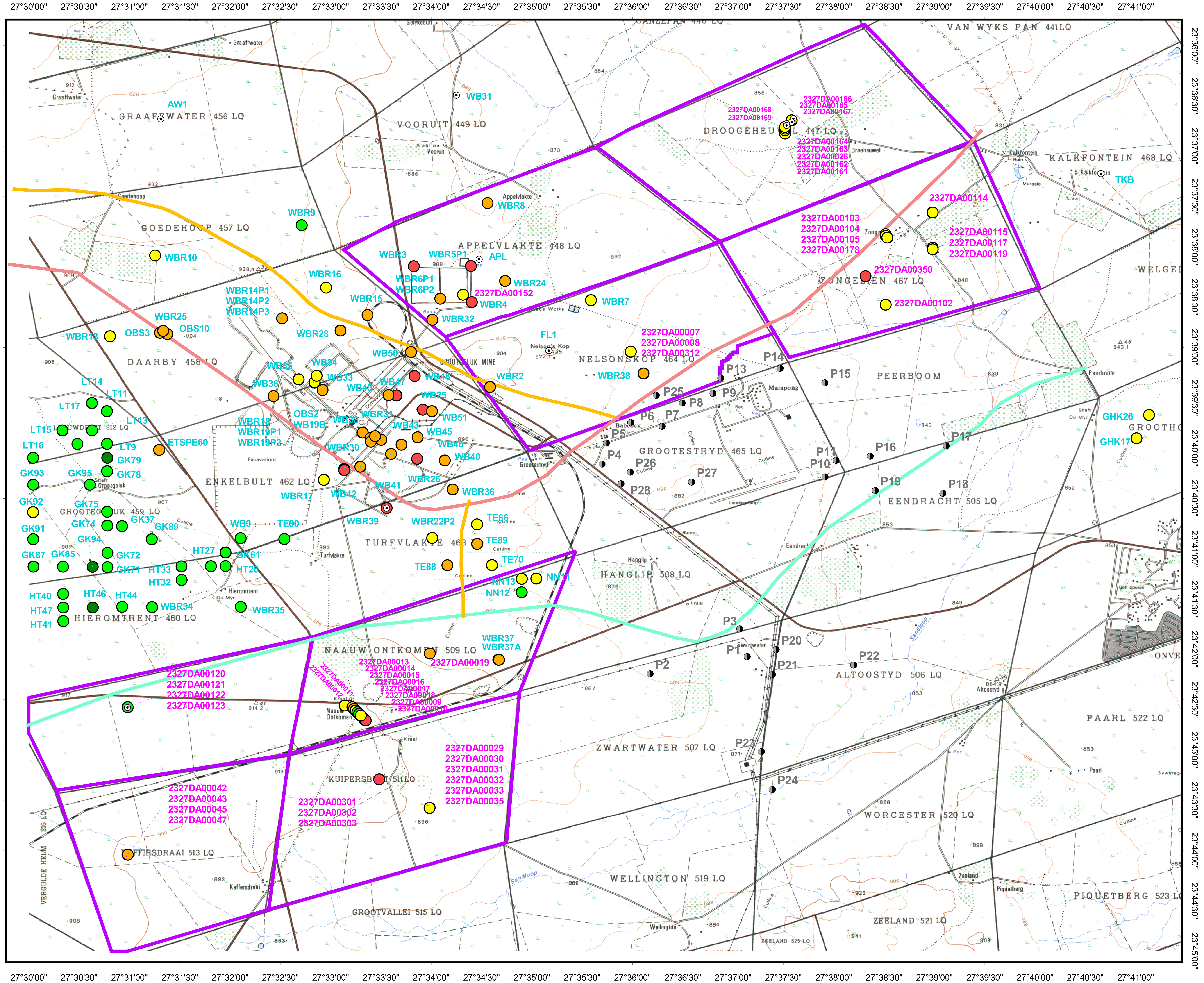
Figure 9

Figure 6.9: Static Water Levels

STATIC WATER LEVELS



LEGEND:

Grootegeluk Boreholes' Waterlevels <= 5m:

SITENAME	ZCOORD	WATERLEVEL	MBGL
WB25	895.30	890.57	4.73
WB46	894.11	890.37	3.74
WB47	896.72	891.91	4.81
WB48	896.02	891.77	4.25
WBR18	892.98	888.46	4.52
WBR19P2	892.90	888.66	4.24
WBR3	893.17	890.17	3.00
WBR39	891.02	886.26	4.76
WBR4	890.44	887.56	2.88
WBR5P1	886.57	884.23	2.34

NGDB Waterlevels <= 5m:

SITE_ID	FARM	ORIG_SITE_	MBGL
2327DA00045	513	KAFFIRSDRAAI PTN. KAFFERSDRAAI	1.83
2327DA00302	511	KUIPERSBULT	3.35
2327DA00303	511	KUIPERSBULT	1.83
2327DA00009	509	NAAUW ONTKOMEN	1.16
2327DA00010	509	NAAUW ONTKOMEN	1.62

Matimba boreholes

Grootgeluk_boreholes_wgsdd.shp
- No Data
- 0 - 5 mbgl
- 5 - 18.9 mbgl
- 18.9 - 35.05 mbgl
- 35.05 - 77.42 mbgl
- 77.42 - 112.78 mbgl

Ngdb_8farms_boreholes_wgsdd.shp
- No Data
- 0 - 5 mbgl
- 5 - 18.9 mbgl
- 18.9 - 35.05 mbgl
- 35.05 - 77.42 mbgl
- 77.42 - 112.78 mbgl

Faults_manual_wgsdd.shp
- Daarby
- Eenzaamheid
- Minor

Farm boundaries (SG)

0.5 0 0.5 1 1.5 Kilometers

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Figure 10

6.4.3. Groundwater use

Limited groundwater abstraction occurs within the study area due to:

- Land use (primarily stock or game watering)
- Reticulated (piped) water is supplied to the area, either via the municipality, Eskom, or Grootegeluk Coal Mine
- Low sustainable borehole yields
- Variable hydrochemistry, high salinity areas
- Little or no domestic groundwater usage due to Mokolo Dam supply to the area

6.4.4. Ambient hydrochemistry

Groundwater quality data from the DWAF's national groundwater database provides an indication of the ambient groundwater quality in the study area. Only four boreholes have been sampled by the DWAF in the area, the sample points are on the farms:

- Nooitgedacht 403 LQ (15 km north of the power station, Clarens Fm sandstone)
- Waterkloof 502 LQ (10 km east of the power station, Swartrant Fm sandstone)
- Ehrenbreitstein 525 LQ (12,5 km southeast of the power station, Mogalakwena Fm sandstone)

Table 6.3 presents the ambient hydrochemical data recorded in the study area.

Table 6.3: Ambient hydrochemistry

Tests	Units	SABS 241[1]	Nooitgedacht	Waterkloof	Waterkloof	Ehrenbreitstein
			14/06/1970	21/08/1970	21/08/1970	26/08/1970
pH	pH units	4 – 10	7.4	7.9	7.4	7.8
Nitrate	mg/l N	20	6.77	< 0.04	< 0.04	< 0.04
Fluoride	mg/l F	1.5	0.1	0.4	-	-
Sodium	mg/l Na	400	*692**	7	7	7
Magnesium	mg/l Mg	100	86	5	5	2
Sulphate	mg/l SO_4	600	*1 920**	< 4	< 4	< 4
Chloride	mg/l Cl	600	*37 630**	11	11	11
Calcium	mg/l Ca	300	*1 080**	14	14	6
EC	mS/m	370	*1 112.2**	13.3	13.3	7.2

* exceeds maximum allowable limits

The limited data indicates that the borehole sampled on the Farm Nooitgedacht, within the Clarens Formation rocks, has elevated concentrations of dissolved solids, Na, Cl, SO_4, and Ca.

The hydrochemistry associated with the boreholes within the Swartrant and Mogalakwena Formations is good potable groundwater.

Unfortunately, fluoride was not recorded in the sample from the Farm Ehrenbreitstein, which is within the Mogalakwena Formation. These rocks contain elevated concentrations of fluorite (apatite and fluorspar), which can increase the fluoride concentrations within the groundwater.

6.4.5. Aquifer classification

Based on the available hydrogeological data the overall aquifer system within the study area can be classified as a Non-Aquifer System (Parsons, 1995[2]), where: -

- *Non-Aquifer System* occurs where the formations have negligible permeability and are generally regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer as

[1] South African Bureau of Standards specifications for drinking water, maximum allowable limits, SABS 241 5th Edition, 2001

[2] WRC Report No. KV 77/95, A South African Aquifer System Management Classification, R. Parsons December 1995.

unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risks associated with persistent pollutants.

Groundwater potential is enhanced along areas of secondary processes, such as faulting, fracturing, etc. allowing for the development of discrete minor aquifer systems, where: -

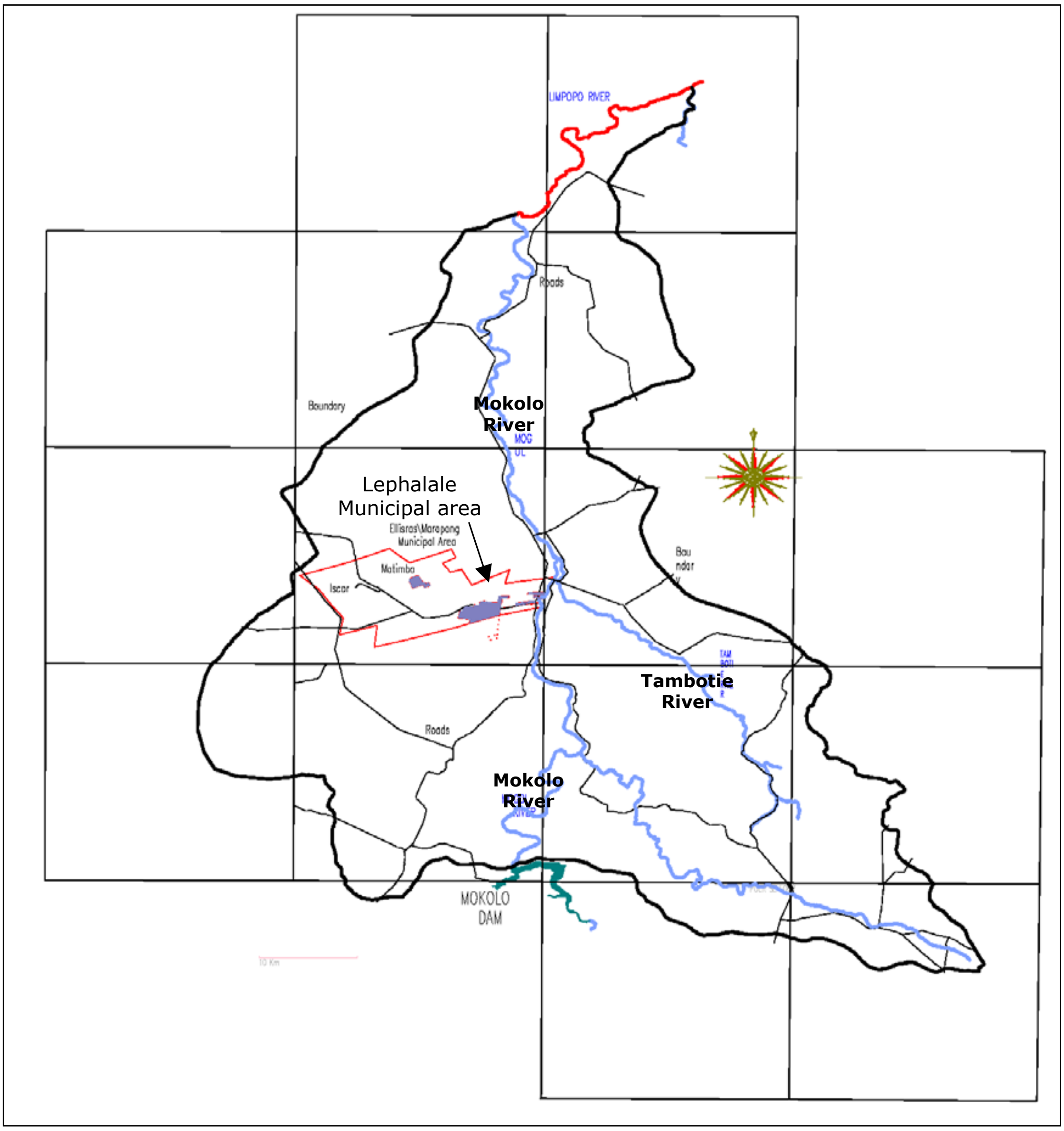
- A *Minor Aquifer System* comprises fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important both for local supplies and in supplying base flow for rivers.

Based on the aquifer types present on site and the variable (high salinity) hydrochemistry a rating of the aquifer vulnerability indicates that limited to low levels of groundwater protection are required for these aquifers.

6.5. Surface Water Hydrology

The study area falls within the Mogol River Catchment, which drains into the Limpopo River to the north (Figure 6.10). The catchment covers an area of 8 387 km^2. The catchment stretches from the Waterberg Mountains though the upper reaches of the Sand River, and includes the Mokolo Dam and a number of small tributaries that join the main Mokolo River up to its confluence with the Limpopo River. The topography of the area is flat, varying between 900 and 922 m amsl[3]. The general topographical drainage system is poorly developed and drains in an easterly direction towards the Mogol River (810 m amsl), (Figure 6.11).

[3] The Nelson's kop is a prominent landmark at 922 m amsl; this hill is an inselberg (erosional relic) of the Clarens Formation sandstone.



The Mogol River Catchment	GCS GROUNDWATER CONSULTING SERVICES WATER, ENVIRONMENTAL & EARTH SCIENCE CONSULTANTS P.O. Box 2597 Tel.: (011) -5726 Rivonia Fax.: (011) 803 5745 2128 jhb@gcs-sa.biz	Figure No: 11 Scale: As shown Project No: 2004.11.535

Figure 6.10: The Mogol River Catchment

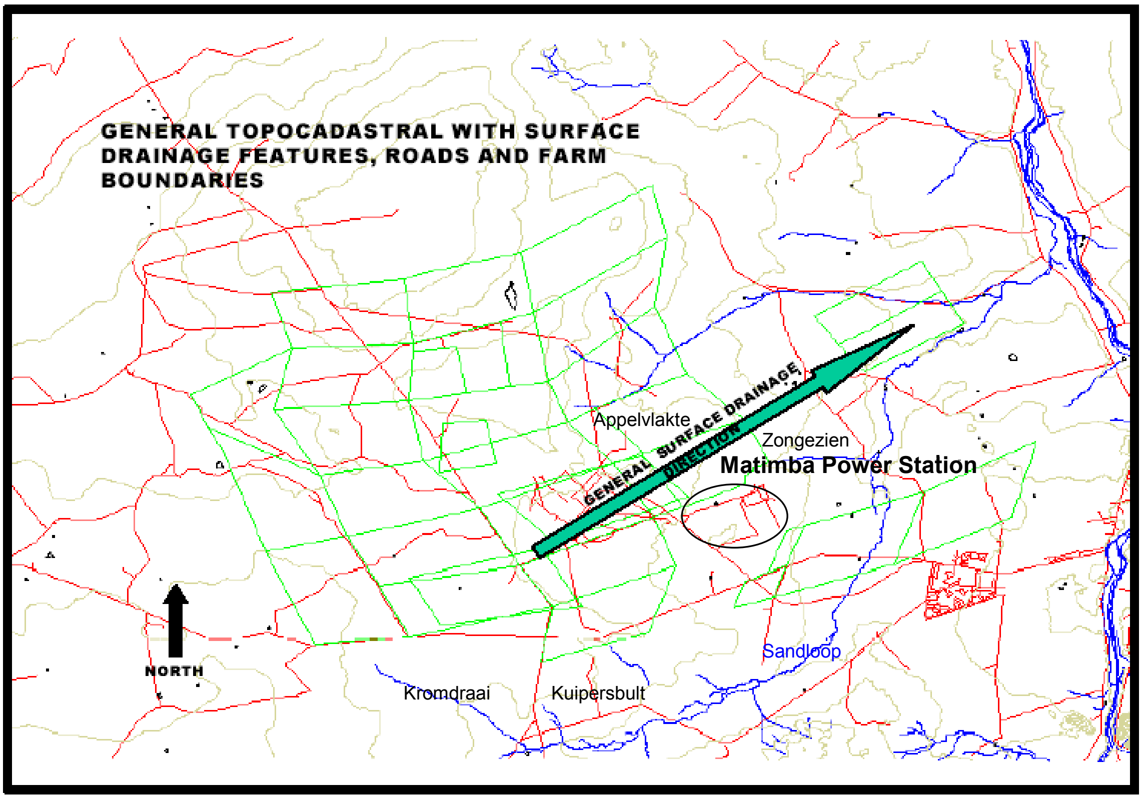


Figure 6.11: Surface drainage within the study area.

The drainage consists primarily of dry sandy gullies, such as the "Sandloop", located to the south and east of the existing Matimba Power Station.

The only recognisable drainage channels in the study area occur along the northern boundary of the farm Appelvlakte 448 LQ, through the center of Kromdraai 513 LQ, through the south of Zongezien 467 LQ, and through the northeastern section of Kuipersbult 511 LQ (refer to Figure 6.7).

The surface water drainage system is poorly developed due to:

- The flat topography (Power Station 880 mamsl to Mogol River 810 m amsl is 70 m over 15 000 m, gradient = 1:214)
- The sandy soil veneer, 1 m – 3 m of high permeable soil cover
- Low annual rainfall, 435 mm per annum (Weather Bureau, 29 year record 1961 – 1990)

Due to the absence of any well-defined or perennial surface water drainage courses within the study area, it is anticipated that the proposed power station and infrastructure will not have a direct impact, in terms of quantity (run off) or quality, on the surface water.

Currently, water use in the catchment broadly comprises (DWAF, 2005):

- 87% for agricultural activities.
- 13% for the industrial, mining, power generation and domestic water supply service sectors (municipalities).

At present, water availability and water use in the catchment are in balance. However, within the provisions of the National Water Act as stipulated in the National Water Resources Strategy, there is a need to meet the water requirements of the Reserve (Basic Human needs and Ecological) in terms of water quantity and quality. Taking the requirements into account, there is insufficient water to maintain the current balance. Added to this, it is anticipated that water demand will increase with new developments proposed in the Mokolo Catchment, such as new or expanded mining activities and new power stations. Refer to Appendix J for a graphical interpretation of the above paragraph.

The supply of additional water from the already stressed catchment may have an indirect impact on the downstream surface water users.

6.5.1. Current surface water supply

Matimba Power Station currently receives its water from the Mokolo dam on the Mogol River (Figure 6.10). Apart from supplying the Matimba Power Station, the

Mokolo dam also supplies the Grootegeluk Coal Mine, Lephalale town, and various settlements and farmers in the area.

The Mokolo River drains the southwestern part of the Limpopo Water Management Area and has various tributaries. Of these tributaries, namely the Sand River and the Grootspruit, originate in the Waterberg mountain range and flow into the Mokolo River upstream of the Mokolo Dam. Other tributaries are the Tambotie River, Poer se Loop, and the Rietspruit River that join the Mokolo River downstream of the Mokolo Dam. The altitude varies from 1 700 m to 790 m at the confluence with the Limpopo River.

The availability of the surface water resulted in extensive irrigation development. This development has been enhanced by the construction of Mokolo Dam, which was developed mainly to support mining and power generation development. The associated infrastructure development was undertaken by Kumba Resources and Eskom.

The Mokolo Dam forms part of a Regional Water Supply Scheme supplying drinking water to Lephalale and irrigation water along the Mokolo River. The Mokolo Regional Water Supply Scheme comprises of the Mokolo Dam (gross capacity 146 x 10^6 m^3, firm yield 27,1 x 10^6 m^3/a) located in the middle reaches of the Mokolo River. The dam was constructed to assure water supply to the Matimba Power Station (allocation 6.5 million m^3/a), Grootegeluk coal mine (allocation 5.6 million m^3/a), Lephalale and adjacent urban water users (allocation 3.9 million m^3/a) and irrigation of an area of 2 000 ha (allocation 10,4 x $10^6 m^3$/a, at lower level of assurance).

Raw water is drawn from the dam and pumped through a 700 mm diameter steel pipeline to Lephalale via a balancing dam at Wolwefontein, some 40 km from Mokolo Dam. Part of the water is treated in a 17 Ml/d raw water treatment works before being delivered through a 450 mm diameter pipeline to Lephalale.

Raw water is drawn from the balancing dam and delivered to Grootegeluk mine and Matimba Power Station. Eskom treats water for own use and also delivers potable water to the adjacent village of Marapong.

Irrigation water is released from Mokolo Dam into the Mokolo River where it is abstracted by riparian irrigators as required.

Based on discussions with the Department of Water Affairs and Forestry (DWAF, *pers comm*) regarding the allocation of water from the Mokolo Dam, the current allocation is as follows:

- Mokolo Irrigation Board Allocation 10,4 million m^3/annum

- Kumba Resources Coal Mine Allocation 17,2 million m^3/annum. From this allocation, Kumba supplies water to a number of users, including Lephalale Municipality, Marapong and 6.5 million m^3/annum for Eskom Matimba

These volumes differ slightly from the Mokolo Regional Water Supply Scheme.

Although the water system is in balance, DWAF indicated that the current system was already stressed due to the fact that there are no additional volumes of water from the Mokolo Dam that could be allocated for use.

- *Power station water use*
  Water consumption at the dry cooled power station is in the order of 0,1 to 0,2 l/kWh (litres per unit of electricity produced). The average water use is 0,12 l/kWh sent out. The power station is capable of generating 3 990 MWh with an Energy Availability Factor (EAF) of 94[4]. The current water use at Matimba Power Station is 3,3 million m^3/annum (*pers comm* Heine Hoffman Eskom, 2005). The power station requires an assured reliable water source in order to generate sufficient energy to meet its demands. The DWAF provides the water at an assurance of 99,5%.
- *Current surface water demand and future capacity*
  At present the only source of water to the existing power station is the Mokolo Dam. Should an additional power station be built, then the demand on the dam will be increased and DWAF will be required to provide an assured water supply. Figure 6.12 illustrates the percentage storage within the dam. Current levels within the dam (May 2005) are at 89%. The storage within the dam dropped to 60% of full storage capacity during March 2004. The Mokolo Dam forms part of the quotas from Government Water Schemes in accordance with Section 56 of the Water Act, 1956 and specific allocations have been made to household and stock watering (quota 0,057 x 10^6 m^3/a) as well as the municipality (quota 0,465 x 10^6 m^3/a). The potential surface water resources within this area are nearly fully developed (the scheme is stressed) with major dams and a host of smaller dams existing in the area. Only the upper Lephalala River and Mokolo River have significant potential for surface water development in terms of the physical requirements for surface water storage infrastructure.

[4] The power station produces full capacity 94% of the time.

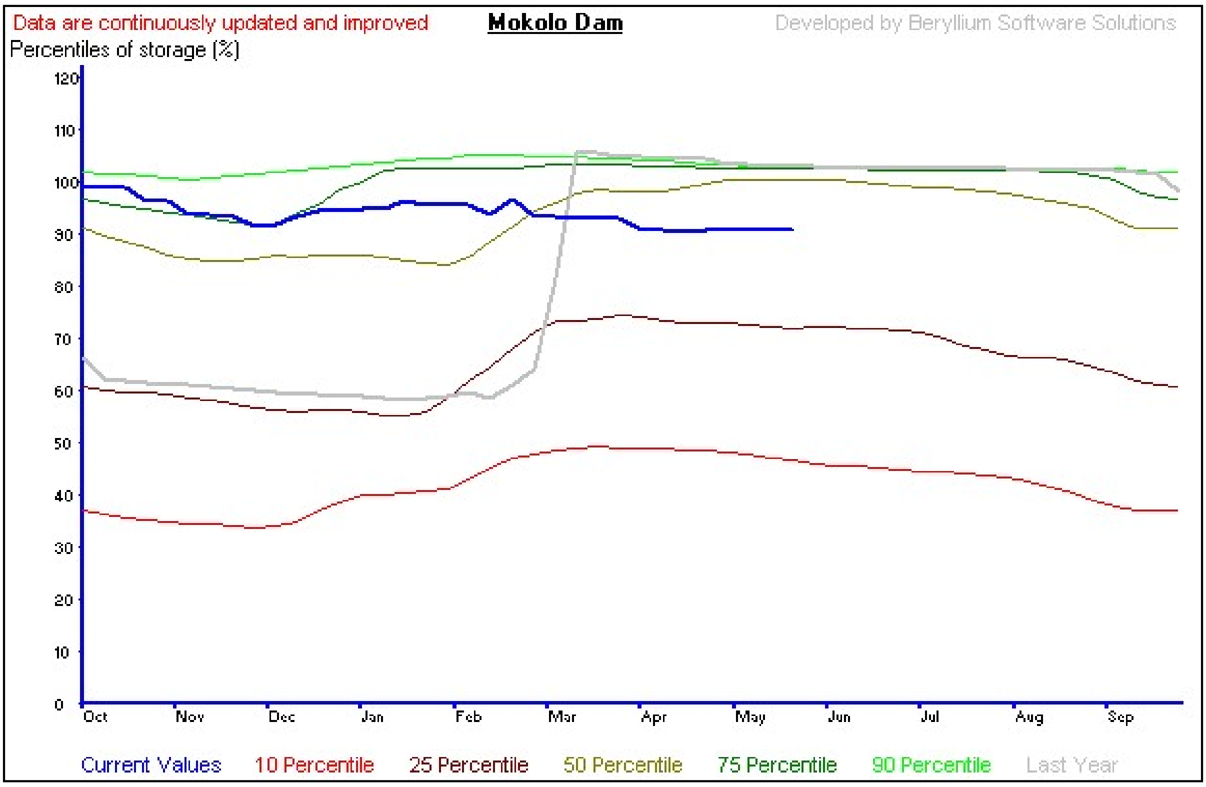


Figure 6.12: Mokolo Dam storage volumes

Table 6.4: Mokolo Dam specifications and water use allocations

Mokolo Dam	Quaternary catchment	Gross capacity	MAR	Required yield	Firm yield	Households	Irrigation	Matimba	Kumba
		10^6m^3	$10^6m^3/a$						
Allocation	A42F	146.0	240.4	28.6	27.1	1.0	10.4	7.3	9.9
Quota						0.522	-	-	-

6.5.2. DWAF studies

- *Background*

  The Department of Water Affairs and Forestry (DWAF) initiated a stakeholder consultation process in the Lephalale area in December 2003 to discuss future developments that were anticipated and the concomitant water requirements. At this time, the inflow to the Mokolo Dam was low and fears developed that the dam would not be able to yield enough water in the event of moving into a period of prolonged low rainfall. This led to DWAF identifying a series of planning studies that would culminate in defining the water use and the availability of water. These studies are as follows:

  * **Verification and Validation study:** This is to verify the water use of each water user and then verify the information. Satellite images, aerial photographs and registered water use information will be used to

determine actual water use. This study will validate how much water is currently being used by the different use sectors and verify the lawfulness of the water users and to determine the existing lawful water use. This information will assist DWAF with the issuing of licences and the evaluation of licenses and the evaluation of the new licence applications. This study is expected to be completed in May 2006.

* **Hydrology Study:** This investigation is aimed at providing DWAF with an updated understanding of how much water (yield) is presently available in the catchment. This work will be based on the analysis of historical rainfall patterns, streamflow, ground and surface water resources. The study will also analyse the performance of the Mokolo Dam under different water abstraction scenarios. This study will provide valuable information to the verigication and validation study on existing lawful water uses and the potential of the catchment to support new developments and new water uses. This study will be completed by December 2006.
* **Water Conservation and Water Demand Management Study:** Water conservation means "minimising water losses and/or wastage and the use of water in an efficient and effective way". Water Demand Management is the adoption and implementation of action plans to influence the demand for, and use of water by consumers. While it is recognised that some sectors in the Mokolo River Catchment are already practicing Water Conservation and Water Demand Management, additional efforts are required to realise additional water conservation and efficient use of this valuable resource. The outcomes of this study will feed into the updated hydrology and systems models (reduced demand) as well as into validation and verification (via improved efficiencies). This is a study to assess the potential to implement further water conservation and water demand management initiatives in the area. This study will be completed by January 2006.
* **Pre-feasibility and Feasibility Studies:** This study will study the feasibility of raising the Mokolo Dam Wall and/or Transfer of water from the Crocodile (West) catchments. The pre-feasibility for an augmentation option had been identified prior to Eskom's intent of developing the new power station for the reasons described above (DWAF, 2005).

The outcomes of these studies will enable the DWAF to be able to take decisions regarding water quantities and supply, water use and imbalances in the system.

A public participation process for these studies was held on 19, 20, 21 July 2005 and was well received (refer to Appendix K). This served as a pre-cursor for future Environmental Impact Assessments that may arise as a result of the outcome of these studies. DWAF will continue this public consultation as the studies progress.

Eskom was part of the initial stakeholder consultation process, and have submitted preliminary water use figures to DWAF, which included water use for a second dry cooled power station in the future. Following the completion of the pre-feasibility phase of the Matimba B project in early 2005, Eskom engaged DWAF in bi-lateral discussions regarding future development and water requirements in the Lephalale region. The discussions have covered the following issues, and proceed on a monthly basis:

* Information sharing regarding the progress of each party – DWAF with regards to the water studies and future water supply development and Eskom in terms of future generation expansion and water requirements.
* Constructing a memorandum of agreement/understanding to enable future co-operation with regards to resource sharing and funding requirements.
* Undertakings required for achieving milestones in future planning e.g. fast-tracking completion dates for studies.

6.5.3. Possible water augmentation sources

The proposed power station size and type has not yet been finalised, thus the exact water demand is not yet known, however it is estimated at approximately 4 – 6 million cubic meter of water. Current use at Matimba Power Station is 3,3 million m^3/annum from an allocation of 7,1 million m^3/annum. This allows for a 99,5% assurance of water supply, which equates to a once in 200 years failure of supply. The water supply allocation will therefore be higher than the use in order for DWAF to assure the supply.

In order to augment the current volumes of water available in the catchment, the following water supply schemes are being considered:

- The supply of 45 million m^3/annum from the Crocodile (West) and Marico catchment to the Limpopo catchment (which contains the study area). This study has been completed by DWAF.
- DWAF have investigated the feasibility of raising the Mokolo dam wall. There is plan to raise the Mokolo Dam wall because initially the dam was designed to be raised. Indications are that the dam wall may be raised by some 15 m to have an ultimate storage capacity of about 303×10^6 m^3. This will only be done after some detailed investigations, especially with regard to the impact on the downstream users.
- Borehole fields with a capacity of $30{,}7 \times 10^6$ m^3/year could be developed in the Mokolo River catchment.

The Matimba Power Station usage is apparently at a constant level, while the Grootegeluk Coal Mine uses less water than allocated. This decrease is because the mine utilises water from the pit and from an adjacent wellfield. Conjunctive water use between the mine and the power station(s) could be considered.

6.5.4. Conclusions

- Matimba Power Station currently uses ± 3,3 million m^3/annum
- Matimba Power Station has an allocation of 6.5 million m^3/annum to ensure supply
- A detailed study has been conducted in the Crocodile (West) and Marico catchment, which could allow 45 million m^3/annum of water to be pumped to the Limpopo catchment
- The Mokolo Dam has a capacity of 146 x 10^6 m^3, and allocations allow for the abstraction of 27,1 x 10^6 m^3/year
- The storage capacity of the Mokolo Dam is significantly less than the mean annual run-off in the Mokolo River, 240,4 x 10^6 m^3/year
- Plans are in place to increase the water resource to assist with development in the area (Limpopo Province Development Blueprint Vision 2020)

Motivations regarding the letter of undertaking from DWAF to Eskom are required for inclusion in the EIA. Details of the DWAF studies EIA processes and Interested and Affected parties contact details are required for inclusion in the EIA for the proposed power station. Although water allocations under DWAF authorization have been granted the DWAF studies must be completed to verify that the current yield is physically available.

6.6. Existing Matimba Power Station

In order to determine the possible impacts the proposed new power station will have on the groundwater, an assessment of the existing Matimba Power Station has been compiled.

6.6.1. Power station infrastructure

The possible sources of contamination or infrastructure that may impact on the groundwater or surface water are:

The coal stockpiles	potential acid generation area
The raw water dam	source of artificial recharge to the groundwater
The sewage plant and dams	irrigation of effluent may impact on groundwater
Treated (de-ionized) water system	brine added to fly ash for deposition on ash dump
Evaporation dams (x2)	source of “poor” quality artificial recharge
Recovery (dirty water) dams (x4)	overflow and irrigation may impact on groundwater
Bunker fuel oil	oil enters water and requires treatment
Ash dump	source of “poor” quality artificial recharge
Ash dump to dam	source of artificial recharge
Solid waste site	source of leachate or poor quality water

6.6.2. Power station geology and hydrogeology

Swartrant Formation sediments, comprising sandstone, gritstone, mudstone, and coal underlie the power station and all its facilities, except the ash dump. A thin layer of soil followed by weathered sediments overlies these rocks. Weathering occurs to a depth of 15 to 25 m and is permeable to water movement. Below the weathered zone is an impermeable layer of black shale.

Contaminants from surface will penetrate the weathered and fractured sediments. Lateral deflection of contaminant migration takes place along the top of the shale.

The ash dump is underlain by Waterberg Group sandstone, which has recrystallised and fully oxidised. Approximately 3 m of permeable sandy soil covers ± 4 m of weathered sandstone. Red hard competent sandstone is intersected below the shallow weathering.

The majority of the 26 monitoring boreholes (Figure 6.8 labeled P1 to P28) drilled and constructed at the power station and the ash dump were dry. Blow-out yields in the successful boreholes did not exceed 500 l/hr. Water strikes in the Karoo sediments ranged from 11 to 29 m, and the water strikes in the Waterberg Group ranged from 14 to 39 m.

These sediments are recognised to be poor aquifers with water moving through the rocks at very low rates. These rates are very low due to the low permeabilities of the rocks and the very low regional groundwater gradients. The groundwater gradients, which mimic the surface water gradients, are to the east at an average gradient of 1:250.

6.6.3. Power station monitoring

Eleven monitoring boreholes have been monitored at Matimba Power Station since 1987. The monitoring shows some degree of groundwater quality deterioration with time. In 2004, an additional 15 new monitoring boreholes were drilled and constructed to further assess the pollution plumes.

- *Water level monitoring*

  Groundwater level depths, before the establishment of the power station, were in the range of 15 m to 20 m below surface.

  The power station infrastructure, including run-off dams, dirty water dams, coal stockpile, the ash dump and toe dam, provided areas of artificial recharge. The water levels on site have risen by more than 10 m in certain areas due to the seepage into the ground. Groundwater contamination can occur as a result of poor quality water recharging the underlying aquifers.

An examination of water level monitoring data from the Grootegeluk Coal Mine indicates the same rise in groundwater levels to the north of the Daarby fault as a result of the slimes dams in the area (on the Farm Appelvlakte).

Examination of the rise in groundwater levels and the hydraulic response of the aquifer in areas away from the artificial recharge points, known as the equalisation reaction, provide an indication of the hydraulic characteristics of the aquifer. Due to the localised nature of the groundwater mounds around the recharge points and the limited zone of influence suggests low regional permeabilities within the Karoo and Waterberg sediments.

The groundwater level data indicates interconnectivity between the power station water infrastructure and the aquifers over a relatively small area, and that groundwater contamination could occur but would migrate at a very slow rate. Pollution plume modelling, conducted by the Institute for Groundwater Studies (IGS) from the University of the Free State, indicate that the rate of plume migration is retarded, due to indirect flow paths along fractures and cracks in the rock and because of chemical reactions and ionic bonding.

Groundwater level monitoring generally indicates that deeper water levels are recorded away from the power station and infrastructure. It is concluded that the hydraulic response due to artificial recharge is localised.

- *Hydrochemistry*

  After 17 years of groundwater monitoring by Eskom, most of the 11 original monitoring boreholes have shown some degree of groundwater quality deterioration. Based on these data pollution plume(s) modelling was conducted and predictions regarding migration were made.

  Based on DWAF requirements, an additional 15 monitoring boreholes were drilled and constructed to further assess the pollution plumes.

  The new monitoring boreholes were drilled to a depth of 40 m and geological records indicate that the strata at 40 m were impermeable.

  Down-the-hole hydrochemical logs were recorded for each of the new boreholes. Variations in vertical hydrochemistry were recorded. The variations are as a result of the sediments naturally containing salts, which is a result of:

  * The drilling has exposed the impermeable shale to water, which allows for the release of salts into the groundwater (natural pollution of the borehole)

* Natural salinities in the groundwater are high due to the dry climate. Long residence time of the groundwater would allow for high concentrations of almost all macro constituents to occur.

Based on the vertical stratification within the monitoring boreholes and the recognised protocol to stratified sampling (DWAF), all 26 monitoring boreholes were sampled in January 2004. The sampling and data analysis was undertaken by IGS.

Table 6.5 presents the current hydrochemistry within the monitoring boreholes at the power station.

The groundwater monitoring and pollution plume mapping conducted by IGS indicates the following:

* Borehole P1 located on the northeast edge of the ash dump is the only monitoring point to have low pH and elevated sulphate concentrations with time (possible AMD[5]). According to IGS, this is a local phenomenon that cannot currently be explained.
* Groundwater within boreholes P2 to P11 indicates some degree of groundwater quality deterioration. The rise in the salt content of the groundwater is due to seepage from surface sources and also because of the dissolution of salt from the previously unsaturated impermeable zone. The increase in salinity is, therefore, a combination of artificial recharge of poor quality (saline) surface water sources and the mobilisation of salts in the exposed impermeable zones in the boreholes.
* A contaminant plume has been identified associated with the ash dump, boreholes P2, P3, P20, P21, P23, and P24. The plume is recognized to migrate to the northeast. P22 located down gradient of the ash dump and plume has not yet been impacted on. Plume migration predictions indicate it will take between 50 and 100 years to alter the hydrochemistry in borehole P22 (IGS, 2004).
* P12 is lost as it was drilled into a fault and collapsed.
* P13, P14, P15, and P25 have been drilled to cover the coal stockyard and associated dirty water dams. Water levels in these holes are shallower than 10 m, suggesting the hydraulic response from water in these areas has already resonated through these boreholes. Due to the naturally elevated salinity within the groundwater, there is insufficient information to determine whether or not pollution has migrated through any of these sites (IGS, 2004).

[5] Acid mine drainage – low pH and elevated sulphate concentrations in groundwater due to the oxidisation of sulphides

* P16, P17, P18, and P19 were constructed down gradient of the surface water run-off dams[6]. Shallow groundwater in P16 indicates possible seepage or leaks from the dams. A contamination plume has been recognised and modelled migrating east / southeast from these dams.
* Borehole P18 is down gradient of the surface water run-off dams. The groundwater within this borehole, drilled into a zone of deeper weathering (38 m), has elevated concentrations of most macros constituents. These concentrations are significantly higher than the regional background values. Additional information is required to determine the source of the salinity.
* Boreholes P26, P27, and P28 were constructed within the power station security fence to monitor possible sources of surface contamination from the solid waste area and the coal stockyard. Borehole P26, located closest to these areas, has the highest salinity. Additional monitoring (quality) data is required to determine whether the salinity originates from pollution sources or it is natural.

The borehole positions, P1 to P28, are presented on Figure 6.7.

[6] Clay and concrete lined recovery dams and canals, complete with oil traps and separators. Used as a source of irrigation water

Table 6.5: Chemistry results for the Matimba power station monitoring holes (January 2004)

Elements	P1	P2	P3	P4	P5	P6	P7	P9	P10	P11	P13	P13	P14	P14
Depth (m)	10	30	13	14	15	13	13	9	6	6	10	29	10	33
pH	3.56	6.77	6.96	6.24	7.18	7.61	7.21	7.83	6.84	6.63	7.25	7.42	7.17	7.32
EC (mS/m)	270	380	97	153	68	345	293	169	67	81	184	192	147	144
Al (mg/l)	33.941	0.035	0.053	0.178	0.111	0.039	0.049	0.055	0.04	0.086	0.039	0.03	0.048	0.135
B (mg/l)	12.197	2.806	0.233	0.247	0.193	0.511	0.303	0.192	0.115	0.126	0.285	0.293	0.2	0.186
Ba (mg/l)	0.065	0.163	0.072	0.086	0.538	0.138	0.174	0.107	0.141	0.175	0.188	0.115	0.132	0.132
Be (mg/l)	0.005	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Br (mg/l)	0.54	0.67	0.13	2.71	0.32	2.83	2.5	0.2	0.45	0.19	0.95	1.03	0.8	0.8
Ca (mg/l)	250	142	43	33	44	90	56	48	26	33	97	104	28	28
Cd (mg/l)	0.003	0.005	0.003	0.003	0.002	0.005	0.004	0.001	0.001	<0.001	0.001	0.001	0.002	0.002
Cl (mg/l)	33	945	21	356	72	645	427	49	109	31	153	171	274	255
Co (mg/l)	0.059	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	0.015	<0.005	<0.005	<0.005	<0.005
Cr (mg/l)	0.026	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cu (mg/l)	0.091	0.115	0.121	0.112	0.107	0.108	0.106	0.101	0.099	0.104	0.107	0.106	0.1	0.098
F (mg/l)	1.21	1.44	0.73	0.26	0.28	1.97	1.44	5.56	0.16	0.67	0.28	0.15	0.86	0.87
Fe (mg/l)	0.224	0.084	4.532	5.664	1.576	0.136	1.446	1.097	0.638	10.933	2.427	1.75	0.098	0.778
K (mg/l)	60.6	41	11.4	4.1	0.5	3.1	12.5	1.6	1.7	2.7	12.4	13.6	1.6	1.7
Li (mg/l)	0.021	0.086	0.015	0.131	0.009	0.028	0.319	0.026	0.016	0.001	0.19	0.212	0.031	0.034
Mg (mg/l)	83	114	31	31	26	146	51	72	15	17	56	57	23	24
Mn (mg/l)	1.431	0.577	0.577	0.122	0.082	0.015	0.462	0.272	0.186	1.164	0.218	0.184	0.118	0.131
Mo (mg/l)	<0.003	<0.003	<0.003	0.006	<0.003	0.020	0.012	0.01	0.007	<0.003	0.005	<0.003	0.012	0.012
Na (mg/l)	219	456	109	237	69	458	550	244	96	119	257	278	252	243
Ni (mg/l)	0.157	0.016	0.01	0.011	<0.01	<0.01	0.01	<0.01	<0.01	0.015	<0.01	<0.01	0.01	0.013
NO_2 (as N)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NO_3 (as N)	7.52	26.25	0.04	0.09	11.84	28.65	<0.045	<0.045	0.22	0.15	0.06	<0.045	6.16	4.89
Pb (mg/l)	0.05	<0.015	<0.015	0.023	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.023
PO_4 (mg/l)	0.21	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.7	0.68
Se (mg/l)	0.086	0.009	<0.006	<0.006	<0.006	0.006	0.007	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
SO_4 (mg/l)	1371	310	346	64	6	284	169	520	14	210	93	103	28	27
Sr (mg/l)	1.76	1.419	0.392	0.292	0.392	1.209	0.675	0.652	0.21	0.192	0.846	0.879	0.245	0.246
V (mg/l)	<0.01	<0.01	<0.01	<0.01	0.022	0.053	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.013	0.013
Zn (mg/l)	0.113	0.075	0.077	0.469	0.08	0.06	0.075	0.061	0.073	0.072	0.069	0.063	0.066	0.112

Red values exceed the SABS 241 maximum allowable limits for Drinking Water (SABS, 2001)

Table 6.5 cont.: Chemistry results for the Matimba power station monitoring holes (January 2004) (Page 2)

Elements	P15	P15	P16	P16	P17	P17	P18	P18	P19	P20	P20	P21	P21	P22
Depth (m)	10	29	10	24	27.5	37	39	31	33	18	33	30	15	39.5
pH	6.76	6.94	7.14	7.3	7.53	7.66	6.76	6.67	7.43	7.12	7.83	6.34	6.41	6.39
EC (mS/m)	79	88	106	109	135	200	917	911	115	48	43	158	159	448
Al (mg/l)	0.062	0.055	0.052	0.063	0.071	0.072	0.302	0.046	0.042	0.077	0.061	0.12	0.174	0.048
B (mg/l)	0.152	0.177	0.211	0.227	0.301	0.348	0.384	0.38	0.223	0.199	0.169	6.428	6.399	0.504
Ba (mg/l)	0.194	0.22	0.211	0.416	0.152	0.098	0.085	0.115	0.247	0.059	0.068	0.062	0.067	0.436
Be (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Br (mg/l)	0.55	0.82	0.72	0.9	0.24	1.21	8.56	8.2	0.82	0.49	0.43	1.16	1.19	6.04
Ca (mg/l)	31	39	31	40	48	28	951	955	51	29	25	141	142	301
Cd (mg/l)	0.001	<0.001	0.001	0.001	0.001	0.002	0.004	0.006	0.002	<0.001	<0.001	<0.001	<0.001	0.004
Cl (mg/l)	162	172	185	192	99	258	2234	2265	195	38	32	30	33	1305
Co (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.016	0.015	<0.005	0.006	0.006	0.023	0.030	0.006
Cr (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cu (mg/l)	0.088	0.077	0.104	0.094	0.111	0.099	0.091	0.101	0.077	0.047	0.047	0.068	0.057	0.077
F (mg/l)	0.18	0.42	0.95	0.89	1.55	1.51	<0.01	<0.01	0.71	1.68	1.82	2.84	2.94	0.17
Fe (mg/l)	2.692	4.845	0.077	0.746	0.069	0.104	10.341	4.734	4.721	4.614	4.55	39.24	42.001	0.116
K (mg/l)	2.7	3.6	1.8	2.9	28.7	20.7	62	60.3	3.4	10.2	10.3	30	31.1	46
Li (mg/l)	0.011	0.039	0.007	0.017	0.023	0.037	0.353	0.341	0.066	0.003	0.004	0.009	0.009	0.076
Mg (mg/l)	16	19	20	20	42	23	568	569	21	15	14	70	73	67
Mn (mg/l)	0.68	0.816	0.156	0.295	0.186	0.084	2.846	2.706	0.632	0.604	0.57	2.772	2.691	2.297
Mo (mg/l)	0.008	0.011	0.064	0.07	0.185	0.54	<0.003	<0.003	0.007	0.006	0.005	<0.003	<0.003	<0.003
Na (mg/l)	115	118	164	160	189	372	500	504	163	51	40	90	94	441
Ni (mg/l)	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.017	0.016	<0.01	0.016	0.01	0.036	0.044	0.017
NO_2(as N)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NO_3(as N)	0.06	<0.045	4.61	1.77	6.19	0.09	0.83	0.05	0.05	0.05	<0.045	0.03	0.16	16.93
Pb (mg/l)	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.057	<0.015	<0.015	<0.015	<0.015	0.039	0.043	<0.015
PO_4 (mg/l)	0.51	1.62	0.4	0.63	3.99	1.25	<0.1	<0.1	<0.1	4.06	0.82	<0.1	<0.1	<0.1
Se (mg/l)	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
SO_4 (mg/l)	6	3	11	12	44	68	1888	1881	16	16	11	805	825	161
Sr (mg/l)	0.204	0.26	0.245	0.341	0.463	0.272	4.099	4.068	0.319	0.13	0.1	1.412	1.236	6.686
V (mg/l)	<0.01	<0.01	<0.01	<0.01	0.037	0.021	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zn (mg/l)	0.07	0.047	0.073	0.066	0.079	0.079	0.084	0.075	0.057	0.047	0.05	0.049	0.074	0.218

Red values exceed the SABS 241 maximum allowable limits for Drinking Water (SABS, 2001)

Table 6.5 cont.: Chemistry results for the Matimba power station monitoring holes (January 2004) (Page 3)

Elements	P23	P24	P24	P25	P25	P26	P27	P27	P28
Depth (m)	34	11	30	19	27	8	8	16	19
pH	7.08	6.78	7.00	6.43	6.50	7.49	6.91	7.03	6.91
EC (mS/m)	314	35	39	128	130	326	96	94	137
Al (mg/l)	0.032	4.213	0.22	0.058	0.042	0.058	0.084	0.05	0.079
B (mg/l)	0.698	0.097	0.104	0.284	0.291	0.522	0.073	0.065	0.226
Ba (mg/l)	0.227	0.492	0.028	0.125	0.121	0.157	0.27	0.215	0.145
Be (mg/l)	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Br (mg/l)	2.45	0.43	0.53	0.74	0.82	2	0.48	0.55	1.58
Ca (mg/l)	133	4	6	38	37	47	19	16	33
Cd (mg/l)	0.002	0.004	<0.001	0.002	0.001	0.004	0.002	0.001	0.002
Cl (mg/l)	478	40	42	174	184	455	207	210	187
Co (mg/l)	0.008	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cr (mg/l)	<0.005	0.014	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cu (mg/l)	0.061	0.102	0.024	0.112	0.077	0.091	0.073	0.019	0.083
F (mg/l)	0.41	2.84	0.75	0.63	0.65	1.52	0.48	0.86	1.1
Fe (mg/l)	2.229	10.427	0.23	2.298	3.695	0.128	0.442	0.052	3.609
K (mg/l)	38.8	11.3	11.7	2.9	2.6	26.2	2.5	2.2	4.9
Li (mg/l)	0.08	0.008	0.006	0.054	0.055	0.123	0.002	0.002	0.018
Mg (mg/l)	57	1	1	43	44	86	22	21	34
Mn (mg/l)	1.389	0.58	0.068	0.247	0.218	0.156	0.044	0.035	0.268
Mo (mg/l)	0.019	<0.003	0.021	0.004	0.007	0.029	<0.003	<0.003	0.006
Na (mg/l)	473	67	71	182	177	589	139	137	222
Ni (mg/l)	0.01	0.034	<0.01	<0.01	0.011	<0.01	0.011	0.01	<0.01
NO_2 (as N)	<0.01	<0.01	<0.01	<0.01	<0.01	0.75	<0.01	<0.01	<0.01
NO_3 (as N)	0.06	<0.045	<0.045	0.18	0.23	1.49	8.35	11.46	0.2
Pb (mg/l)	<0.015	0.124	<0.015	<0.015	<0.015	0.022	<0.015	<0.015	<0.015
PO_4 (mg/l)	2.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Se (mg/l)	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
SO_4 (mg/l)	533	17	19	31	28	106	38	39	28
Sr (mg/l)	1.835	0.227	0.092	0.376	0.366	0.694	0.158	0.145	0.331
V (mg/l)	<0.01	0.033	<0.01	<0.01	<0.01	0.017	<0.01	<0.01	<0.01
Zn (mg/l)	0.096	0.295	0.012	0.086	0.102	0.106	0.09	0.074	0.067

Red values exceed the SABS 241 maximum allowable limits for Drinking Water (SABS, 2001)

6.6.4. Impact Assessment Regarding Existing Matimba Power Station

Based on the available data the following conclusions are made:

- Borehole yields and groundwater potential within the power station study area are very low.
- Water levels in the boreholes adjacent to the power station and infrastructure are elevated by 5 – 10 m because of infiltration (artificial recharge from water use on site).
- Artificial recharge from the power station infrastructure is impacting on the groundwater.
- The hydraulic response in the aquifer is much faster than that of the spread of contaminants (water rise in the boreholes but there is no associated increase in salinity), the elevated water levels are thus not an indication of contamination rather recharge.
- Groundwater quality is very variable and generally high in salinity. The source of salinity is difficult to establish as it can either be naturally occurring salt (released from impermeable shale exposed during drilling) or derived from pollution sources at the power station.
- Modelled pollution plumes have only extended over small areas / distances due to the non-aquifer system, low groundwater gradients, and limited rainfall recharge.
- Persistent sources of contaminants can alter the hydrochemistry, causing an increase in dissolved solids and metals.

6.7. Candidate Site Study

The preliminary site suitability, for the development of a power station and infrastructure, of each of the eight (8) candidate sites was assessed based on hydrogeological criteria[7]. The candidate site study assessed all eight sites to determine the preferred site for both the power station and the ancillary infrastructure.

The existing power station, associated waste (ash, brine, water) infrastructure, coal stockpiles, and dams are recognised to have had an impact on the local hydrogeology, either by enhanced recharge and/or by altering the hydrochemistry within the aquifer(s).

In order to assess the candidate sites from a groundwater perspective an assessment of each site has been conducted based on the following criteria:

[7] This methodology is a modification of the Waste – Aquifer Separation Principle approach, Jolly and Parsons WRC Report No. 485/1/94, June 1994

- The *threat* posed by the power station and infrastructure
- The *barrier* between the power station and the groundwater resources
- The groundwater *resource*

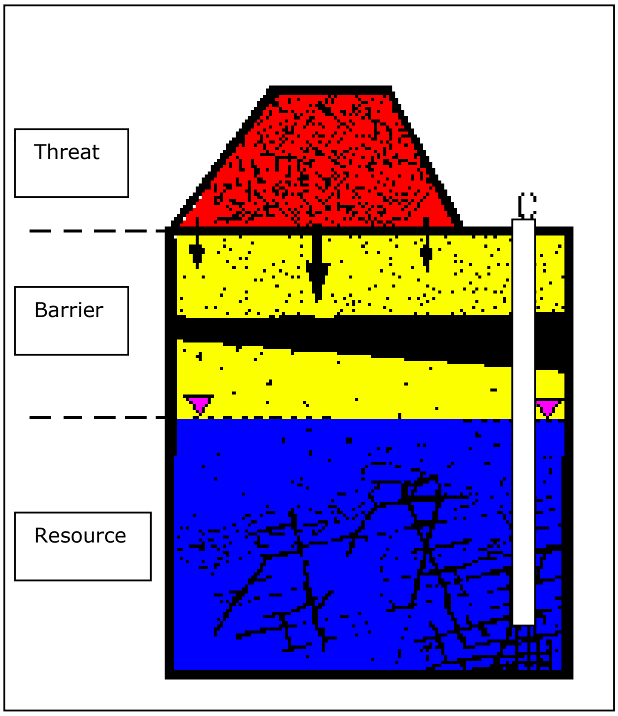


Figure 6.13: The assessment criteria to determine site suitability from a groundwater perspective.

The vulnerability of the groundwater and risk to the current groundwater users (or future use) is then examined and the most suitable site(s) identified. The preliminary site suitability assessments have been conducted using available data. Additional site-specific data will be required once the proposed power station site has been nominated, to conduct a more detailed investigation.

6.7.1. Threat factor

The threat to the groundwater resources posed by the proposed power station and associated infrastructure has been identified based on the existing Matimba power Station, existing ancillary infrastructure, available groundwater monitoring data, and the recognition of potential sources of contamination.

These include:

- The coal stockpiles, a potential source of acid generation and sulphate.
- Areas of artificial recharge, which include the raw water dam and the ash dump toe dam.

- Areas of artificial recharge with poor quality water, which are recognised as the sewage plant and dams, the evaporation dams, and the ash dump (including brine deposits from the de-ionised water system).
- Recharge and contamination from the recovery / surface water run-off dams, through seepage, spillage, and overflow.
- Bunker fuel oil storage. Oil enters the surface water run-off dams and requires treatment.
- Surface water contamination from the solid waste site (if required at the proposed new power station).

Monitoring reports for Matimba Power Station indicate that the groundwater quality has deteriorated with time and pollution plumes have developed within the immediate areas surrounding the various infrastructures on site.

It is, therefore, recognised that the threat of the proposed power station and infrastructure will be the same for each site and will comprise of:

- Artificial recharge causing an increase in groundwater levels, change in groundwater flow patterns and gradients.
- Artificial recharge of poor quality water causing an increase in salinity in the groundwater.

The threats can be re-evaluated once the power station and infrastructure design has been finalised.

6.7.2. Barrier factor

The unsaturated zone represents the barrier between the proposed power station and infrastructure and the groundwater. It is within this zone that attenuation will occur. The attenuation processes can include chemical precipitation, adsorption, dilution, dispersion, and biodegradation.

Attenuation is a set of complex and often inter-related processes governed by a number of factors. The modelling of attenuation processes is hence extremely difficult. It is therefore necessary to assess the time taken for poor quality water to migrate through the unsaturated zone, from the surface contaminant source to the groundwater level.

The travel time through the unsaturated zone is dependent on the depth of the groundwater and the porosity and permeability of the unsaturated material. Preferential pathways, such as faults, fractures or weathering, can increase the travel time and reduce the attenuation.

The vulnerability of the groundwater is determined by assessing the unsaturated zone at each of the candidate sites. Farms with identified geological structures, which may act as preferential pathways for contaminant movement from surface to groundwater, are identified as less suitable.

6.7.3. Resource factor

The groundwater resource at each candidate farm is assessed to determine the significance of the groundwater in terms of current and potential use.

The resource assessment identifies both the current groundwater usage and hydrochemistry, and the groundwater potential for possible future use.

6.7.4. Site Suitability Assessment

As the threat to each of the farms is the same, an assessment of the barrier and resource factors was conducted for each of the farms. Table 6.6 presents the suitability assessment.

Based on the assessment of the barriers and groundwater resources at each of the sites, it is established that the farms that are underlain by the Waterberg Group have the least vulnerable groundwater due to: -

- Deep groundwater levels, longer travel time and attenuation.
- Limited geological structures, apart from the Eenzaamheid Fault, and limited development of secondary aquifers.
- Low yielding boreholes with limited groundwater resource development potential.

The most suitable farms for the construction of the proposed new power station and infrastructure is the majority of the farm Eenzaamheid (south of the Eenzaamheid Fault) and the farm Kromdraai.

It is envisaged that the proposed power station and all other infrastructure including the ash dam can be constructed on these two farms. However, should additional area be required then the portion of the farm Naauwontkomen, south of the Eenzaamheid Fault is proposed as being suitable for use.

For the farms to the north of the Daarby Fault, underlain by complex geology, numerous geological structures, and variable groundwater levels and quality, the farm Zongezien is identified as the most suitable candidate site. However, additional studies regarding the permeability of the Daarby fault in this area would be required.

Table 6.6: Site suitability assessment

Farm	Threat	Barrier	Resource	Comments
Appelvlakte 448 LQ	Artificial recharge causing an increase in groundwater levels, change in groundwater flow patterns and gradients Poor quality recharge causing an increase in salinity	Shallow groundwater (2 – 11m) occur adjacent to mine slimes dam Unaffected levels at 21 mbgl Clarens Fm sandstone Minor faulting and three distinct aerial magnetic lineations Plume migration along lineation (Figure 7)	Moderate aquifer potential Yields range 0.27 l/s to 0.57 l/s at depths 50 m to 80 m Secondary aquifers associated with faulting and geological structures Current abstraction for stock watering has potential for use Contamination of aquifers occurs adjacent to slimes dam and plume migration	Surface drainage along northern boundary Sample point APL indicates high salinity, Chloride and Sulphate on site
Droogeheuvel 447 LQ	Artificial recharge causing an increase in groundwater levels, change in groundwater flow patterns and gradients Poor quality recharge causing an increase in salinity	Deep groundwater - 21 to 27 m barrier Clarens Fm sandstone Two NE-SW trending faults across site (Fig. 2)	Moderate aquifer potential with borehole yields ranging from 0.21 l/s to 0.64 l/s Secondary aquifers associated with faulting No identified contaminant sources on site Hydrochemistry can contain elevated dissolved salts	No surface water drainage Wind pumps at Droëheuwel farm house – indicates domestic use

Table 6.6 cont.: Site suitability assessment (Page 2)

Farm	Threat	Barrier	Resource	Comments
Eenzaamheid 512 LQ	Artificial recharge causing an increase in groundwater levels, change in groundwater flow patterns and gradients Poor quality recharge causing an increase in salinity	Very deep groundwater (77 – 113 m) Waterberg Group sandstone, ± 3 m of permeable soil covers ± 4 m weathered sandstone. Red hard competent sandstone Grootegeluk FM rocks north of Eenzaamheid fault No sills or dykes	Low borehole yields, dry to 0.25 l/s Aquifer potential enhanced along Eenzaamheid fault Current abstraction for stock watering only Groundwater can contain elevated concentrations of fluoride	No surface drainage Could be impacted on by plume migration from Turfvlakte[8] along the Eenzaamheid fault
Kromdraai 513 LQ	Artificial recharge causing an increase in groundwater levels, change in groundwater flow patterns and gradients Poor quality recharge causing an increase in salinity	Groundwater levels 32 – 35 mbgl Shallow groundwater in deep (400m) hole as a result of piezometeric pressure Waterberg Group sandstone, with fault on eastern boundary	Very low borehole yields, dry to 0.07 l/s Yield of deep hole enhanced to 0.85 l/s Fluorspar on site may impact on groundwater quality	Non-perennial tributary draining through center of farm Wind pump at farm house, possible domestic use Linear features from API identified on site

[8] Irrigation with poor quality water was conducted by Grootegeluk on this farm, poor quality groundwater has resulted and is modelled to migrate south towards the Eenzaamheid fault

Table 6.6 cont.: Site suitability assessment (Page 3)

Farm	Threat	Barrier	Resource	Comments
Kuipersbult 511 LQ	Artificial recharge causing an increase in groundwater levels, change in groundwater flow patterns and gradients Poor quality recharge causing an increase in salinity	Groundwater levels range between 18 and 48 mbgl Shallow groundwater levels were measured in two boreholes, < 4 mbgl These may be related to a fault recognised in the sediments Waterberg sandstone Stone aggregate mining is recognised to occur on Kuipersbult	The boreholes have typically low yields, 0.01 to 0.33 l/s The highest borehole yield recorded in the study, 3.2 l/s, was measured on Kuipersbult – fault related Fluorspar and mining on site may impact on groundwater quality	Small drainage line along southwest boundary Linear features from API identified on site
Naauwontkomen 599 LQ	Artificial recharge causing an increase in groundwater levels, change in groundwater flow patterns and gradients Poor quality recharge causing an increase in salinity	Variable groundwater levels due to complex geology Shallow groundwater associated with Karoo rocks and faults Deep groundwater levels 30 – 50 m associated with Waterberg sediments Stone aggregate mining occurred on the farm	Borehole yields are low, however, faulting has enhanced the groundwater potential Yields range from 0.06 to 0.98 l/s No groundwater abstraction on farm Poor quality groundwater from irrigation at Turfvlakte impacts on farm and along fault	No surface drainage Old quarries / borrow pits on site

Table 6.6 cont.: Site suitability assessment (Page 4)

Farm	Threat	Barrier	Resource	Comments
Nelsonskop 464 LQ	Artificial recharge causing an increase in groundwater levels, change in groundwater flow patterns and gradients Poor quality recharge causing an increase in salinity	Shallow groundwater (8 m – 13 m) occur on site due to sewage works, coal stockyard and dirty water evaporation dams Unaffected levels at 27 / 28 mbgl Variable groundwater levels due to complex geology Faulting and aerial magnetic lineations Plume migration modelled on farm	Moderate borehole yields, 0.32 to 0.85 l/s Secondary aquifers associated with faulting and geological structures No current abstraction Contamination of aquifers can occur due to sewage works, coal stockyard, and dirty water evaporation dams on the farm	Daarby fault and thrust fault on site Minor fault trending SW-NE across middle of farm No surface water drainage Groundwater monitoring indicates variable hydrochemistry
Zongezien 467 LQ	Artificial recharge causing an increase in groundwater levels, change in groundwater flow patterns and gradients Poor quality recharge causing an increase in salinity	Deep water levels 24 to 33 mbgl Clarens Fm sandstone and Swartrant Fm sandstone separated by Daarby Fault No minor faulting or lineations	Poor to moderate aquifer potential with borehole yields ranging from dry to 0.79 l/s Secondary aquifers may be associated with Daarby fault No contaminant sources on site	Non-perennial surface water drainage southwest corner of farm

6.8. Conclusions

6.8.1. Alternative Site Rating

A site assessment rating has been compiled for the farms Appelvlakte, Nelsonskop, Eenzaamheid, and Naauwontkomen, with regards to the most suitable farm for the construction of the proposed power station. The remaining candidate sites have been rated with regards to the ancillary infrastructure.

The results of the rating are presented in Table 6.7 power station rating and Table 6.8 ancillary infrastructure rating.

Table 6.7: Rating assessment for the proposed power station

Impacts	Appelvlakte 448 LQ	Nelsonskop 464 LQ	Naauwontkomen 509 LQ	Eenzaamheid 687 LQ
Poor Quality water stored on site recharging the ground water	1	2	3	4
Artificial recharge impacting on groundwater	2	2	3	4
Poor quality surface water on site	3	3	3	3
Surface water drainage	2	4	4	4

Preferred sites for the power station are Eenzaamheid and Naauwontkomen

Eenzaamheid is preferable due to:

- The Eenzaamheid fault is located ± 250 m from the northern border of the farm, whereas the Eenzaamheid fault is located through the middle of Naauwontkomen – this could cause difficulties when placing the infrastructure on Naauwontkomen.
- There is shallow coal to the north of the Eenzaamheid fault. The coal reserve would be sterilised if the power station is built on these farms, and this will have an economic impact
- Shallow contamination occurs on Turfvlakte, which is predicted to impact on Naauwontkomen; there could be issues of liability and remediation in the future.

Table 6.8: Rating assessment for the proposed ancillary infrastructure

Impacts	Appelvlakte 448 LQ	Nelsonskop 464 LQ	Naauwontkomen 509 LQ	Eenzaamheid 687 LQ	Droogeheuwel 447 LQ	Zongezien 467 LQ	Kuipersbulit 511 LQ	Kromdraai 690 LQ
Poor Quality water stored on site recharging the ground water	1	2	3	4	2	3	3	3
Artificial recharge impacting on groundwater	2	2	3	4	2	2	3	3
Poor quality surface water on site	3	3	3	3	2	2	3	2
Surface water drainage	2	4	4	4	3	2	4	2
Seepage below the ash dump	2	2	3	3	3	4	4	4

Preferred sites for the ancillary infrastructure are Kuipersbult and Kromdraai.

Kromdraai is the preferred site as there is a strong yielding borehole on Kuipersbult, associated with a fault on the farm. A small tributary of the Sandloop drains Kromdraai, and therefore this surface water channel would have to be diverted prior to use of the property. A permit would be required from DWAF for the diversion of the watercourse.

6.8.2. Site Preference Rating

The site preference rating for the sites in terms of water resources is outlined in Table 6.9 and Table 6.10.

Table 6.9: The Site Preference Rating of the alternative Sites for the power station with regards to water resources

Farm name	Site Preference Rating
Farm Appelvlakte 448 LQ	2 (not preferred)
Farm Nelsonskop 464 LQ	2 (not preferred)
Farm Naauwontkomen 509 LQ	3 (acceptable)
Farm Eenzaamheid 687 LQ	4 (preferred)

Table 6.10: The Site Preference Rating of the alternative sites for the ancillary infrastructure with regards to water resources

Farm name	Site Preference Rating
Farm Appelvlakte 448 LQ	2 (not preferred)
Farm Nelsonskop 464 LQ	2 (not preferred)
Farm Naauwontkomen 509 LQ	3 (acceptable)
Farm Eenzaamheid 687 LQ	4 (preferred)
Farm Droogeheuwel 447 LQ	2 (not preferred)
Farm Zongezien 467 LQ	3 (acceptable)
Farm Kuipersbult 511 LQ	3 (acceptable)
Farm Kromdraai 513 LQ	4 (preferred)

6.8.3. General

- The study area is underlain by complex faulted Karoo sediments and unaltered older Waterberg Group sandstone.
- Large faults, aerial magnetic lineations, and minor faulting occur across the study area, these geological structures can enhance the groundwater potential in the area and act as preferential pathways for groundwater and contaminant migration.
- The regional hydrogeology comprises a non-aquifer system, with very low yielding boreholes and incidents of very high salinity hydrochemistry.
- Little or no groundwater use occurs within the area, however, persistent contamination can have an impact on the groundwater users with time.
- Surface water resources are limited due to low rainfall, flat gradients, and permeable soil cover.
- Groundwater has been impacted on by the existing power station and infrastructure; the impact on hydrochemistry is not quantified due to natural pollution.
- A preliminary site suitability assessment indicates that the groundwater resources within the Waterberg Group sediments are the least vulnerable and

that the farms within this area are more suitable for the development of a new power station.

- Site-specific studies will be required to position the power station and infrastructure within the suitable farms.

6.9. Recommendations

Due to the severe nature of the expected impacts, it is considered imperative to conduct additional studies during the EIA on the preferred site/s. This would include, but not necessarily be limited to:

- A risk assessment regarding groundwater and surface water resources. The methodology should be as follows:
    - A description of intention
    - Hazard identification
    - An estimation of the probability and magnitude of the consequences of the hazard
    - A risk estimate
    - A risk evaluation
    - An overall risk assessment
    - Risk management recommendations
- A comprehensive borehole census is to be conducted to identify neighbouring groundwater users and use once the candidate site has been identified. In addition all existing boreholes on the farms selected for development need to be identified for possible use as monitoring holes or for backfilling.
- Geophysical surveys are to be conducted across the selected sites to identify and assess the underlying geological structures, this will assist in positioning of dams, dumps, etc.
- Motivations regarding the letter of undertaking from DWAF to Eskom are required for inclusion in the EIA.
- Details of the DWAF studies EIA processes and Interested and Affected parties contact details are required for inclusion in the EIA for the proposed power station, especially with regards to the impact of increased water use with respect to the regional availability and current demand.

Further to the EIA studies, through the Environmental Management Plan (EMP), the following would be required:

- Monitoring boreholes are to be drilled and constructed on site. The groundwater monitoring points are to include a shallow (± 10 m) and a deep (± 30 m) pair of monitoring boreholes. The pair of monitoring boreholes is to be designed and constructed to allow sampling of the shallow weathered aquifer and the deeper fractured rock aquifers. The monitoring boreholes are to be located adjacent to the potential contaminant sources and approximately 30 to 50 m down gradient of the identified sources.

- Groundwater water levels and hydrochemistry are to be monitored on a quarterly basis. The list of determinants for analysis is the same as presented in Table 6.5.
- Groundwater modelling and potential plume migration is recommended to assess risk reduction measures and potential impacts.