9. GROUNDWATER IMPACT ASSESSMENT.

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9.1 Introduction

An initial scoping phase assessment of three potential sites near Upington in the Northern Cape Province was carried out in February and March 2006. This study ranked the suitability of the three sites for the construction of a concentrating solar power (CSP) plant, and one of the sites, the farm "Olyvenhoutsdrift", was chosen as the most suitable for the proposed development. This assessment precipitated the second phase of the work, an Environmental Impact Assessment (EIA) of the chosen site, to which this document refers.

A site visit was made to Olyvenhoutsdrift in November 2006, and groundwater samples were collected for laboratory analysis. The primary aim of the sampling was to better establish the existing or "baseline" groundwater quality conditions, so that any future impacts on groundwater quality can be put into context. Six groundwater samples and one river water sample were collected on Thursday 9th and Friday 10th November (see table 9.1). Unfortunately the depth to groundwater could not be successfully determined at any of the borehole sites, because standard windpump installations lack access for a dipmeter.

Table 9.1: Water samples collected, November 2006

Sample #	Type	Latitude	Longitude	Date
U1	Groundwater	28º26'05.5"	20º50'17.2"	9 Nov 06
U2	Groundwater	28º25'49.8"	20º56'23.9"	9 Nov 06
U3	Groundwater	28º27'42.3"	20º56'46.4"	9 Nov 06
U4	Groundwater	28º28'40.1"	21º00'45.5"	9 Nov 06
U5	Groundwater	28º27'58.9"	21º04'16.2"	9 Nov 06
U6	Groundwater	28º32'48.2"	21º09'53.7"	10 Nov 06
U7	Surface water	28º27'50.0"	21º14'31.1"	10 Nov 06
Note: datum used for coordinates is WGS84				

The farm Olyvenhoutsdrift extends northwest for about twelve kilometres from its approximately four kilometres of river frontage (see figure 1). Groundwater abstraction over the majority of the area is restricted to windpumps for stock watering, each estimated to deliver less than 0.1 litres per second. More intensive use of groundwater seems to occur close to the river, to the southeast of the national road (the N14), where several smallholdings appear to use groundwater for domestic purposes and garden irrigation. The area of the farm to the northwest of the national road has a very low population density, with an estimated one or two households present year round and an influx of a few more farm workers during times of work with stock such as dipping or shearing. Five of the groundwater samples were taken from boreholes in the general area to the north of the national road, with the sixth coming from the area of smallholdings closer to the river (see figure 9.1). Note that only two of the groundwater samples are from boreholes within the actual area of the farm Olyvenhoutsdrift, the other four coming from adjacent properties. This is due to the low number of operating boreholes in the area, which made it impossible to obtain an adequate number of samples from the farm itself.

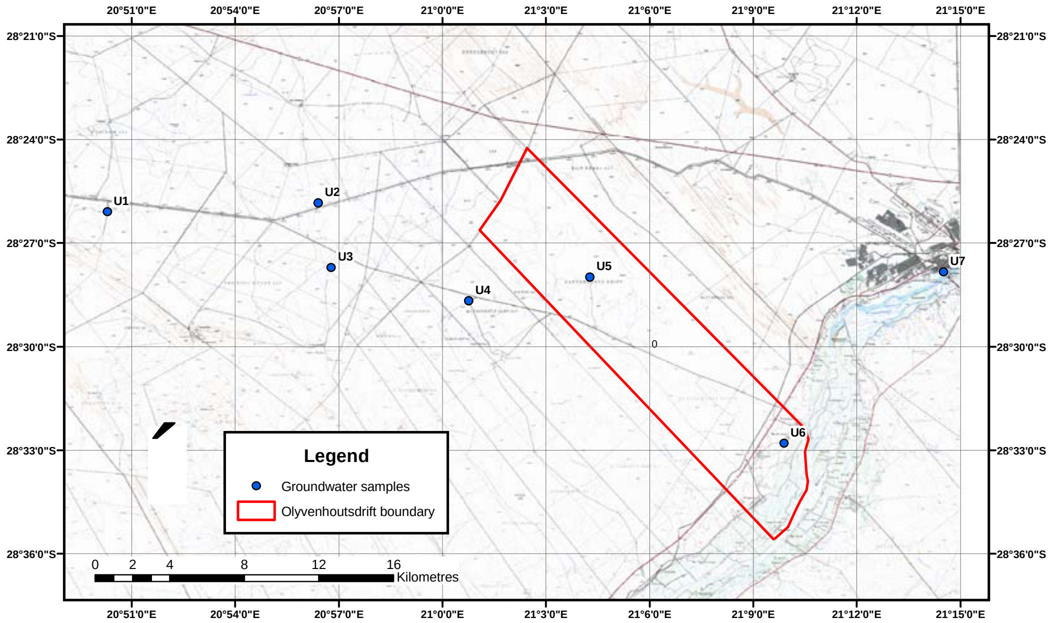

Figure 9.1: Locations of groundwater sampling points

9.2. Topography and Geology

The area is fairly flat, with the land rising gently to the north and northeast. The slope increases towards the river, on the southeast side of the national road. The area is sparsely vegetated, and sandy soils predominate. The geology at the site consists mainly of Keimoes Suite Granitoids (acid intrusives) e.g. Louisvale Granite, and fractured metamorphic rocks of the Areachap Sequence (schists, gneisses, quartzites and conglomerates). Low outcrops of the various rock types can be seen sticking up out of the sands at the site in places, although for the most part the overlying sands prevent a detailed examination of the geology.

9.3. Hydrogeology

The pre-Cambrian age metamorphic rocks underlying the site are considered to be poor aquifers. Groundwater storage and movement is mainly via fractures, fissures and other secondary features in the rock.

Fractured aquifers are more vulnerable to pollution than aquifers where the storage and transmission of groundwater is primarily intergranular, due to the higher rates of groundwater movement and lower attenuation potential. Once polluted, such aquifers are difficult and expensive to remediate. Soluble pollutants are likely to travel vertically downwards to the water table together with recharging water, and then move with the water in the direction of regional groundwater flow. Recharge mechanisms in this area are not fully understood, but are thought to be episodic, following sporadic heavy rainfall.

Although abstractions are low, and boreholes widely spaced, groundwater is nevertheless an important strategic resource in this area, since perennial surface water is non-existent (apart from the Orange River). Groundwater is used mainly for domestic purposes by farmers and for stock watering in the area. More groundwater is used by smallholders closer to the river, but abstraction volumes are probably low. Most boreholes are pumped by windpumps, which typically deliver less than 0.1 l/s. Since wind speeds are variable, water is commonly stored in concrete reservoirs of approximately 40 m^3 in volume against times of low wind. Stock watering is achieved by reticulation to water troughs, regulated by ball valves. The Department of Water Affairs and Forestry (DWAF) keeps borehole records, and table 9.2 summarises the records for the relevant map sheet. Since it was not possible to obtain an accurate water level in the field, the DWAF data together with information from the farmer is the only water level data available at present.

Table 9.2: Summary of DWAF values for the area

Water level (DWAF mean for 1:50 000 map sheet 2821AC)	39.3 metres below ground level (m bgl)
Water level reported by farmer	40 – 50 m bgl
Mean yield from DWAF database	0.53 litres per second (l/s)
DWAF groundwater occurrence classification (DWAF classification system combining borehole yield class and aquifer type)	Mostly d2 (Intergranular and Fractured aquifer of yield 0.1 – 0.5 l/s), with some b2 (fractured aquifer of yield 01 – 0.5 l/s) in the northwest
Other notes from farmer	Borehole depth 120 m

9.4. Groundwater chemistry

Groundwater samples were taken at six sites, two on the farm itself and a further four to the northwest of the farm. Sampling was restricted to sites where windpumps were present and in working order. A seventh sample was taken of the Orange River in Upington. See table 9.1 and figure 9.1 for the site locations. The samples are marked U1 to U7, in the order in which they were collected. Sample U1 was taken from standing water in the concrete tank adjacent to the borehole, since the windpump was not operating at the time of sampling (no wind). Sample U2 was taken from the end of an approximately 200 m long steel pipe on the ground surface carrying (flowing) water from the borehole equipped with an electric submersible pump to a remote storage tank. The other four groundwater samples were all taken from a flowing outlet at or near the top of boreholes equipped with windpumps. Field temperature, conductivity and pH were determined using a Hanna Instruments H198130 pocket meter for five of the borehole sites, and samples were transferred to a cooler box packed with ice for storage. The samples were delivered to the CSIR analytical laboratory on the afternoon of Friday 10 November, although analysis was carried out early the following week. The samples were stored in a refrigerated room over the weekend.

Table 9.3: Summary of chemistry results

Constituent	Unit	U1	U2	U3	U4	U5	U6	U7
Alkalinity	mg/ℓ CaCO3			279	197	365	426	80
Arsenic – (inorg)	mg/ℓ As			0.002	0.005	0.03	0.008	0.002
Calcium	mg/ℓ Ca			216	197	137	101	19
Chloride	mg/ℓ Cℓ			682	573	369	261	6.4
Elect conductivity	mS/m [25°C]	444*	429	427	358	256	238	20.2
Fluoride	mg/ℓ F			2.6	3.4	4.1	6.0	0.33
Iron	mg/ℓ Fe			0.16	0.03	0.04	<0.03	1.8
Magnesium	mg/ℓ Mg			109	66	78	60	8
Nitrate nitrogen	mg/ℓ N			73	63	18	53	0.35
Ortho Phosphate	mg/ℓ P			0.21	<0.20	<0.20	<0.20	<0.20
pH	pH units [25°C]	8.52*	6.93	7.06	7.2	7.16	7.9	8.2
Potassium	mg/ℓ K			21	18	19	9	3
Sodium	mg/ℓ Na			485	415	253	335	9
Sulphate	mg/ℓ SO4			617	1130	320	280	24
% ionic balance	n/a			-1.7	-17.5	-1.8	-1.4	-4.9

Notes: Figures in red were determined in the field, all other figures determined in the laboratory.
Samples U1 and U2 were not analysed in the laboratory due to cost constraints.
* Measurements taken at open tank of standing water, as borehole not flowing when visited.

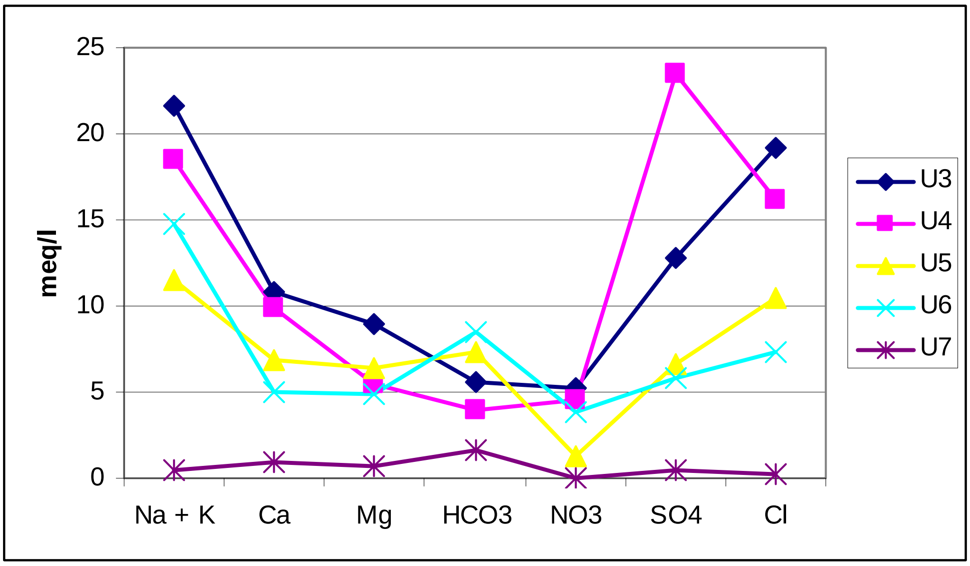

Chart 9.1: Summary of major ion chemistry

Five of the samples were analysed for major ions, and were also scanned for minor ions. The chemistry results are presented in table 9.3 and chart 9.1. Samples U1 and U2 were not analysed in the laboratory due to cost constraints.

The results show that the groundwater in the area is generally brackish (mean conductivity of the six groundwater samples was 359 mS/m), and that the conductivity appears to increase with distance from the river. pH values are generally neutral to slightly alkaline (mean pH was 7.25, excluding the river sample and sample U1 which had been standing in a tank). Field temperature was determined for those samples where there was access to flowing water very close to the top of the borehole, and the mean was 28.2 ºC. The groundwater is of the sodium chloride type. Chart 1 shows the relative ionic concentrations in all the groundwater samples follow the same general pattern, apart from the SO_4 concentration in sample U4, which is likely to be incorrect and the cause of that sample's large negative ionic imbalance. Nitrate levels are relatively high in all of the groundwater samples (mean of 52 mg/l as N), but low in the river water. It is likely that the nitrate concentrations are largely natural, since nitrate is known to build up in groundwater in such environments. However, a contribution to the nitrate levels by stock gathering around boreholes is also possible (Tredoux and Talma, 2006). Phosphate concentrations are all below the detection limit of 0.20 mg/l, apart from sample U1 (0.21 mg/l) which may have been contaminated by bird droppings since it was taken from an open tank.

9.5 Significance rating scales

Table 9.4 includes possible impacts and a summary of possible mitigation measures for the potential impacts identified.

Table 9.4: Possible impacts, and summary of mitigation strategies

Impact	Temporal	Spatial	Severity	Significance	Risk or likelihood	Degree of confidence	Mitigation
Contaminants from Orange River water used at the plant migrate into groundwater.	Long term	Household or localised	Moderately severe	Low	May occur	Possible	Risk likely to be low, since contaminants in river water generally very diluted. Risk could be further reduced by being aware of specific incidents of river pollution and acting accordingly.
Migration of hydrocarbon fuel spillage at the plant into the groundwater.	Long term	Household or localised	Moderately severe (a catastrophic spill of large amounts of fuel will however have a severe impact on the local groundwater)	Moderate	May occur	Possible	Risk will be reduced if refuelling takes place in bunded or impermeable areas such as concrete aprons, and storage of fuel is in bunded tanks if above ground, or in appropriately constructed (e.g. double lined) tanks if below ground.
Leaching of herbicides used in ground sterilisation beneath the mirrors into the groundwater.	Long term	Household or localised	Moderately severe	Moderate	May occur	Possible	Risk could be eliminated if herbicides are not used. Alternatively, strict use of the appropriate type of herbicide at recommended concentrations is advised.
Leaching of Na/K-NO_3 salts into the groundwater (the salt is used as the power station's coolant).	Long term	Household or localised	Moderately severe	Moderate	May occur	Possible	All spillages of salt should be cleaned up, and salt should not be stored in the open where rainwater could carry it into groundwater.

9.6. Conclusions and Recommendations

Groundwater on the farm "Olyvenhoutsdrift" is currently used mainly for stock watering, with some more intensive use by smallholders in the south. Abstractions are generally low. Groundwater quality is moderate to poor, with nitrates and total dissolved solids both exceeding common recommended limits, but the resource is of critical importance for some users. The proposed development is likely to have only a marginal impact on the groundwater quality, unless a large spill of contaminants (e.g. hydrocarbon fuel) takes place, or large amounts of Na/K-NO_3 salt are left on the ground surface.

It is recommended that transport, transfer and storage of all potential groundwater contaminants (fuel, Na/K-NO_3 salt, herbicides, etc) be subject to strict controls, and that these substances are handled in bunded areas at the site. The leaking of underground fuel storage tanks is very common, and measures should be taken to ensure that this risk is as low as possible. It is likely that the eventual receptor of any groundwater contaminants will be the Orange River, together with the shallow groundwater used by smallholders along the banks. Contamination of groundwater is difficult and expensive to remediate once it has taken place.