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## Hydrogeological Report for

# Waterloo PV Plant, North West Province

October 2015 REF: JG0021/400/2015/10/2635

**Report to:**

SunEdison

# SMEC REPORT
# QUALITY ASSURANCE ISSUE DATA

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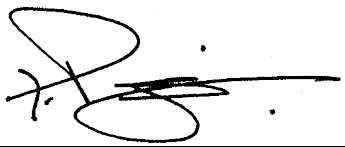
**Approved by:**  30-10-2015

**Signed** **Date**

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# 1. INTRODUCTION

A desk study was undertaken to gather relevant hydrogeological information at the proposed site of the Waterloo photovoltaic (PV) solar plant, approximately 8km south of Vryburg, North West Province. Information was sought from the National Groundwater Archive, and data was found for several boreholes in the area. The groundwater recharge was calculated using the recharge program developed by the groundwater institute of the University of the Free State.

The groundwater resource map series of the Republic of South Africa from the Water Research Commission and the Department of Water Affairs was used to gather information on the nature of the water bearing rocks in the area. The Groundwater Harvest Potential map of the Republic of South Africa was used to attain information regarding the water quality of the area, the average borehole yield and the harvest potential of the area.

# 2. DESK STUDY INFORMATION

## 2.1 Existing Information from the National Groundwater Archive

The National Groundwater Archive was used to get borehole information for the area. A search was conducted to find boreholes within an area of 5km$^2$ from the centre of the site (2.82km radius). Information on 8 boreholes were found in the archive. The information is contained in Table 2.1. The locations of the boreholes can be seen on Figure 2.1.

The only noteworthy information obtained from the archives about the boreholes, was the depth to the groundwater level. Borehole blow yield information could only be found for a single borehole.

The land use of the area around the site is characterised mostly by livestock farming. The density of the water points found in the search is low with approximately 8 points per 5km$^2$ in the region of the site. Groundwater use in the area is therefore estimated to be low due to this borehole density. It is assumed that boreholes located near the proposed photovoltaic plant are used for irrigation and livestock purposes.

**Figure 2.1.** Location of Existing Data Points from the National Groundwater Archive

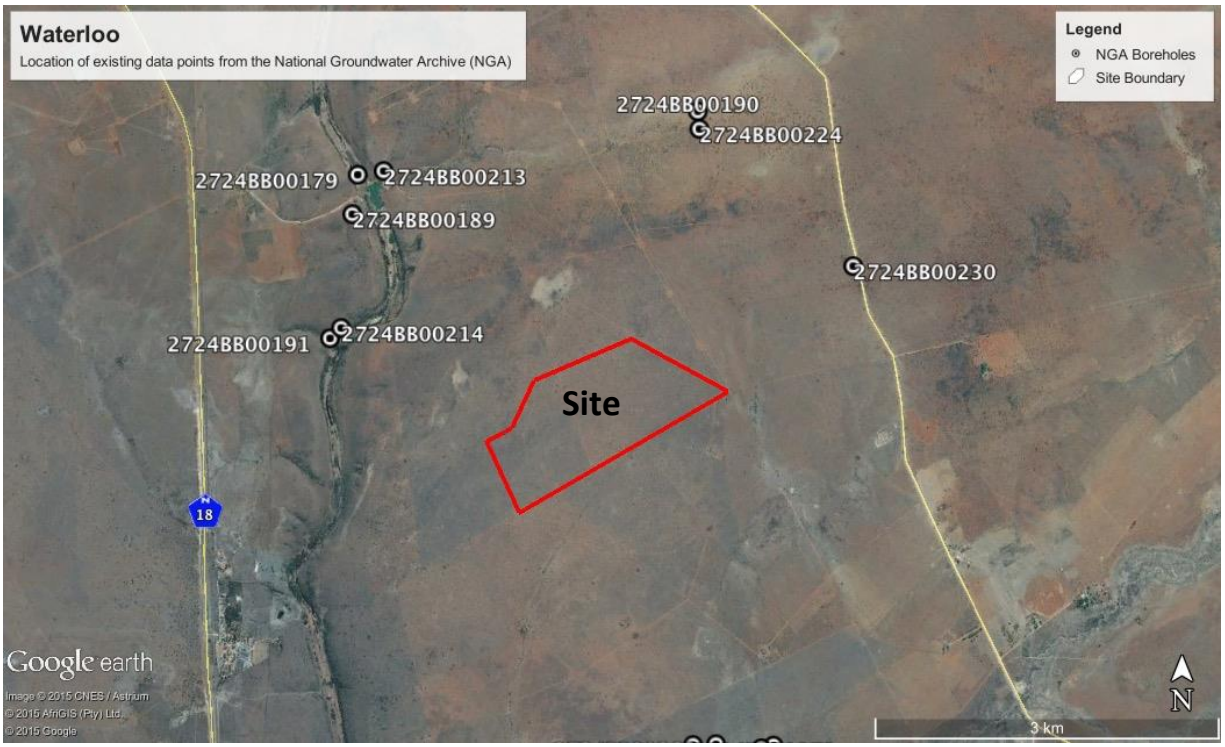



**Table 2.1.** Data from the National Groundwater Archive

| Identifier | Latitude | Longitude | Elevation (mamsl) | Construction Completion Date | Water Level (mbgl) | BH Depth (mbgl) | Seepage - Depth To Top (mbgl) | Blow Yield (l/s) |
|---|---|---|---|---|---|---|---|---|
| 2724BB00275 | -27.06394 | 24.80471 | 1140 | - | 18.23 | 46.6 | - | - |
| 2724BB00264 | -27.06372 | 24.80375 | 1140 | - | 26.36 | 40.5 | - | - |
| 2724BB00272 | -27.06351 | 24.80481 | 1140 | 1963/01/02 | - | 36.6 | - | - |
| 2724BB00273 | -27.06347 | 24.79773 | 1150 | - | 22.9 | 32.9 | - | - |
| 2724BB00268 | -27.0634 | 24.79975 | 1150 | - | | - | - | - |
| 2724BB00191 | -27.03158 | 24.76578 | 1150 | - | | 9.1 | - | - |
| 2724BB00214 | -27.03077 | 24.76675 | 1140 | 1993/05/06 | | - | - | - |
| 2724BB00230 | -27.02592 | 24.81182 | 1210 | - | 23.27 | 33.27 | - | - |
| 2724BB00189 | -27.02185 | 24.76774 | 1160 | - | 9.17 | 26 | - | - |
| 2724BB00179 | -27.01876 | 24.76822 | 1150 | - | 3.34 | 19.1 | - | - |
| 2724BB00213 | -27.01847 | 24.7705 | 1150 | | 6.4 | 26 | - | - |
| 2724BB00224 | -27.01517 | 24.79828 | 1210 | 1983/04/12 | 53.74 | 145 | 105 | 0.83 |
| 2724BB00190 | -27.01379 | 24.79814 | 1210 | - | 48.1 | 101.5 | - | - |

## 2.2 Water Quality

No water samples were taken as part of the study. The National Groundwater Archive did not have water quality data available for the area. The Groundwater Harvest Potential Map for South Africa produced by the Department of Water Affairs and Sanitation give a geometric mean concentration value of between 500 and 750 mg/l for total dissolved solids (TDS). Water with a TDS value as up to 1000mg/l is drinkable and can be classed as Class 0. This means the water can be used for human consumption without treatment. However, this information needs to be verified on site.

## 2.3 Average Borehole Yield

The Groundwater Harvest Potential Map for South Africa shows that the mean borehole yield for the area is between 0.8 and 1.5 l/s. Only a single borehole yield value was obtained in the area from the National Groundwater Archive, and this corresponds to the typical lower-bound blow yield for the area, of approximately 0.83 l/s.

## 2.4 Harvest Potential

The harvest potential means the maximum volumes of groundwater ($m^3/km^2$/annum) that may annually be abstracted per surface area of an aquifer system to preserve a sustained abstraction. The Harvest Potential of the area is between 6 000 and 10 000 $m^3/km^2$/annum. The factor that restricts the harvest potential for this area is the volume of effective storage. This means that although recharge occurs regularly most years, it cannot all be absorbed into the aquifer due to its characteristic low storage.

## 2.5 Nature of Water Bearing Rock

Regionally, the area is predominantly underlain by meta-argillaceous rocks (quartzites) with some dolomites, shales, and conglomerates. The storage medium is generally fractures that are restricted to a zone directly below groundwater level, and more specifically a zone that is transitional between weathered and fresh rock. In fresh rock, water-bearing fractures are comparatively sparse.

## 2.6 Probability of Drilling a Successful Borehole

The probability of drilling a borehole yielding more than 2 l/s is 20 to 30% which means that drilling a low yielding borehole is 70 to 80%. This phenomenon is confirmed by the low harvest potential figures.

# 3. ASSESSMENT

## 3.1 Groundwater Level Depth

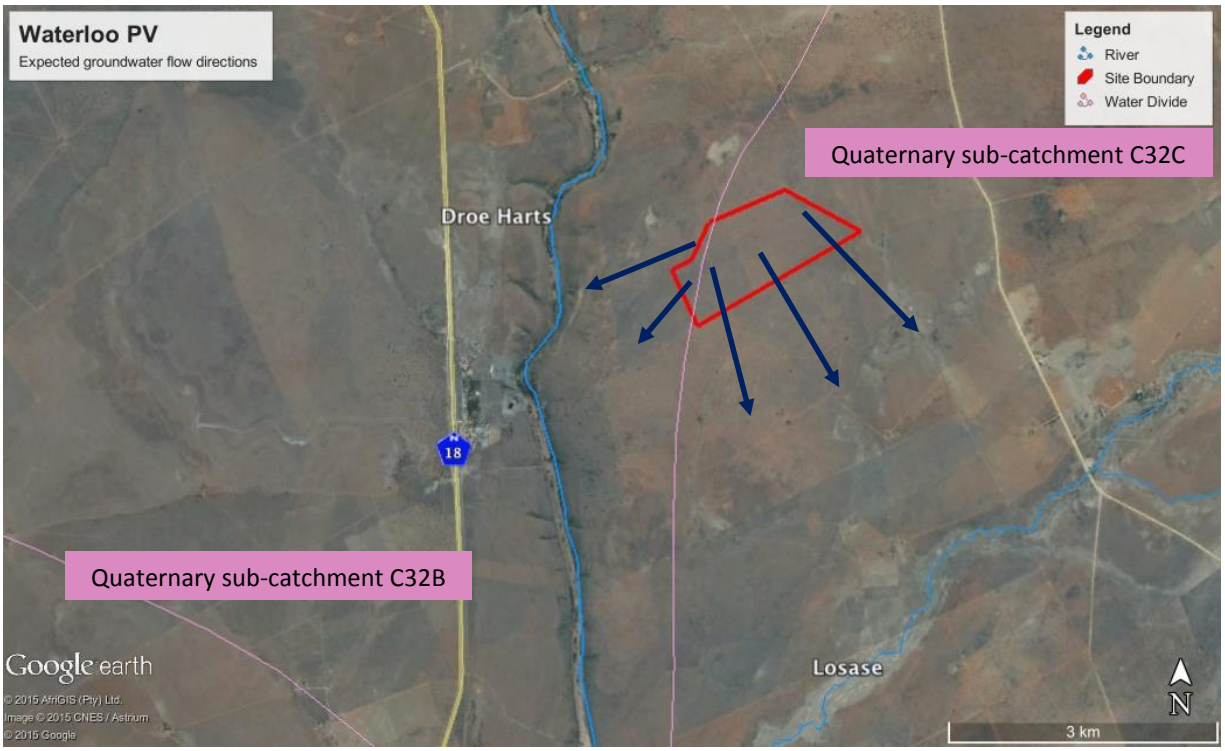
The Groundwater Resources Map of South Africa suggests a depth to groundwater of between 10 to 20 m, and furthermore recommends a drilling depth of less than 20 m below this groundwater table for a successfully yielding borehole. Existing water levels reported at boreholes in the area range from 3.34m depth, adjacent to the Droe Harts River, to 48.1m depth, on top of the watershed divide. Joints and fractures in the quartzites can be targeted for groundwater development, whereby yields up to 2 l/s can be sought. It is also anticipated that groundwater levels will be shallower (<10 m depth) in close proximity to the Droe Harts River.

## 3.2 On Site Surface Water Drainage and Groundwater Movement

The proposed site is located on top of a watershed divide that forms the boundary of quaternary sub-catchment C32B and C32C. This watershed divide will dictate the surface and groundwater flow directions in the area. The larger eastern portion of the site which lies in sub-catchment C32C slopes gently towards the Losase River in a south-easterly direction. The smaller western portion which forms part of sub-catchment C32B slopes towards the Droe Harts River in a south-westerly direction.

Groundwater movement on site will therefore generally be in this same south-easterly and south-westerly direction across the site. Figure 3.1 aims to explain the possible groundwater movement directions in the area.

**Figure 3.1.** Expected Groundwater Flow Directions




## 3.3 Groundwater Recharge

The groundwater recharge program from Gerrit van Tonder and Yongzin Xu was used to estimate a mean groundwater recharge figure. This was done for the groundwater catchment area delineated by the boundary of the Waterloo PV plant site which is in the order of 1.30km$^2$. The mean value of the soil, geology, Vegter, Acru, harvest potential and chloride methods were used, together with a weighting ratio, to estimate the groundwater recharge figure for the specific site.

Figure 3.2 gives the mean groundwater recharge figure, calculated by the six methods mentioned, on the development area defined by the site boundary. The figure summarizes all the methods used, as well as the weighting ratios used. The groundwater recharge program gives a mean groundwater recharge on the specific proposed development portion of 18.2mm/a or 5.3% of mean annual precipitation (MAP) or 74.89m$^3$/d. If more information becomes available during a more formal hydrogeological study, this value can be verified.

**Figure 3.2.** Groundwater Recharge Values and Percentages

**Summary of Recharge** MAIN

Waterloo

| Method | mm/a | % of rainfall | Certainty (Very High=5 ; Low=1) |
|---|---|---|---|
| CI | 1.1 | 0.3 | 4 |
| SVF: Equal Volume | | #DIV/0! | 4 |
| SVF: Fit | | | 4 |
| CRD | | #DIV/0! | 4 |
| Qualified Guesses : | | | |
| Soil | 88.9 | 25.9 | 5 |
| Geology | 11.0 | 3.2 | 4 |
| Vegter | 20.0 | 5.8 | 3 |
| Acru | 9.0 | 2.6 | 4 |
| Harvest Potential | 8.0 | 2.3 | 5 |
| Expert's guesses | | | 3 |
| Base Flow (minimum Re) | 9.0 | 2.6 | 1 |
| $^{2}$H displacement method | | | 1 |
| Carbon 14 method | | | 1 |
| EARTH Model | | | 1 |
| Groundwater Flow Model | | | 1 |
| Average recharge | 18.2 | 5.3 | |
| Recharge = | 18.2 | 5.3 | |

= 0.027337 $Mm^3/a$

= 74.89 $m^3/d$

= 0.87 L/s

| | |
|---|---|
| Area ($Km^2$) = | 1.5 |
| Annual Rainfall (mm) = | 344 |

## 4. RECOMMENDATIONS

During the hydrogeological desk study the following conclusions could be made:

- The mean annual precipitation (MAP) is approximately 344mm/a.
- Information on 8 boreholes could be found in the National Groundwater Archive.
- It is estimated that the water level depths for the area are between 10 to 20 metres below ground level, however closer to the Droe Harts River shallower water levels can be expected (<10 m depth).
- Groundwater use in the area is for irrigation purposes and usage is estimated to be moderate.
- The Groundwater Harvest Potential Map for South Africa produced by the Department of Water Affairs and Sanitation give a geometric mean concentration value of between 500 and 750mg/l for total dissolved solids (TDS).
- The single borehole yield information obtained from the National Groundwater Archive, confirms the expected values which are published on the harvest potential map, which states that average borehole yields for the area range between 0.8 and 1.5 l/s.

- The harvest potential of the area is between 6 000 and 10 000 $m^3/km^2$/annum.
- The probability of drilling a borehole yielding more than 2 l/s is 20 to 30% which means that drilling a low yielding borehole is 70 to 80%.
- The proposed site is located on top of a watershed divide that forms the boundary of sub-catchments C32B and C32C.
- Groundwater movement on site will be in a south-eastern direction towards the Losase River and south-western towards the Droe Harts River.
- The mean groundwater recharge is calculated at 18.2mm/a or 5.3% of MAP or 74.89$m^3$/d.

The following recommendations are made:

- The water level depth needs to be confirmed and measured on site.
- The quality of the groundwater on site must be analysed for verification