SOIL, LAND CAPABILITY AND AGRICULTURAL POTENTIAL STUDY FOR THE PROPOSED SOLAR DEVELOPMENT ON THE FARM WATERLOO 992, VRYBURG

NOVEMBER 2012

CONDUCTED BY:

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EXECUTIVE SUMMARY

Based on the findings of the soil and land capability study it is the opinion of the soil scientist and botanist, from a soil conservation and agricultural potential point of view, that the proposed development be considered favourably provided that due care is taken to minimise impacts on soils and land capability through the minimization of footprint areas and through good soil management principles.

Introduction

Environment Research Consulting (ERC) was appointed by Subsolar Energy (Pty) Ltd. to conduct a soil, land capability and agricultural potential study for a proposed solar development on a portion (150 ha) of the farm Waterloo 992 just south of Vruburg in the North-West Province. A soil survey and a veld condition assessment of the project area were conducted on 09 November 2012 by A.R. Götze of ERC, a registered Professional Natural Scientist. The purpose of the study was to determine the soil forms and current land capability of the area where the proposed project will be situated. Soil samples for chemical analysis were also sampled during the site visit.

Land type information

The dominant land type in the study area is Ag10. This land type represents red or yellow apedal, freely drained soils with a high base status and is generally shallower than 300 mm deep with severe limitations in terms of arability.

Soil classification

Only one soil form was identified on the study site. The total study site is underlain by extremely shallow Mispah soils which consist of an orthic A-horizon overlying hard rock.

Chemical soil properties

The pH (KCl) of the analyzed soil samples range between 5.1 and 5.7 and can be described as mildly acidic. The cation chemistry (Ca, Mg, K, Na) is typical of the soil forms occurring in the area of the proposed project. No extremes in terms of the soil chemistry were recorded.

Land use and veld condition

Generally it is evident that the 150 ha portion of the farm Waterloo 992, which makes up the study area, has been managed as a cattle farm for many years. Some game species also occur in the area. Some signs of moderate veld degradation are visible in vegetation and can be attributed to moderately heavy grazing and possible drought conditions in the past. Generally, however, the veld condition is good. No signs of soil erosion were present on site.

There are also no buildings or other permanent infrastructure that has been constructed on site.

The surrounding land in the area is also used for extensive cattle and possibly game farming activities. No industries or tourism activities are present within a 500m radius surrounding the site. It is anticipated that the proposed change in land use of the study site will not result in any negative impact on the surrounding land users for it will not result in any physical or chemical pollution that will affect neighbouring properties.

Agricultural potential

The study site has no dry land or irrigated crop production due to the limitations of soil forms present (restricted soil depth) as well as the limiting climate (low and erratic rainfall). The site has potential for extensive cattle or game farming. With an average grazing capacity of 7.23 ha/LSU, the proposed development site of 150 ha can potentially accommodate 20 heads of cattle for one calendar year with average rainfall. It can be concluded that should the development be authorised, it will have a low negative impact on agricultural potential in terms of cattle production in the area, and no negative impact on crop production.

Environmental impacts

There are four possible impacts on the soil of the area observed. Table A below summarises the findings indicating the significance of the impact before mitigation takes place and the likely impact of management when mitigation takes place. When considering mitigation it is assumed that a high level of mitigation takes place that does not lead to prohibitive costs. From the table it is evident that prior to mitigation all of the impacts range between high and low level impacts but with proper mitigation measures all impacts can be reduced to low level.

Table A: A summary of the results impacts assessed

Impact	**Impact level pre-mitigation**	**Impact level post mitigation**
Soil erosion	High	Medium-low
Soil compaction	Medium-low	Low
Chemical soil pollution	High	Low
Change in grazing land use	Low	Low

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1. INTRODUCTION

Environment Research Consulting was appointed by Subsolar Energy (Pty) Ltd to conduct a soil, land capability and agricultural potential study for a proposed solar development on a 150 ha portion of the farm Waterloo 992 just south of Vruburg in the North-West Province. A soil survey and a veld condition assessment of the project area were conducted on 09 November 2012 by A.R. Götze of ERC, a registered Professional Natural Scientist. The purpose of the study was to determine the soil forms and current land capability of the area where the proposed project will be situated. Soil samples for chemical analysis were also sampled during the site visit.

The objectives of this assessment were:

- to describe the soils (distribution, types, depth, surface features, suitability for agriculture, physical and chemical characteristics, fertility, erodibility, dry land production potential and irrigation potential),
- to determine the pre-development land capability,
- to determine the present land use,
- to conduct an Impact Assessment for the soils and land capability which will feed into the overall Environmental Impact Assessment, and
- to propose mitigation measures for the impacts to form part of the Environmental Management Program.

Since agricultural potential of land is largely determined by the soil characteristics together with climatic conditions, a soil survey was conducted to establish homogenous soil units and their distribution. These units could, in turn, be assessed in terms of their agricultural potential for different farming operations like animal production and irrigated crop production, taking the rainfall, temperature and soil potential into consideration.

2. LOCALITY OF THE STUDY AREA

The study area is located on the farm Waterloo 992 approximately 9km south of Vryburg in the North-West Province. The area that was specifically studied covers approximately 150 ha of Waterloo 992. The site for the proposed development is situated between 27° 01' 54.60"S and 24° 47' 32.30" E on its northern most point and 27° 02'08.80"S and 24° 48' 03.06"E on the most eastern tip. The most southern point on the proposed site is at 27° 02' 43.42"S and 24° 46' 56.54" E and the most western point at 27° 02' 23.01"S and 24° 46 '45.87"E.

The site is accessed from Vryburg by following the N18 towards Taung. Approximately 5km outside Vryburg a gravel farm road gives access to the farm Waterloo on the right. On the farm itself the only access to the proposed development site is via farm road and tracks and can only be accessed with a vehicle with good ground clearance. The site is divided into two camps with barbed-wire fence and the camps can be accessed with farm roads.

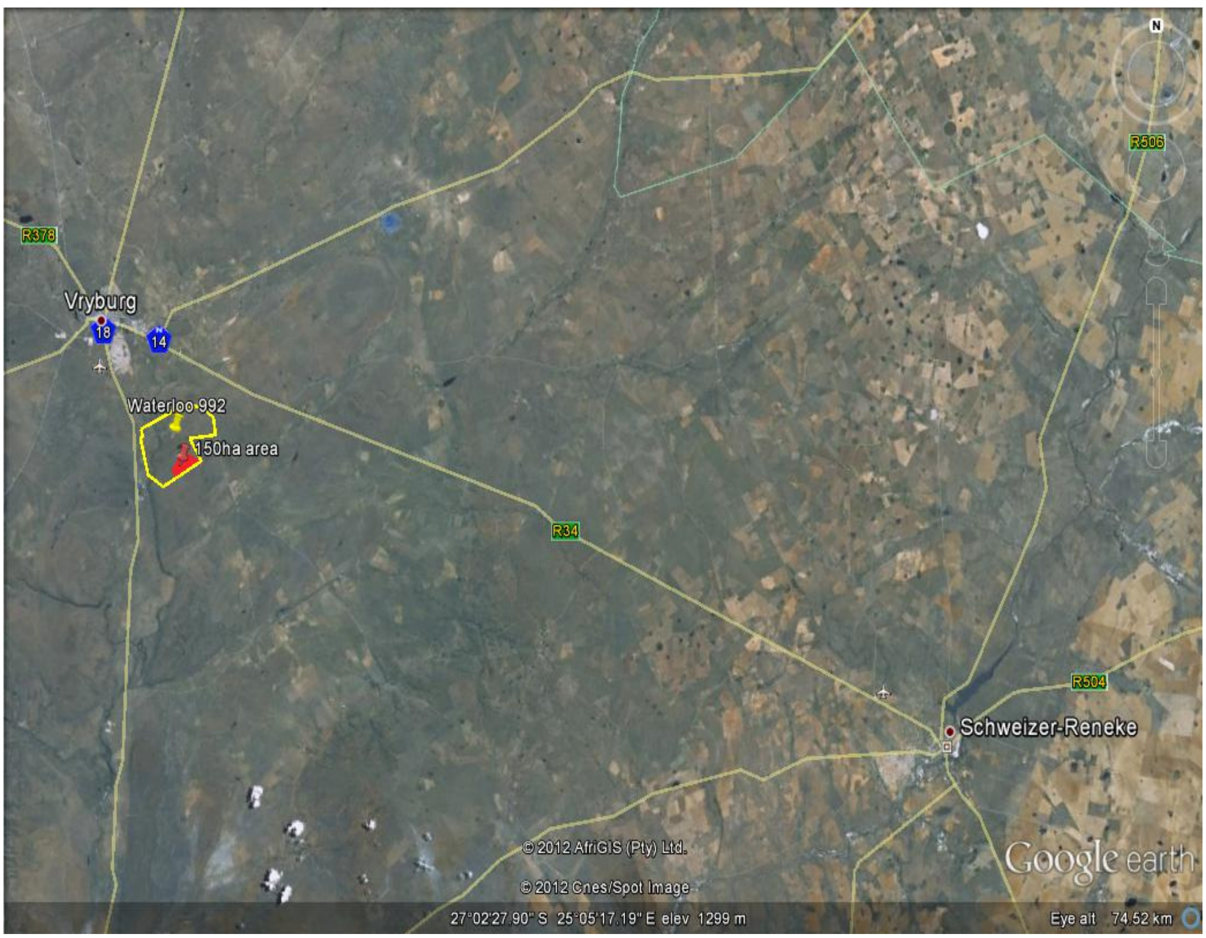

Figure 1: Google earth™ image indicating the regional locality of the study area.

3. CLIMATE OF THE STUDY AREA

Vryburg normally receives about 340 mm to 400 mm of rain per year, with most rainfall occurring mainly during summer. It receives the lowest rainfall (0mm) in June and the highest (70mm) in February. The climate can be considered to be semi-arid with hot summers and cold winter temperatures. The monthly distribution of average daily maximum temperatures range from 19 ℃ in June to 32.9 ℃ in January. The region is the coldest during July when the mercury drops to 0℃ on average during the night. The highest temperature recorded is 41.8 ºC and the lowest – 8.6 ºC. On average frost occurs on 33 days between the end of May and the beginning of September.

4. GEOLOGY AND TOPOGRAPHYOF THE STUDY AREA

The study area is mostly underlain by dolomite, sandstone and shale of the Campbell and Griquastad Groups of the Griqualand West Sequence (Geological Survey, 1984). Andesitic to basaltic lava of the Ventersdorp Supergroup, sometimes overlain by calcrete also occur in the area. Quartzite of the Vryburg Formation and Dwyka tillite also occur in places.

The topography of the 150 ha studied area includes gently undulating midslopes with **slopes** of between 2 º to 10 º mostly with a southern to south eastern aspect.

5. IDENTIFICATION OF ASSUMPTIONS AND LIMITATIONS

The following knowledge gaps existed during compilation of this report and may have an effect on the conclusions made:

- No project description or background information document was provided by the client.
- The exact layout of the proposed project was not made available.
- The method of construction and operation of the proposed solar plant was not provided.

The following assumptions were made with regards to assessing the potential soil impacts:

- The project cycle will consist of construction, operational and decommissioning phases.
- The photo-voltaic panels will be constructed with concrete piers.
- Batteries and other equipment will not be disposed on site.
- The area will not expand beyond the current footprint.

6. LAND TYPE DATA ASSESSMENT

6.1 Background information

The following abstract from Sililo *et al*. (2000) gives an introduction into the development and usefulness of a land type data system:

“In South Africa, land type maps were designed to assist in assessing agricultural potential. The procedure followed in mapping land types was described by the Institute of Soil, Climate and Water (Land type Survey Staff, 1987).”

Land type data was developed by superimposing broad soil groups developed from the Binomial Soil Classification System (MacVicar, 1977) with maps of climate zone. This resulted in the land type maps that indicated land type boundaries with an inventory for each land type that include clay percentage as well as other information regarding the area that can be used to interpret soil classification results more successfully.

8.2 Land type results

According to the available Land Type data two land types occur in the studied area (Figure 2). These land types are Ag10 and Ae36:

- **Land type Ag10** covers more than 90% of the study area and consists of red to yellow apedal, freely drained soils. Red soils have high base status. Ag10 soils are generally soils with minimal development, usually shallow (less than 300 mm deep) and occur on hard or weathering rock. Areas of the Ag10 land type are not suitable for crop production as very severe limitations in terms of effective soil depth occur.
- The **Ae36 land type** also consists of high base status red or yellow apedal, massive or weakly structured, freely drained soils and are generally more than 300 mm deep (no dunes are present). 10 - 30% of the area of Ae36 is marginally suitable for crop production, but mostly with severe limitations.

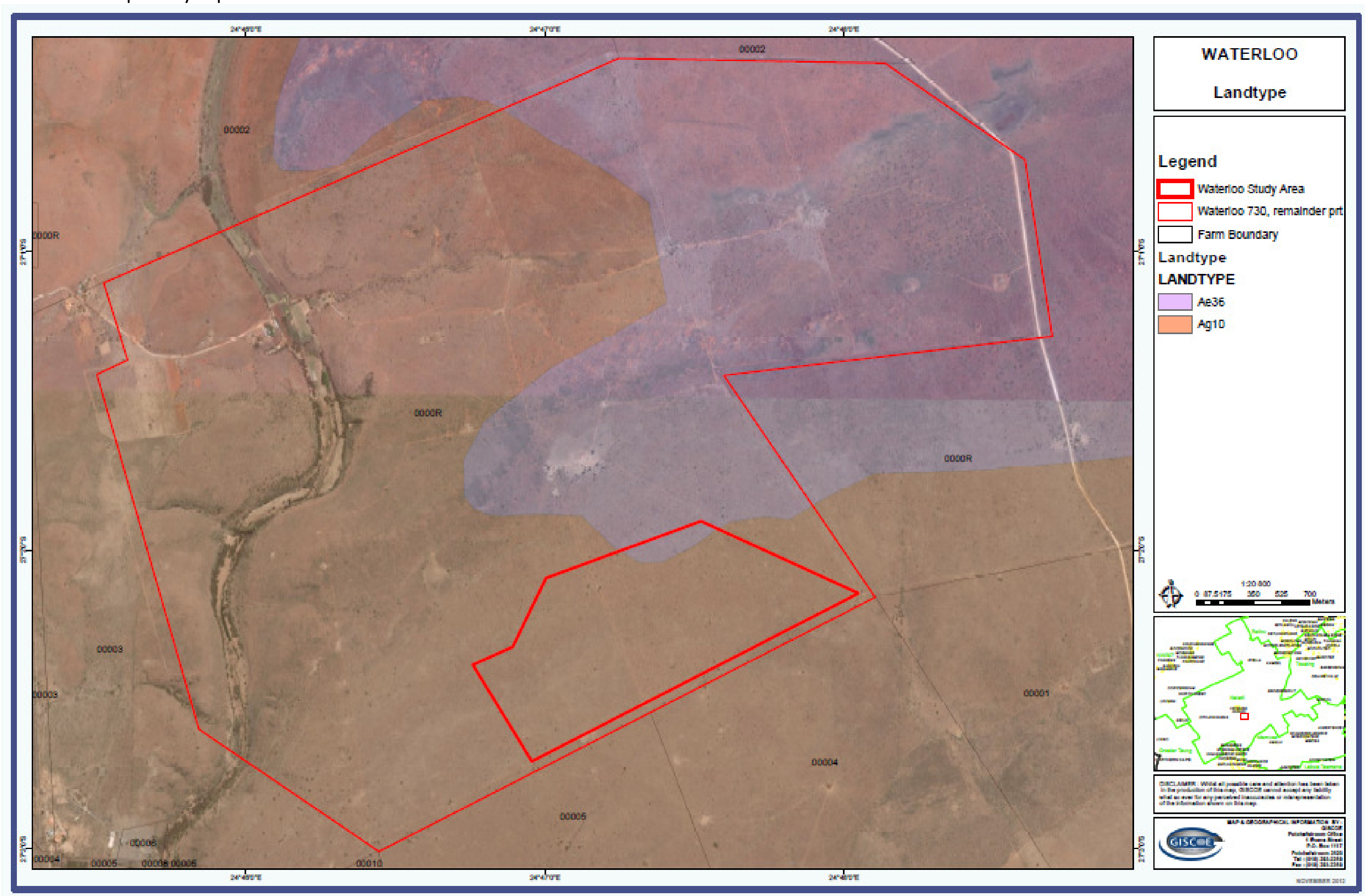

Figure 2: Land type map for Waterloo 992, Vryburg.

7. SOIL CLASSIFICATION

7.1 Soil surveying and classification method

A systematic soil survey was undertaken with sampling points between 150 and 200m apart on the study area. Observations were made regarding soil texture, structure, soil depth and slope of the area. Due to the very shallow nature of the soil form present on site and the presence of hard or weathering rock, it was often not possible to auger deeper than 0.1 meters or sometimes not at all due to rocky outcrops.

Soils are described using the South African Taxonomic Soil Classification System (Soil Classification Working Group, 1991) published as memoirs on the Agricultural Natural Resources of South Africa No.15. Soils are grouped into classes with relatively similar soil characteristics. Soils are grouped into classes with relatively similar soil properties and pedogenesis. A cold 10% hydrochloric acid solution was used on site to test for the presence of carbonates in the soil. A broad soil group reference based on international standards is also described (Fey, 2010).

Five soil samples were collected in the study area for physical and chemical soil analysis. Samples were analyzed for pH, phosphorus content, macro nutrients (calcium, magnesium, and potassium) and electrical conductivity.

7.2 Soil classification

Only one **soil form**, from one soil family, was recorded in the study area. The site is dominated by shallow, marginal soils (between 50 to 300 mm deep) (Figure 3) which consists of an orthic A-horizon on hard rock and is known as the Mispah soil form. The family under the Mispah form that occurs in the study area is Myhill, which represents Mispah soil forms with unbleached and non-calcareous A-horizons. Many rocky dolerite outcrops occur on site (Figure 4). The **soil colour** is homogenous throughout the study area and according to the Munsell colour chart the soil colour is recorded as: 7.5 YR 5/4 – bright brown.

The occurrence of the recorded soil form and the points at which the sampling for the soil classification took place are illustrated on Figure 5. Table 1 gives the coordinates of each classification point and also includes information regarding the soil form and effective soil depth at each point.

Figure 3: Soil auger indication the shallow rocky nature of the Mispah soils in the study area.

Figure 4: Example of the rocky dolerite outcrops present in the study area.

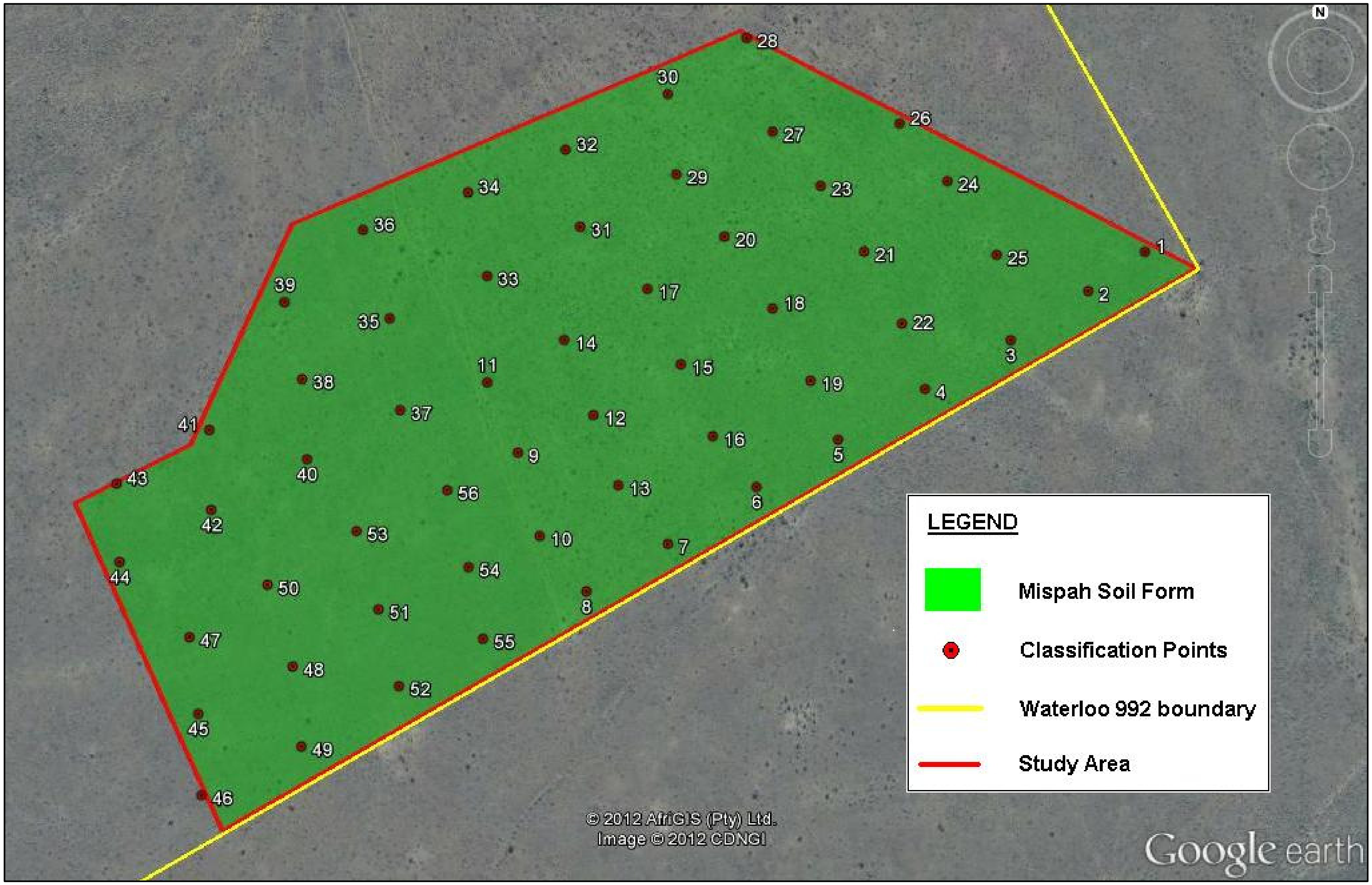

Figure 5: Google earth™ image indicating the study area with the soil form recorded and the points at which soil classification was done.

Table 1: Information regarding soil forms and effective soil depth at each soil classification point

Soil classification point no.	Recorded soil form	Effective soil depth (mm)	Coordinates	
			Lat (S):	Long (E):
1	Mispah	150	27º 02' 07.6"	24º 47' 59.7"
2	Mispah	100	27º 02' 10.0"	24º 47' 55.8"
3	Mispah	100	27º 02' 13.0"	24º 47' 50.5"
4	Mispah	200	27º 02' 16.0"	24º 47' 44.6"
5	Mispah	200	27º 02' 19.1"	24º 47' 38.6"
6	Mispah	150	27º 02' 22.0"	24º 47' 33.0"
7	Mispah	150	27º 02' 25.5"	24º 47' 26.9"
8	Mispah	50	27º 02' 28.4"	24º 47' 21.3"
9	Mispah	100	27º 02' 19.9"	24º 47' 16.6"
10	Mispah	100	27º 02' 25.0"	24º 47' 18.1"
11	Mispah	150	27º 02' 15.6"	24º 47' 14.5"
12	Mispah	150	27º 02' 17.6"	24º 47' 21.8"
13	Mispah	200	27º 02' 21.9"	24º 47' 23.5"
14	Mispah	100	27º 02' 13.0"	24º 47' 19.8"
15	Mispah	150	27º 02' 14.5"	24º 47' 27.8"
16	Mispah	250	27º 02' 18.9"	24º 47' 30.0"
17	Mispah	200	27º 02' 09.9"	24º 47' 25.5"
18	Mispah	100	27º 02' 11.1"	24º 47' 34.1"
19	Mispah	100	27º 02' 15.5"	24º 47' 36.7"
20	Mispah	200	27º 02' 06.7"	24º 47' 30.8"
21	Mispah	300	27º 02' 07.6"	24º 47' 40.4"
22	Mispah	150	27º 02' 12.0"	24º 47' 43.0"
23	Mispah	200	27º 02' 03.6"	24º 47' 37.4"
24	Mispah	200	27º 02' 03.3"	24º 47' 46.1"
25	Mispah	250	27º 02' 07.8"	24º 47' 49.5"
26	Mispah	250	27º 01' 59.8"	24º 47' 42.8"
27	Mispah	150	27º 02' 00.3"	24º 47' 34.1"
28	Mispah	100	27º 01' 54.6"	24º 47' 32.3"
29	Mispah	150	27º 02' 02.9"	24º 47' 27.5"
30	Mispah	100	27º 01' 58.0"	24º 47' 26.9"
31	Mispah	200	27º 02' 06.1"	24º 47' 20.9"
32	Mispah	150	27º 02' 01.4"	24º 47' 19.9"
33	Mispah	150	27º 02' 09.1"	24º 47' 14.5"
34	Mispah	100	27º 02' 04.0"	24º 47' 13.2"
35	Mispah	150	27º 02' 11.7"	24º 47' 07.8"
36	Mispah	50	27º 02' 06.3"	24º 47' 06.0"
37	Mispah	100	27º 02' 17.3"	24º 47' 08.5"
38	Mispah	100	27º 02' 15.4"	24º 47' 01.8"
39	Mispah	150	27º 02' 10.7"	24º 47' 00.6"
40	Mispah	150	27º 02' 20.3"	24º 47' 02.1"
41	Mispah	200	27º 02' 18.5"	24º 46' 55.4"
42	Mispah	150	27º 02' 23.4"	24º 46' 55.5"
43	Mispah	100	27º 02' 21.8"	24º 46' 49.0"
44	Mispah	100	27º 02' 26.6"	24º 46' 49.2"

Soil classification point no.	Recorded soil form	Effective soil depth (mm)	Coordinates	
			Lat (S):	Long (E):
45	Mispah	100	27º 02' 35.9"	24º 46' 54.6"
46	Mispah	50	27º 02' 40.9"	24º 46' 54.8"
47	Mispah	50	27º 02' 31.2"	24º 46' 54.0"
48	Mispah	150	27º 02' 33.0"	24º 47' 01.1"
49	Mispah	100	27º 02' 37.9"	24º 47' 01.7"
50	Mispah	150	27º 02' 28.3"	24º 47' 00.0"
51	Mispah	150	27º 02' 29.5"	24º 47' 07.0"
52	Mispah	200	27º 02' 34.2"	24º 47' 08.4"
53	Mispah	150	27º 02' 24.7"	24º 47' 05.5"
54	Mispah	100	27º 02' 26.9"	24º 47' 13.2"
55	Mispah	200	27º 02' 31.3"	24º 47' 14.2"
56	Mispah	100	27º 02' 21.6"	24º 47' 12.3"

8. SOIL CHEMISTRY

8.1 Soil chemical characteristics and soil fertility

A chemical analysis of five soil samples randomly collected within the study area is included as baseline data. The results of the analyses are included in Figure 6 (p.16).

8.1.1 Soil pH

Soil pH is an indicator of soil acidity and alkalinity. Most soils have a pH in the range of 4 to 10. The pH of a particular soil, such as 5 or 8, reflects a certain chemical and mineralogical environment in that specific soil, and therefore the pH is of great importance to plant roots and microbial activity. Soil pH is one of the most important factors affecting soil fertility. Many parent materials and young soils are alkaline, but old and intensely weathered soils are typically acidic. Descriptive terms commonly associated with different ranges in soil pH are presented in Table 2.

Table 2: Terminology associated with soil pH

pH range	Description
< 4,5	Extremely acidic
4,5 – 5,0	Very strongly acidic
5,1 – 5,5	Strongly acidic
5,6 – 6,0	Moderately acidic

pH range	Description
6,1 – 6,5	Mildly acidic
6,6 – 7,3	Neutral
7,4 – 7,8	Mildly alkaline
7,9 – 8,4	Moderately alkaline
8,5 – 9,0	Strongly alkaline
> 9,0	Very strongly alkaline

The pH of the analyzed soil samples, collected in the study area, range between 5.1 and 5.7 (Table 3). According to the descriptions of Table 2 the soils found in the study area can therefore be described as strongly to moderately acidic.

8.1.2 Other soil elements

Soil fertility describes the potential of land for successful crop production. Soil fertility can usually be improved by the addition of chemical fertilizers. However, with sharp increases in the price of these fertilizers and the negative environmental impact that these chemicals have on groundwater and surface water runoff quality it is becoming increasingly important to manage the inherent soil fertility correctly. This fertility is the combined result of the cation exchange capacity (CEC) of the soil, as well as the exchangeable bases namely Ca (calcium), Mg (magnesium), K (potassium) and Na (sodium).

Potassium (K) plays many essential roles in plants. It is extremely mobile within the plant and helps regulate the opening and closing of stomata in the leaves as well as the uptake of water by root cells. It is also essential for photosynthesis, protein synthesis and starch formation. Potassium levels range from sufficient to moderately high from 109 to 184 mg/kg. The phosphorus (P) levels measured range between 3 and 5 mg/kg. Although this seems very low for a crop production situation, these are normal levels for South African veld conditions. The cation chemistry (Ca, Mg, K, Na) is typical to that of the soil forms in the area of the proposed project.

8.1.3 Soil texture

The soil texture of all the samples analysed are indicated as Loamy Sand, which implies that the soil in the study area has a relatively low **clay percentage** of between 10 to 15 %.

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Date: 13 November 2012

Sample no	Lab no	pH(KCl)	EC	P (Bray1)	K		Ca		Mg		Na	
			mS m^{-1}	mg kg^{-1}	cmol kg^{-1}	mg kg^{-1}	cmol kg^{-1}	mg kg^{-1}	cmol kg^{-1}	mg kg^{-1}	cmol kg^{-1}	mg kg^{-1}
Waterloo 1	J2749	5.1	11.5	4	0.279	109	1.830	366	0.479	58	0.007	2
Waterloo 2	J2750	5.7	20.0	4	0.473	184	3.071	614	0.783	95	0.008	2
Waterloo 3	J2751	5.3	10.1	3	0.307	120	1.843	369	0.456	55	0.008	2
Waterloo 4	J2752	5.1	10.6	3	0.295	115	1.777	355	0.458	55	0.008	2
Waterloo 5	J2753	5.2	13.9	4	0.323	126	1.621	324	0.604	73	0.008	2

Sample no	Lab no	Ca:Mg	Mg:K	Ca+Mg:K	K%	Ca%	Mg%	Na%	Texture
Waterloo 1	J2749	3.8	1.7	8.3	10.7	70.5	18.5	0.3	Loamy Sand
Waterloo 2	J2750	3.9	1.7	8.2	10.9	70.8	18.1	0.2	Loamy Sand
Waterloo 3	J2751	4.0	1.5	7.5	11.7	70.5	17.4	0.3	Loamy Sand
Waterloo 4	J2752	3.9	1.6	7.6	11.6	70.0	18.0	0.3	Loamy Sand
Waterloo 5	J2753	2.7	1.9	6.9	12.6	63.4	23.6	0.3	Loamy Sand

Figure 6: Laboratory results for the analyses of soil samples collected in the study area on Waterloo 992.

9. AGRICULTURAL POTENTIAL

9.1 Veld condition and grazing capacity

9.1.1 Methodology

Before surveying commenced a visual terrain reconnaissance of the study area was done by vehicle and on foot. Only one homogenous vegetation unit was identified. The vegetation of the study area consists of a semi closed shrubland with a very well developed grass layer.

a) Veld Condition

The veld condition index is an indication of the condition or health of veld in terms of its functional characteristics. It is also indicative of the forage or fuel production, resistance to soil erosion and plant species composition of natural veld. The ecological index method (Vorster, 1982) is a commonly used index for veld condition (VC). With this technique the VC of any given survey site is compared to with that of a theoretic benchmark or reference site, which represents veld in an absolute optimal condition for sustained animal production. The assessment of the VC of a site is based on the herbaceous plant species composition and more specifically that of the grass layer.

By using the descending point method (Roux, 1963) along a line (Mentis 1981) at 1 m intervals (100 points), the nearest grass species to each point was recorded. The percentage frequency of occurrence of each grass species was subsequently determined at six different positions in the study area. Two surveys were per broad vegetation unit were conducted. In the frequency data the grass species are classified according to their ecological or grazing status/value, which is determined by its palatability and its preference as fodder by grazers (Bothma, 2002). The following five classes of ecological or grazing status/value (ecological classes) are used to determine VC:

- Decreaser: species abundant in veld that is in a good condition, but decreases in frequency when the veld is over- or underutilized (grazing value = 10).
- Increaser 1: species that generally increases in veld that is being underutilized (grazing value = 7).
- Increaser 2a: species that increases in frequency in veld that is utilized lightly or overgrazed selectively (grazing value = 5).
- Increaser 2b: species that increases in veld that is utilized moderately or overgrazed selectively (grazing value = 4).

- Increaser 2c: species that increases in frequency when veld is trampled, disturbed or over utilized severely (grazing value = 1).

The total percentage frequency of each ecological class is calculated from the frequency data acquired from the point survey. This percentage is multiplied by the grazing value of the relevant ecological class. The sum of these values represents the ecological index value for that particular site. The maximum value is 1000, which represents the value of the theoretical benchmark, which is used to compare the value for each site with in order to calculate the VC value. The nett result is a VC index value which is expressed as a percentage. For example: if the sum of the grazing values for a given site is 562 the calculations will look as follows:

VC value = (562/1000) x 100 = 56.2 %

Broadly speaking, a VC value of less than 40% indicates poor veld, 40 – 60% indicates veld in a moderate condition and one with a value of more than 60% veld in a good condition (Bothma, 2002).

b) <u>Grazing Capacity</u>

In this study the method described by Danckwerts & Teague (1989) was used to calculate grazing capacity (GC). Danckwerts & Teague (1989) developed a GC model based on the veld condition score and the mean annual rainfall. The model is applicable to areas where woody vegetation is neither dominating nor absent. The short-term grazing capacity is derived from the rainfall of the previous season and the long-term mean annual precipitation (MAP), and the long-term GC is calculated by taking only the long term MAP into account.

The equation of Danckwerts & Teague (1989) is as follows:

GC = [(-0.03) + (0.00289) (X)] + [(Y – 419.7) (0.0006333)]

Where:

GC = grazing capacity expressed in Large Stock Units per hectare (LSU/ha)

X = veld condition value (%) and

Y = MAP (mm)

Using the VC value calculated previously with a MAP of 400mm the calculations will be as follows:

GC = [(-0.03) + (0.00289) (**56.2**)] + [(**400** – 419.7) (0.0006333)]

= 0.12 LSU/ha

This answer is inverted to give a value in ha/LSU, thus:

1 ÷ 0.12 LSU/ha = 8.34 ha/LSU.

8.34 ha are therefore required to sustain one LSU for an entire year. One LSU is described as an animal of 450kg utilizing 10kg of forage per day (Meissner, 1982 & Meissner *et al* 1983).

9.1.2 Results

Detail results of the veld condition (VC) assessment and grazing capacity (GC) calculations of the study area are included in Appendix A. The results show that veld is generally in a good condition with an average VC of 66.9 % (Table 3). The average GC is 0.138 LSU/ha or 7.23 ha/LSU. Table 3 gives a summary of the frequency data, the VC and GC of each survey site as well as the average figures for the study area.

Table 3: Summary of frequency data and veld condition (VC) and grazing capacity (GC) values for the study area.

	Survey no.	1	2	3	Average
VC (%)		69	58	74	66.9
GC (LSU/ha)		6.9	9.0	6.3	7.23
Frequency (%)	Decreaser	53	44	67	55
	Increaser 1	9	4	1	5
	Increaser 2a	8	11	4	8
	Increaser 2b	9	4	6	6
	Increaser 2c	18	27	13	19
	Forbs & sedges	3	9	9	7
	Bare soil & rock	0	1	0	0

9.2 Water availability

Water is a major limiting factor to local agricultural enterprises and the sites neither contain nor border a perennial river or freshwater impoundment which could be used as a source of irrigation water. A concrete dam about 500m north of the proposed development site, which is presumably supplied from a borehole, provides cattle with drinking water.

The site does not currently accommodate any centre pivots, irrigation schemes or active agricultural fields. There are no arable lands which could be impacted upon by the proposed development.

9.3 Conclusions on agricultural potential

Following the conclusions of the soil classification and grazing capacity analysis, it can be concluded the study site has no potential for dry land or irrigated crop production due to the limitations of soil forms present (restricted depth) as well as the limiting climate (low and erratic rainfall). According to the Land Type information available these conclusions in terms of the potential for arable land in the study area is confirmed by Figure 7. The site has potential for extensive cattle or game farming. With a good veld condition of 67% and an average grazing capacity of 7.2 ha/LSU, the proposed development site of 150 ha can accommodate 20 head of cattle per year under average rainfall conditions. It can be concluded that should the development be authorised, it will have a low impact on agricultural potential of cattle production in the area and no impact on crop production.

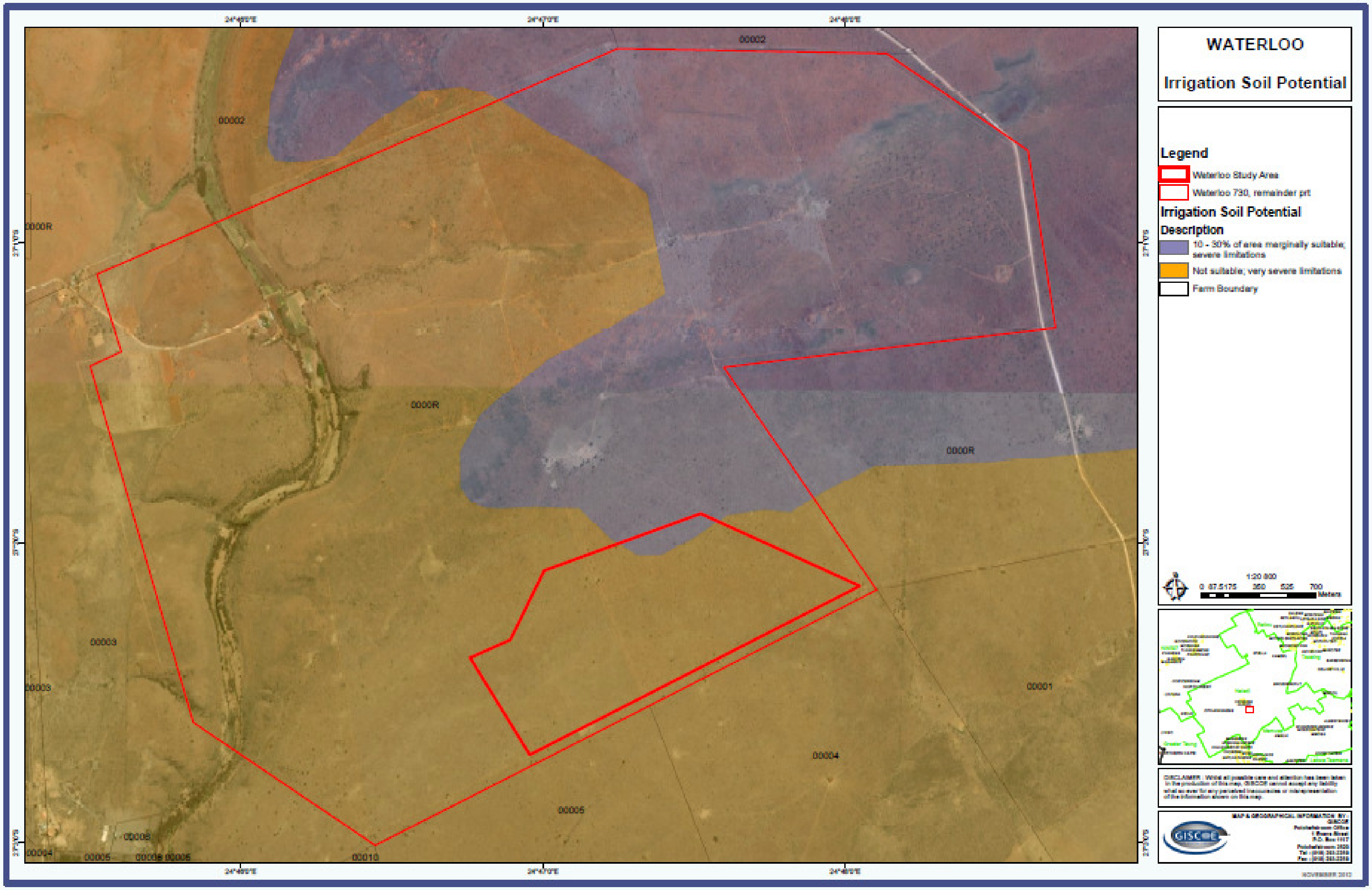

Figure 7: Irrigation soil potential for Waterloo

10. LAND USE AND LAND CAPABILITY

10.1 Current status of the land

Fencing in and around the studied area consist of six strand cattle fences and it is generally evident that the portion of the farm Waterloo, which makes up the 150 ha study area, has been utilized for livestock, mainly cattle, for many years. Some small game species also occur in the area. Signs of moderate veld degradation, in the form of moderate levels of bush encroachment, are visible in the vegetation layer and can be attributed to periods of heavy grazing and possible drought conditions, followed by good rains in the past. Generally, however, the veld condition is good. No signs of serious soil erosion were recorded on site. There are also no buildings or other permanent infrastructure that has been constructed on site. The road infrastructure on site consists of farm tracks that can only be used by vehicles with a high ground clearance. An ESCOM power line runs on the eastern boundary of the proposed development site.

Van Oudtshoorn (1999) emphasizes the fact that grasses and the soil that it grows in are one of our most valuable natural resources and that we (the land users) should do all that is in our power to conserve it in a good condition for future generations. Care should be taken not to injudiciously destroy or degrade natural rangelands. It is recommended that the natural veld in the area of the solar panels be utilized by game or other livestock if at all possible. The reason for this recommendation is that under-utilization of natural veld in the long run is just as detrimental to the sustainability of natural veld as is the case with over utilization. According to Van Oudtshoorn (1999) a tuft of grass will smother from the inside if dead plant material is allowed to accumulate when no defoliation takes place through grazing or periodic burning. The effects of under-utilization, just as with over utilization, may also cause the deterioration of the veld condition, which will lead to bare patches in the vegetation and subsequently lead to higher levels of erosion and soil surface deterioration. If grazing is not an option, grass cutting (to be used or sold as dry fodder in the form of bales) or periodic burning is strongly recommended.

10.2 Surrounding land use

The surrounding land in the area is also used for extensive cattle and possibly game farming activities. No industries, crop farming or tourism activities are present within a 500m radius surrounding the site. It is anticipated that the proposed change in land use of the study site will not result in any negative impact on the surrounding land users as it should not result in any physical or chemical pollution that will affect neighbouring properties and farming practises.

11. IMPACT ASSESSMENT

11.1 Methodology

In order for the EAP to allow for sufficient consideration of all environmental impacts, impacts were assessed using a common, defensible method of assessing significance that will enable comparisons to be made between risks/impacts and will enable authorities, stakeholders and the client to understand the process and rationale upon which risks/impacts have been assessed. The method to be used for assessing risks/impacts is outlined in the sections below.

The first stage of risk/impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions used in the impact assessment are presented below.

- An activity is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or infrastructures that are possessed by an organisation.
- An environmental aspect is an ‘element of an organizations activities, products and services which can interact with the environment’1. The interaction of an aspect with the environment may result in an impact.

Environmental risks/impacts are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity, for example, disturbance due to noise and health effects due to poorer air quality. In the case where the impact is on human health or wellbeing, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is.

- Receptors can comprise, but are not limited to, people or human-made systems, such as local residents, communities and social infrastructure, as well as components of the biophysical environment such as wetlands, flora and riverine systems.

[1] The definition has been aligned with that used in the ISO 14001 Standard.

- Resources include components of the biophysical environment.
- Frequency of activity refers to how often the proposed activity will take place.
- Frequency of impact refers to the frequency with which a stressor (aspect) will impact on the receptor.
- Severity refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.
- Spatial extent refers to the geographical scale of the impact.
- Duration refers to the length of time over which the stressor will cause a change in the resource or receptor.

The significance of the impact is then assessed by rating each variable numerically according to the defined criteria. Refer to the tables below. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 10. The values for likelihood and consequence of the impact are then read off a significance rating matrix and are used to determine whether mitigation is necessary[2].

The assessment of significance is undertaken twice. Initial significance is based on only natural and existing mitigation measures (including built-in engineering designs). The subsequent assessment takes into account the recommended management measures required to mitigate the impacts. Measures such as demolishing infrastructure and reinstatement and rehabilitation of land are considered post-mitigation. The model outcome of the impacts was then assessed in terms of impact certainty and consideration of available information to be in line with international best practice guidelines in instances of uncertainty or lack of information by increasing assigned ratings or adjusting final model outcomes. In certain instances where a variable or outcome requires rational adjustment due to model limitations, the model outcomes have been adjusted.

[2] Some risks/impacts that have low significance will however still require mitigation

Table 4: Criteria for assessing significance of impacts

CONSEQUENCE DESCRIPTORS

Severity of impact	**RATING**
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful	5
Spatial scope of impact	**RATING**
Activity specific	1
Development specific (within the site boundary)	2
Local area (within 5 km of the site boundary)	3
Regional	4
National	5
Duration of impact	**RATING**
One day to one month	1
One month to one year	2
One year to ten years	3
Life of operation	4
Permanent	5

Table 5: Criteria for assessing significance of impacts

LIKELIHOOD DESCRIPTORS

Frequency of activity/ duration of aspect	**RATING**
Annually or less / low	1
6 monthly / temporary	2
Monthly / infrequent	3
Weekly / life of operation / regularly / likely	4
Daily / permanent / high	5
Frequency of impact	**RATING**
Almost never / almost impossible	1
Very seldom / highly unlikely	2
Infrequent / unlikely / seldom	3
Often / regularly / likely / possible	4
Daily / highly likely / definitely	5

Table 6: Significance rating matrix

	CONSEQUENCE (Severity + Spatial Scope + Duration)														
LIKELIHOOD (Frequency of activity + Frequency of impact)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 7: Positive/Negative Mitigation Ratings

Significance Rating	Value	Negative Impact Management Recommendation	Positive Impact Management Recommendation
Very high	126-150	Improve current management	Maintain current management
High	101-125	Improve current management	Maintain current management
Medium-high	76-100	Improve current management	Maintain current management
Medium-low	51-75	Maintain current management	Improve current management
Low	26-50	Maintain current management	Improve current management
Very low	1-25	Maintain current management	Improve current management

The following points were considered when undertaking the assessment:

- Risks and impacts were analysed in the context of the project's area of influence encompassing:
    - Primary project site and related facilities that the client and its contractors develop or control;
    - Areas potentially impacted by cumulative impacts for further planned development of the project, any existing project or condition and other project-related developments; and

- Areas potentially affected by impacts from unplanned but predictable developments caused by the project that may occur later or at a different location.

- Risks/Impacts were assessed for all stages of the project cycle including:
  - Construction;
  - Operation; and
  - Rehabilitation.
- If applicable, trans-boundary or global effects were assessed;
- Individuals or groups who may be differentially or disproportionately affected by the project because of their disadvantaged or vulnerable status were assessed.

Mitigation measure development

The following points present the key concepts considered in the development of mitigation measures for the proposed development.

- Mitigation and performance improvement measures and actions that address the risks and impacts[3] are identified and described in as much detail as possible.
- Measures and actions to address negative impacts will favour avoidance and prevention over minimisation, mitigation or compensation.
- Desired outcomes are defined, and have been developed in such a way as to be measurable events with performance indicators, targets and acceptable criteria that can be tracked over defined periods, with estimates of the resources (including human resource and training requirements) and responsibilities for implementation.

11.2 Impact rating

Due to the nature of the project and the aim of generating sustainable electricity from a renewable energy source, it is not foreseen that there will be a decommissioning phase for this project. Four possible impacts on soil resulting from the proposed project are expected. These impacts are:

- Soil erosion due to increased run-off from the surfaces of the panels of the photo-voltaic plant.

[3] Mitigation measures should address both positive and negative impacts

- Soil compaction caused by transport of equipment on and off site during construction and operation. This also includes transport during the operational phase to do maintenance work.
- Chemical soil pollution that may result from batteries being disposed of during the decommissioning phase as well as fuel and oil spills from vehicles transporting equipment.
- Change in grazing land use.

11.1.1 ISSUE: Soil erosion

Environmental significance:

Soil erosion will not be a problem during the construction phase for the PV plants will be cemented into the soil and very little natural vegetation will be removed. The largest risk factor for soil erosion will be during the operational phase when storm water run-off from the surfaces of the photo-voltaic panels could cause erosion.

Erosion will be localised within the site boundary but will have a permanent effect that would stretch into the operational phase of the project. This will ultimately lead to the irretrievable commitment of this resource. The measurable effect of reducing erosion by utilising mitigation measures may reduce possible erosion significantly. The significance of this potential impact is considered to be high.

Assessment of impact before mitigation

Likelihood		**Consequence**			
Frequency of activity	*Freq of impact*	*Benefit/Severity of impact*	*Spatial/Population Scope*	*Duration*	*Rating*
5 Highly likely	4 Often	4 Great	3 Local area	5 Permanent	High
Score	9	12			108

Mitigation measures:

- To avoid soil erosion, it will be a good practice to design storm water canals into which the water from the panels can be channelled. These canals should reduce the speed of the water and allow the water to drain slowly onto the land.

- Another important measure is to avoid stripping land surfaces of existing vegetation by only allowing vehicles to travel on existing roads and not create new roads.

Through mitigation measures the potential impact can be reduced from high to low.

Assessment of impact after mitigation

Likelihood		**Consequence**			
Frequency of activity	*Freq of impact*	*Small*	*Spatial/Population Scope*	*Duration*	*Rating*
4 Life of operation	2 Highly unlikely	1 Insignificant	3 Local area	4 Life of operation	Low
Score	6	8			48

11.1.2 ISSUE: Soil compaction

Environmental significance:

Soil compaction due to unnatural load in the area will change the soil structure. Although there is already some soil compaction due to sections of the study site being used as a farm road, soil compaction will increase because of the increase in activity. The effect of this will largely be within the site boundary and will continue during the operational phase. If probable mitigating measures are not implemented the effect of the compaction will affect soil structure of soils on the site. The significance of this potential impact is considered to be medium-high.

Assessment of impact before mitigation

Likelihood		**Consequence**			
Frequency of activity	*Freq of impact*	*Benefit/Severity of impact*	*Spatial/Population Scope*	*Duration*	*Rating*
4 Regularly	2 Temporary	3 Significant	3 Local area	4 Life of operation	Medium-High
Score	6	10			90

<u>Mitigation measures:</u>

- The most effective mitigation will be the minimisation of the project footprint by using the existing roads in the area and not create new roads to prevent other areas also getting compacted.

Therefore the effect of compaction mitigation will be localised within the area and will only have an effect during the construction and operational years. The significance of this potential impact, after mitigation, is considered to be low.

Assessment of impact after mitigation

Likelihood		Consequence			
Frequency of activity	*Freq of impact*	*Benefit/Severity of impact*	*Spatial/Population Scope*	*Duration*	*Rating*
2 Temporary	3 Infrequent	2 Potentially harmful	2 Study area specific	4 Life of operation	Low
Score	5	8			40

11.1.3 ISSUE: Chemical soil pollution

<u>Environmental significance:</u>

The use of vehicles that can result in oil and fuel spills on site as well as waste generation by construction and construction workers can result in possible chemical soil pollution. Chemical soil pollution can also be caused by unlawful discarding of broken and old batteries. The effect can stretch beyond the site boundaries and the significance of this potential impact is considered to be high.

Assessment of impact before mitigation

Likelihood		Consequence			
Frequency of activity	*Freq of impact*	*Benefit/Severity of impact*	*Spatial/Population Scope*	*Duration*	*Rating*
5 Permanent	5 Daily	4 Harmful	3 Local area	4 Life of operation	High
Score	10	11			110

Mitigation measures:

Soil pollution within and outside the site boundary can be prevented through mitigation the anticipated impact can be reduced from high to low. The following mitigation measures are suggested:

- All waste generated on site during construction should be stored in waste bins and removed from site on a regular basis.
- Vehicles accessing the site should regularly be checked for fuel and oil spills. In case of spillage, the contaminated soil should be removed and transported to a designated waste site.
- No broken or old batteries or components of the PV plant should be dumped on or around the site but should be removed immediately and taken to a special chemical waste facility.

Assessment of impact after mitigation

Likelihood		**Consequence**			
Frequency of activity	*Freq of impact*	*Benefit/Severity of impact*	*Spatial/Population Scope*	*Duration*	*Rating*
2 Temporary	5 Infrequent	1 Insignificant	3 Local	4 Life of operation	Low
Score	5	8			35

The significance of this potential impact, after mitigation, is considered to be low.

11.1.4 ISSUE: Change in grazing land use

Environmental significance:

The use of the area for the construction and operation of the PV plant will result in the area not being used for livestock grazing anymore. This will result in the loss of grazing for potentially 11 large stock units (cattle). However, this impact is low.

Assessment of impact before mitigation

Likelihood		Consequence			
Frequency of activity	*Freq of impact*	*Benefit/Severity of impact*	*Spatial/Population Scope*	*Duration*	*Rating*
5 Definitely	1 Annually	1 Insignificant	3 Local area	4 Life of operation	Low
Score	6	8			48

Mitigation measures:

Due to the permanent nature of the project it is not foreseen that it can be mitigated to any lower impact.

IMPACT SUMMARY

Based on the above assessment it is evident that there are four possible impacts on the soil of the area observed. The table below summarises the findings indicating the significance of the impact before mitigation takes place and the likely impact if management when mitigation takes place. In the consideration of mitigation it is assumed that a high level of mitigation takes place but does not lead to prohibitive costs. From the table it is evident that prior to mitigation all of the impacts range between high and low level impacts but with proper mitigation measures all impacts can be reduced to low level.

Table 8: A summary of the results impacts assessed

Impact	**Impact level pre-mitigation**	**Impact level post mitigation**
Soil erosion	High	Medium-low
Soil compaction	Medium-low	Low
Chemical soil pollution	High	Low
Change in grazing land use	Low	Low

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APPENDIX A: FREQUENCY, VELD CONDITION AND GRAZING CAPACITY DATA AND RESULTS

Table 9: Frequency, VC and GC data for survey site 1

Survey date:	09-Nov-12			
Locality:	Waterloo			
Survey site:	1			
Exact position:	27º 02' 07.6"			
	24º 47' 59.7"			
MAP (mm) :	380			
Ecological Class	**Ecological value**	**Frequency (%)**	**EI**	**%**
Decreaser	10	53	530	76.81
Increaser 1	7	9	63	9.13
Increaser 2a	5	8	40	5.80
Increaser 2b	4	9	36	5.22
Increaser 2c	1	18	18	2.61
Forbs	1	2	2	0.29
Sedges	1	1	1	0.14
Bare soil	0	0	0	0.00
Bare rock	0	0	0	0.00
TOTAL		**100**	**690**	**100.00**
VC Value (%):	**69.0**	**GC:**	**LSU/Ha**	**Ha/LSU**
			0.144	**6.93**

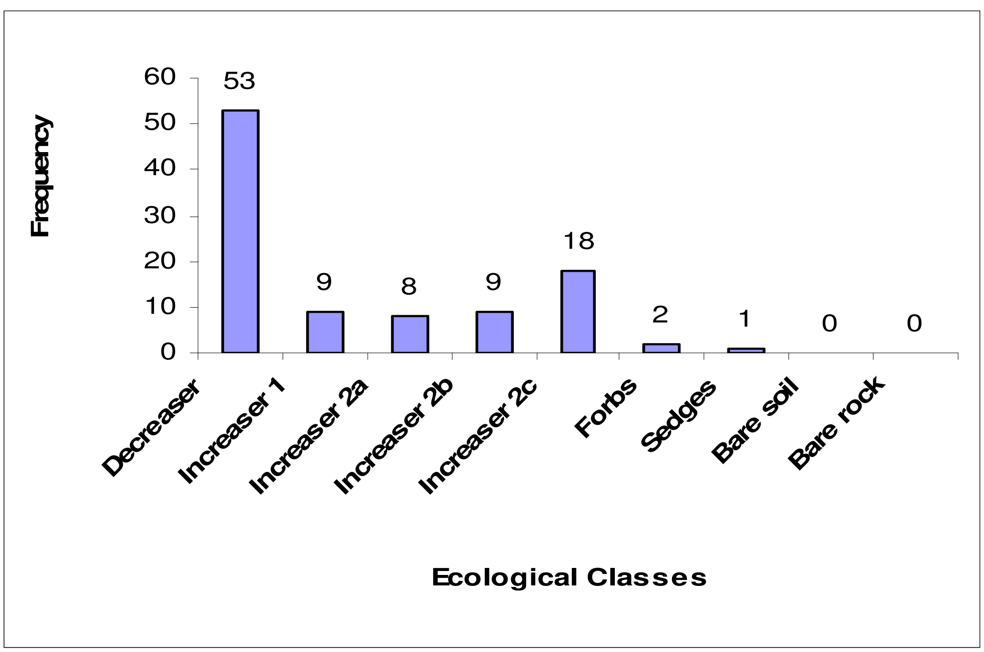

Figure 8: Chart indicating the frequency data of different ecological classes in survey site 1

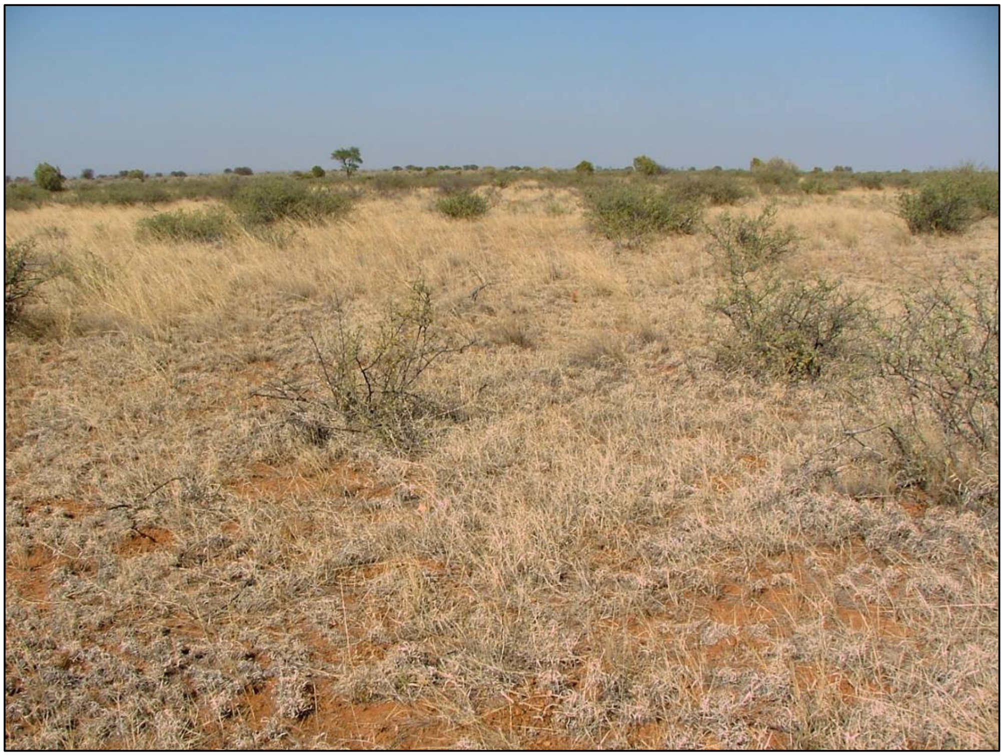

Figure 9: Photographic image of survey site 1

Table 10: Frequency, VC and GC data for survey site 2

Survey date:	09-Nov-12			
Locality:	Waterloo			
Survey site:	2			
Exact position:	27º 02' 17.6"			
	24º 47' 21.8"			
MAP (mm) :	380			
Ecological Class	**Ecological value**	**Frequency (%)**	**EI**	**%**
Decreaser	10	44	440	76.52
Increaser 1	7	4	28	4.87
Increaser 2a	5	11	55	9.57
Increaser 2b	4	4	16	2.78
Increaser 2c	1	27	27	4.70
Forbs	1	6	6	1.04
Sedges	1	3	3	0.52
Bare soil	0	1	0	0.00
Bare rock	0	0	0	0.00
TOTAL		**100**	**575**	**100.00**
VC Value (%):	**57.5**	**GC:**	**LSU/Ha**	**Ha/LSU**
			0.111	**9.01**

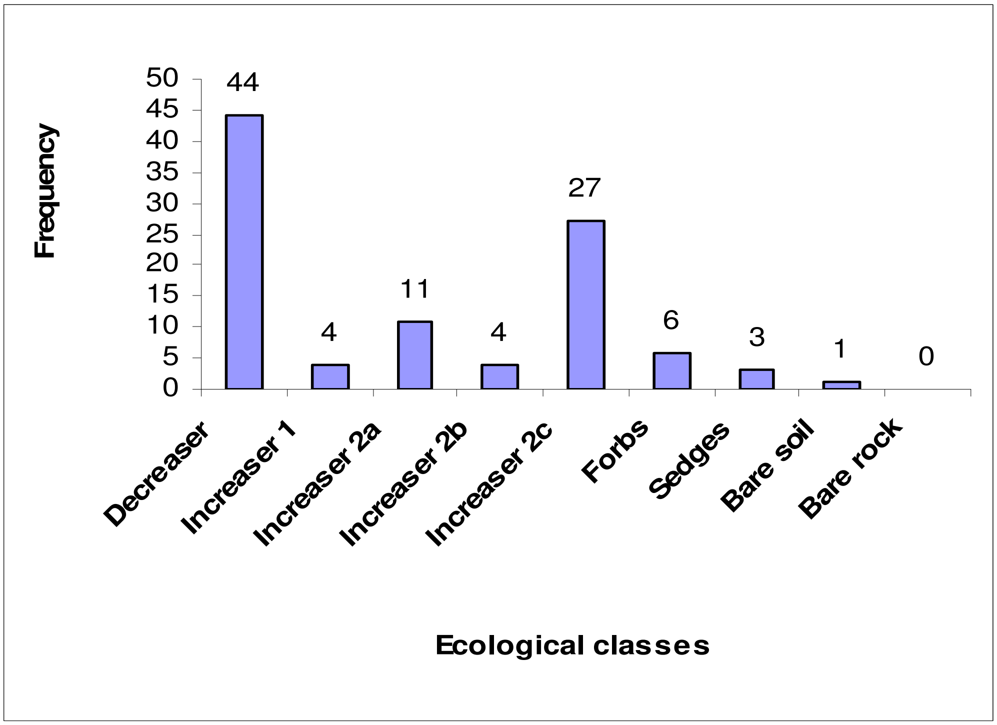

Figure 10: Chart indicating the frequency data of different ecological classes in survey site 2

Figure 11: Photographic image of survey site 2

Table 11: Frequency, VC and GC data for survey site 3

Survey date:	09-Nov-12			
Locality:	Waterloo			
Survey site:	3			
Exact position:	27º 02' 20.3"			
	24º 47' 02.1"			
MAP (mm) :	380			
Ecological Class	**Ecological value**	**Frequency (%)**	**EI**	**%**
Decreaser	10	67	670	90.17
Increaser 1	7	1	7	0.94
Increaser 2a	5	4	20	2.69
Increaser 2b	4	6	24	3.23
Increaser 2c	1	13	13	1.75
Forbs	1	3	3	0.40
Sedges	1	6	6	0.81
Bare soil	0	0	0	0.00
Bare rock	0	0	0	0.00
TOTAL		**100**	**743**	**100.00**
VC Value (%):	**74.3**	**GC:**	**LSU/Ha**	**Ha/LSU**
			0.160	**6.27**

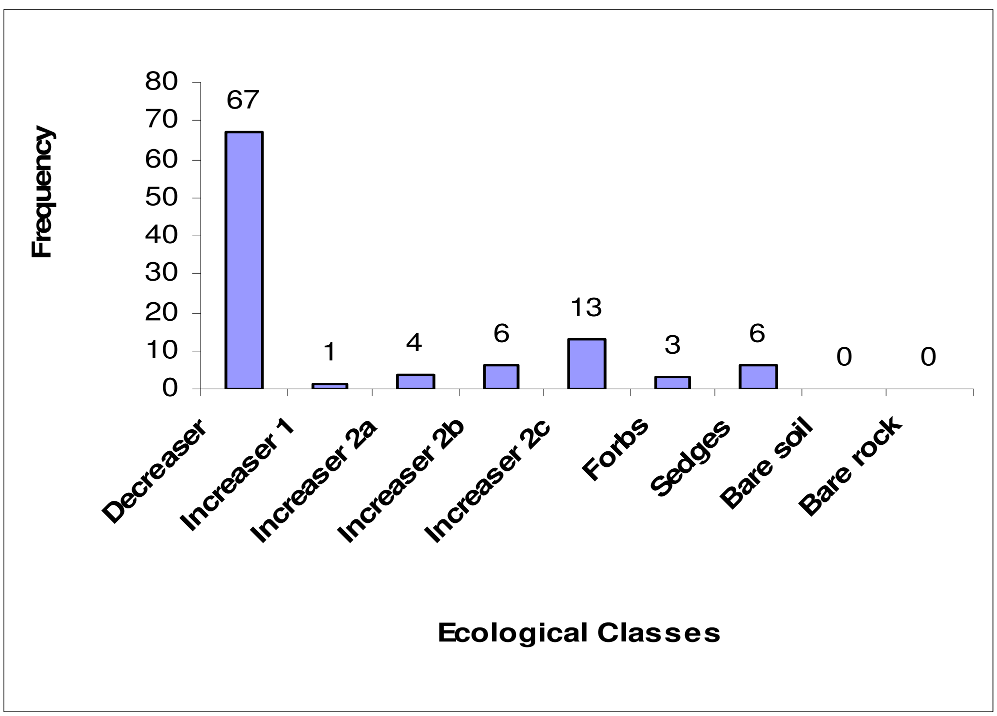

Figure 12: Chart indicating the frequency data of different ecological classes in survey site 3

Figure 13: Photographic image of survey site 3

Table 12: Average frequency, VC and GC data for all survey sites

Survey date:	09-Nov-12			
Locality:	Waterloo			
Survey site:	Average			
MAP (mm) :	380			
Ecological Class	**Ecological value**	**Frequency (%)**	**EI**	**%**
Decreaser	10	55	547	81.67
Increaser 1	7	5	33	4.88
Increaser 2a	5	8	38	5.73
Increaser 2b	4	6	25	3.78
Increaser 2c	1	19	19	2.89
Forbs	1	4	4	0.55
Sedges	1	3	3	0.50
Bare soil	0	0	0	0.00
Bare rock	0	0	0	0.00
TOTAL		**100**	**669**	**100.00**
VC Value (%):	**66.9**	**GC:**	**LSU/Ha**	**Ha/LSU**
			0.138	**7.23**

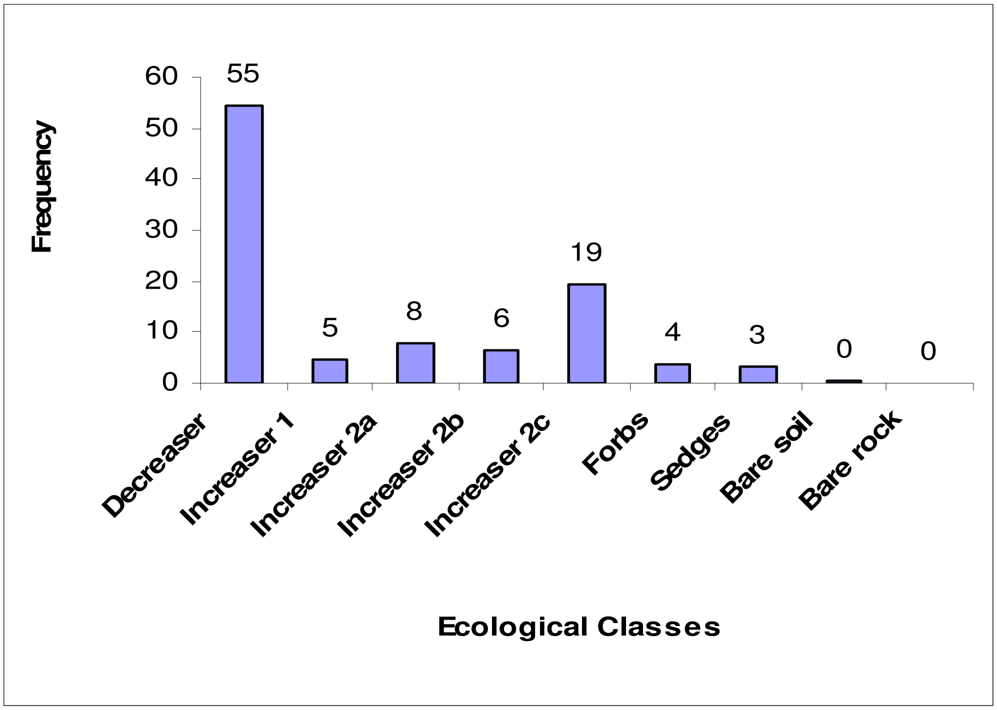

Figure 14: Chart indicating the average data of different ecological classes in the study area