The development of a 400 MW Solar Photovoltaic (PV) facility and associated infrastructure (Phase 3) on the Remainder of Farm Goede Hoop 26C, Portion 3 of Farm Goede Hoop 26C and other properties, between De Aar & Hanover, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province, South Africa

June 2022

by
Hennie van den Berg
and Francois Botha

IRIS
International

Hennie van den Berg
M.Sc. Botany
PostNet Suite # 141
Private Bag X1288
Potchefstroom, 2531
Cell: +27 82 878 1760
hennievdb1@gmail.com

Eco Soil

ECOsoil

Francois Botha
B.Sc, (Honn) Pedology
12 Olienhout str
Miederpark
Potchefstroom, 2531
Cell: +27 84 900 5933
fbecosoil@gmail.com

EXECUTIVE SUMMARY

The soil mapping and grazing assessment was an integrated effort from 2016 - 2022 and the final maps and findings were the results of a collaborative approach between the soil and grazing assessment teams. The soil and grazing assessment reports and maps should be kept and used together as they are interdependent on each other.

This report focuses on the Phase 3 Photo Voltaic (PV) development footprint. However, it is situated adjacent the Phase 2 PV development footprint and three additional soil observation sites were added inside the extension to the West of the Phase 2 footprint. This resulted in an enlargement of approximately 40 ha of the original Phase 2 area and all area calculations and soil properties statistics were also re-done for the Phase 2 area and these were included in this report.

Both areas are characterised by very shallow soils and the Mispah soil form is the dominant soil form. Sub dominant soil forms are, Glenrosa, Oakleaf, Swartland and Valsrivier forms.

The agricultural potential of these soils is very low and extensive grazing at a low intensity is the only long term viable agricultural option. It is possible that the shading effect of the proposed solar panels will increase soil moisture content and therefore improve the general grazing capacity of the study areas to some extent.

The clayey soils and most noticeably the Swartland and Valsrivier soils may restrict vehicle movement during the wet season. The Swartland and Valsrivier soils may also have an influence on foundations.

No severe soil erosion has been observed in the study areas, but care should be taken when constructing infrastructure such as roads to reduce run-off. The floodplains outside the study area are showing signs of severe erosion caused by flash floods in years of exceptional rainfall. In general, the Phase 2 area has limited to no flood risk, while the Phase 3 area is dissected by bottomlands with ephemeral drainage lines that can have some flooding and the restriction of vehicle movement.

Soil unit maps, soil capability maps and grazing unit maps were created for both areas. Soil property statistics and area analyses were provided for the soil maps and grazing unit maps. Al these datasets are provided as digital GIS maps and A0 print files.

Contents

1 INTRODUCTION

Fieldwork for soil, and grazing assessments for the project (2016/2017): Proposed development of a 225MW solar PV plant on several portions of the farm Goedehoop also known as part of the farm De Bad, Hanover District, Northern Cape was done in December 2016 and January 2017 for 3 focus areas or alternatives (1 508 ha in total) (Van den Berg, 2017). In February 2021 another 319 ha was assessed and combined with the Alternative 2 area to cover the currently (called) Phase 1 footprint area (Van den Berg, 2021). The soil mapping was used in both projects to correlate vegetation patterns and grazing potential and to assist in the spatial delineation of grazing units. Floodplain mapping was done (2017) for the three initial study areas and the general area between the three study areas (11 242 ha). The soil, grazing units and veld condition mapping was a combined and integrated mapping effort by both Hennie van den Berg and Francois de Wet for the 2017 and 2021 periods (De Wet 2017, De Wet 2021, Van den Berg 2017 and Van den Berg 2021). The mapping was extended to an area adjacent and North of the Alternative 3 area (now called Phase 2) and the original team of Francois de Wet and Hennie van den Berg was joined by De Villiers (Shobie) Arnoldi and Francois Botha. Soil and grazing unit maps were produced for this new area now called Phase 3 (2022). The detail of the grazing assessments for Phases 1, 2 and 3 is provided by the grazing assessment reports of February 2017 (De Wet, 2017) and February 2021 (De Wet, 2021) by Francois de Wet and June 2022 by Francois de Wet and De Villiers Arnoldi (De Wet and Arnoldi, 2022).

Soil and vegetation surveys (outside the footprint of Phase) were also done in April 2022. They were done for a staging area (part of the Phase 1 project) and an extension area to the West of Phase 2 and part of Phase 2. The Phase 2 soil and grazing unit maps were updated with the additional fieldwork. All the fieldwork sites, field databases and the new Phase 2 and Phase 3 soil, soil capability and grazing unit maps were distributed as GIS files. Although above background of the three phases gives the context around the Phase 3 footprint, this report will focus mainly on the Phase 3 soil survey with some reference to the updating of the Phase 2 soil and grazing units maps.

The current project titles for the 3 Phases are:

Phase 1: The development of a 300 MW Solar Photo-Voltaic (PV) facility, comprising 3 interconnected 100 MW plants, one sub-station that ties into existing overhead ESKOM 400kV transmission lines, and associated infrastructure including containerised lithium-ion battery storage and gas turbines, on several portions of farms in the Hanover District, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province.

Phase 2: The development of a 300 MW Solar Photovoltaic (PV) facility on the Remainder of Riet Fountain 39C, Remainder of Kwanselaars Hoek 40C, Portion 6 of Leuwe Fountain 27C and the Remainder of Farm Goede Hoop 26C between De Aar & Hanover, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province, South Africa.

Phase 3: The development of a 400 MW Solar Photovoltaic (PV) facility and associated infrastructure (Phase 3) on the Remainder of Farm Goede Hoop 26C, Portion 3 of Farm Goede Hoop 26C and other properties, between De Aar & Hanover, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province, South Africa.

2 STUDY AREA

Figure 1 shows the footprint of the three Phases inside South Africa. Figure 2 gives the context of the 3 areas mapped in 2017 in relation to the current 3 Phases, the staging area, and the extension of Phase 2.

All the study areas surveyed during 2016/2017, 2021 and 2022 are part of the Beaufort Group of the Karoo Supergroup of geology in South Africa and consist mainly of sandstones and shales. Dolerite koppies also form a small but conspicuous part of the landscape. The current land-use on all 3 areas is extensive grazing on veld (natural vegetation). The Phase 3 area mapped is 1175.5ha in size and larger than the PV footprint, as it includes bottomlands with ephemeral drainage lines and dolerite and sandstone koppies.

.

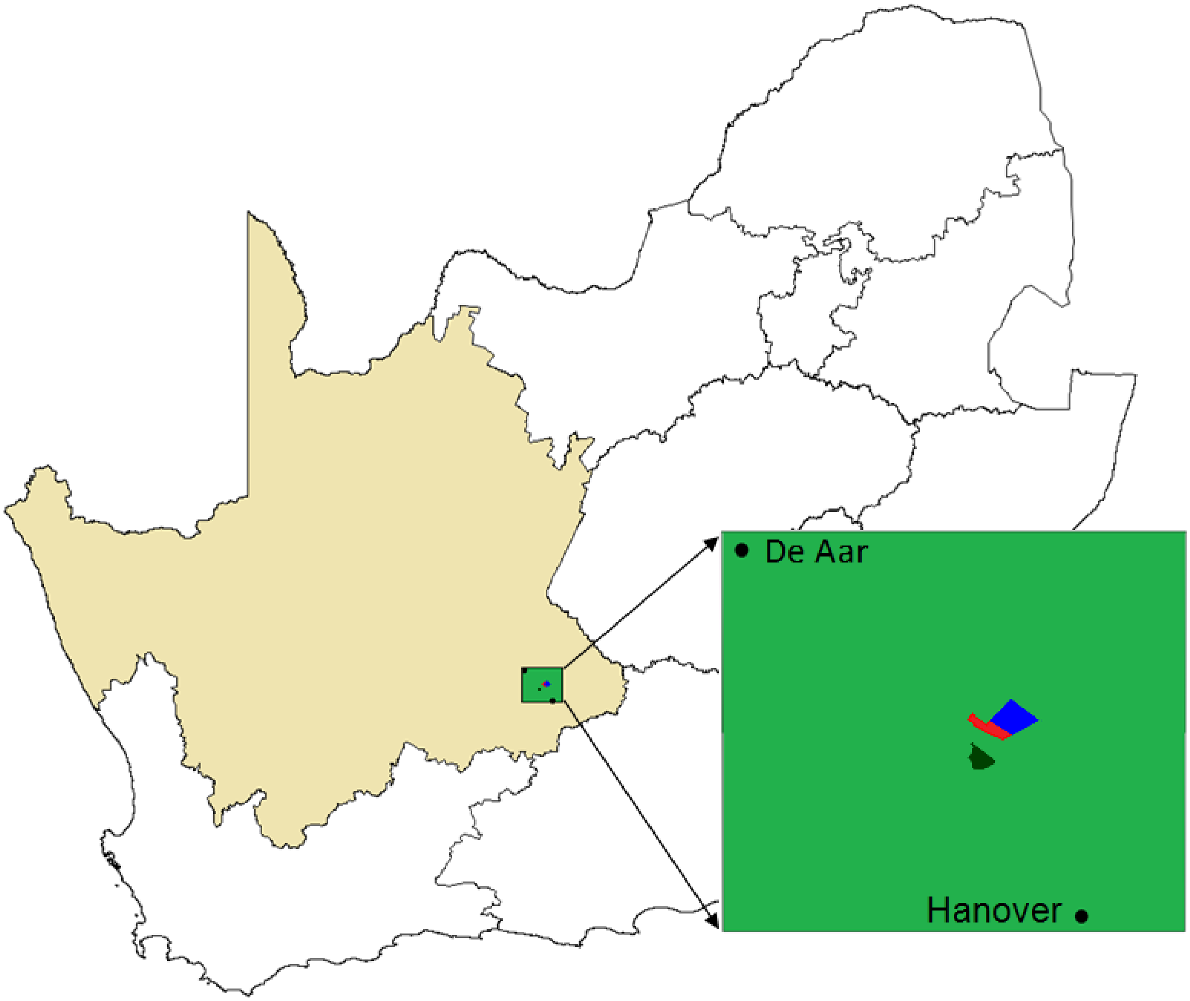


Figure 1. The locations of the Phase 1, 2 and 3 study areas are shown by the green block inside the Northern Cape Province (South Africa). This block is expanded to show the 3 areas in relation to the De Aar and Hanover towns. The Phase 1 area is shown in dark green, the Phase 2 area is shown in red, and the Phase 3 area is shown in blue.

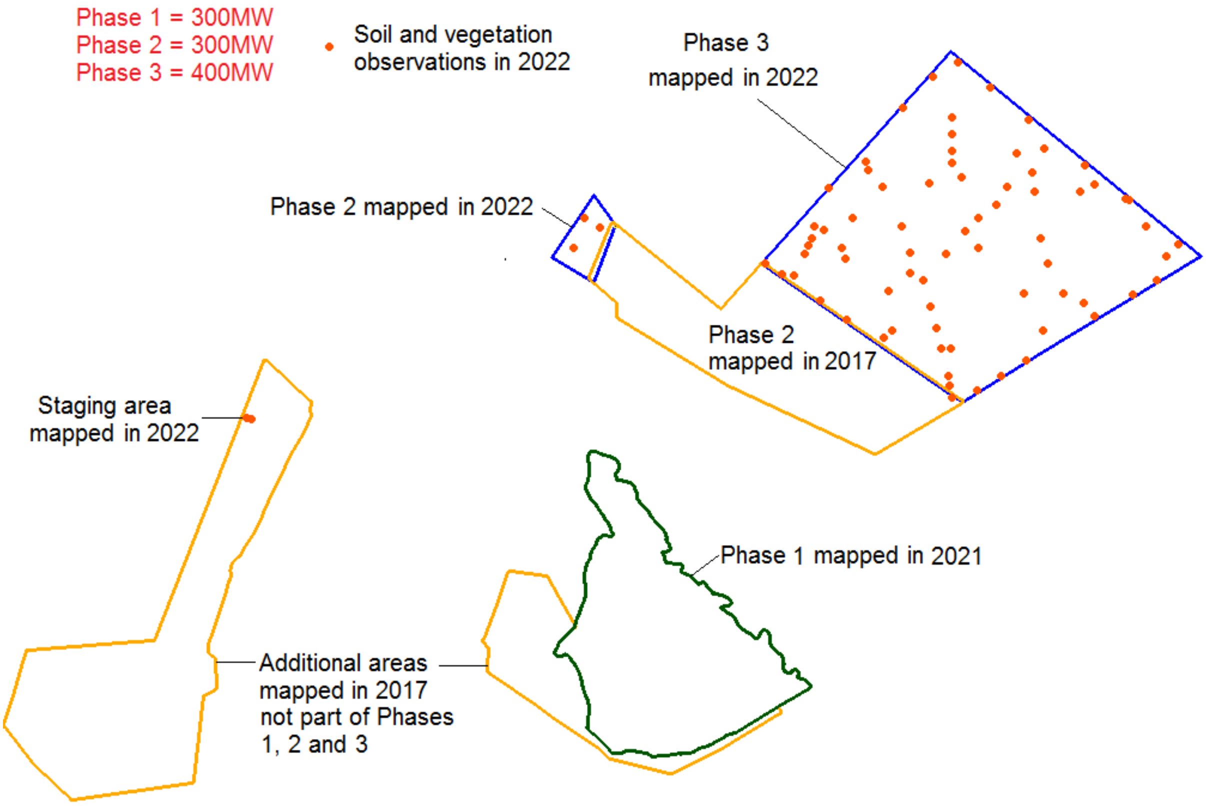


Figure 2. The three areas mapped in 2017 are shown in relation to Phase 1, 2, and 3, the staging area and the extension of Phase 2. The soil and vegetation observations of 2022 are shown by orange dots. Areas delineated in blue are the extension of Phase 2 to the West and Phase 3.

The Phase 3 footprint was extended to a large block of 1 175 ha to include bottomlands with ephemeral drainage lines, koppies and a buffer zone around the footprint area.

3 METHODS

1.1 Soil field survey

In total 77 soil observations were made mostly by hand augering until an impenetrable layer, mostly hard rock, was found. Of these 77 observations 2 were made in the staging area, 3 in the extension to the West of Phase 2 and 72 in the Phase 3 area. All soil observations were done in accordance with the South African Taxonomic System (MacVicar CN (ed.), 1991). Additionally, the coverage of common and dominant plant species was recorded at most of the observation sites.

1.2 Mapping of soil units and grazing units

Soil patterns were mapped mainly from a Google image mosaic and the enhancement products of a Sentinel image of 20 December 2020. Figures 3 and 4 show the Sentinel image enhancements. An ALOS Digital Surface Model (DSM) at a 30m resolution was interpolated to 10m resolution. A slope map with 5 slope classes was created (Figure 5). The main streamlines were digitised from the Google Earth and Sentinel data and used to correct stream flow on the DSM. Terrain morphological mapping was done on the DSM and a terrain unit map was created (Figure 6). The field observations, terrain units, slope and direct mapping on the Google Earth and enhanced Sentinel imagery and the adjacent Phase 2 soil map were used to do the interpolation and mapping of soil patterns for the Phase 3 area.

The drainage area dissecting Phase 3 (and technically outside the project area) was mapped from Google Earth and Sentinel imagery. No infield boundary delineations were made since it was an extremely wet season that could have resulted in the overestimation of the boundary.

Grazing units were mapped by correlating the results of the grazing potential assessment by Francois de Wet and Shobie Arnoldi (De Wet and Arnoldi, 2022), the additional vegetation cover information of the soil survey and the mapped soil units. This resulted effectively in combining soil units to form larger grazing units.

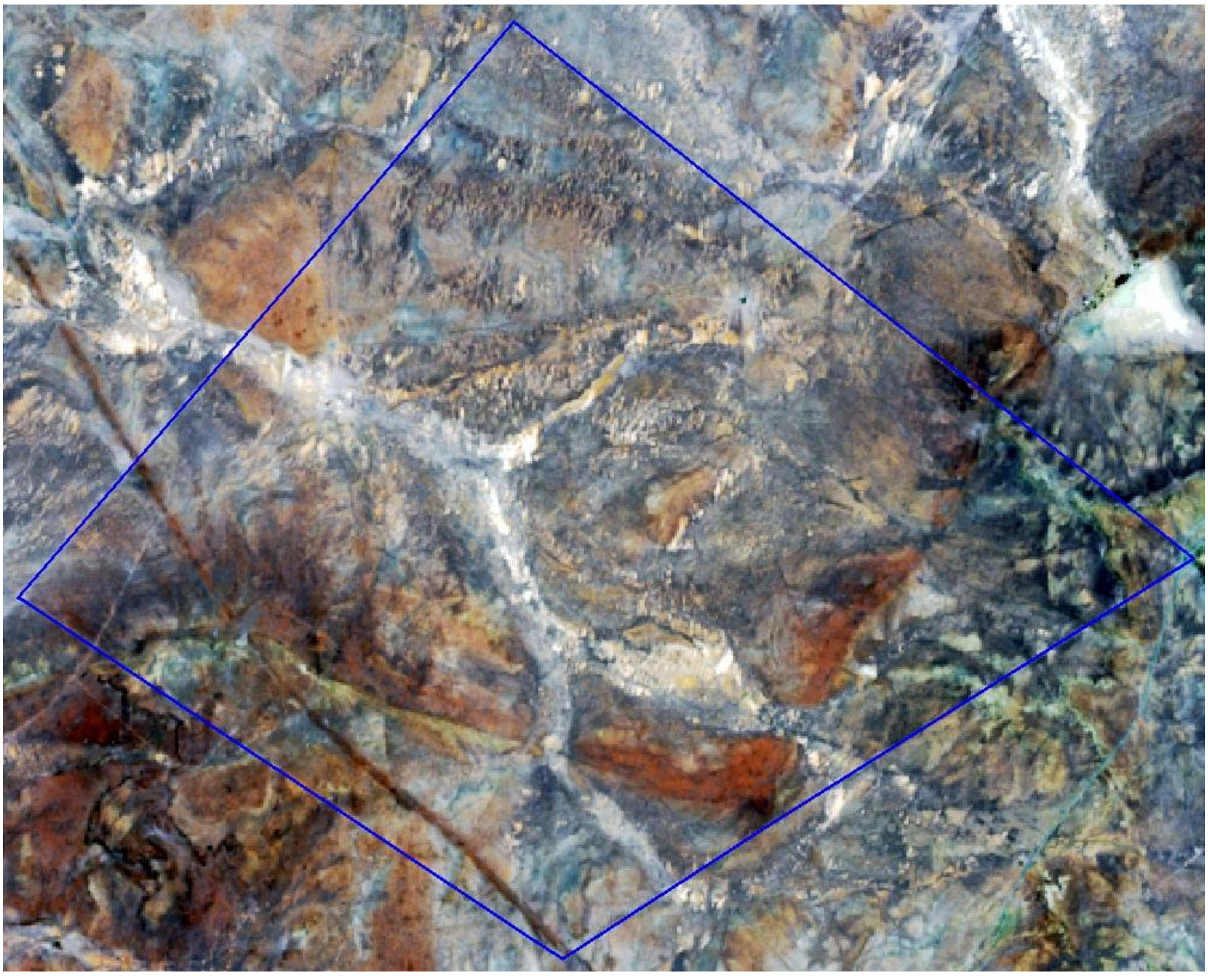


Figure 3. Contrast enhanced Sentinel image (bands 4, 3 and 2 displayed as RGB).

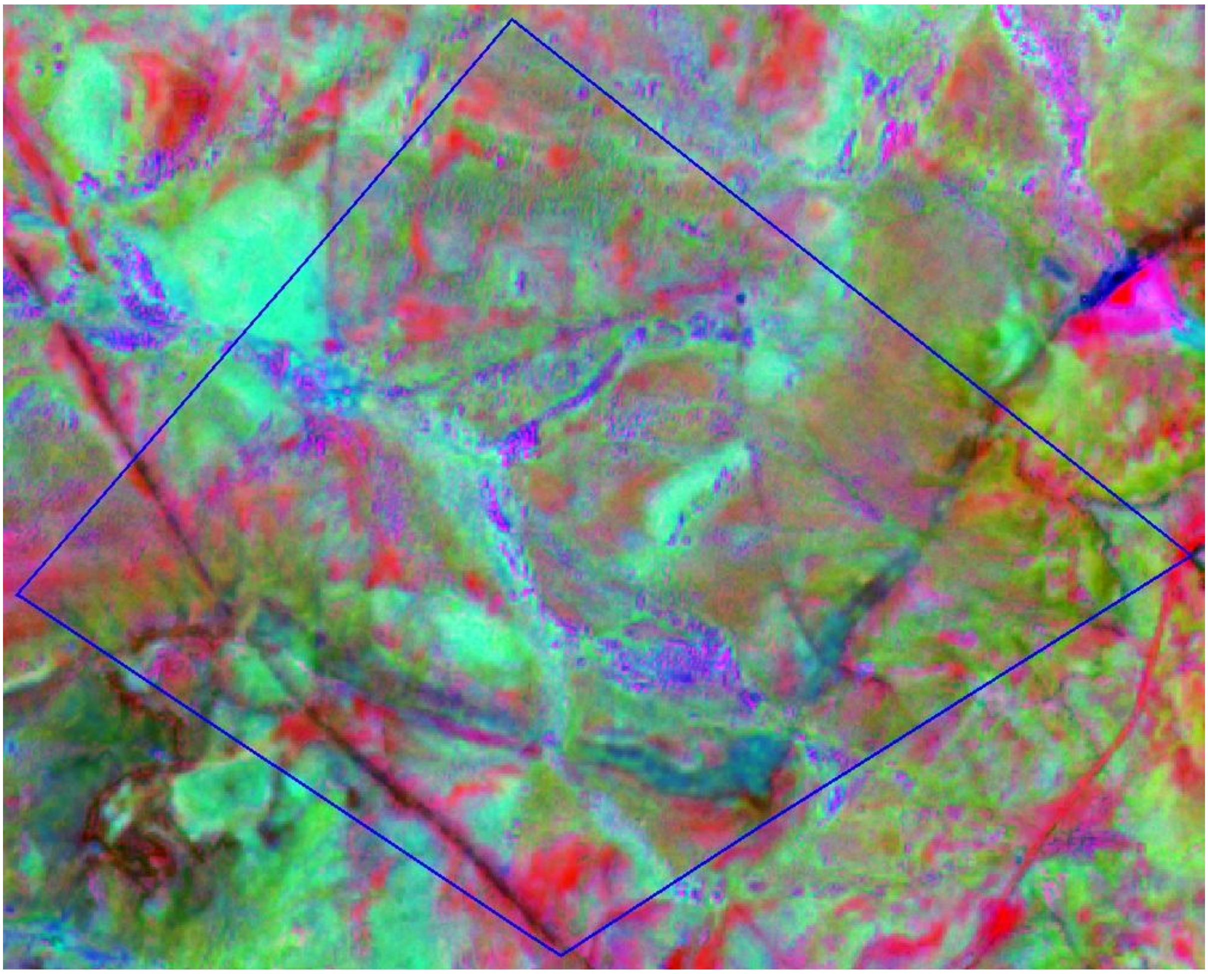
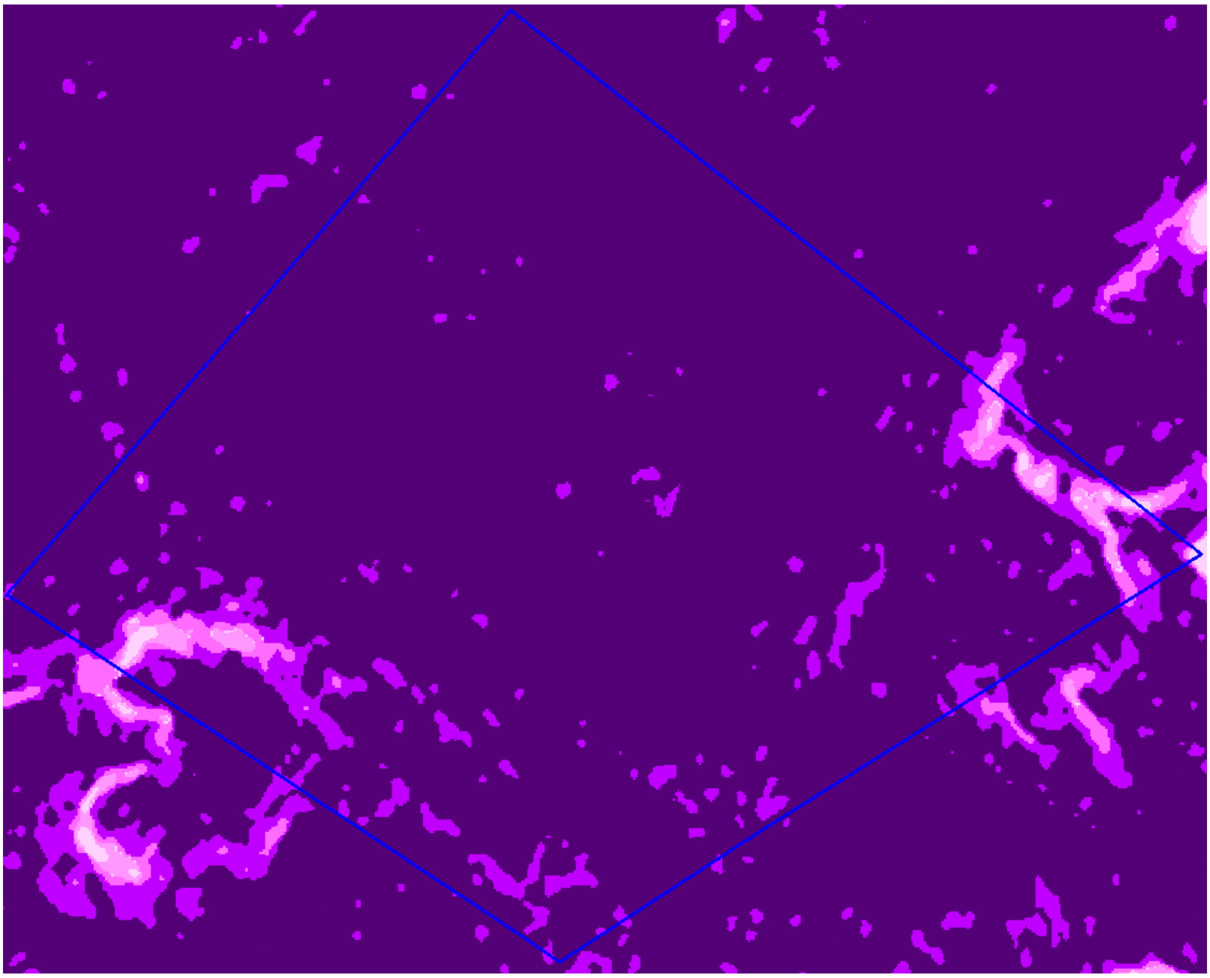
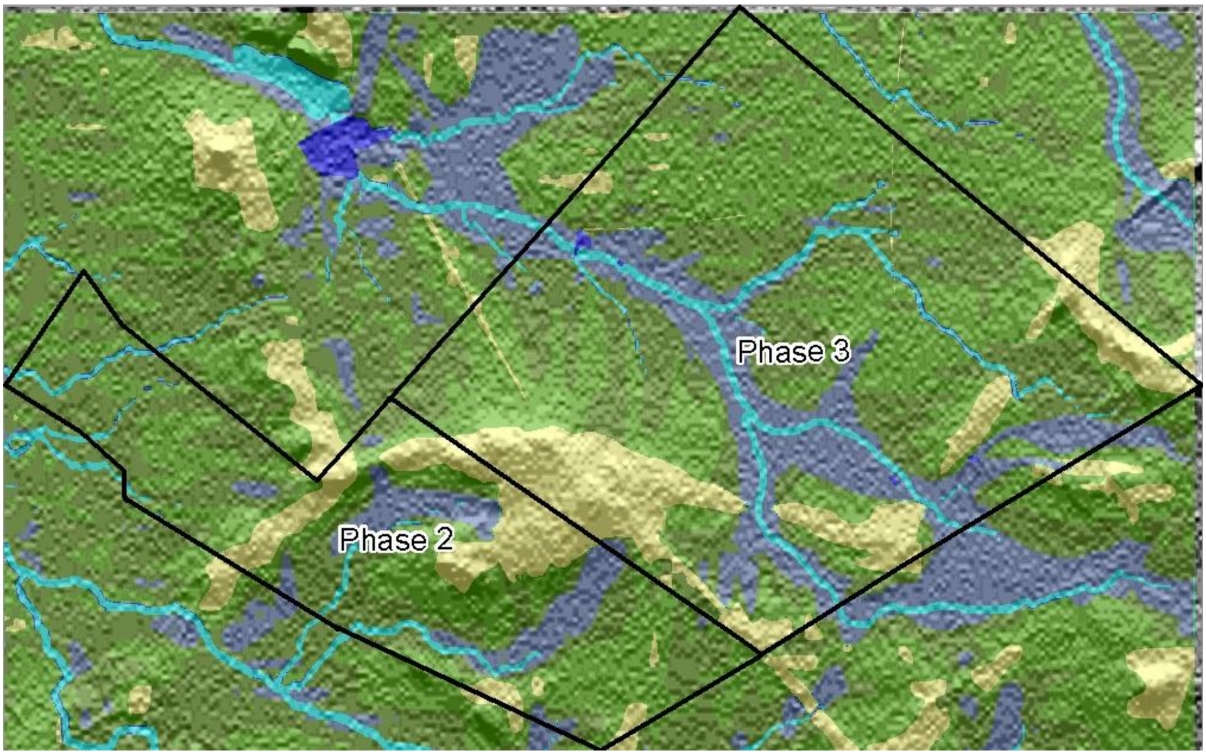


Figure 4. PCA enhanced Sentinel image (PC 1, 2 and 3 displayed as RGB).



Colour	No	Class
	1	0-4%
	2	4-6%
	3	6-8%
	4	8-10%
	5	>10%

Figure 5. Slope map derived from the ALOS DSM.



Colour	No	Class
	1	Crest
	2	Midslope convex
	3	Midslope concave
	4	Footslope
	5	Valley bottom
	6	Water

Figure 6. Terrain units derived from the ALOS DSM.

1.3 Soil capability

A soil capability model was used to derive 3 soil potential classes from the soil map and the slope map.

1.4 Rainfall analysis

NOAA Rainfall Estimation (RFE) data (3 decals per month) was used to construct average seasonal rainfall for the combined Phase 1, 2 and 3 footprints for 22 seasons.

1.5 Cumulative effects of all proposed (until June 2022) PV developments in a 30km radius from Phase 3

A watershed analysis was done on ALOS DSM data for the wider area, including the 30 km radius and beyond. Flow accumulation was used to calculate the runoff contribution of each footprint of Phases 1, 2 and 3. The same was done for the PV developments downstream from Phases 1, 2 and 3. The combined contribution of all these developments including Phases 1, 2 and 3 was then calculated.

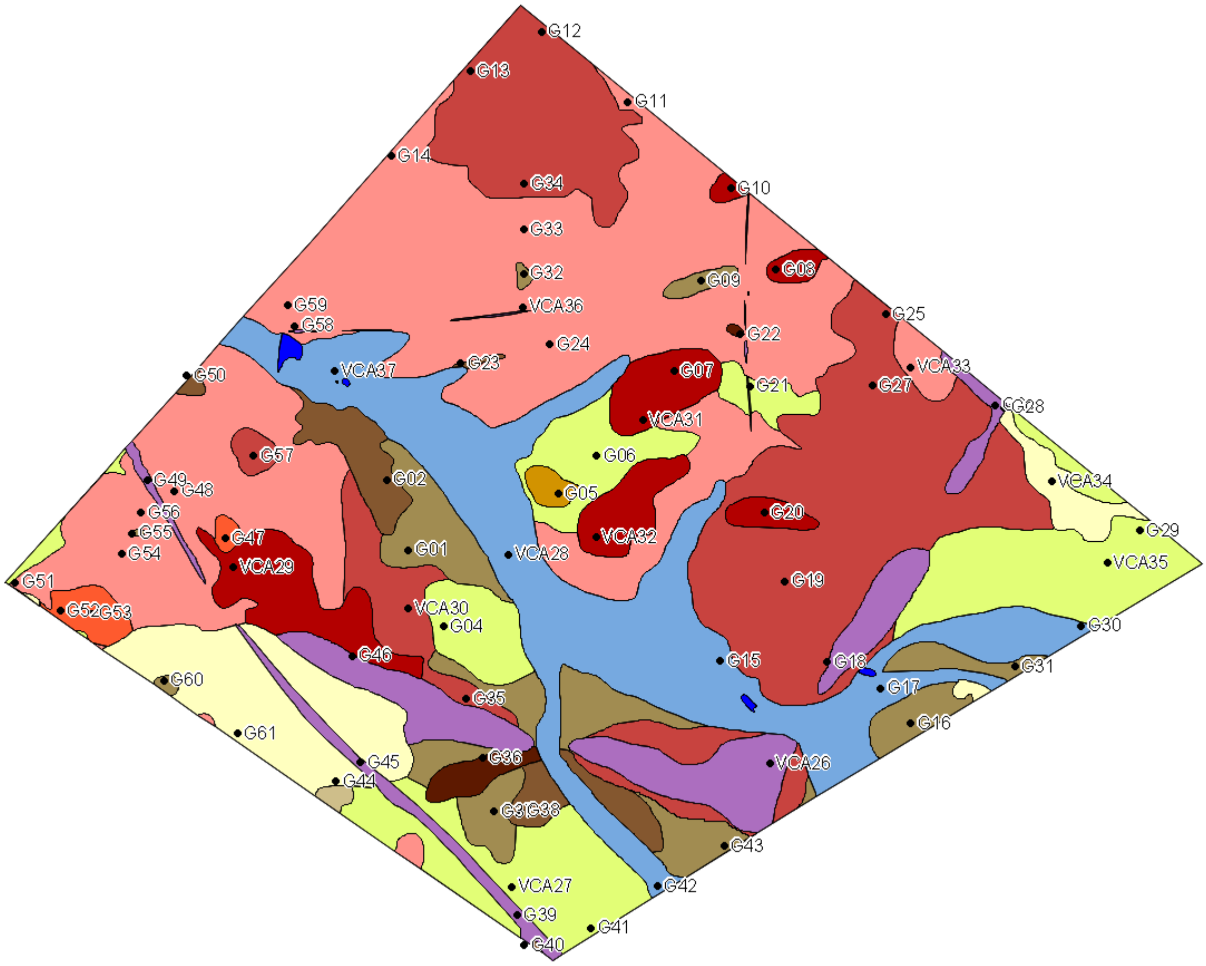
1.6 Soil capability and agriculture compliance

The screening tool: https://screening.environment.gov.za/screeningtool was used to determine the environmental sensitivity in terms of agriculture. The fieldwork data and soil assessment were used to confirm the results of the screening tool. The agriculture compliance was determined by using the land capability system described by Collet (2019) and the GN 320 of 20th March 2020 - Gazetted_General_Requirement_Assessment_Protocols.pdf (environment.gov.za) as guidelines.

4 RESULTS

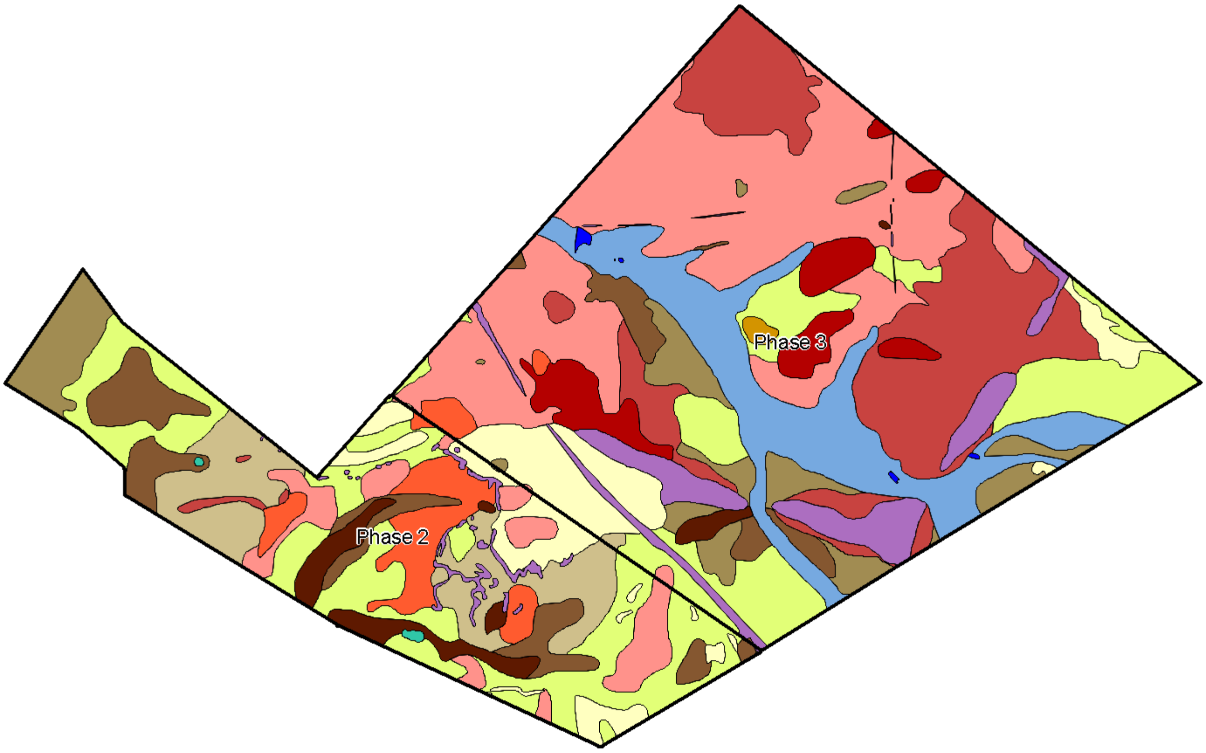
4.1 Soil map

The soil map for the Phase 3 study area can be seen in Figure 7. Figure 8 shows the mapping for the combined Phase 2 and Phase 3 areas. Tables 1 and 2 show the area analyses of Phase 3 and Phase 2.



Colour	No	Class	Dominant soils
	1	Sandstone outcrops	Outcrop/Ms complex
	2	Dolerite outcrops	Outcrop
	3	Very shallow yellow brown loamy soils	Ms
	4	Very shallow yellow brown clayey soils	Ms
	5	Very shallow red loamy soils	Ms, Gs
	6	Very shallow red clayey soils	Ms, Hu, (Gs)
	7	Shallow to medium deep yellow brown loamy soils	Gs, (Ms, Cv)
	8	Shallow to medium deep yellow brown clayey soils	Oa, Ad, Ag, (Gm)
	9	Shallow to medium deep red loamy soils	Hu, (Gs)
	10	Shallow to medium deep red clayey soils	Hu, Oa, Et, Ky,
	11	Structured shallow soils	Sw
	12	Structured medium deep soils	Va
	13	Permanent wetland - artificial	
	14	Bottomlands with ephemeral drainage lines	Va, Tu
	15	Water	

Figure 7. The soil map for the Phase 3 area. Soil survey sites are shown as black dots.



Colour	No	Class	Dominant soils
	1	Sandstone outcrops	Outcrop/Ms complex
	2	Dolerite outcrops	Outcrop
	3	Very shallow yellow brown loamy soils	Ms
	4	Very shallow yellow brown clayey soils	Ms
	5	Very shallow red loamy soils	Ms, Gs
	6	Very shallow red clayey soils	Ms, Hu, (Gs)
	7	Shallow to medium deep yellow brown loamy soils	Gs, (Ms, Cv)
	8	Shallow to medium deep yellow brown clayey soils	Oa, Ad, Ag, (Gm)
	9	Shallow to medium deep red loamy soils	Hu, (Gs)
	10	Shallow to medium deep red clayey soils	Hu, Oa, Et, Ky,
	11	Structured shallow soils	Sw
	12	Structured medium deep soils	Va
	13	Permanent wetland - artificial	
	14	Bottomlands with ephemeral drainage lines	Va, Tu
	15	Water	

Figure 8. The combined soil map for the Phase 2 and 3 areas (including the extension area of Phase 2).

Table 1. Area analysis of the soil map - Phase 3.

No	Class	Dominant soils	%	Area (ha)
1	Sandstone outcrops	Outcrop/Ms complex	5.5	64.2
2	Dolerite outcrops	Outcrop	5.9	69.9
3	Very shallow yellow brown loamy soils	Ms	11.6	136.9
4	Very shallow yellow brown clayey soils	Ms	6.1	71.2
5	Very shallow red loamy soils	Ms, Gs	28.7	337.8
6	Very shallow red clayey soils	Ms, Hu, (Gs)	19.5	228.7
7	Shallow to medium deep yellow brown loamy soils	Gs, (Ms, Cv)	0.1	1.4
8	Shallow to medium deep yellow brown clayey soils	Oa, Ad, Ag, (Gm)	0.3	3.2
9	Shallow to medium deep red loamy soils	Hu, (Gs)	0.7	8.4
10	Shallow to medium deep red clayey soils	Hu, Oa, Et, Ky,	5.1	59.8
11	Structured shallow soils	Sw	2.2	25.7
12	Structured medium deep soils	Va	0.5	6.4
13	Permanent wetland - artificial		0.0	0.0
14	Bottomlands with ephemeral drainage lines	Va, Tu	13.6	160.3
15	Water		0.1	1.6
	Total		**100.0**	**1175.5**

Table 2. Area analysis of the soil map - Phase 2.

No	Class	Dominant soils	%	Area (ha)
1	Sandstone outcrops	Outcrop/Ms complex	7.9	43.5
2	Dolerite outcrops	Outcrop	1.9	10.2
3	Very shallow yellow brown loamy soils	Ms	29.1	159.2
4	Very shallow yellow brown clayey soils	Ms	5.9	32.3
5	Very shallow red loamy soils	Ms, Gs	9.2	50.2
6	Very shallow red clayey soils	Ms, Hu, (Gs)	0.7	3.7
7	Shallow to medium deep yellow brown loamy soils	Gs, (Ms, Cv)	18.0	98.7
8	Shallow to medium deep yellow brown clayey soils	Oa, Ad, Ag, (Gm)	0.0	0.0
9	Shallow to medium deep red loamy soils	Hu, (Gs)	9.2	50.4
10	Shallow to medium deep red clayey soils	Hu, Oa, Et, Ky,	0.0	0.0
11	Structured shallow soils	Sw	12.3	67.6
12	Structured medium deep soils	Va	5.7	31.0
13	Permanent wetland - artificial		0.2	1.2
14	Bottomlands with ephemeral drainage lines	Va, Tu	0.0	0.0
15	Water		0.0	0.0
	Total		**100.0**	**548.0**

4.2 Statistical analysis of important soil properties

Statistics for the soil point database (72 observations) for Phase 3 and (46 observations) for Phase 2 are provided in Tables 3 to 15.

Table 3. Average clay percentage for the A and B horizons, Effective Rooting Depth (ERD), and slope percentage of the soils - Phase 3

Soil form	A horizon clay % (Avg)	B horizon clay % (Avg)	ERD cm (Avg)	Slope (Avg)	% of observations	No of observations
Ag	42	46	50	3	1	1
Et	34	42	50	2	3	2
Gs	20	0	32	5	4	3
Hu	18	18	40	4	1	1
Ky	25	30	60	0	1	1
Ms	27	0	17	3	61	44
Oa	30	33	65	3	11	8
Rock outcrop	0	0	0	3	4	3
Sw	33	34	48	2	6	4
Tu	35	42	80	3	1	1
Va	33	38	67	2	6	4
Total					**100**	**72**

Table 5. Average clay percentage for the A and B horizons, Effective Rooting Depth (ERD), and slope percentage of the soils - Phase 2

Soil form	A horizon clay % (Avg)	B horizon clay % (Avg)	ERD cm (Avg)	Slope (Avg)	% of observations	No of observations
Cg	18	0	25	3	2	1
Et	30	37	50	2	2	1
Gs	23	20	25	3	26	12
Hu	20	23	50	4	4	2
Ms	24	0	14	3	33	15
Outcrop	0	0	0	6	4	2
Sw	30	37	17	2	20	9
Va	31	39	35	2	9	4
Total					**100**	**46**

Table 6. Minimum clay percentage for the A and B horizons, Effective Rooting Depth (ERD), and slope percentage of the soils - Phase 3

Soil form	A horizon clay % (Min)	B horizon clay % (Min)	ERD cm (Min)	Slope (Min)	% of observations	No of observations
Ag	42	46	50	3	1	1
Et	32	38	50	1	3	2
Gs	18	0	20	3	4	3
Hu	18	18	40	4	1	1
Ky	25	30	60	0	1	1
Ms	0	0	5	0	61	44
Oa	25	0	40	2	11	8
Rock outcrop	0	0	0	2	4	3
Sw	28	0	45	0	6	4
Tu	35	42	80	3	1	1
Va	30	32	50	1	6	4
Total					**100**	**72**

Table 7. Minimum clay percentage for the A and B horizons, Effective Rooting Depth (ERD) and slope percentage of the soils - Phase 2

Soil form	A horizon clay % (Min)	B horizon clay % (Min)	ERD cm (Min)	Slope (Min)	% of observations	No of observations
Cg	18	0	25	3	2	1
Et	30	37	50	2	2	1
Gs	10	0	15	1	26	12
Hu	15	20	40	3	4	2
Ms	0	0	0	0	33	15
Outcrop	0	0	0	5	4	2
Sw	28	32	10	0	20	9
Va	27	38	30	0	9	4
Total					**100**	**46**

Table 8. Maximum clay percentage for the A and B horizons, Effective Rooting Depth (ERD), and slope percentage of the soils - Phase 3

Soil form	A horizon clay % (Max)	B horizon clay % (Max)	ERD cm (Max)	Slope (Max)	% of observations	No of observations
Ag	42	46	50	3	1	1
Et	35	45	50	3	3	2
Gs	22	0	40	8	4	3
Hu	18	18	40	4	1	1
Ky	25	30	60	0	1	1
Ms	45	0	40	11	61	44
Oa	35	45	100	4	11	8
Rock outcrop	0	0	0	4	4	3
Sw	35	45	50	3	6	4
Tu	35	42	80	3	1	1
Va	35	45	80	3	6	4
Total					**100**	**72**

Table 9. Maximum clay percentage for the A and B horizons, Effective Rooting Depth (ERD) and slope percentage of the soils - Phase 2

Soil form	A horizon clay % (Max)	B horizon clay % (Max)	ERD cm (Max)	Slope (Max)	% of observations	No of observations
Cg	18	0	25	3	2	1
Et	30	37	50	2	2	1
Gs	27	27	30	7	26	12
Hu	25	25	60	5	4	2
Ms	45	0	30	4	33	15
Outcrop	0	0	0	8	4	2
Sw	33	40	25	4	20	9
Va	35	40	45	4	9	4
Total					**100**	**46**

Table 10. Soil colour of the A horizon of the soils - Phase 3

Soil form	A horizon soil colour	% of observations	No of observations
Ag	Red	1	1
Et	Red Brown	3	2
Gs	Brown	1	1
Gs	Red	3	2
Hu	Brown	1	1
Ky	Yellow	1	1
Ms	-	6	4
Ms	Brown	6	4
Ms	Red	25	18
Ms	Red Brown	17	12
Ms	Yellow	6	4
Ms	Yellow Brown	1	1
Ms	Yellow Red	1	1
Oa	Red	7	5
Oa	Red Brown	3	2
Oa	Yellow	1	1
Rock outcrop		4	3
Sw	Red	3	2
Sw	Red Brown	1	1
Sw	Yellow	1	1
Tu	Pale Yellow	1	1
Va	Red Brown	4	3
Va	Yellow	1	1
Total		**100**	**72**

Table 11. Soil colour of the A horizon of the soils - Phase 2

Soil form	A horizon soil colour	% of observations	No of observations
Ms	-	2	1
Outcrop	-	4	2
Cg	Brown	2	1
Et	Brown	2	1
Gs	Brown	17	8
Hu	Brown	2	1
Ms	Brown	11	5
Sw	Brown	15	7
Va	Brown	4	2
Gs	Red	7	3
Hu	Red	2	1
Ms	Red	4	2
Sw	Red	4	2
Va	Red	2	1
Ms	Red Brown	7	3
Gs	Yellow	2	1
Ms	Yellow	9	4
Va	Yellow	2	1
Total		**100**	**46**

Table 12. Soil colour of the B horizon of the soils - Phase 3

Soil form	B horizon soil colour	% of observations	No of observations
Ag	Red	1	1
Et	Red	3	2
Gs	-	4	3
Hu	Red	1	1
Ky	Red	1	1
Ms	-	61	44
Oa	Red	7	5
Oa	Red Brown	4	3
Rock outcrop	-	4	3
Sw		1	1
Sw	Red	4	3
Tu	Yellow	1	1
Va	Brown	3	2
Va	Red	3	2
Total		**100**	**72**

Table 13. Soil colour of the B horizon of the soils - Phase 2

Soil form	B horizon soil colour	% of observations	No of observations
Cg	-	2	1
Gs	-	4	2
Ms	-	33	15
Outcrop	-	4	2
Gs	Brown	15	7
Gs	Red	7	3
Hu	Red	4	2
Sw	Red	20	9
Va	Red	9	4
Et	Yellow	2	1
Total		**100**	**46**

Table 14. The distribution of soil forms over terrain units - Phase 3

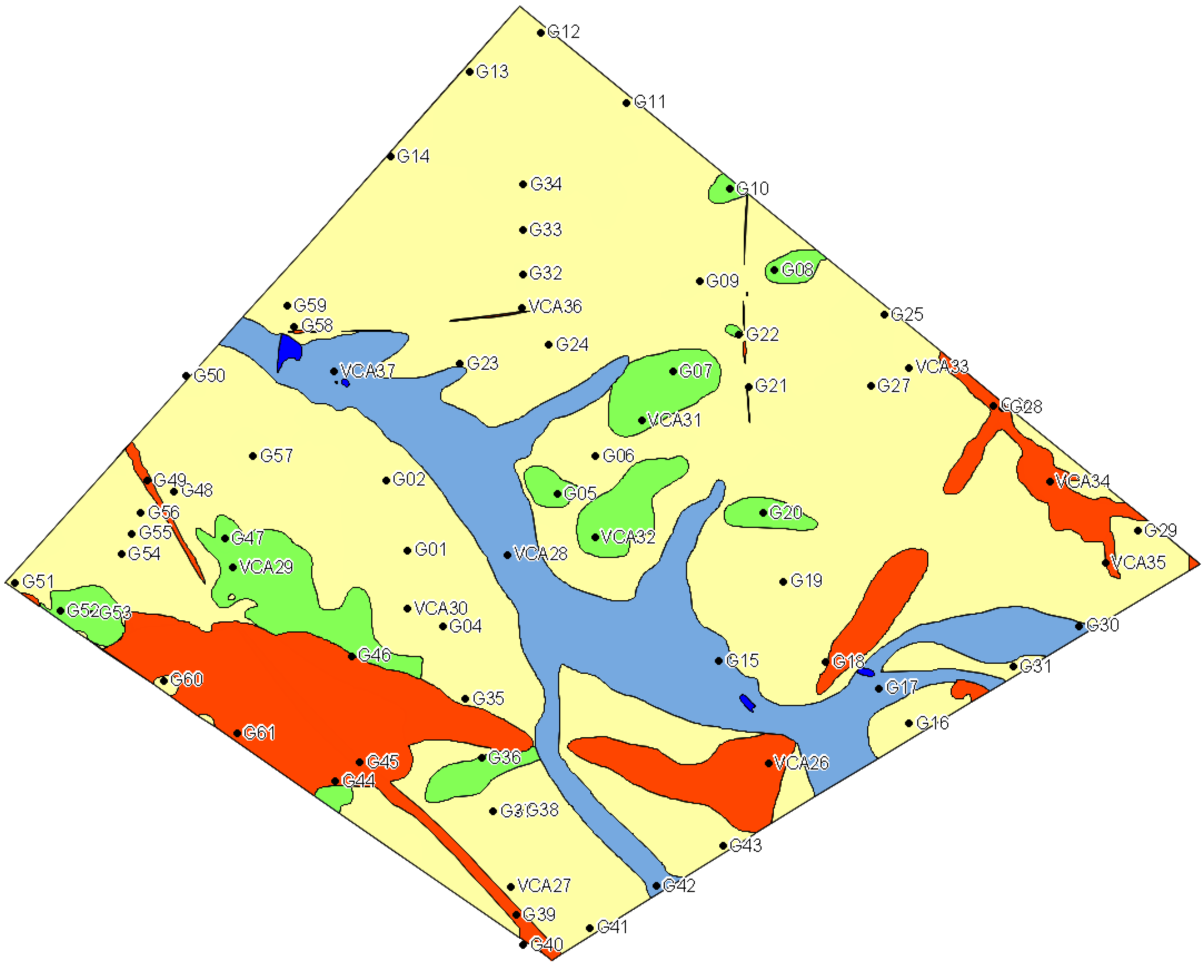
Soil form	Terrain unit	% of observations	No of observations
Ag	Midslope convex	1	1
Et	Footslope	1	1
Et	Midslope concave	1	1
Gs	Midslope convex	4	3
Hu	-	1	1
Ky	Midslope convex	1	1
Ms	-	13	9
Ms	Footslope	4	3
Ms	Valley bottom	1	1
Ms	Midslope convex	33	24
Ms	Midslope concave	10	7
Oa	-	4	3
Oa	Midslope convex	3	2
Oa	Midslope concave	4	3
Rock outcrop	Crest	4	3
Sw	-	1	1
Sw	Footslope	1	1
Sw	Midslope concave	3	2
Tu	Footslope	1	1
Va	-	1	1
Va	Valley bottom	3	2
Va	Midslope concave	1	1
Total		**100**	**72**

Table 15. The distribution of soil forms over terrain units - Phase 2

Soil form	Terrain unit	% of observations	No of observations
Cg	Midslope convex	2	1
Et	Midslope concave	2	1
Gs	Footslope	2	1
Gs	Midslope convex	20	9
Gs	Midslope concave	4	2
Hu	Midslope convex	4	2
Ms		4	2
Ms	Crest	2	1
Ms	Valley bottom	2	1
Ms	Midslope convex	20	9
Ms	Midslope concave	4	2
Outcrop	Crest	2	1
Outcrop	Midslope convex	2	1
Sw	Midslope convex	7	3
Sw	Midslope concave	13	6
Va	Midslope convex	2	1
Va	Midslope concave	7	3
Total		**100**	**46**

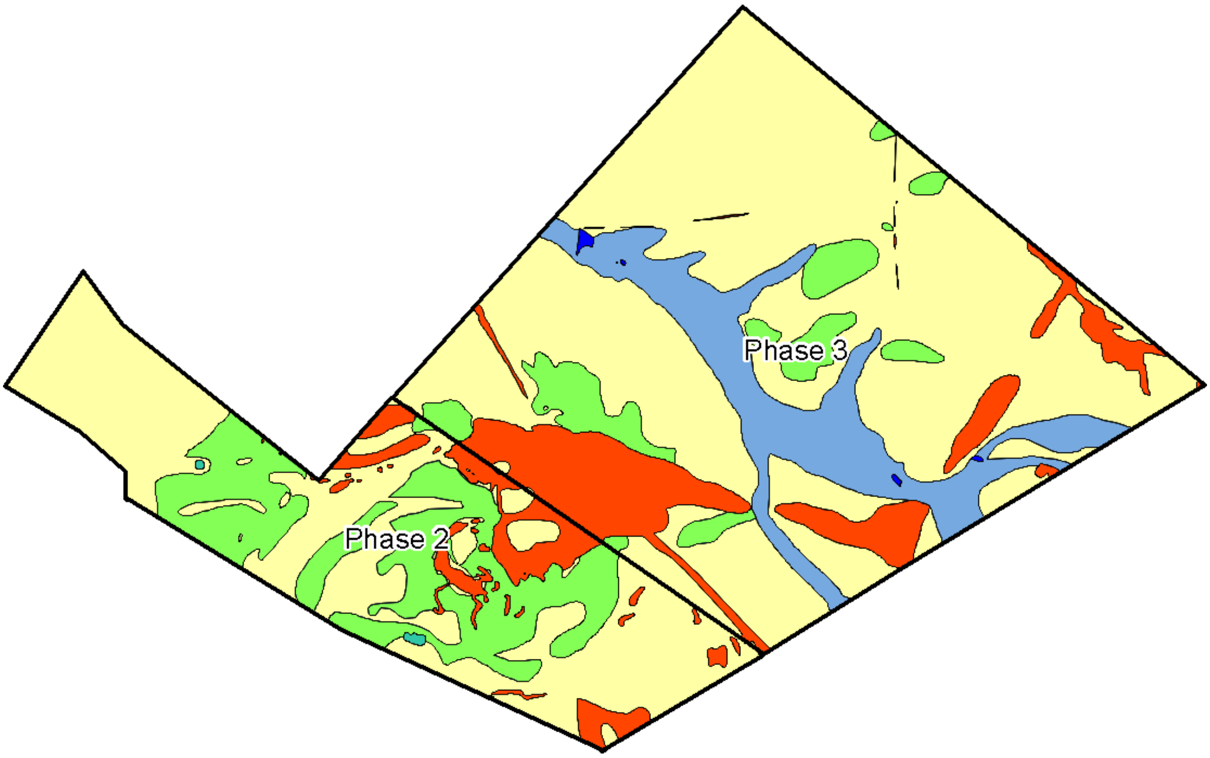
4.3 Soil capability map

The soil capability map for the Phase 3 study area can be seen in Figure 9. Figure 10 shows the mapping for the combined Phase 2 and Phase 3 areas.



Colour	No	Class	Soil depth, dominant soils and slope limitations
	1	Low to moderate soil capability	Shallow to medium deep soils, Hu, Cv, Oa, Ad, Ag, Et, Ky, Va
	2	Low soil capability	Very shallow soils, Ms, Gs, Sw, (Hu) and all areas with slopes 6%-8%
	3	Very low soil capability	Outcrops and all areas with slopes >8%
	4	Permanent wetland - artificial	
	5	Bottomlands with ephemeral drainage lines	Va, Tu
	6	Water	

Figure 9. Soil capability for Phase 3. Soil survey sites are shown as black dots.



Colour	No	Class	Soil depth, dominant soils and slope limitations
	1	Low to moderate soil capability	Shallow to medium deep soils, Hu, Cv, Oa, Ad, Ag, Et, Ky, Va
	2	Low soil capability	Very shallow soils, Ms, Gs, Sw, (Hu) and all areas with slopes 6%-8%
	3	Very low soil capability	Outcrops and all areas with slopes >8%
	4	Permanent wetland - artificial	
	5	Bottomlands with ephemeral drainage lines	Va, Tu
	6	Water	

Figure 10. Soil capability for the Phase 2 and 3 areas.

Table 16 shows the area analysis for the Phase 3 soil capability map and Table 17 the area analysis for the Phase 3 soil capability map.

Table 16. Area analysis for the Phase 3 soil capability map.

Class	Soil depth, dominant soils and slope limitations	%	Area (ha)
Low to moderate soil capability	Shallow to medium deep soils, Hu, Cv, Oa, Ad, Ag, Et, Ky, Va	6.68	78.5
Low soil capability	Very shallow soils, Ms, Gs, Sw, (Hu) and all areas with slopes 6%-8%	67.80	797.0
Very low soil capability	Outcrops and all areas with slopes >8%	11.75	138.1
Permanent wetland - artificial		0.00	0.0
Bottomlands with ephemeral drainage lines	Va, Tu	13.63	160.3
Water		0.13	1.6
Total		**100.00**	**1175.5**

Table 17. Area analysis for the Phase 2 soil capability map.

Class	Soil depth, dominant soils and slope limitations	%	Area (ha)
Low to moderate soil capability	Shallow to medium deep soils, Hu, Cv, Oa, Ad, Ag, Et, Ky, Va	31.45	172.3
Low soil capability	Very shallow soils, Ms, Gs, Sw, (Hu) and all areas with slopes 6%-8%	57.68	316.1
Very low soil capability	Outcrops and all areas with slopes >8%	10.65	58.4
Permanent wetland - artificial		0.22	1.2
Bottomlands with ephemeral drainage lines	Va, Tu	0.00	0.0
Water		0.00	0.0
Total		**100.00**	**548.0**

4.4 NOAA-RFE analysis

Figure 11 shows the NOAA-RFE rainfall analysis for 22 seasons.

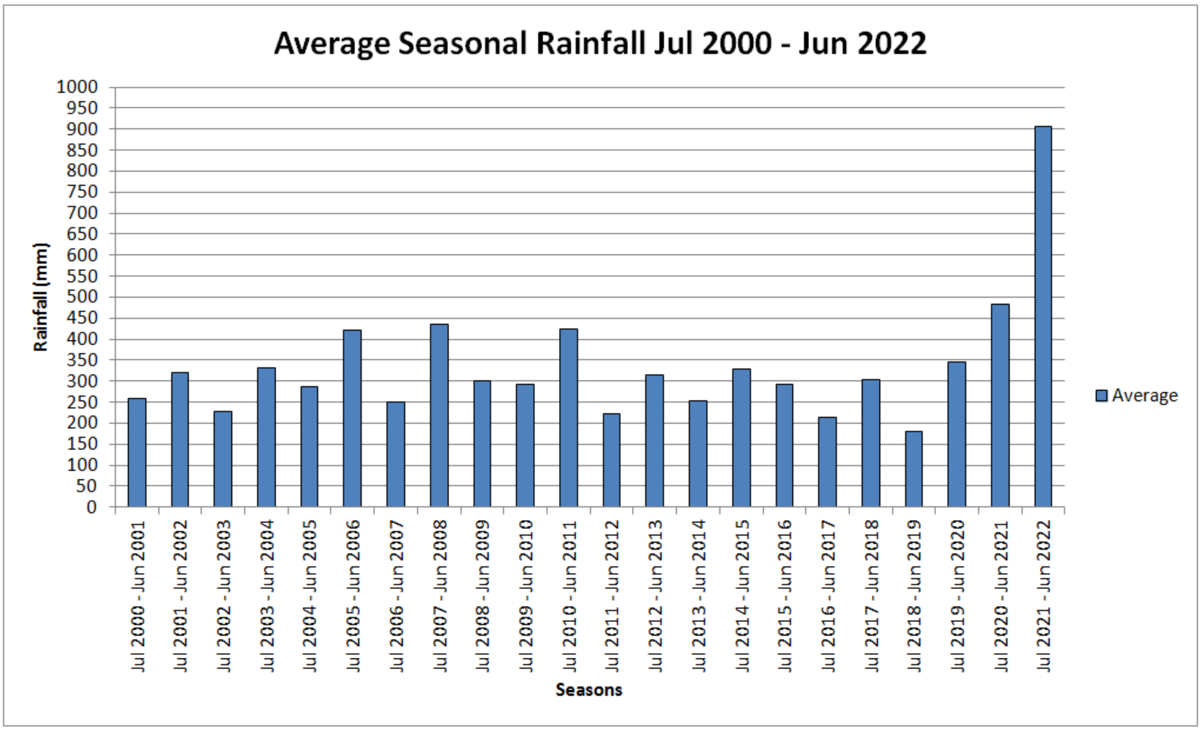


Figure 11. NOAA-RFE - average seasonal rainfall for 22 seasons.

(NOAA RFE decal data:

https://www.cpc.ncep.noaa.gov › products › GIS › GIS_DATA › rfe

http://www.cpc.ncep.noaa.gov/products/fews/RFE2.0_tech.pdf)

The average rainfall for the 22 seasons was 336mm.

4.5 Cumulative effects of all proposed PV developments in a 30km radius from Phase 3

The 30km radius area is shown in Figure 12. Phases 1, 2 and 3 and the other proposed or existing PV developments are shown in relation to each other and stream flow (Strahler stream orders 3-6) derived from the ALOS DSM. Measuring points where flow accumulation exited from Phases 1, 2 and 3 are shown by Figure 13. Measuring points where flow accumulation entered the downstream PV developments end measuring points were flow accumulation exited the PV developments are shown by Figure 14.

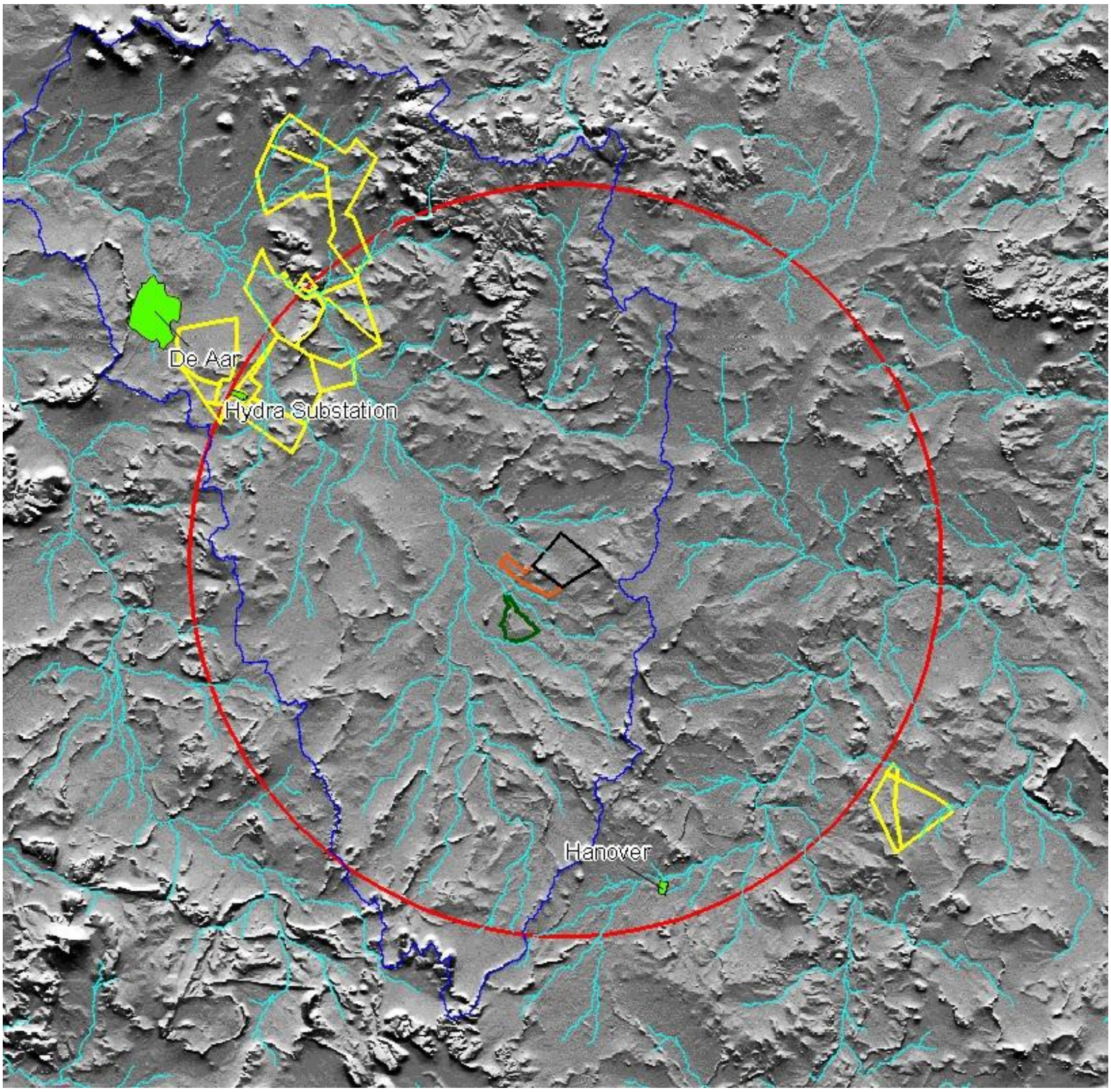


Figure 12. Potential cumulative runoff of from all proposed PV developments in a 30km radius (red circle) from Phase 3 - overlaid on an ALOS DSM hill-shading. Phases 1, 2 and 3 are shown respectively in green, orange and black delineations. The catchment (41 085 ha) containing all three Phases and the downstream PV developments is shown by a dark blue delineation. The potential PV developments other than the Phase 1, 2 and 3 areas are shown by yellow delineations. The Hydra substation and towns of De Aar and Hanover is also indicated in the figure. Strahler stream orders 3-6 are shown in cyan.

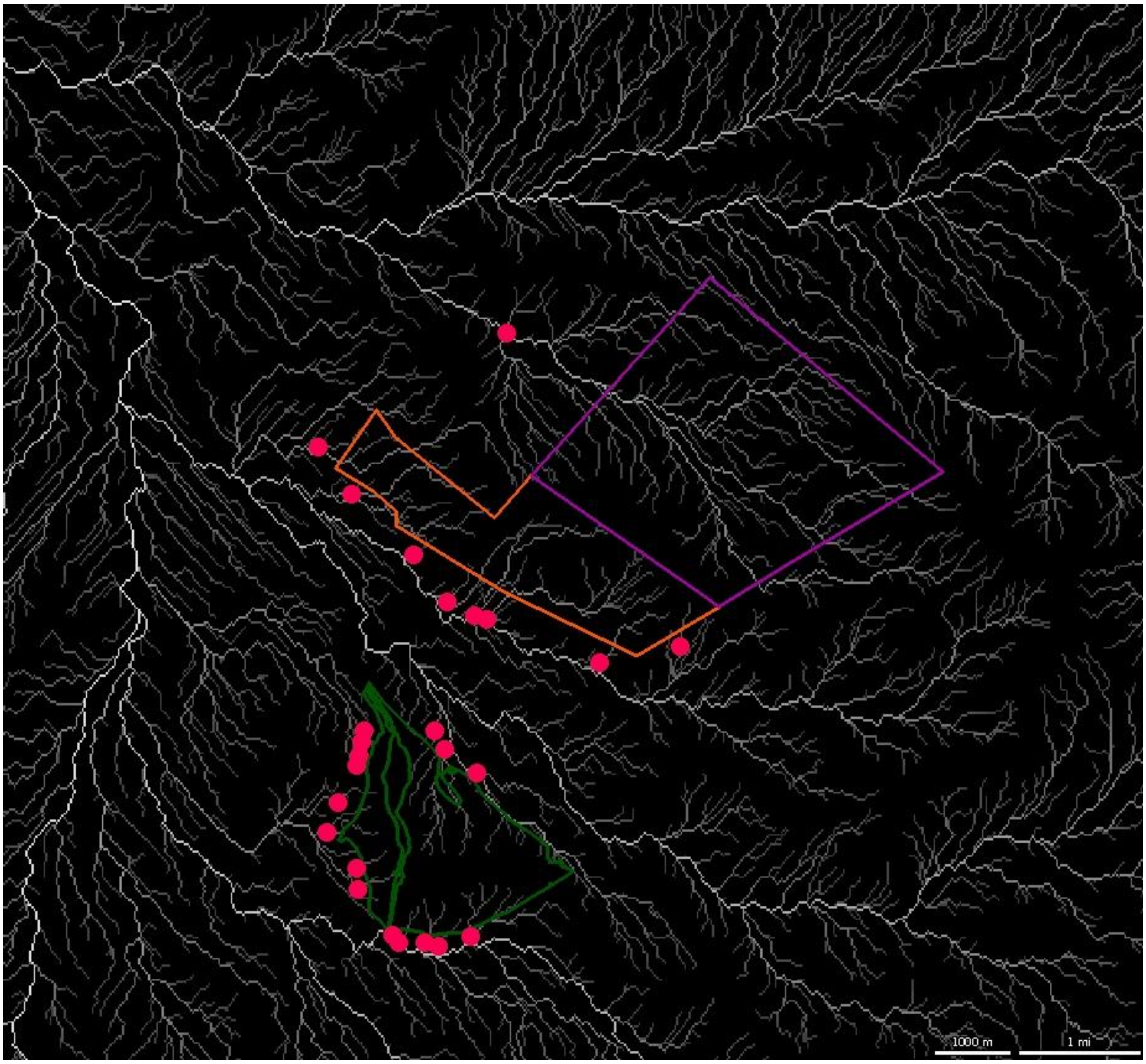


Figure 13. Measuring points where flow accumulation exciting Phases 1, 2 and 3 are shown in pink. Phases 1, 2 and 3 are shown respectively in green, orange, and purple delineations.

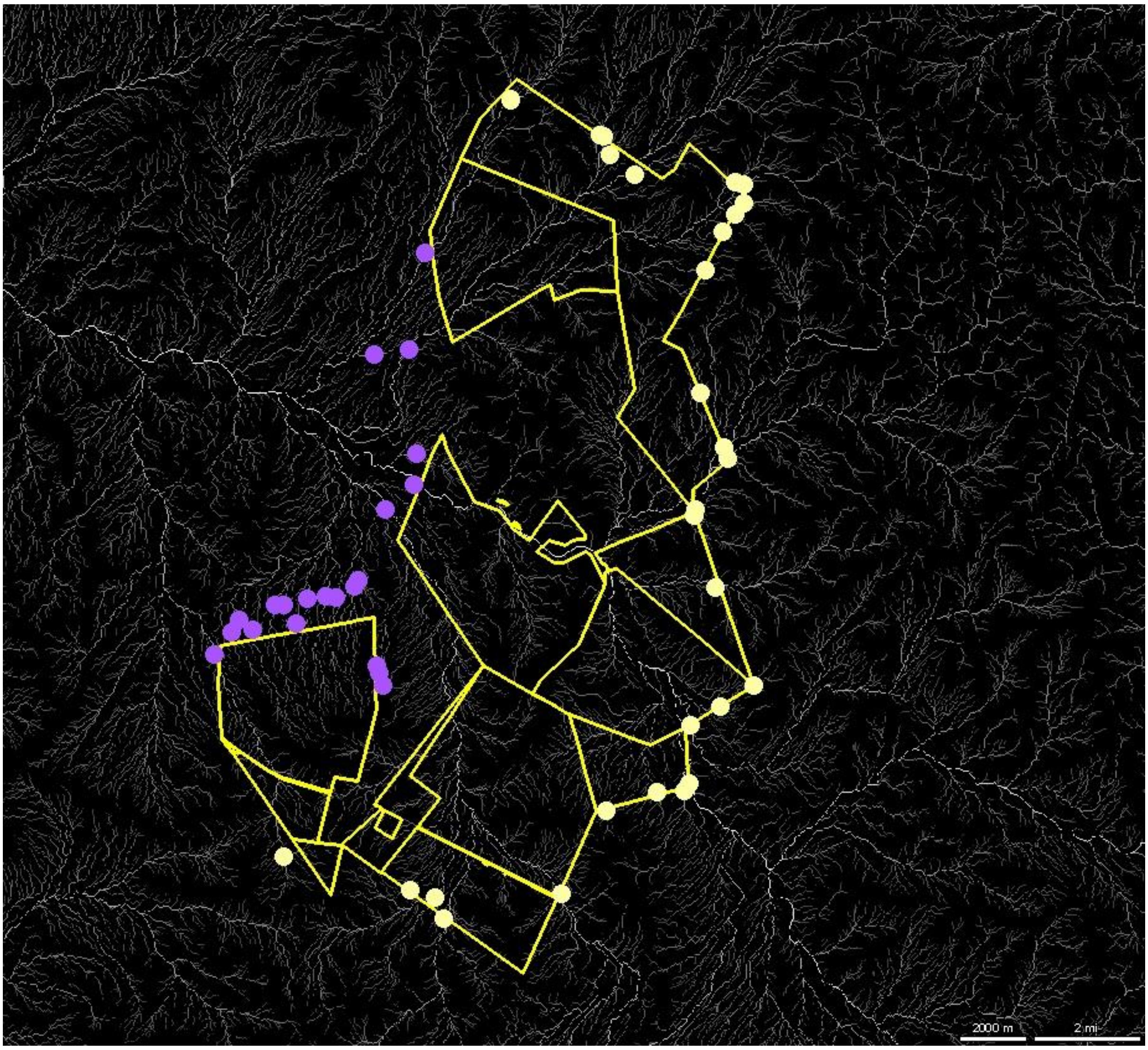


Figure 14. Measuring points where flow accumulation entering downstream PV developments are shown in light yellow. Measuring points where flow accumulation exciting downstream PV developments are shown in purple. PV developments are shown as yellow delineations.

Table 18 shows the runoff from each Phase and the runoff from the downstream PV developments minus the input. All the contributions are also expressed as percentage per development and as a percentage of the whole catchment.

Table 18. Runoff from each Phase is expressed as total cells, % Of all projects and % of the total catchment runoff.

Project	Runoff per project (cells)	Runoff - whole catchment (cells)	% of all projects	% of catchment
Phase 1	9 389	2 935 952	2.35	0.32
Phase 2	8 232	2 935 952	2.06	0.28
Phase 3	23 222	2 935 952	5.82	0.79
Other PV projects down stream	358 046	2 935 952	89.76	12.20
Total	**398 889**	**2 935 952**		**13.59**
Total of Phase 1 and 2 and 3	**40 843**		**10.24**	**1.39**

A cell is 30mx30m = 900m^2. The catchment is 41 085 ha.

Table 18 shows the runoff from all three phases to be only 10.24% of all the PV projects inside the catchment. So this will be a 10% addition to the cumulative effect of the other PV developments. The overall runoff from three projects is only 1.39% of the total runoff from the catchment and just 0.79% from Phase 3.

This implies that the cumulative effect (in terms of sediment load carried by the watercourses) of all three phases on developments downstream will be relative small, even with some potential higher runoff during the construction of these phases. Recommendations to reduce post construction runoff are given in the mitigation section below.

4.6 Soil capability - agriculture compliance statement

The screening tool showed low and medium sensitivity for the footprint area of Phase 2 and Phase 3 with land capabilities ranging from moderate to very low (Figure 15). This has been confirmed with the soil surveys in 2016 and 2022 for the two Phases respectively. The area analyses (Tables 1 and 2) show that 6.7% of Phase 3 and 32.9% of Phase 2 are shallow to medium deep soils. The rest are shallow soils to very shallow soils to rock outcrops.

The soil capability map for both Phases 2 and 3 shown by Figure 10 has very low to moderate soil capability classes. The area analyses of the soil capability map (Tables 16 and 17) show that 6.68% of Phase 3 and 31.45% of Phase 2 have a low to moderate soil capability and the rest a low to very low soil capability. Combining the soil capability with the low average rainfall of 336mm per annum relates to a generaly low to very low land capability for both areas.

The only area of concern is potential enhanced soil erosion by the developments on the footprints of both Phases. Some infrastructure e.g., substations will have weatherproof surfaces and will cover in general relative small areas with very little influence on soil erosion. Most of the areas will be covered by PV solar panels. It is possible that the shading effect of the proposed solar panels will increase soil moisture content and therefore improve the vegetation cover underneath the solar panels. Good grazing management as discussed in the grazing report (De Wet and Arnoldi, 2022) should keep the vegetation cover and condition intact. A grazing regime by small stock underneath the solar panels is also in our opinion the most environmentally friendly and cost effective option to keep soil erosion to the bare minimum for the development areas. Roads should also be well planned and kept to a minimum to reduce soil erosion and excessive runoff.

The potential cumulative runoff of from all proposed PV developments in a 30km radius analysis (section 4.5) shows that the footprints of Phases 2 and 3 have very small sub catchments compared to the larger catchment area and the runoff contribution from both areas are around 1% of the main catchment.

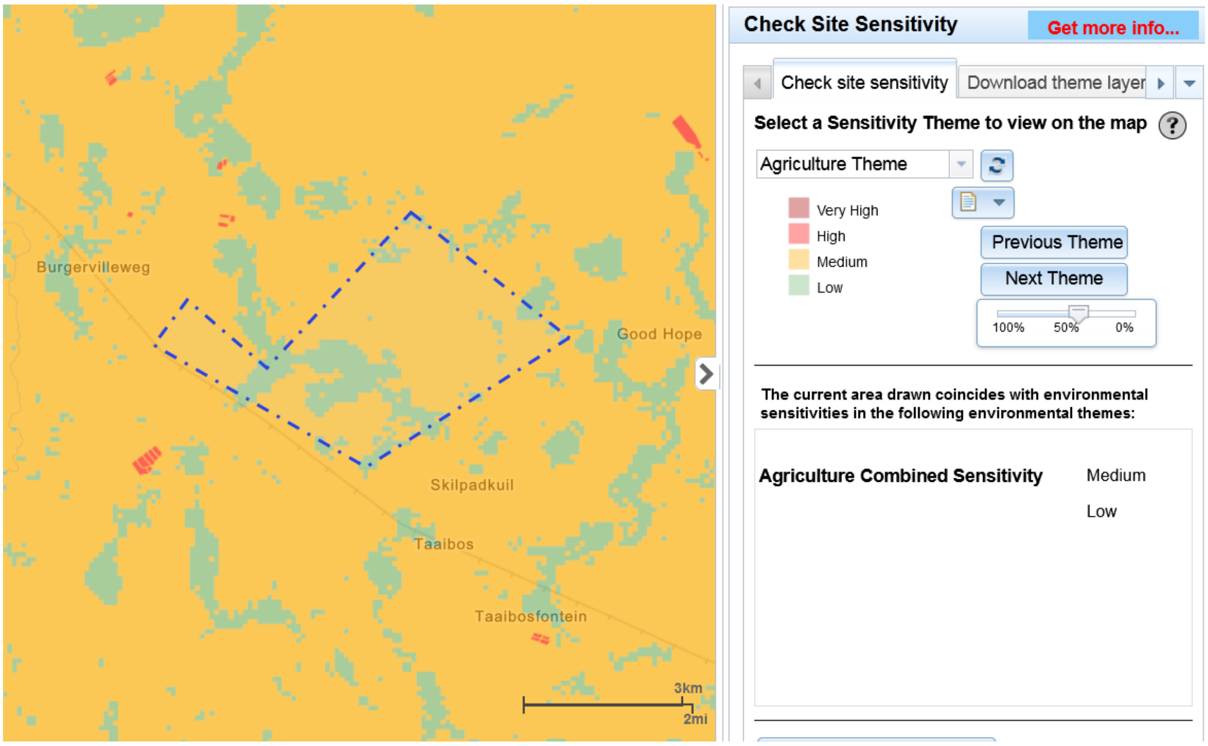


Figure 15. Agriculture sensitivity generated by the screening tool for the Phase 2 and 3 footprints.

4.7 Identified impacts and associated mitigations for planning and design phase, pre-construction, construction and post construction phases

Access roads to the project areas should be well planned to minimise soil erosion. Especially the roads that cross the large flood plains and severe gulley erosion (observed outside the three project areas) should be planned well to reduce soil erosion. Clearing of vegetation for the construction of substations and other infrastructure that will be covered with weather proof surfaces should preferably be done outside the main rainfall periods. This will ensure there will not be unnecessary sediment load in the water courses before the cleared areas can be stabilized. This is also true for temporary access roads to install the solar panels. During the rainy season terrain mobility on high clay soils in low lying areas with drainage lines will be difficult and might increase soil erosion when drainage lines are disturbed. However, it is important to note that rainfall is highly unpredictable with frequent droughts for the project areas.

Keeping as much of the original vegetation intact should be a high priority during all phases. Where the original vegetation was cleared or severely disturbed, rehabilitation measures should be put in place. Water infiltration can be improved by means of mechanical intervention and the application of gypsum or similar ameliorants. The project areas are situated on Karoo sediments that are known for high sodium and magnesium content in the soil. It is suggested that a few topsoil samples should be taken and analysed for sodicity. The sowing of grass seeds in combination with the chemical and mechanical water infiltration improvement measures should also be considered for highly degraded areas.

It is important that a good long-term grazing strategy (with small stock) is implemented as suggested by the grazing assessment report (De Wet and Arnoldi, 2022). Maintaining the natural vegetation in an optimal state is seen as the best and most cost-effective method to limit soil erosion to the minimum.

5 DISCUSSION

Seven soil forms have been identified from 46 soil observation sites for Phase 2. The Phase 2 area is dominated by the Mispah and Glenrosa soil forms. Sub dominant soil forms are Swartland and Valsrivier forms.

Ten soil forms have been identified from 72 soil observation sites for Phase 3. The Phase 3 area is dominated by the Mispah soil form. Sub dominant soil forms are Swartland and Oakleaf forms.

The majority of the soils for both Phases are very shallow with an average depth of less than 30cm. Clay content ranges from sandy loam to very clayey. Calcareous soils are covering relatively small areas. Soils are unsuitable for most types of agriculture. Extensive grazing with relative low animal numbers is the most suitable agricultural application.

No severe donga erosion has been observed in the study areas. Minor to moderate plate erosion is present. Severe donga and sheet erosion have been observed on flood plains outside the study areas.

There are no significant wetlands present in the Phase 2 area. The most conspicuous wetlands are small artificial permanent wetlands around watering points. There is no major flood danger inside the Phase 2 area.

The Phase 3 area is dissected into 2 parts by bottomlands with ephemeral drainage lines of 160 ha. Unlike other floodplains, of areas surrounding the Phase 2 and 3 areas, this area has in general a very good vegetation cover. The grazing capacity range was also some of the highest of the grazing units identified by the grazing assessment (De Wet and Arnoldi, 2022). In fact, it had the highest grazing capacity for the 2022 assessment of all the grazing units assessed. It must also be mentioned that the 2021-2022 season had the highest ever rainfall for the past 22 seasons. During the field survey of 2022 this drainage area (bottomlands with ephemeral drainage lines) was very wet at places, and care had to be taken not to get stuck with a vehicle.

It is not envisaged that the proposed development will result in major soil erosion or any other degradation of the soils of the focus areas if there is proper runoff management from roads and other bare areas. Good rangeland management for the areas underneath the solar panels will be essential to maintain a good vegetation cover and to reduce soil erosion and runoff. The shallow soils may present a challenge for some construction items like poles that need to be planted. The clayey soils and most noticeably the Swartland and Valsrivier soils may restrict vehicle movement during the wet season. The Swartland and Valsrivier soils may also have an influence on any foundations. It is possible that the shading effect of the proposed solar panels will increase soil moisture content and therefore improve the general grazing capacity of the study areas.

6 GIS DATA AND A0 PRINT FILES

The following data products were distributed with this report:

Vector maps (shape files and KMZ)

- Grazing units Phase 2 and 3 combined area
- Soil map Phase 2 and 3 combined area
- Soil capability Phase 2 and 3 combined area V2

Raster maps (GeoTIFF)

- Terrain units

Vector point files (shape files and KMZ)

- Phase 2 extra and 3 soil observations April 2022
- Phase 2 extra and 3 VCA sites April 2022

Included is also the Excel database with 77 Soil and vegetation observations for 2022.

Vector Study areas (shape files and KMZ)

- Final Phase 2 Lo25 N
- Final Phase 3 Lo25 N

Colour legends and A4 maps

- Grazing units Phase 3 and VCA sites V2
- Grazing units Phase 2 and 3 V2
- Soil map Phase 3 and soil sites
- Soil map Phase 2 and 3 V2
- Soil capability Phase 3 and soil sites
- Terrain units over ALOS final Phase 2 and 3

A0 print files

- Graxing Units Phase 3 - 2022 A0 print file
- Soil Units Phase 3 - 2022 A0 print file
- Soil Capability Phase 3 - 2022 A0 print file

Coordinate Reference System used for all the maps: Hartebeesthoek 94 / Lo25 (North oriented). Datum: Hartebeesthoek 94

The point files are in a Geographic Coordinate Reference System. Datum: WGS 84

7 REFERENCES

De Wet, S.F., 2017. SOVENTIX SOLAR PV PROJECT in the HANOVER DISTRICT, Northern Cape (De Aar/Hanover area). Grazing Assesment Report for the De Bad farm. Unpublished report to Ecoleges Ecological Consultants.

De Wet, S.F., 2021. SOVENTIX SOLAR PV PROJECT IN THE HANOVER DISTRICT, NORTHERN CAPE (DE AAR/HANOVER AREA). Grazing Potential Assessment on several portions of farms in the Hanover District, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province.

De Wet, S.F. and Arnoldi. F.A., 2022. Grazing Assessment for the development of a 400 MW Solar Photovoltaic (PV) facility (Phase 3) on the Remainder of the farm Goedehoop 26C and of the Portion 3 of Farm Goede Hoop 26C, between De Aar & Hanover, Emthanjeni Local Municipality, Pixley Ka Seme District Municipality, Northern Cape Province, South Africa.

Collet, A., 2019. LAND CAPABILITY EVALUATION AND CLASSIFICATION FOR SOUTH AFRICA, Version 1: 2018. Compiled by: A. Collett, 2019. Natural Resource Inventories and Assessments. Directorate: Land Use and Soil Management

MacVicar C.N. (ed.), 1991. Soil classification. A taxonomic system for South Africa. Second Edition. Memoir 15, Department of Agricultural Development, Pretoria.

Van den Berg, H.M., 2017. SOVENTIX SOLAR PV PROJECT in the HANOVER DISTRICT, Northern Cape. Soil Mapping Report for the De Bad farm. Unpublished report to Ecoleges Ecological Consultants.

Van den Berg, H.M., 2021. SOVENTIX SOLAR PV PROJECT in the HANOVER DISTRICT, Northern Cape. Soil assessment for PV02 area. Unpublished report to Ecoleges Ecological Consultants.

8 ACKNOWLEDGEMENTS

The contributions of the following persons assisting with fieldwork for the soil survey are acknowledged:

The farm owner of De Bad: Willem Retief for his assistance with the 2016/2017, 2021 and 2022 surveys.

Soil technicians: Lourens Janse van Rensburg and Drihan van der Westhuizen for assistance with the 2016 survey.

Soil technician: David Botha for assistance with the 2022 survey.