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Irrigation Suitability Report for Portion 1 of the farm Harrisdale 226 - Kilmorey, near Kimberley, Northern Cape Province

for

Turn180

June 2019

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Executive summary

A soil survey was conducted for *Turn180* on approximately 75 ha of land near Kimberley, Northern Cape to assess the suitability of the area for irrigation and cultivation of lucerne. The soils of the study area comprise of Hutton, Bloemdal, Oakleaf and Valsrivier forms. The latter, covering around 20 ha, is deemed unsuitable for irrigation due to a strongly developed structure and high clay contents. The remainder of the soils contain morphological, chemical and physical properties which complies to the Northern Cape Department of Agriculture's irrigation and cultivation requirements and are therefore suitable to highly suitable (Figure A).

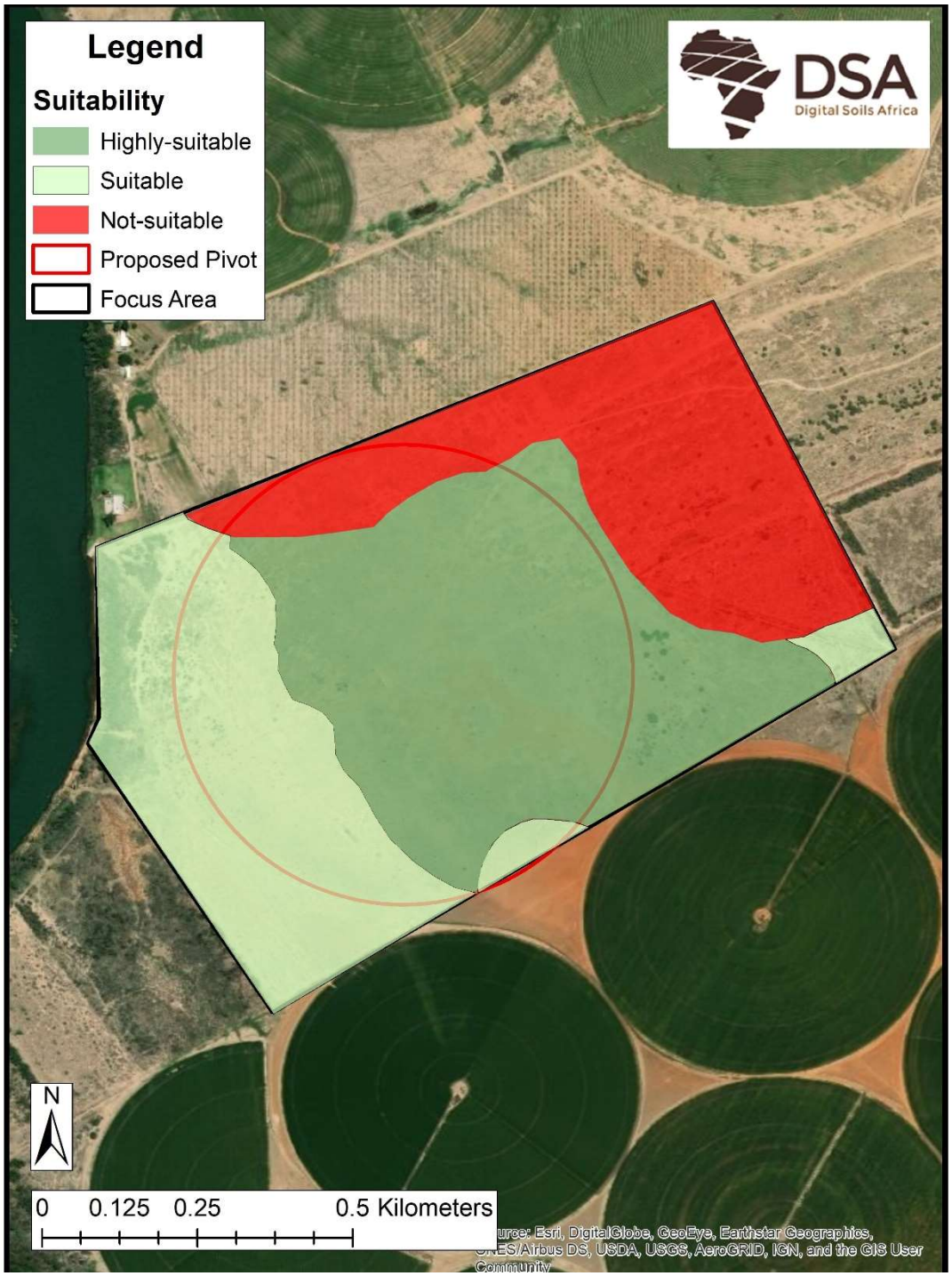

Figure A: Area suitable for irrigation at the Witdam site.

1. Introduction

Digital Soils Africa conducted a soil survey on approximately 75 ha on portion 1 of the farm Harrisdale portion 226 - Kilmorey, near Kimberley in the Northern Cape Province. The aim of the survey was to determine the suitability of the soils for cultivation of Lucerne under irrigation. For sustainable irrigation of land the soils the risk of water logging and salinization need to be established. When irrigation water is applied, dissolved salts are applied with the water, but plants mainly remove water through transpiration resulting in the accumulation of salts in the soils, which may result in yield decreases and crop losses. In extreme cases, salinization will reach the extent that the soil cannot be vegetated anymore. These effects can be negated with proper management on soils with certain properties. For this reason, the Department of Agriculture, Northern Cape, has provided guidelines to which soil properties must adhere before a ploughing license can be granted. These properties are related to the water infiltration of the soil, as well as salt and sodium built up. On this site the properties of the soils and the distribution thereof were investigated and areas where irrigation can be managed sustainable identified.

2. Location

Kilmorey, the focus area, is located approximately 25 km north-west of Kimberley and approximately 15 km east from Barkley West (Figure 1). An area, previously under centre pivot irrigation was identified as the best potential layout for irrigation. The coordinates of the focus area as well as for the centre pivot is presented in Table 1.

Table 1: **Coordinates of selected points on the perimeter of the studied area**

Nr	X	Y
1	24.659	-28.487
2	24.650	-28.491
3	24.653	-28.498
4	24.662	-28.492
Middle of Pivot	24.654	-28.493

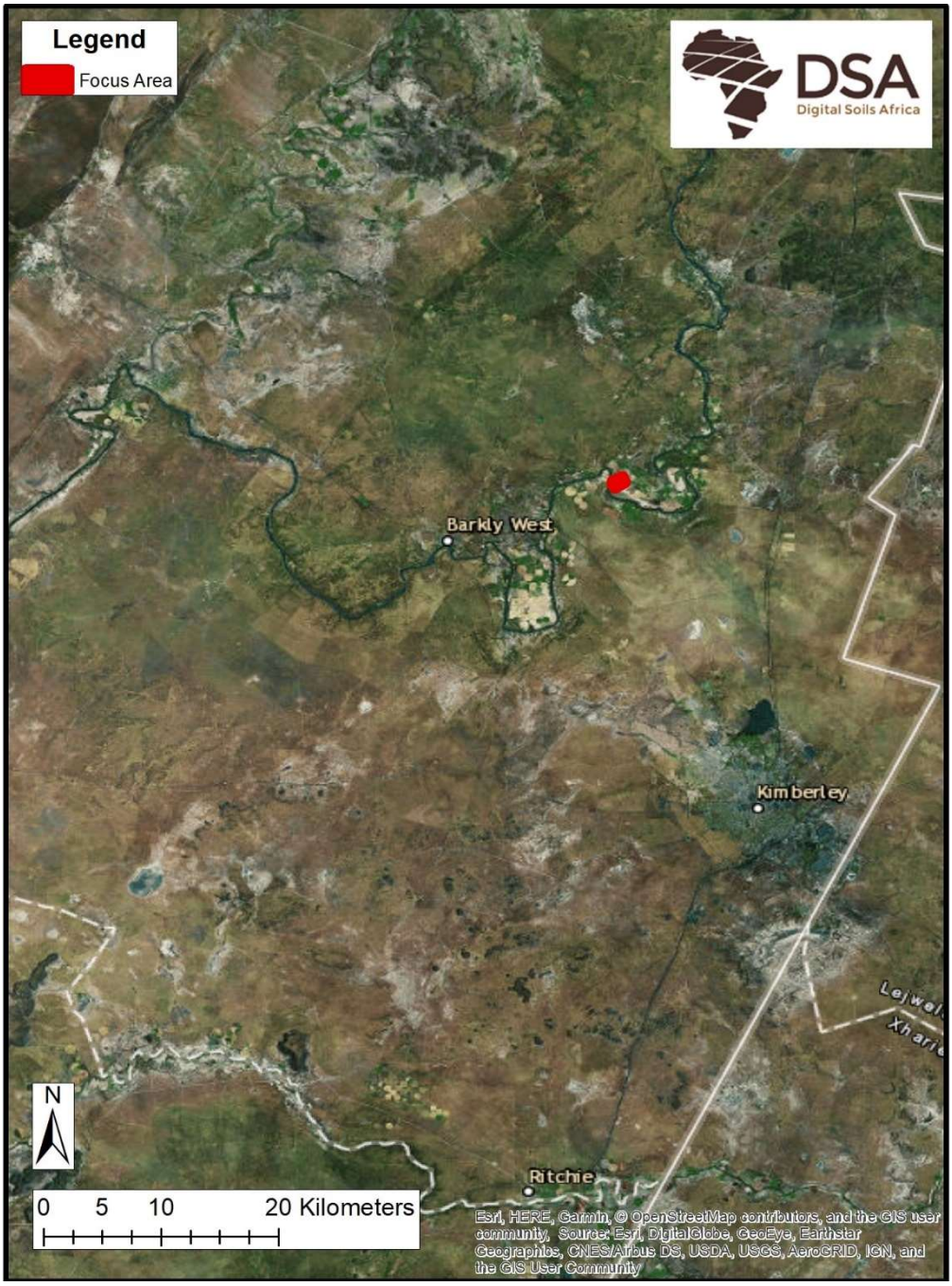

Figure 1: **The location of the Kilmorey farm, focus area of the study.**

3. Methodology

A field visit was conducted on the 22nd of May 2019. A total of 23 profiles were opened by the client to a depth of approximately 3 500 mm, using a TLB (Figure 2). Soils were classified according to the Taxonomic Soil Classification System (Soil Classification Working Group, 1991). Soil depth, freely drainable depth and limiting material were noted and mapped. Samples of modal profiles were taken for chemical and physical analysis, this included four topsoil samples (0 – 300 mm) and four subsoil samples (300 – 600 mm), and one sample of the deep subsoil (1200 mm+) (see Table 2). Texture was measured with the pipette method, basic cations from a 1:10 NH4OAc extract (White 2006) and soil

pH in a 1:2.5 KCl extract. Phosphorus was measured with Bray I method and micro-nutrients with the DTPA method.

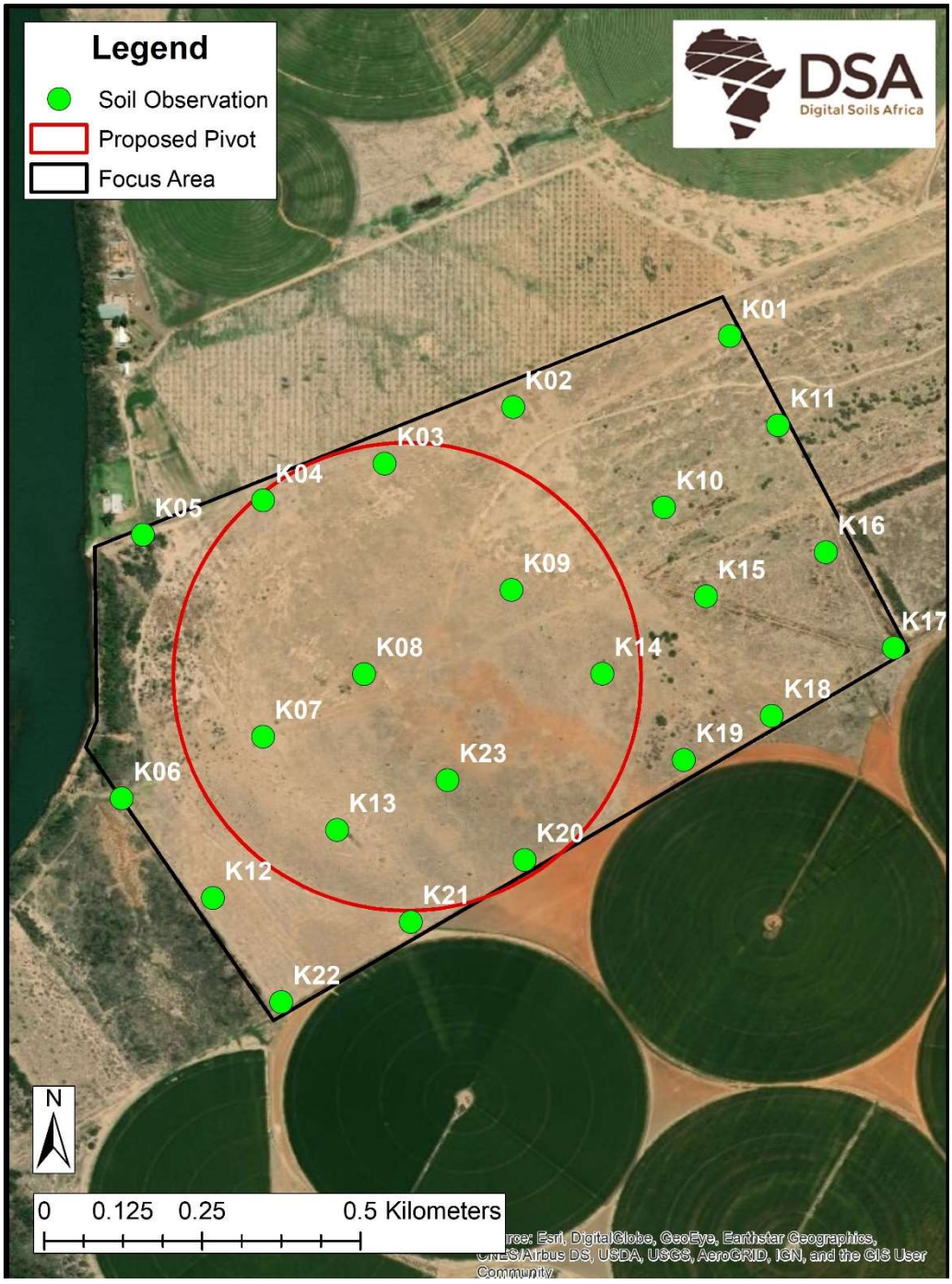

Figure 2: Focus area, centre pivot and soil observation locations for the Kilmorey site.

Table 2: **Observation locations of the Kilmorey study site and type of observations**

GPS	X	Y	Observation Type
K01	24.65915	-28.4879	Profile with samples
K02	24.65607	-28.4889	Profile
K03	24.65424	-28.4897	Profile
K04	24.65251	-28.4903	Profile
K05	24.65081	-28.4908	Profile
K06	24.6505	-28.4945	Profile with samples
K07	24.65251	-28.4936	Profile
K08	24.65395	-28.4927	Profile with samples
K09	24.65604	-28.4915	Profile
K10	24.65821	-28.4904	Profile
K11	24.65984	-28.4892	Profile with samples
K12	24.6518	-28.4959	Profile
K13	24.65356	-28.4949	Profile
K14	24.65734	-28.4927	Profile
K15	24.65881	-28.4916	Profile
K16	24.66051	-28.491	Profile
K17	24.66148	-28.4924	Profile
K18	24.65975	-28.4933	Profile
K19	24.6585	-28.494	Profile
K20	24.65623	-28.4954	Profile
K21	24.65461	-28.4963	Profile
K22	24.65277	-28.4974	Profile
K23	24.65513	-28.4942	Profile

4. Results

4.1. Soils forms

The soils of the study area vary considerably (Figure 3). Freely drained, apedal Hutton soils cover 31.3 ha (42%) of the surveyed area. Strongly structured Valsrivier soils occur in the north and north-eastern parts of site, below an old slimes dam (approximately 20 ha). Oakleaf soil forms were observed in the eastern corner of the site as well in the south-western areas adjacent to the river, covering 22.3 ha. A small area of approximately 0.8 ha (1% of the surveyed site) is occupied by Bloemdal soils.

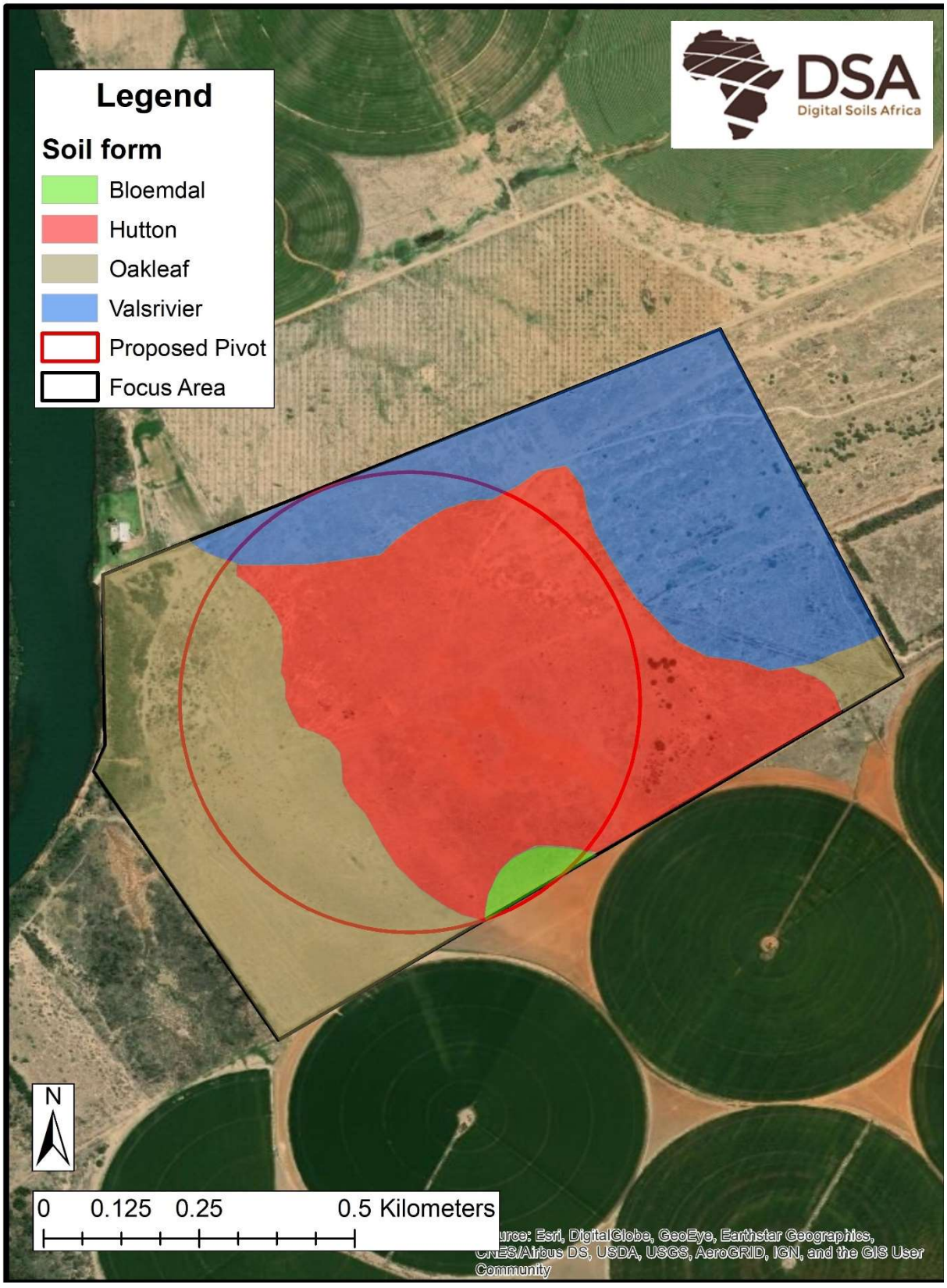

Figure 3: **Soil map of the Kilmorey site**.

4.1.1. Hutton 3100

A Hutton 3100 soil consists of an orthic A horizon overlying a red apedal B horizon. In this area the Hutton soils were very deep, exceeding 3 500 mm. The red colour of both the A and the B horizons is an indication of freely drained conditions. The 3100 family is eutrophic (not leached) and non-luvic

(Figure 4). The depth, apedal structure and red colours are all indications of a soil very suitable for irrigation

Figure 4: **Hutton 3100 soil form represented by a) K08 and K09 respectively.**

4.1.2. Valsrivier 1121 & 2122

The Valsrivier soil form consist of an orthic A horizon overlying a pedocutanic B horizon on unconsolidated material without signs of wetness. The pedocutanic horizon is typical of a duplex soil with structure stronger than moderate. In both the 1121 and 2122 families the structure is medium to coarse angular. In the 1121 family the A horizon is not bleached and there is no lime accumulations in the pedocutanic or upper part of the C horizon (Figure 5c). The 2122 family has a bleached A horizon, with a calcareous B and upper C horizon (Figure 5a&b).

The strong structure and high clay contents of the pedocutanic B horizons will limit vertical drainage of irrigation water and roots. The effective depth of both the Valsrivier 1121 & 2122 is there restricted

to the depth of the orthic A horizon (i.e. approximately 300 mm). This will deem it unsuitable for irrigation.

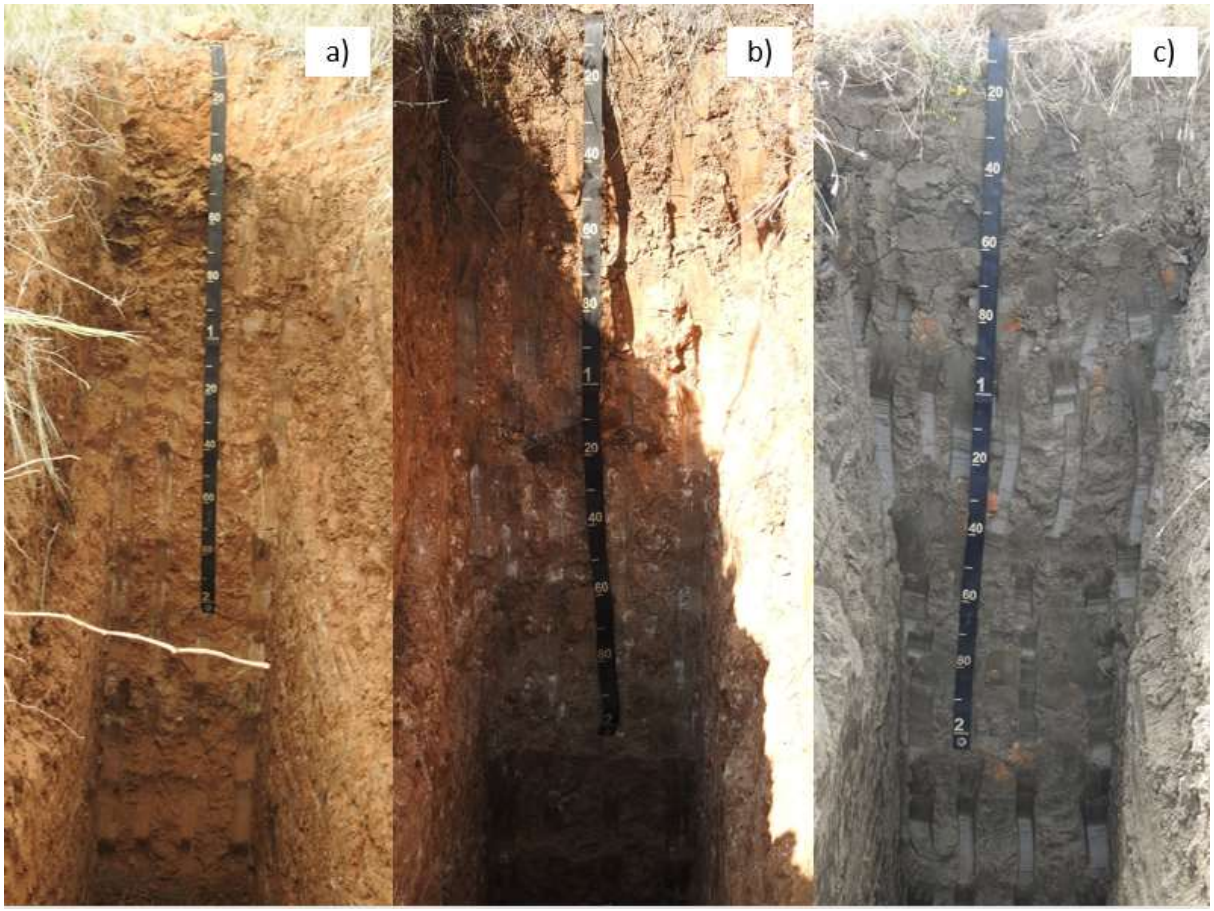

Figure 5: Valsrivier soil forms: 2122 family represented by K01 (a) and K03 (b) and 1121 family represented by K04 (c).

4.1.3 Oakleaf 1110

The Oakleaf soil form consist of an orthic A horizon overlying a neocutanic horizon. In this area these soils were very deep (>3 500 mm). The 1110 family has non-bleached A horizon and non-red and aluvic B horizon (Figure 6). Although there were some variation in the structure within the soil forms, the structure was generally weaker than moderately developed in the neocutanic B horizon. The very deep soil depth, relatively weak structural development and relatively low clay contents makes these soils suitable for irrigation.

Figure 6: Typical Oakleaf 1110 soils of the study area represented by K06 (a) and K17 (b).

4.1.4 Bloemdal 1100

Bloemdal soils consist of an orthic A horizon overlying a red apedal horizon on top of unspecified material with signs of wetness. The 'signs of wetness' are grey colours (matrix or mottles) which forms due to removal of Fe under anaerobic (saturated) conditions. In this site on Bloemdal profile was observed (K20 - Figure 2) with the signs of wetness starting at approximately 1 300 mm. Although the redoximorphic features were not well developed (Figure 7), but worth noting. The signs of saturation likely formed due to over-irrigation in the past. The small area covered by this soil form, weakly developed reductiomorphic features and absence of depth limiting layer (e.g. rock, thick grey etc), suggest that this soil could've formed in a drainage channel from the previous pivot.

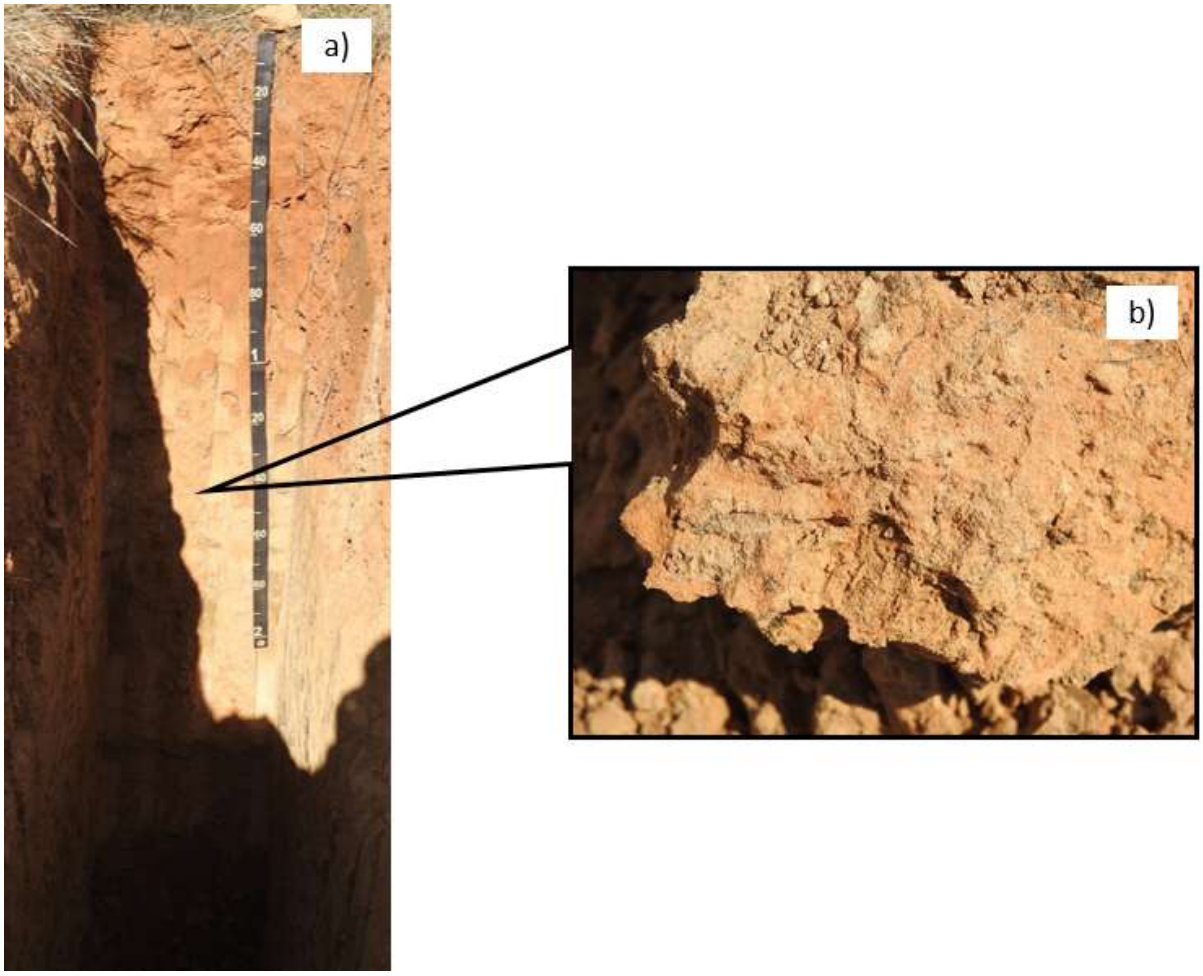

Figure 7: Bloemdal 1100 soil represented by K20; b) signs of wetness at around 1 300 mm.

4.2. Soil Depth

The soils in the studied area are deep, exceeding 3 500 mm in all the observations (Figure 8). The freely drained depth in the Oakleaf and Hutton soils are equal to the total soil depth (Figure 9). For the Valsrivier soils, the freely drained depth is only the thickness of the orthic A horizon. The pedocutanic B horizon is the depth limiting layer (Figure 10). For the Bloemdal soil, the unspecified material with signs of wetness is the depth limiting layer and occur at approximately 1 300 mm.

The drainable depth (Figure 11) is considered the depth to where drainage can be installed. On the drainable depth is therefore the entire soil depth and exceeds 2 500 mm for the entire site.

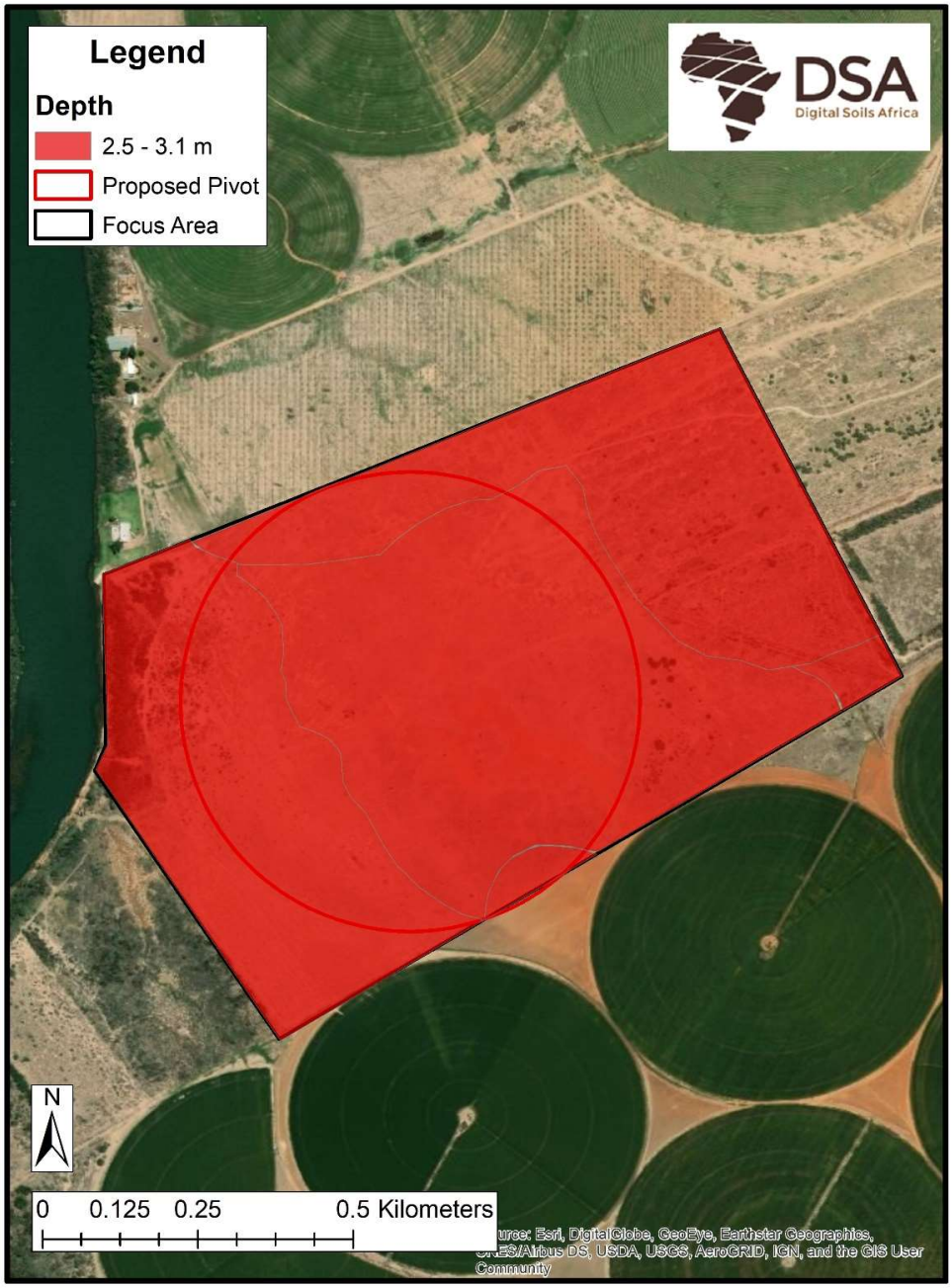

Figure 8: Total soil depth of the Kilmorey site.

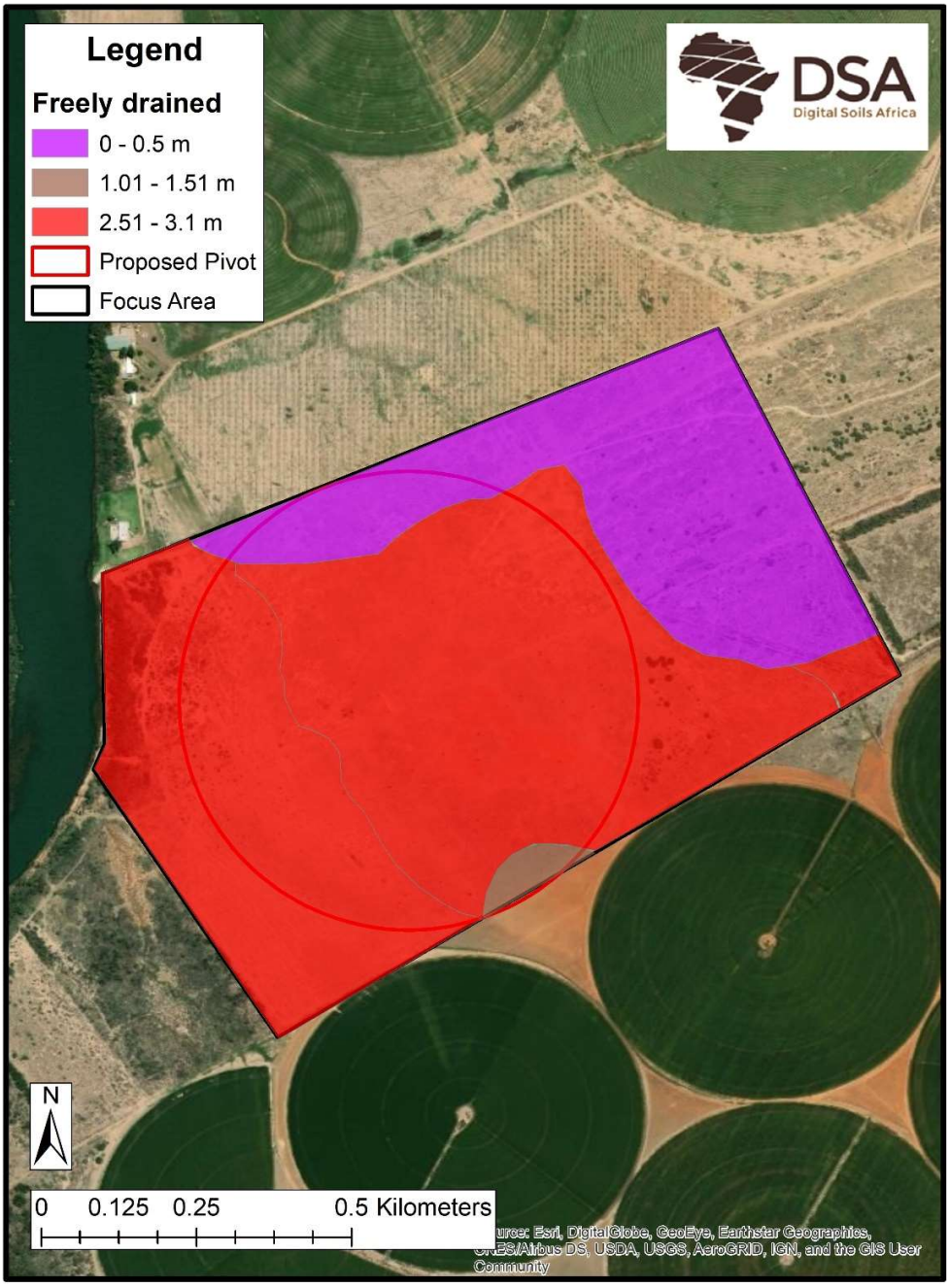

Figure 9: **Freely drained depth of the Kilmorey site.**

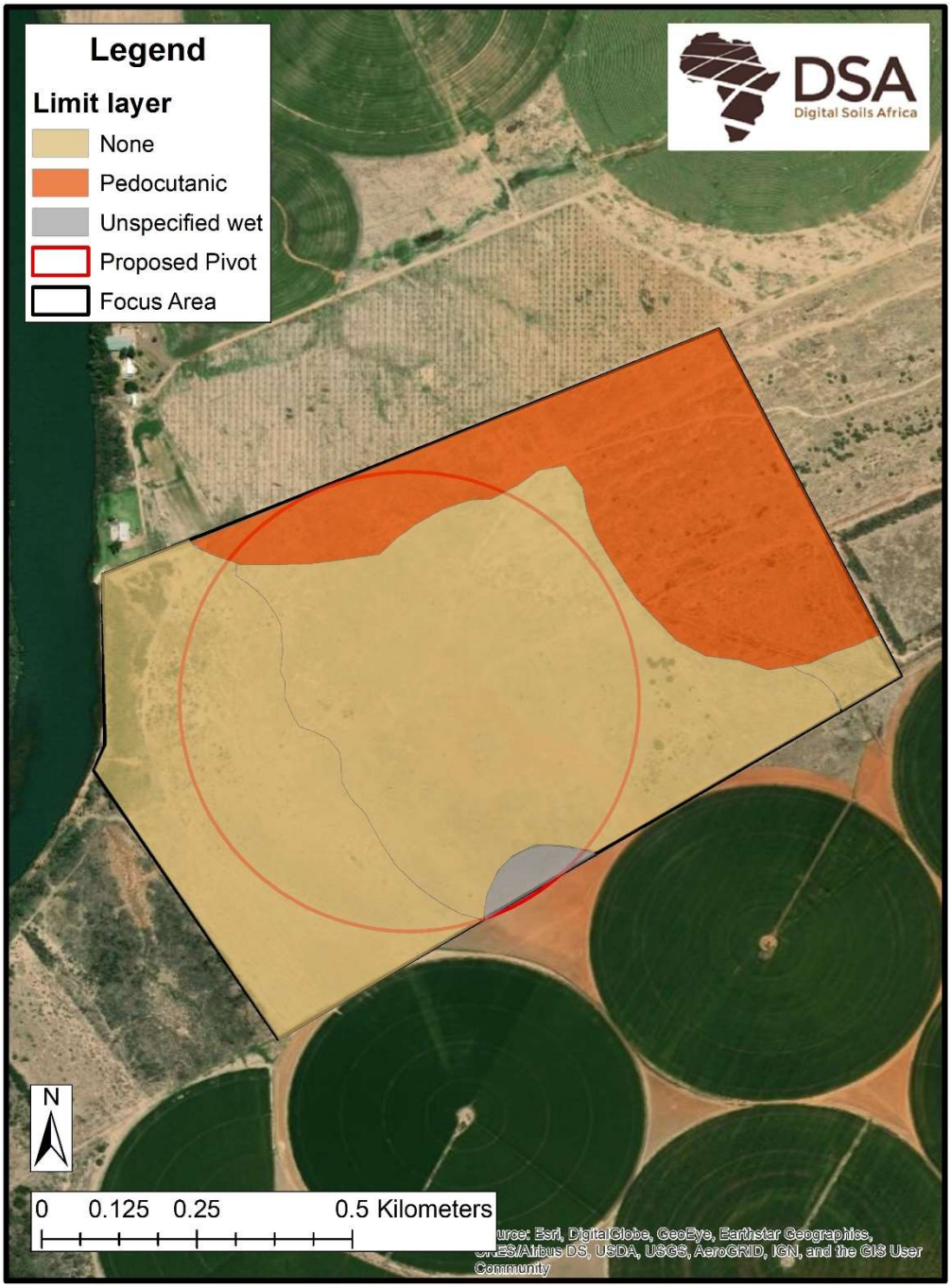

Figure 10: **Depth limiting layers of the Kilmorey site.**

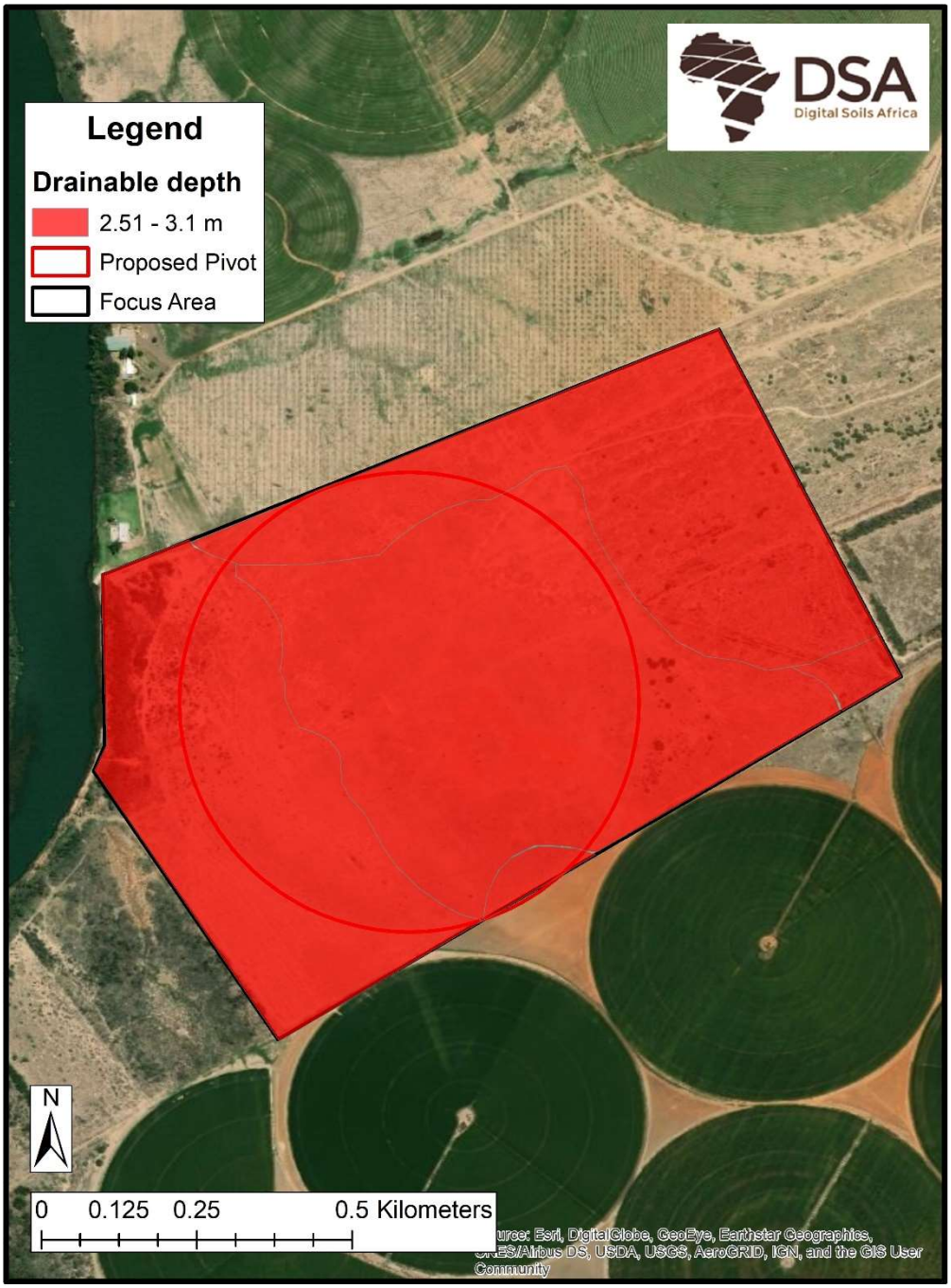

Figure 11: **Drainable depth of the Kilmorey site.**

4.3. Chemical and soil texture analysis

Table 3 (chemical) and Table 4 (texture) present selected soil properties of samples taken from modal profiles. Based on the chemical analysis, all the soils are suitable for irrigation. The particle size distribution reveals however that the clay contents of both Valsrivier 1121 and 2122 are above the threshold value of 35% and are therefore not suitable for irrigation.

Table 3: Selected chemical properties for modal soil profiles

Observation	Soil form	Horizon	pH (KCl)	EC	Ca	Mg	K	Na	CEC	ESP	S	P	B	Cu	Fe	Mn	Zn
				mS/m	cmol(+)/kg						mg/kg						
K08	Hu3100	ot	6.76	76.8	3.4	1.8	0.5	0.6	6.3	9.85	22.3	41.8	2.2	3.0	10.9	28.5	2.4
K08	Hu3100	re	6.77	68.4	4.6	2.7	0.3	0.8	8.5	9.92	13.4	27.4	4.2	5.0	12.9	30.5	4.4
K01	Va1121	ot	7.05	78.0	33.3	9.3	0.8	0.8	44.2	1.75	57.0	26.2	6.2	7.0	14.9	32.5	6.4
K01	Va1121	vp	7.32	220.5	16.9	11.4	0.5	1.8	30.6	5.74	155.7	23.6	8.2	9.0	16.9	34.5	8.4
K01	Va1121	ud	7.01	260.8	15.2	10.5	0.8	2.8	29.3	9.59	215.8	25.0	10.2	11.0	18.9	36.5	10.4
K06	Oa1110	ot	6.12	70.4	5.6	3.6	0.7	0.7	10.7	6.64	16.9	29.4	12.2	13.0	20.9	38.5	12.4
K06	Oa1110	ne	6.32	74.4	7.5	4.5	0.6	0.9	13.4	6.42	13.4	24.0	14.2	15.0	22.9	40.5	14.4
K11	Va2122	ot	7.10	90.0	23.5	10.2	0.9	1.1	35.7	3.06	40.6	28.4	16.2	17.0	24.9	42.5	16.4
K11	Va2122	vp	7.31	128.5	31.5	12.4	0.8	2.2	46.9	4.73	89.7	24.0	18.2	19.0	26.9	44.5	18.4

Table 4: Particle size distribution of modal soil profiles

Observation	Soil form	Horizon	Clay	Silt	Sand	Texture Class
			%			
K09	Hu3100	ot	9.20	4.40	88.08	Sand
K09	Hu3100	re	10.40	3.00	86.48	LoamySand
K01	Va1121	ot	42.20	6.20	53.46	SandyClay
K01	Va1121	vp	46.20	10.60	45.14	Clay
K01	Va1121	ne	47.00	10.40	41.63	Clay
K07	Oa1110	ot	20.80	8.00	70.63	SandyClayLoam
K07	Oa1110	ne	22.80	10.40	67.31	SandyClayLoam
K11	Va2122	ot	42.00	6.60	51.62	Sandy Clay
K11	Va2122	vp	48.20	7.00	45.34	SandyClay

The pH of the soils ranged between 6.12 and 7.32, bordering the guidelines of below 7.5. It is however expected that irrigation with high quality irrigation water will leach some of the base forming cations out of the soil profiles and thereby lower the pH. The electrical conductivity (EC) values are within the expectable norms of > 300 Ohms and < 400 mS/m respectively. The Exchangeable Sodium Percentage (ESP) is relatively high in the Hutton and Oakleaf soils but could be managed to the well-drained nature of these soils. The excess Na should be leached out with the application of gypsum and excess irrigation water. This program should be determined by a qualified soil scientist and must be monitored. The P contents are relatively high and signify a land that has been subjected to cultivation in the past. Imbalances in cations should be addressed prior to establishment of lucerne.

The clay content of the Valsrivier soils are very high and exceed the norm of <35% proposed by the Department of Agriculture of the Northern Cape. Clay contents are more than 40% in the orthic A horizon and up to 48% in the pedocutanic B horizon of K11. The clay contents of the remainder of the samples are below 30%. The majority of the samples form part of the Sandy-Clay-Loam texture class (Table 4).

5. Suitability

Based on soil morphology and laboratory analysis, the site can be divided into three suitability classes for irrigation namely highly suitable, suitable and not-suitable (Figure 12). Hutton soils are considered highly suitable, Oakleaf and Bloemdal soils moderately suitable and Valsrivier soils not-suitable. The majority (73%) of the area is considered to be suitable for irrigation and cultivation in accordance to the guidelines of the Northern Cape Department of Agriculture. When the proposed location of the centre pivot is concerned, only around 2.8 ha of the 39 ha pivot is deemed not suitable, i.e. around 7%. Although the remainder is considered suitable, and even highly suitable, careful leaching of Na with application of gypsum and excess irrigation water should be conducted, and salt and sodium contents should be monitored through regular sampling.

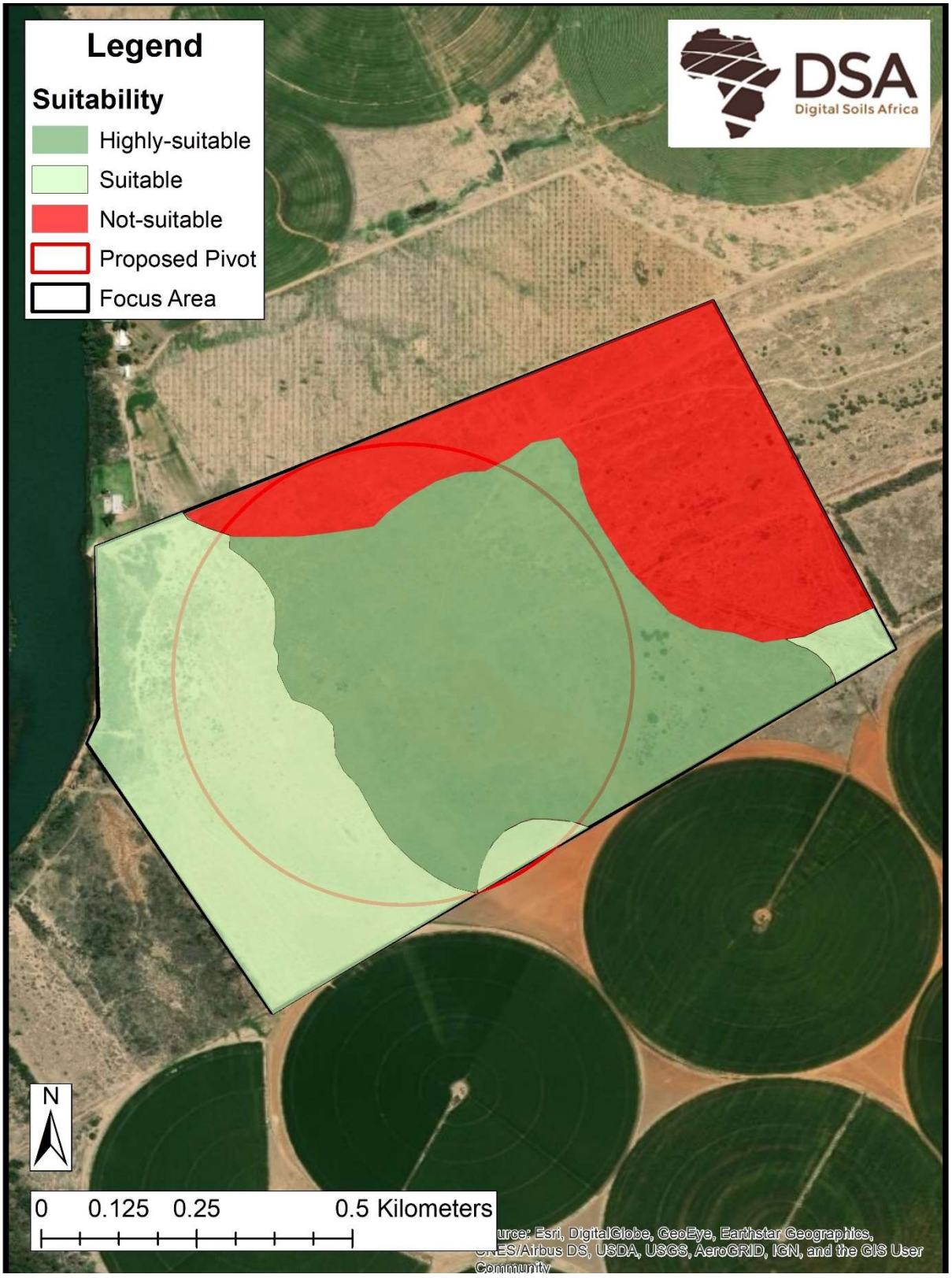

Figure 12: **Suitability for cultivation and irrigation of the Kilmorey site.**

The perimeter points of the final suitable areas for irrigation and lucerne production are shown in Table 5. The suitable area covers approximately 54.4 ha.

Table 5: Perimeter points of the highly-suitable and suitable areas from Figure 12 for the Kilmorey site.

No	Class	X	Y	No	Class	X	Y
1	Highly-suitable	24.65209	-28.4908	37	Suitable	24.66085	-28.4929
2	Highly-suitable	24.65252	-28.4913	38	Suitable	24.66172	-28.4924
3	Highly-suitable	24.65276	-28.4927	39	Suitable	24.66139	-28.4918
4	Highly-suitable	24.65296	-28.4932	40	Suitable	24.66095	-28.492
5	Highly-suitable	24.65356	-28.4936	41	Suitable	24.66055	-28.4921
6	Highly-suitable	24.65362	-28.494	42	Suitable	24.66017	-28.4923
7	Highly-suitable	24.65404	-28.4946	43	Suitable	24.65568	-28.4959
8	Highly-suitable	24.65446	-28.4952	44	Suitable	24.65576	-28.4955
9	Highly-suitable	24.65482	-28.4956	45	Suitable	24.65601	-28.4951
10	Highly-suitable	24.65545	-28.4959	46	Suitable	24.65643	-28.4949
11	Highly-suitable	24.65566	-28.4959	47	Suitable	24.657	-28.4949
12	Highly-suitable	24.65573	-28.4955	48	Suitable	24.65726	-28.495
13	Highly-suitable	24.65599	-28.4951	49	Suitable	24.65645	-28.4955
14	Highly-suitable	24.65645	-28.4949	50	Suitable	24.65266	-28.4977
15	Highly-suitable	24.65702	-28.4949	51	Suitable	24.64999	-28.4938
16	Highly-suitable	24.65722	-28.495	52	Suitable	24.65017	-28.4934
17	Highly-suitable	24.66082	-28.4929	53	Suitable	24.65014	-28.4909
18	Highly-suitable	24.66073	-28.4927	54	Suitable	24.65137	-28.4904
19	Highly-suitable	24.66043	-28.4924	55	Suitable	24.65206	-28.4908
20	Highly-suitable	24.66013	-28.4923	56	Suitable	24.65251	-28.4913
21	Highly-suitable	24.65977	-28.4923	57	Suitable	24.65276	-28.4927
22	Highly-suitable	24.65935	-28.4922	58	Suitable	24.65298	-28.4931
23	Highly-suitable	24.65892	-28.4921	59	Suitable	24.65359	-28.4936
24	Highly-suitable	24.65848	-28.4919	60	Suitable	24.65361	-28.494
25	Highly-suitable	24.6579	-28.4913	61	Suitable	24.65406	-28.4946
26	Highly-suitable	24.65748	-28.4907	62	Suitable	24.65449	-28.4952
27	Highly-suitable	24.65719	-28.4902	63	Suitable	24.65486	-28.4956
28	Highly-suitable	24.65709	-28.4897	64	Suitable	24.65549	-28.4959
29	Highly-suitable	24.65682	-28.4894	65	Suitable	24.65569	-28.496
30	Highly-suitable	24.65642	-28.4894				
31	Highly-suitable	24.65588	-28.4898				
32	Highly-suitable	24.65539	-28.4899				
33	Highly-suitable	24.65466	-28.4902				
34	Highly-suitable	24.65416	-28.4906				
35	Highly-suitable	24.65326	-28.4907				
36	Highly-suitable	24.65264	-28.4908				

6. Conclusion

The soil survey and accompanying analysis of soil properties indicate that the majority of the 75 ha Kilmorey site is suitable for cultivation and irrigation of lucerne according to the norms and standards provided by the Northern Cape Department of Agriculture. An area occupied by Valsrivier soils are not suitable due to the strong structure and high clay contents of the pedocutanic B horizon. Sodium leaching and salt monitoring should occur frequently.

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7. Disclaimer

Digital Soils Africa cannot be held responsible for any advice given based on incorrect laboratory analysis given by our providers. Although all care is taken to ensure that the results reported are correct, we are dependent on services from other companies.

9. Appendices

Appendix 1: Modal soil profile descriptions

General Information						
Site:	Kilmorey – K01				Soil form:	Valsrivier
Map/Photo example:	Figure 5a				Soil family:	2122
GPS Position:	24.65915; -28. 4879				Colour	Grey
Surface stones:	0%				Occurrence of flooding:	None
Altitude:	1129 m				Wind erosion potential:	Low
Terrain unit:	Mid slope				Water erosion potential:	Low
Slope:	1%				Vegetation/Land use:	Old land
Slope shape:	Planform	Straight	Profile	Straight	Water table:	None
Aspect:	None					
Micro-relief:	None				Described by:	J van Tol
Parent material solum:	Shales				Date described:	2019-05-22
Geological group:	Dwyka/Ecca group				Weathering of underlying material:	

Profile Information						
Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 300	Orthic A	Grey, brown	Moderate, medium, SANBL	Few, yellow mottles	Present	Clear
B 1200	Pedocutanic	Brown	Strong, medium, SANBL	None	Present	Clear
B 3000	Neocarbonate	Brown	Medium, medium, SANBL	None	Present	Clear

General Information

Site:	Kilmorey – K08				Soil form:	Hutton
Map/Photo example:	Figure 4a				Soil family:	3100
GPS Position:	24.65395 -28.4927				Colour	Red
Surface stones:	0%				Occurrence of flooding:	None
Altitude:	1129 m				Wind erosion potential:	Medium
Terrain unit:	Mid slope				Water erosion potential:	High
Slope:	1%				Vegetation/Land use:	Old land
Slope shape:	Planform	Straight	Profile	Straight	Water table:	None
Aspect:	None					
Micro-relief:	None				Described by:	J van Tol
Parent material solum:	Shales/wind blown sands				Date described:	2019-05-22
Geological group:	Dwyka/Ecca group				Weathering of underlying material:	

Profile Information

Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 300	Orthic A	Red	Apedal	None	Absent	Gradual
B 3500+	Red apedal	Red	Apedal	None	Absent	Gradual

General Information						
Site:	Kilmorey – K06				Soil form:	Oakleaf
Map/Photo example:	Figure 6a				Soil family:	1110
GPS Position:	24.6505 -28.4945				Colour	Brown
Surface stones:	0%				Occurrence of flooding:	Low
Altitude:	1129 m				Wind erosion potential:	Low
Terrain unit:	Mid slope				Water erosion potential:	Medium
Slope:	1%				Vegetation/Land use:	Old land
Slope shape:	Planform	Straight	Profile	Straight	Water table:	None
Aspect:	None					
Micro-relief:	None				Described by:	J van Tol
Parent material solum:	Shales/alluvial deposits				Date described:	2019-05-22
Geological group:	Dwyka/Ecca group				Weathering of underlying material:	Not reached

Profile Information

Horizon Depth (mm)	*Diagnostic Horizon*	*Colour*	*Structure*	*Redoximorphic features*	*Lime*	*Transition*
A 300	Orthic A	Brown	Moderate, medium, SANBL	None	Present	Clear
B 3500+	Neocutanic	Red/white	Moderate, medium, SANBL	None	Present	Clear

Appendix 2: Agronomical Report

Compiled by Dr. G.M. van Zijl

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1. General soil requirements lucerne (*Medicago sativa*) production

The suitability of the area of Witdam site described in this report for lucerne production is based on the physical and chemical soil properties presented in this report. Lucerne (*Medicago sativa*) has a very strong root system and therefore can grow in a range of soil conditions. Lucerne prefers soils with light to medium texture (i.e. sandy to sandy loam), with a minimum of 600 mm of the soil being freely drained. The roots can penetrate up to 3 000 mm but the majority of the water are extracted from the first 1 200 mm (Smith, 2006).

In general lucerne can be cultivated in a wide range of climates, but needs approximately 1 000 mm of water during growing season; about 75 mm of water for producing 1 ton of dry matter (Smith, 2006). Based on the climate (cold winters with approximately 750 mm rain) and management option (irrigation), the yield potential is approximately 15 $t.ha^{-1}$ dry matter (Fertilizer Handbook, 2000). Lucerne requires P, K, Ca and S as well as Gypsum; fertilizer requirements should however be based on soil analysis of soil samples which should preferably be taken in May – June on established crops or prior to establishment.

2. Physical properties

a. Soil depth

Lucerne roots can extend, if root growth is not restricted, to a depth of 2 to 3 m. The soil majority of the soils on the site has a drainable depth of more than 1.5 m and is therefore suitable for lucerne production. Problems might however be encountered on the area deemed 'unsuitable'.

b. Soil texture

Lucerne can be cultivated on soils with a clay content that varies from less than 10% to more than 30%. The preferred texture classes are however between 10% and 30% as a result of air and water regimes that are optimal for high potential maize production. The texture of the soil profiles within

the suitable area is ranged between sandy-clay to sandy-clay-loam with a clay percentages between 9 - 23%. This is within the acceptable range for lucerne production. Wind erosion, surface encrustation after planting and soil compaction might however occur. These factors can and has to be managed by the producer in accordance to the selected tillage system.

3. Chemical properties

a. pH

Lucerne can be produced on soils with a $pH_{(H2O)}$ of 5.5-8.0, but the optimum $pH_{(H2O)}$ range for lucerne is 6.5-7.5. The $pH_{(KCl)}$ of the soil samples are between 6.1 – 7.3. Liming is not required at this stage. It is anticipated that the pH will lower once irrigation commence and regular soil sampling will inform the farmer of best management practices concerning alkalinity/acidity.

b. Salinity

The highest Electrical Conductivity and Resistance measurements are within the norms and standards for lucerne production. In terms of soil salinity this area is therefore conducive to lucerne production. Sodicity poses a problem if left unattended. Although not a specific requirement for Lucerne production, excess Na degrades the soil structure, which in time will make Lucerne production difficult to impossible. Due to the well drained nature of the suitable soils, the Na could be leached out. Sodium levels should also be closely monitored.

c. Other chemical elements

Lucerne requires P, K, Ca and S as well as Gypsum; fertilizer requirements should however be based on soil analysis of soil samples which should preferably be taken in May – June on established crops or prior to establishment.

4. Conclusion

The available soil properties, soil depth, soil texture, soil pH and EC values of the suitable areas are all within the required range for lucerne production under irrigation. Leaching of sodium should be done, and sodium and salinity levels monitored on a yearly basis.