Land capability analysis for the Bospoort Pipeline and Reservoirs

HM van den Berg

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IRIS International
Integrated Resource Information Systems

EXECUTIVE SUMMARY

The soils in the study area are dominated by high clay content soils of the Arcadia soil form. The underlying geology is Gabbro and Norite and soils have developed mostly in-situ from these basic igneous rock formations.

The combination of moderate but highly variable rainfall and mostly medium soil capability resulted that most of the area (60%) is covered by low to moderate land capability classes followed by 31% (including the 6% covered by water) of the area covered by low to very low land capability classes. In terms of a sensitivity rating of land capability classes only 0.6% of the area is covered by soils having a high sensitivity rating. The proposed pipeline, reservoirs and access roads are exclusively on land with a low to medium sensitivity rating and will not cross any of the soils having a high sensitivity rating.

The ideal land use in terms of the agricultural potential of the area is rangeland and nature conservation for the steep areas. It is only the area covered by settlements along the Hexrivier that is dominated by red Valsrivier soils that have a moderate potential for small scale cultivation under irrigation. The areas dominated by Arcadia soils are also problematic for any infrastructure development due to the swelling and shrinking properties of this soil type. These properties should also be taken into consideration in the construction of the proposed pipeline.

For this study a soils map, a land capability map, a sensitivity rating map and a soil observation point database were produced. Area analyses were provided for all the maps. Al these datasets were also provided as digital print and GIS maps.

Contents

1 INTRODUCTION

Fieldwork for soil and land capabilities for the Bospoort pipeline and reservoirs impact area was done in February 2019. Limited soil observations (mostly by the means of a soil augur) were made across the study area. Terrain data and satellite imagery were used to do detailed mapping on a 2m cell grid where differences were visible and where it was possible to extrapolate the soil observations. A soils map, a land capability map, a sensitivity rating map and a soil observation point database were produced. Area analyses were also done for all three maps.

2 STUDY AREA

Figure 1 shows the study area in the North West Province in South Africa. A study area block of about 7x7km (5357ha) was created for the soil and land capability survey

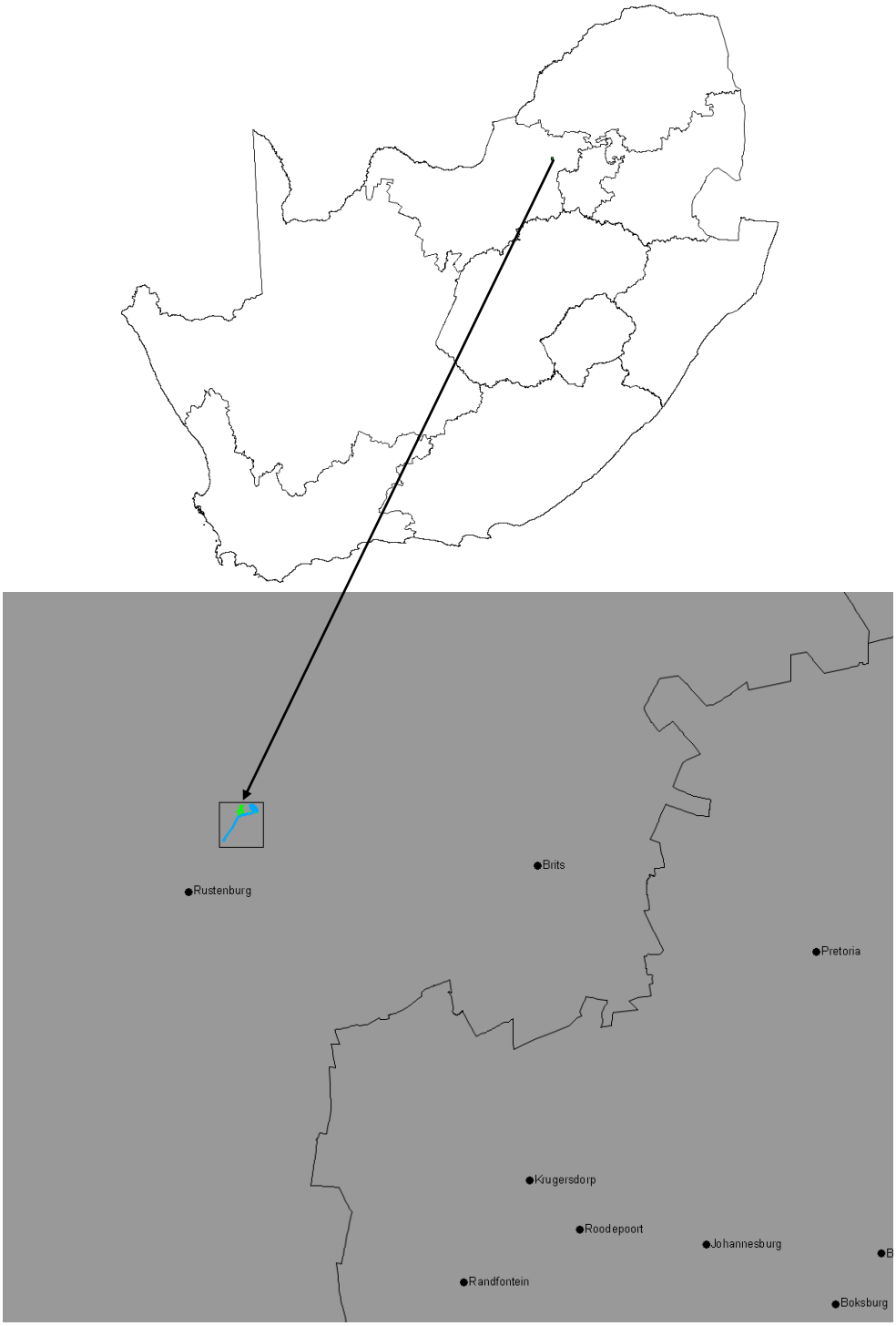


Figure 1. The location of the study area in South Africa and the North West Province. The locations of the proposed pipelines, access roads and reservoirs are also shown in cyan and green.

3 METHODS

3.1. Soil and land capability field survey

Roads were delineated on Google Earth imagery. Predetermined observation sites were identified on the Google Imagery and 2 Landsat 8 images and 1 Sentinel image to represent the main visible soil patterns on the imagery. An enhanced Digital Elevation Model (DEM) from SRTM (Shuttle Radar Topographic Mission, http://www2.jpl.nasa.gov/srtm/) data was also used to get a 3D perspective of the terrain. In total 21 soil observations were made mostly by hand auguring (Figure 2) until an impenetrable layer, mostly hard rock or a gleyed horizon, was found. All soil observations were done in accordance to the South African Taxonomic System (MacVicar CN (ed.) (1991). Soil classification. A taxonomic system for South Africa. Second Edition. Memoir 15, Department of Agricultural Development, Pretoria).

Figure 2. A hand soil augur used for the soil survey.

3.2. Mapping of soil units, land capability and sensitivity rating

Soil patterns were mapped mainly from a Google image mosaic and the enhancement products of a Landsat 8 image of 2017 08 11, 2018 10 01 and a Sentinel image of 2018 11 16 (Figure 3) and the field observations and from interpretations from the SRTM data that were used to derive terrain morphology and slope.

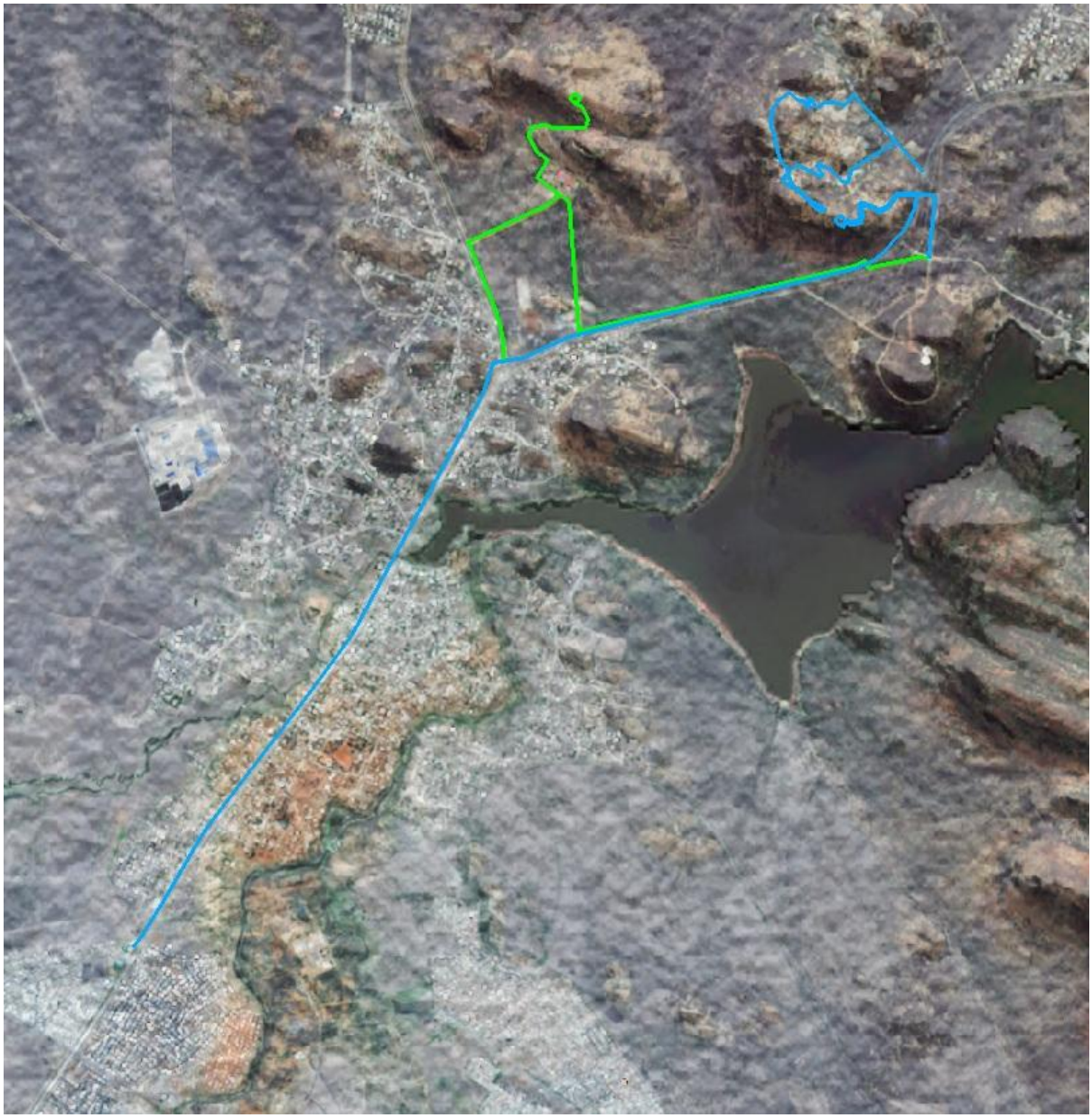


Figure 3. Sentinel image draped on SRTM hill-shading (bands 4, 3 and 2 displayed as RGB. The locations of the proposed pipelines, access roads and reservoirs are also shown in cyan and green.

Soil capability guidelines from (Schoeman, J. L., Van der Walt, M., Monnik, K. A., Thackrah, A., Malherbe, J., & Le Roux, R. E. (2000). The Development and Application of a Land Capability Classification System for South Africa. ARC-Institute for Soil, Climate and Water. Pretoria: ARC-ISCW report no GW/A/2000/57.) and the SRTM data were used to derive land capability classes according to the guidelines of Collet (DAFF) 2017. (land capability & the preservation and ... - Biodiversity Advisor)

A sensitivity rating was done according to the following guidelines: https://screening.environment.gov.za/ScreeningDownloads/Assessment/General/DraftAgricultureProtocol.pdf

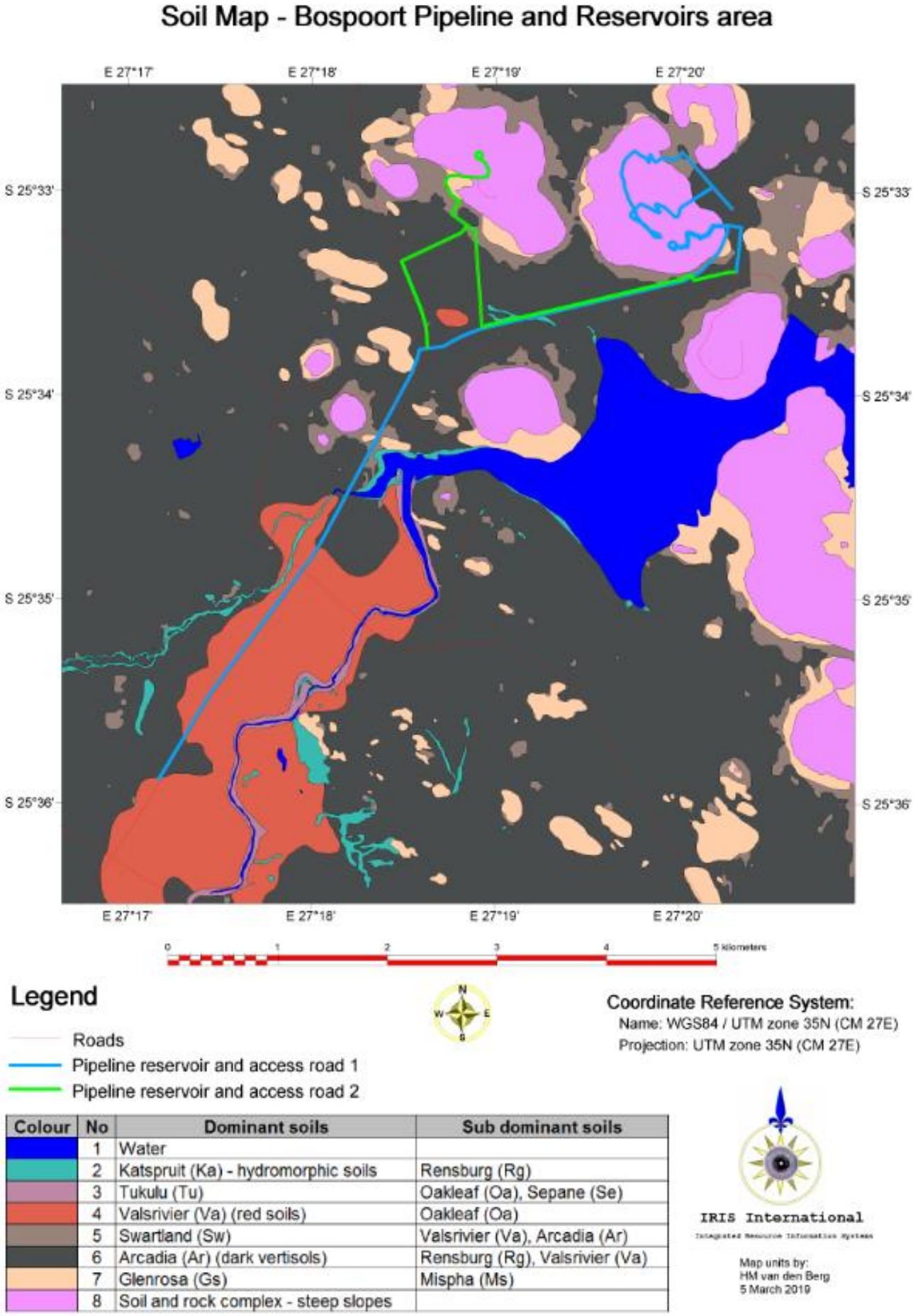
4 RESULTS

4.1. Soil map

The soil map for the study area can be seen in Figure 4. Table 1 shows the area analysis of the soil units.

Table 1. Area analysis of the soil map.

No	Dominant soils	Sub dominant soils	%	Area (ha)
1	Water		6.4	343.1
2	Katspruit (Ka) - hydromorphic soils	Rensburg (Rg)	1.1	60.4
3	Tukulu (Tu)	Oakleaf (Oa), Sepane (Se)	0.6	33.6
4	Valsrivier (Va) (red soils)	Oakleaf (Oa)	8.3	447.3
5	Swartland (Sw)	Valsrivier (Va), Arcadia (Ar)	5.6	301.6
6	Arcadia (Ar) (dark vertisols)	Rensburg (Rg), Valsrivier (Va)	59.6	3191.0
7	Glenrosa (Gs)	Mispha (Ms)	6.5	349.7
8	Soil and rock complex - steep slopes		11.8	630.7
	Total		**100.0**	**5357.4**



Colour	No	Dominant soils	Sub dominant soils
	1	Water	
	2	Katspruit (Ka) - hydromorphic soils	Rensburg (Rg)
	3	Tukulu (Tu)	Oakleaf (Oa), Sepane (Se)
	4	Valsrivier (Va) (red soils)	Oakleaf (Oa)
	5	Swartland (Sw)	Valsrivier (Va), Arcadia (Ar)
	6	Arcadia (Ar) (dark vertisols)	Rensburg (Rg), Valsrivier (Va)
	7	Glenrosa (Gs)	Mispha (Ms)
	8	Soil and rock complex - steep slopes	

Figure 4. Soil map for the study area.

4.2. Land capability map

The Land capability map is shown in Figure 5. The area analysis for the area covered by this map is shown in Table 2.

Table 1. Area analysis of the soil map.

No	Land capability class	%	Area (ha)
1	Moderate to high	0.6	33.6
2	Moderate	8.3	447.3
3	Low to moderate	59.6	3190.5
4	Low	13.3	712.3
5	Very low	11.8	630.6
6	Water	6.4	343.1
	Total	**100.0**	**5357.4**

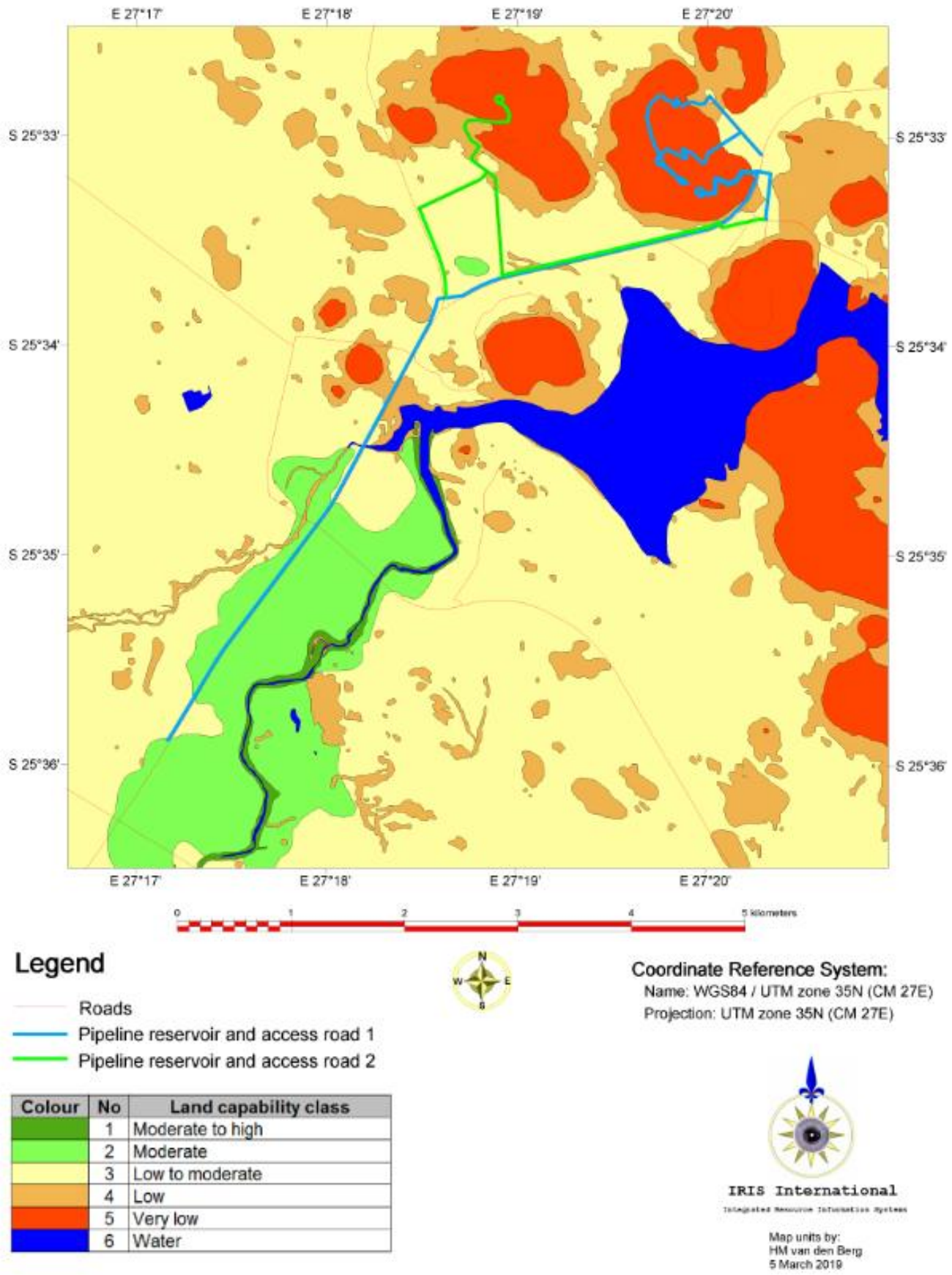


Figure 5. Land Capability map for the study area.

4.3. Sensitivity rating map

The sensitivity rating for the study area can be seen in Figure 6. Table 3 shows the area analysis.

Table 3. Area analysis of the sensitivity rating map.

.No	Sensitivity rating class	%	Area (ha)
1	High	0.6	33.6
2	Medium	67.9	3637.9
3	Low	25.1	1342.8
4	Water	6.4	343.1
	Total	**100.0**	**5357.4**

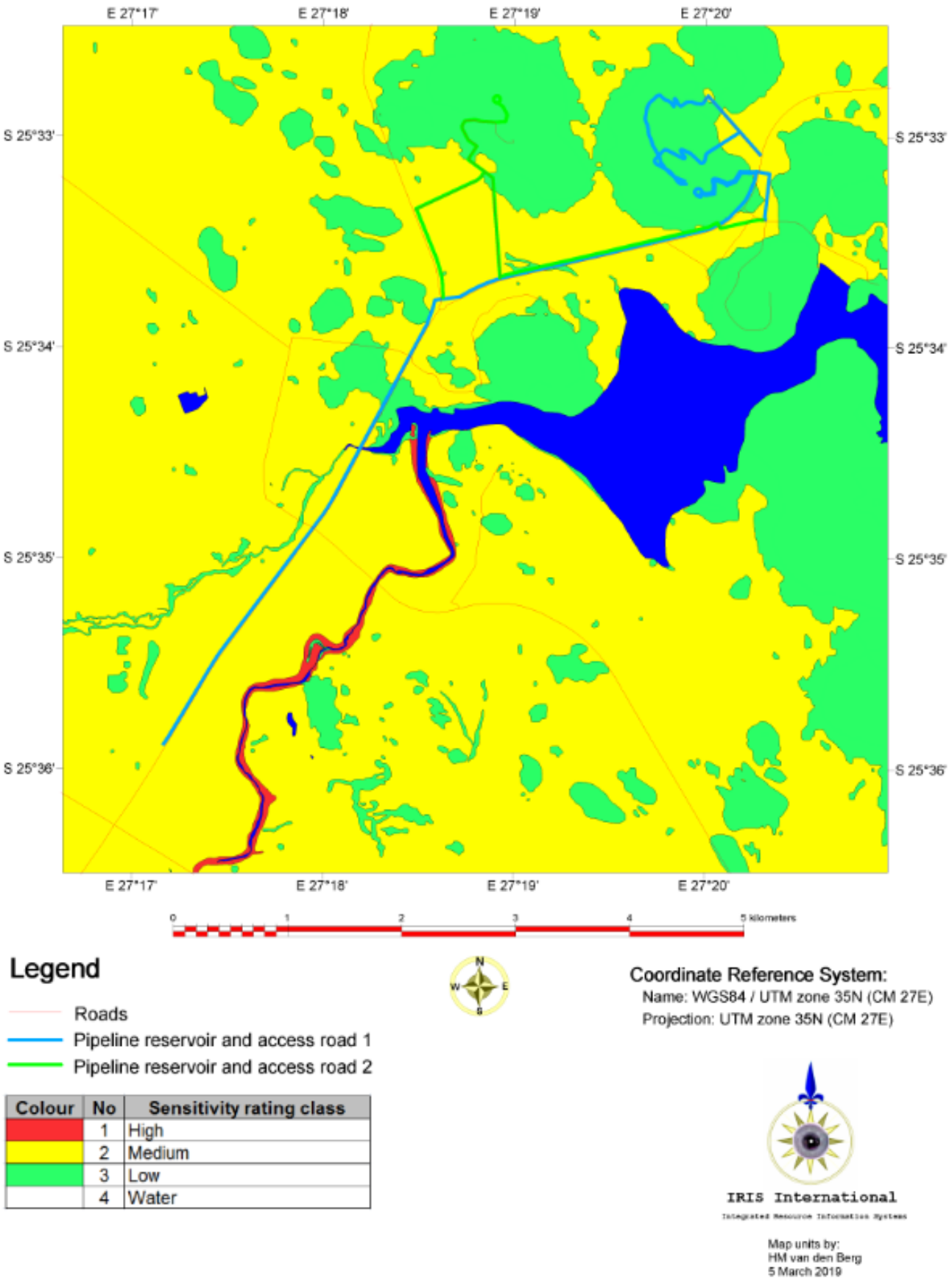


Figure 6. Sensitivity rating map for the study area.

5 DISCUSSION

The study area is dominated by the Arcadia soil form. Other dominant soil forms are Glenrosa, Swartland Valsrivier, Tukulu and Katspruit for their mapping units. Sub dominat soil forms are Rensburg, Oakleaf. Sepane, Arcadia, Valsrivier and Mispah. The very steep areas of the study area are dominated by a soil and rock complex with extremely shallow soils.

Some donga erosion has been observed along the Hexrivier. The agricultural potential for dry land crops is generally low due to the high clay content soils that are physiologically dry soils that retain a significant moisture component that is not available to plants. This is aggravated by the unpredictable moderate rainfall of the area. The highest soil potential is represented by the deep Tukulu and Oakleaf soil forms. However, these soils are mostly along a narrow band next to the Hexrivier and no agricultural or other development should take place here due to the possibility of soil erosion and proximity to the river. The proposed pipelines, reservoirs and access roads will not cross these soils.

The Arcadia mapping unit with sub dominant Rensburg and Valsrivier (not red) soil forms covers 60% of the study area. These soils are problematic for the development of infrastructure due to the very high clay content of around 50%+ and very strong swelling and shrinking properties and very slow infiltration rate when wet. Inherently these soils are very fertile and provides for good grazing.

The soil and rock complex is the next largest mapping unit (11%) and represent the koppies in the study area and have generally very steep slopes. The red Valsrivier mapping unit (8%) is mainly covered by settlements. This unit has the highest agricultural potential for the study area but as it is already mostly built-up land it is more suitable for small-scale back yard crop production under irrigation. The rest of the study area is covered by low potential soils (e.g. Katspruit, Glenrosa and Swartland) for crop production.

6 ACKNOWLEDGEMENTS

The contribution of the following person assisting with fieldwork for the soil survey and base data preparation is acknowledged:

Soil and GIS technician: Lourens Janse van Rensburg.

APPENDIX B

Digital data and print maps

The following A3 soft copy print maps were produced and are part of this report:

- A3 map - Soil map Bospoort
- A3 map - Land capability map Bospoort
- A3 map - Sensitivity rating map Bospoort

The following shape and TIFF files were produced and are part of this report:

- Soil map Bospoort - UTM35N
- Soil observations - point data - Geographic
- Land capability map Bospoort - UTM35N
- Sensitivity rating map Bospoort - UTM35N

APPENDIX C

CV - HM van den Berg

Hennie van den Berg
IRIS International
20 Boom Street
Potchefstroom
2531
South Africa
Tel.:+27 (0) 18 2976287
Fax.:+27 (0) 88 018 2976287
Cell.: +27 (0) 82 8781760
e-mail: hennievdb1@gmail.com

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IRIS International specialises in the application of the latest technology to characterize the spatial distribution of natural resources. Remote sensing and GIS technologies are applied in mapping and spatial modelling applications. Custom-made solutions are provided for packaging, distribution and retrieval of spatial data. National and international networking creates synergy for a multidisciplinary approach. Currently IRIS International employs a number of part time specialists on project demand.

IRIS International has extensive experience in the mapping and modelling of natural resources. Remotely sensed data and other spatial data layers are integrated in a GIS environment and supported by relevant fieldwork. Experience gained over the past 28 years includes:

- Soil and vegetation modelling and mapping
- Natural resource auditing
- Land-cover mapping
- Vegetation biomass estimations

- Terrain-mobility analysis for military applications
- DEM correction, terrain morphological mapping and hydrological modelling
- Mineral exploration
- The creation of electronic data atlases
- Spatial sampling designs and accuracy assessment of spatial data
- Project management for large projects
- Remote Sensing and GIS training - nationally and internationally
- Map composition and spatial data creation / integration
- Presentation of research work at various national and international conferences, seminars, workshops and exhibitions
- Scientific publications
- International networking

Projects from 2002-2019:

- Project management and technical assistance to the National Land-Cover 2000 project – NLC 2000. The duties included technical consortium member evaluation and selection, acting project leader, edge-matching of classifications, quality control, training and accuracy assessment. CSIR and ISCW NLC 2000 project consortium, South Africa.
- The mapping of natural resources (soils and vegetation) and land-cover for 5 provinces (30 million ha) in Angola at a 1:50 000 - 1:100 000 scale.
- The creation of electronic data atlases for several regions in Angola.
- The compilation of Rural Rapid Appraisal (RRA) maps for a number of municipals in southern Angola.
- Technical assistance for natural resource auditing in development nodes 1 and 4 in South Africa.
- Digital and hard copy vegetation map creation for the greater St. Lucia Wetland Park (South Africa) - EcoTrust.
- Geo-rectification of MSS satellite imagery for the National Department of Agriculture – South Africa.
- Geo-rectification of Landsat ETM and ASTER data for vegetation mapping for a number of farms close to Ghanzi in Botswana - space-map compositions.
- Space-maps for updating the vegetation types of the Kgalagadi Transfrontier Park (South Africa and Botswana).
- Digital vegetation map, area analysis and map compositions for the KGNP
- Digital vegetation map, area analysis and map compositions for several private game reserves (including Phinda, Ithala and Timbavati) - EcoTrust.
- Digital vegetation map, area analysis and map compositions for the Roggeveld region in the Northern and Western Cape - Department of Botany University of Pretoria
- High-resolution land-cover, land-use and transformation mapping for EIA studies (South Africa).
- Terrain mobility assessment for Africa on various scales – SANDF peacekeeping operations.
- *Ad hoc* space map compilation, and digital map creation for vegetation surveys – various areas in South Africa.
- Ortho-rectification of QuickBird imagery for a number of towns in Angola.

- Ortho-rectification of 140 SPOT 4 and 2 images for South Africa.
- Ortho-rectification of Landsat TM images covering the whole of Namibia.
- Hydrological modelling for Porto Amboim (Angola).
- DEM correction and hydrological modelling for the Cape floristic region and California (USA).
- Soil modelling for the Katse and Mohale catchments in Lesotho.
- Characterization of the agricultural potential of Tchiange and Uaba areas in Angola.
- Desktop study on natural resources – sugar production in the Cunene province in Angola.
- Aerial photo mosaic's for a number of farms in South Africa and Botswana (including contour generation and the creation of digital atlases).
- Transformation mapping of forests, woodlands and sensitive ecosystems in Angola (national project).
- Conservation potential studies and desktop mapping for the Tundavala area (Angola).
- The mapping and characterization of natural resources in Namibe province in Angola – ongoing assistance for a PhD study.
- MODIS biomass monitoring for Northwest Province – SA.
- MODIS biomass monitoring for Kuanza Sul and Malange provinces.
- Habitat modelling for the Molopo area.
- Sampling frame for a national alien vegetation survey in Swaziland.
- Vegetation and habitat modelling for Bezuidenhoutshoek private game range.
- Vegetation and habitat modelling for Crock River Gorge conservancy.
- Vegetation and habitat modelling for Sabie Sand game reserve.
- Biomass mapping for power line routing (Delta Epsilon project – Enviro Pulse, PBA and ESKOM 2009).
- Soil modelling and mapping for 3 tertiary catchments in South Africa (3.5 million ha).
- Soil modelling and mapping for KZN and parts of adjacent provinces (15 million ha on 1:100 000 scale) – National Dept of Agriculture .
- Land-Cover mapping for the Free State Province SA (2010-2011).
- Detailed soil mapping for an area of more than 3 000 ha in the Kuanza Sul province of Angola for an irrigation scheme feasibility study (2009-2011).
- Extensive digital elevation data correction for an area of more than 3 000 ha in the Kuanza Sul province of Angola for an irrigation scheme feasibility study (2009-2011).
- National dry-land cotton and maize production potential modelling for Angola (2010-2011).
- Hydrological correction of SRTM digital elevation data for South Africa, Swaziland and Lesotho and full catchment areas stretching into Zimbabwe, Botswana and Namibia – Water Research Commission project (2009-2011).
- Geological feature mapping for study areas in Liberia and the Congo (2011) - Southern Mapping Company.
- Image geo-rectification for Rakodzi, Sable and Springvale farms in Zimbabwe (2011).
- View sheds from the SRTM Digital Elevation Model for southern Africa - SKA telescope project (2011)

- Semi detail soil mapping (2 000ha) for the Nkomazi area (2011).
- Land-cover mapping for the Upper Orange River catchment (31 SPOT 5 images – 2011).
- Iron deposit probability mapping for the Melmoth area – Southern Mapping Company (2011).
- Field maps and burn management map compositions for Alicecot, Inyati and Ulusaba - Sabie Sand Game reserve (2011).
- Biodiversity, habitat land-use mapping for Jagtlust – Mpumalanga (2011) – joint project with EnviroPule.
- Fire scar mapping for 3 seasons Pilanesburg National Park and surrounding areas (2011).
- Evelyn vegetation map composition – (2012) Department of Botany University of Pretoria
- Map compositions to show the area affected by the 2011 veld fire for 3 study areas (Amalia, Ventersdorp and Bodibe) NW University (2012)
- Habitat, bush density and biomass maps for the Mier and Khuis areas (Kalahari Namib project) – NW University (2012).
- Map compositions for the Amalia, Ventersdoerp and Bodibe areas affected by the 2011 veld fire) – NW University (2012).
- Geological feature mapping for study areas in the DRC – Southern Mapping Company (2012).
- Flood analysis for a catchment in the Central African Republic – Southern Mapping Company (2012).
- Soil and vegetation mapping for the SASOL Sasolburg and Secunda conservation and farming areas – joint project with EnviroPulse (2012).
- Geological feature mapping and target mineral probability mapping and modelling for a study area in Madagascar – Southern Mapping Company (2012).
- Kloof Driefontein Complex - East vegetation map composition – (2012) Ecotrust
- Geological feature mapping for a study area in Sudan – Southern Mapping Company (2012).
- SKA -telescope core area flood risk mapping – Southern Mapping Company (2012)
- Vegetation map compilations Roodepoort – EnviroPulse (2012)
- Black Eagle Valley map composition - Heli Trace Trust (2012)
- Congo - Sintikoula vegetation map composition - FLORA FAUNA & MAN, Ecological Services Ltd (2012)
- Mineral exploration in Madagascar using multi-spectral and hyper-spectral satellite imagery - Southern Mapping Company (2013)
- Soil and terrain survey for the Wonderwater mine rehabilitation - SASOL (2013)
- Wetland mapping for Kruger, Marekele and Mapungubwe National Parks - IP (2013)
- Land-use change mapping for the period 1985-2010 Congo Mayoko Exxaro study area (2013)
- Hinda land-use change mapping for the period 1990 - 2014 Congo - FLORA FAUNA & MAN, Ecological Services Ltd. Dr. Jerome Gaugris (2014)

- Soil mapping (project manager and coordinator) in the Kilombero valley in Tanzania (52 000 ha semi-detail) – Southern Mapping Company and CDM Smith International (USAID project) (2013 - 2015)
- Soil mapping in Angola for Fazenda Cristalina - Farmsecure/IrriCheck (2013-2014)
- Soil mapping for the Chrisiesmeer conservancy 185 000 ha - EnviroPulse (2013-2014)
- Vegetation condition mapping for the Mier area in the Northern Cape (NWU - 2015)
- BBK flood modelling. Flood modelling for the Pilanesberg and Bakgatla Ba Kgafela Traditional Administration areas - SATPLAN (2014/2015)
- Dish Mountain Project. Land use change mapping in Ethiopia - FLORA FAUNA & MAN, Ecological Services Ltd. Dr. Jerome Gaugris (2015)
- Dish Mountain Project. Field maps (Ecotrust, 2015)
- Weedy forbs mapping Sasolburg and Secunda rangeland and wildlife areas. SASOL and EnviroPulse (2015)
- One Tree-Hill soil and vegetation mapping assistance to EnviroPulse (2015)
- Consultancy to upgrade the AMESD Drought Monitoring System (DMS) (Software/application) for the Monitoring for Environment and Security in Africa (MESA) - RS/GIS consultant in collaboration with Dr Markus Metz of Geospatial Data Services - MESA SADC THEMA Grant Contract No. FED/2014/328-638 (2015).
- Secunda (SASOL plant and surrounding properties) detailed and simplified land cover maps.(SASOL, 2016)
- Weedy forbs mapping - 3 x focus areas Secunda (Enviropulse, 2016)
- Kathu Bushveld Kathu Bushveld study: research offset for first development phase of Adams Solar Energy Facility - Mapping of habitat and vegetation types and woody density mapping for 1.4 million ha. (2014-2016 - ENEL and Ecotrust)
- Pre-feasibility study: Habitat and ecological capacity assessments for the Catofe and Somue properties (Sociedade Agro-pecuaria, Sagrada Esperança, 2016)
- Potential alluvial gold deposit mapping - Utah, USA (Oremax and SWIFT Geospatial Solutions, 2017)
- Weedy forbs and veld condition trend mapping - 3 x focus areas Secunda (Enviropulse, 2017)
- Dunn Roman - Tea Estate, land-cover, frost risk and tea water stress mapping (2017 - Bongani Consulting)
- Borehole identification by satellite imagery and terrain analysis - Rietfontein (Shaun Harrop-Allin, 2017)
- Soil mapping for the 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 (Ecoleges and Soventix 2017)
- Vegetation map - Dish Mountain Project Ethiopia (FLORA FAUNA & MAN, Ecological Services Ltd., 2018)
- Construction of timeline and supporting images for Carolina farm dam development - Mpumalanga (DICK KERSLAKE FAMILY TRUST, 2018)
- Land-cover-use analysis - Dish Mountain Project Ethiopia (FLORA FAUNA & MAN, Ecological Services Ltd., 2018)

- Vegetation growth analyses for various locations in North West Province, RSA (Geolab, 2018 - ongoing project).
- High resolution multi-sensor developmental project - NW province (Gyrolag 2018 - ongoing project)
- Soil modelling - NW province and parts of Freestate- and Northern Cape provinces (Geolab, 2018 - ongoing project)
- Land-use analysis - Guinea land-use for periods 1994, 2002 and 2019 (FLORA FAUNA & MAN, Ecological Services Ltd., 2019)
- Rangeland early warning system for southern, central and western Angola (EDIFOX, 2019 - ongoing project)

Hendrik Marthinus (Hennie) van den Berg (Remote Sensing and GIS specialist, vegetation ecology and soil science)

Hennie has 28 years experience in natural resource applications using GIS and remote sensing technologies. He obtained M.Sc. in vegetation ecology from the University of Pretoria in 1993. He has extensive experience in stereoscopic interpretation of black and white aerial photographs and obtained in 1989 a postgraduate diploma (NWU) in terrain evaluation for military applications. From 1990 to 1995 he worked in the natural resource section of the Transvaal Region of the Department of Agriculture. Here he was given the opportunity to do digital image processing on SPOT and Landsat satellite data for natural resource characterization. He was employed in 1995 at the Geo-informatics division at the Institute for Soil, Climate and Water. He was project leader for the National Land-Cover and land-cover change-mapping projects at the Institute. He was also project leader and co-worker on various other projects integrating remotely sensed data with other spatial data for monitoring and mapping of natural resources. He specialized in spatial modelling, spatial sampling designs and accuracy assessment of spatial data. In the beginning of 2002 he formed IRIS International including strategic alliances with various specialists inside and outside South Africa.

Project management

Extensive experience in project management has been acquired over the past 28 years. Hennie has been project leader for various local, regional and international projects. Multidisciplinary teams have been managed and extensive liaison has been done with clients to develop and structure projects.