Hydropedological Assessment of the proposed Kopanya Solar Photovoltaic (PV) 2 Project

Thaba Chweu Local Municipality, Ehlanzeni District Municipality in the Mpumalanga Province, South Africa

03/11/2026

Prepared by:

The Biodiversity Company

Cell: +27 81 319 1225

Fax : +27 86 527 1965

info@thebiodiversitycompany.com

www.thebiodiversitycompany.com

Report Name	**Hydropedological Assessment of the proposed Kopanya Solar Photovoltaic (PV) 2 Project**	
Specialist Theme	Hydropedological Assessment	
Project Reference	Kopanya Solar PV 2 Project	
Report Version	03/11/2026	
Environmental Assessment Practitioner	GCS Environment South Africa	
Technical Support	Andrew Husted (SACNASP 400213/11)	
Responsible specialist	Matthew Mamera (SACNASP 116356)	
Declaration	The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the Environmental Impact Assessment Regulations, Amended. We have no conflicting interests in the undertaking of this activity and have no interest in secondary developments resulting from the authorisation of this project. We have no personal stake in the project, other than providing a professional service within the constraints of the project (timing, time, and budget) based on the principals of science.	

Executive Summary

The Biodiversity Company was appointed to undertake a Level 2 hydropedological assessment in support of the Integrated Water Use Licence Application for the proposed Kopanya Solar PV 2 Project near Mashishing, within the Thaba Chweu Local Municipality, Mpumalanga. The assessment covered the 20 MWAC solar PV facility and associated infrastructure, with the primary objective of identifying dominant hillslopes and conceptualising hillslope hydrological responses relevant to water-resource management and wetland protection. The approach included a desktop review and field verification, with eight representative transects surveyed across the site and soils classified to family level, incorporating wetland delineation data.

The assessment identified a mix of recharge, recharge-slow, and responsive-wet hydropedological conditions. Upland and midslope areas are dominated by well-drained recharge soils (Mispah, Glenrosa, Hutton, Nkonkoni, and Vaalbos forms), supporting vertical flow and groundwater recharge, while valley-bottom areas include Tubatse and Katspruit soils, associated with slower recharge and prolonged saturation, resulting in overland flow and greater hydrological sensitivity. Four distinct hillslope hydrological patterns were identified, with most of the development footprint situated on recharge-dominated hillslopes, where the project is expected to have a limited effect on overall hillslope hydrology. However, localized impacts may arise from soil compaction, surface sealing, concentrated runoff, reduced diffuse infiltration, and altered lateral flow connectivity, particularly near lower-lying or responsive areas.

The report concludes that the proposed development will have acceptable and manageable hydropedological impacts, with a small reduction in recharge (estimated at 1%–3%) that is not expected to materially affect total streamflow or broader catchment functioning. The overall impact significance is reduced to low after mitigation, with sensitive valley-bottom and wetland-associated soils remaining the key receptors of concern. Key recommendations include minimising soil compaction, maintaining vegetative cover, using infiltration-promoting stormwater controls, establishing vegetated buffer strips, avoiding development within delineated wetland areas, preventing leaks or spills, and ensuring stormwater is managed to maintain infiltration. In conclusion, the specialist finds that the Kopanya Solar PV 2 Project can be authorised, as the predicted impacts on flow paths and catchment water regimes are minimal to acceptable post-mitigation and can be sustainably managed through appropriate design, siting, and operational controls.

Table of Contents

1 Introduction 1
1.1 Background 1
1.2 Project Description 1
1.2.2 Project Components 2
1.2.3 Project Area 6
1.3 Scope of Work 7
1.4 Assumptions and Limitations 7
2 Literature Review 8
2.1 Hydropedological Flow Paths 8
3 Methodology 10
3.1 Desktop Assessment 10
3.2 Field Procedure 10
3.2.1 Identification of Soil Types and Hydrological Soil Types 11
4 Results and Discussions 13
4.1 Desktop Information 13
4.2 Climate 13
4.2.1 Vegetation 14
4.2.2 Geology and Soils 15
4.3 Identified Soil Forms 19
4.4 Hillslope Hydrology 21
4.5 Conceptual Impact Prediction 25
4.6 Impact Assessment 28
4.6.1 Construction and Operation Phase 28
4.6.2 Decommissioning and Closure Phase 30
4.6.3 Mitigation Measures 31
5 Conclusion 33
5.1 Impact Statement 33
5.2 Specialist Opinion 34
6 References 35
7 Appendix A: Decision Tree for When and the Type of Hydropedological Assessment Required 36
8 Appendix B: Specialist Declaration 38

9 Appendix C: Curriculum Vitae 39

List of Tables

Table 3-1 Hydrological soil types of the studied hillslopes (van Tol et al., 2019) 11

Table 3-2 Revised hydrological soil types of the representative hillslopes (van Tol et al and Bouwer, 2024) 12

Table 4-1 Soils expected at the respective terrain units within the Ab 29 land type (Land Type Survey Staff, 1972 – 2006) 17

Table 4-2 Soils expected at the respective terrain units within the Ac 74 land type (Land Type Survey Staff, 1972 – 2006) 17

Table 4-3 Soils expected at the respective terrain units within the Ac 75 land type (Land Type Survey Staff, 1972 – 2006) 17

Table 4-4 Soils expected at the respective terrain units within the Fa 327 land type (Land Type Survey Staff, 1972 – 2006) 17

Table 4-5 Soils expected at the respective terrain units within the Fa 343 land type (Land Type Survey Staff, 1972 – 2006) 18

Table 4-6 Soils expected at the respective terrain units within the Ib 31 land type (Land Type Survey Staff, 1972 – 2006) 18

Table 4-7 Soils expected at the respective terrain units within the Ib 154 land type (Land Type Survey Staff, 1972 – 2006) 18

Table 4-8 Identified hillslope dominant soil forms and hydropedological groups 22

Table 4-9 Impact assessment of erosion due to increased overland flow on the environment 29

Table 4-10 Impact assessment of potential decrease in subsurface lateral flow and return flow on the environment 29

Table 4-11 Impact assessment of erosion due to increased overland flow on the environment 30

Table 4-12 Impact assessment of potential decrease in subsurface lateral flow and return flow on the environment 30

Table 4-13 Impact assessment of erosion due to increased overland flow on the environment 31

Table 4-14 Impact assessment of potential decrease in subsurface lateral flow and return flow on the environment 31

List of Figures

Figure 1-1 Map illustrating the layout of the proposed Project components 6
Figure 1-2 Spatial context of the proposed Project 7
Figure 2-1 Illustration of the interactive nature of hydropedology and its potential applications (van Tol et al., 2017) 8
Figure 2-2 Illustration of different hydropedological soil types (van Tol et al., 2017) 9
Figure 2-3 Illustration of different hydropedological soil types (van Tol et al., 2017) 10
Figure 3-1 Transects and Observation Sites 13
Figure 4-1 Summarised climate for the region (Mucina & Rutherford, 2006) 14
Figure 4-2 Illustration of land type Ab 29 terrain units (Land Type Survey Staff, 1972 - 2006) 15
Figure 4-3 Illustration of land type Ac 74 terrain units (Land Type Survey Staff, 1972 - 2006) 15
Figure 4-4 Illustration of land type Ac 75 terrain units (Land Type Survey Staff, 1972 - 2006) 16
Figure 4-5 Illustration of land type Fa 327 terrain units (Land Type Survey Staff, 1972 - 2006) 16
Figure 4-6 Illustration of land type Fa 343 terrain units (Land Type Survey Staff, 1972 - 2006) 16
Figure 4-7 Illustration of land type Ib 31 terrain units (Land Type Survey Staff, 1972 - 2006) 16
Figure 4-8 Illustration of land type Ib 154 terrain units (Land Type Survey Staff, 1972 - 2006) 16
Figure 4-9 Land types present within the proposed Kopanya Solar PV 2 Project`s surroundings 19
Figure 4-10 Soil forms and the respective soil families identified within representative hillslope transects 20
Figure 4-11 Diagnostic soil horizons identified on-site: A) Orthic topsoil with a neocutanic horizon. B-C) Orthic topsoil with a red apedal horizon. D) Orthic topsoil with a lithic horizon. E) Orthic topsoil with a hard rock layer below 21
Figure 4-12 Diagnostic soil horizons identified on-site: A-D) Orthic topsoil with a with gley subsurface horizons 21
Figure 4-13 Diagnostic soil horizons identified on-site: A-C) Examples of surface return/overland flows and lateral flows pathways 21
Figure 4-14 Hillslope hydrology one of four of the distinct hydropedological patterns prior to construction of the proposed Kopanya Solar PV 2 Project and associated infrastructure 23
Figure 4-15 Hillslope hydrology two of four of the distinct hydropedological patterns prior to construction of the proposed Kopanya Solar PV 2 Project and associated infrastructure 23
Figure 4-16 Hillslope hydrology three of four of the distinct hydropedological patterns prior to construction of the proposed Kopanya Solar PV 2 Project and associated infrastructure 23
Figure 4-17 Hillslope hydrology four of four of the distinct hydropedological patterns prior to construction of the proposed Kopanya Solar PV 2 Project and associated infrastructure 24

Figure 4-18 Hillslope hydrology one of four of the distinct hydropedological patterns after the construction of the Kopanya Solar PV 2 Project and associated infrastructure 26

Figure 4-19 Hillslope hydrology two of four of the distinct hydropedological patterns after the construction of the Kopanya Solar PV 2 Project and associated infrastructure 27

Figure 4-20 Hillslope hydrology three of four of the distinct hydropedological patterns after the construction of the Kopanya Solar PV 2 Project and associated infrastructure 27

Figure 4-21 Hillslope hydrology four of four of the distinct hydropedological patterns after the construction of the Kopanya Solar PV 2 Project and associated infrastructure 28

Table of abbreviations

Abbreviation/ Acronym	Full Meaning
AC	Alternating Current
APCV	Annual Precipitation Coefficient of Variation
ARC	Agricultural Research Council
BS Mine	Booysendal South Mine
DWS	Department of Water and Sanitation
EAP	Environmental Assessment Practitioner
e-houses	Electrical houses
ET	Evapotranspiration
GPS	Global Positioning System
GCS	GCS Environment South Africa (Pty) Ltd / GCS impact matrix methodology
ha	Hectares
HGM	Hydrogeomorphic
HGM	Hydrogeomorphic Unit
IWULA	Integrated Water Use Licence Application
km	Kilometres
Ks	Saturated Hydraulic Conductivity / Soil Hydraulic Conductivity
kV	Kilovolt
m	Metres
m^3	Cubic metres
MAP	Mean Annual Precipitation
MASMS	Mean Annual Soil Moisture Stress
MAT	Mean Annual Temperature
MFD	Mean Frost Days
MAPE	Mean Annual Potential Evaporation
mm	Millimetres
MPCA	Minnesota Pollution Control Agency
MWAC	Megawatt Alternating Current
NEM:WA	National Environmental Management: Waste Act

NPDES	National Pollutant Discharge Elimination System
OHL	Overhead Power Line
ºC	Degrees Centigrade / Degrees Celsius
PL	Power Line
PTY LTD / (Pty) Ltd	Proprietary Limited
PV	Photovoltaic
QR	Quick Response (code)
R540 / R36 / R37 / R577	Regional road numbers
SACNASP	South African Council for Natural Scientific Professions
SANBI	South African National Biodiversity Institute
SAS	Scientific Aquatic Services
STS	Scientific Terrestrial Services
TMU	Terrain Morphological Unit
W	Watts
WUL	Water Use Licence

1 Introduction

1.1 Background

The Biodiversity Company was appointed to conduct a specialist hydropedological level two (2) assessment for the Integrated Water Use Licence Application for the proposed Kopanya Photovoltaic (PV) 2 Project (the proposed Project). The proposed Project is located on Portion 8, 15 and 17 of Farm No. 53 JT, near Mashishing, within the Thaba Chweu Local Municipality, Ehlanzeni District Municipality in the Mpumalanga Province, South Africa. The proposed Project will comprise a solar PV facility and associated infrastructure.. The hydropedological site assessment was conducted on the 26th to 30th of January 2026. The hydropedological assessment was completed in fulfilment to obtain a Water Use Licence authorisation for the proposed Project.

This report should be interpreted in conjunction with the findings and recommendations provided by the specialist herein. It should inform and guide the Environmental Assessment Practitioner and regulatory authorities, enabling informed decision making regarding the management of water resources in relation to the proposed Project.

1.2 Project Description

The following has been provided by GCS Environment South Africa (Pty) Ltd.

1.1.1 Introduction

Booysendal Platinum (Pty) Ltd (the Applicant / Booysendal) proposes to develop the Kopanya Solar Photovoltaic 2 Project (the proposed Project), comprising a 20 megawatt alternating current (MWAC) utility-scale solar photovoltaic facility and associated infrastructure at the Booysendal South Mine in Mpumalanga Province. The proposed Project will be located within the existing Booysendal Mining Right held by Booysendal, a subsidiary of Northam Platinum Holdings Limited.

The proposed Project requires Environmental Authorisation (EA) in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA), read with the Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) Government Notice Regulation (GN R) 982 (EIA Regulations, 2014). A Basic Assessment (BA) process is being undertaken to assess potential environmental impacts and risks, consider reasonable and feasible alternatives, facilitate participation by interested and affected parties (I&APs) and relevant organs of state, and provide the competent authority with sufficient information to decide the application.

GCS Environment South Africa (Pty) Ltd (GCS) has been appointed as the independent Environmental Assessment Practitioner (EAP) responsible for managing the environmental assessment process, facilitating public participation and preparing the application documentation for submission to the Department of Mineral and Petroleum Resources (DMPR).

1.1.2 Project Background

The proposed Project will be located on Portion 8, the Remaining Extent of Portion 15 and Portion 17 of the Farm No. 53 JT, approximately 30 kilometres (km) west of Mashishing, within the Thaba Chweu Local Municipality and Ehlanzeni District Municipality. The proposed development footprint is approximately 41 hectares (ha).

The proposed Project will comprise up to approximately 35,000 bifacial photovoltaic panels mounted on single-axis tracking systems, together with an on-site substation, inverters, transformer stations, electrical houses, access and internal roads, operations and maintenance facilities, security and telecommunications infrastructure, and an overhead power line of up to 132 kilovolts (kV). A detailed Project description is provided in Section 2.

Electricity generated by the proposed Project will primarily supplement the electricity requirements of the Booysendal South Mine. The proposed Project forms part of Northam Platinum Holdings Limited's energy resilience and sustainability strategy.

1.1.3 Description of the Proposed Development

This section describes the principal components, supporting infrastructure and lifecycle activities associated with the proposed Project. The need and desirability of the proposed Project are assessed.

1.2.1.1 Project Overview

The Project comprises a 20 MWAC solar PV facility and associated grid connection and support infrastructure within the existing Booysendal South Mine. Electricity generated will primarily supply the Mine, with any surplus export subject to the applicable grid connection arrangements.

1.2.2 Project Components

1.1.3.1 Overview of the Proposed Facility

The facility will have an installed generation capacity of 20 MWAC and will integrate with existing mining and electrical infrastructure.

The proposed Project will utilise single-axis tracking bifacial solar photovoltaic panels to optimise solar exposure throughout the day. Locating the facility within an established mining area and using modular infrastructure may reduce the need for additional land disturbance.

1.1.3.2 Solar PV Arrays and Tracking System

The facility will comprise up to approximately 35,000 bifacial PV panels, each with a typical capacity greater than 600 watts (W), mounted on single-axis tracking systems to optimise energy yield.

The racking and tracking systems will be constructed from steel sections supported by driven piles, reducing the need for extensive concrete foundations and limiting ground disturbance. Panel structures will be designed to accommodate site-specific geotechnical conditions, wind loading, and long-term operational requirements.

1.1.3.3 Electrical Infrastructure and Grid Connection

The Project will include the following electrical and grid connection infrastructure:

- An overhead power line of up to 132 kV connecting the solar PV facility to the grid connection infrastructure;
- An on-site PV substation to collect and regulate electricity generated by the PV arrays;
- A substation adjacent to the existing Eskom substation; and
- Power transformer stations, inverters and associated electrical infrastructure housed in prefabricated units or electrical houses.

Electricity generated will primarily supply the Booysendal South Mine. Any surplus export will be subject to the final grid connection arrangements.

1.1.3.4 Temporary Construction Infrastructure

Temporary infrastructure required during the construction phase will include:

- A construction yard and laydown areas of approximately 1 ha;
- Site offices, storage areas, and temporary ablution facilities;
- Internal access roads and construction traffic routes; and
- Temporary services required to support construction activities.

Construction of the proposed Project is anticipated to occur over a period of approximately 15 months. At peak construction, an estimated 300 personnel will be employed, comprising skilled and semi-skilled labour associated with civil works, electrical installation, and commissioning activities.

1.1.3.5 Permanent Operational Infrastructure

Permanent operational infrastructure associated with the proposed Project will include:

- Buildings for operations, maintenance, control, and storage purposes;
- An operations and maintenance warehouse;
- Parking areas for operational staff and service vehicles; and
- Security facilities, including access control points.

The operational lifespan of the proposed Project is anticipated to be approximately 25 years, during which an estimated 20 personnel will be employed for routine operation, maintenance, and security functions.

1.1.3.6 Supporting Infrastructure and Services

Additional supporting infrastructure will include:

- Water-supply infrastructure and conservancy tanks for the collection of domestic wastewaters;
- Internal and access roads, linking the facility to existing Mine infrastructure;
- Security and access control infrastructure, including perimeter fencing of up to approximately 3 100 metres (m); and
- Telecommunications systems to support monitoring, control, and security operations.

Stormwater infrastructure will be designed to maintain natural drainage patterns, promote dispersed flow and infiltration, and prevent erosion, sedimentation and concentrated discharge into wetlands and drainage features. The final design may include vegetated swales, berms, energy dissipation measures, cross-drainage structures and sediment-control measures.

1.1.3.7 Water Requirements and Management

Water will be required during construction for dust suppression, concrete works and general construction activities. Total construction phase demand is estimated at approximately 1 790 m³.

Operational water demand, associated mainly with domestic use and routine maintenance, is estimated at approximately 518 m³/a.

Water will be sourced from existing authorised Mine supplies and/or boreholes. No new abstraction infrastructure is proposed, and water use will be managed in accordance with the Mine's water management procedures.

No process wastewater will be generated during normal operation. Domestic wastewater will be collected in conservancy tanks and removed by an appropriately authorised service provider for disposal at an approved facility.

1.1.3.8 Waste Management

Waste generated during construction, operation and decommissioning will be managed in accordance with the Mine's approved waste management procedures, the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008), and applicable good practice.

1.1.3.8.1 Construction Phase

During the construction phase, both non-hazardous and hazardous waste streams will be generated. Waste volumes are anticipated to be temporary and largely associated with civil works, installation activities, and workforce-related activities.

Non-hazardous waste will include:

- General domestic waste generated by construction personnel;
- Packaging materials associated with solar PV components, including wooden pallets, cardboard, plastics, polystyrene, and strapping materials;
- Scrap metal arising from mounting structures, tracker systems, cable trays, and minor steel off-cuts;
- Construction off-cuts, including electrical cabling, conduits and plastic materials;
- Minor quantities of inert waste, such as concrete residues generated during foundation works; and
- Damaged, defective, or broken solar PV panels arising from transport, handling, or installation activities.

Solar PV panels damaged during delivery or installation will be handled with care to prevent further breakage. Intact but defective panels will, where possible, be returned to the supplier under warranty agreements. Broken panels will be stored in a designated, secure area to prevent glass dispersion and environmental contamination. Panels suitable for recycling will be sent to appropriately authorised recycling facilities.

Hazardous waste generated during construction will be limited in volume and will include:

- Small quantities of waste fuels, oils and hydraulic fluids generated during the use and maintenance of construction vehicles and equipment;
- Oily rags, absorbent materials, used filters, and contaminated materials; and
- Empty containers that previously contained hazardous substances, such as oils, greases, and cleaning agents.

Hazardous waste will be stored in clearly demarcated, bunded areas with impermeable surfaces. Waste will be removed by appropriately registered or authorised service providers and taken to authorised facilities.

1.1.3.8.2 Operational Phase

Waste generation during the operational phase is expected to be minimal and largely associated with routine maintenance and administrative activities.

- Non-hazardous waste during operation will primarily include:
- Limited domestic waste generated by operational and maintenance personnel;
- Minor packaging waste associated with spare parts and replacement components; and
- Scrap metal and redundant components arising from maintenance activities.

Hazardous or potentially hazardous waste may include:

Used oils, lubricants, and cleaning materials associated with maintenance activities;

- Oily rags, absorbent materials and used filters;
- Damaged or replaced solar PV panels arising from storm events, mechanical failure, vandalism, or routine replacement; and
- Electrical components such as inverters or transformers containing oils or electronic parts.

Damaged, defective and end-of-life PV panels will be assessed and managed according to their condition and applicable waste classification requirements. Suppliers take-back, reuse and recycling will be prioritised where reasonably available, and panels awaiting removal will be stored in a secure, weather-protected area.

All operational waste will be collected, transported and disposed of in accordance with approved waste management procedures.

1.1.3.8.3 **Decommissioning Phase Waste**

At the end of the proposed Project's operational lifespan, the facility may be decommissioned, repowered, or refurbished. The decommissioning phase will generate both non-hazardous and hazardous waste streams associated with dismantling and removal of infrastructure.

Waste generated during decommissioning will include:

- Non-hazardous waste, such as dismantled equipment, scrap metal, concrete material, fencing, and general waste associated with infrastructure removal;
- Solar PV panels, including damaged, obsolete, or end-of-life panels and associated mounting structures and electrical components; and
- Hazardous waste, including electronic components, oils and other hazardous materials.

Solar PV panels removed during decommissioning will represent a primary waste stream. Functional panels may be reused, resold or incorporated into a repowering programme, while end-of-life panels will be prioritised for recycling to recover glass, aluminium frames and other reusable materials.

Electrical components, including inverters and transformers, will be assessed for potential refurbishment or recycling. Hazardous materials will be separated and managed in accordance with applicable waste legislation.

Decommissioning waste will be transported by appropriately registered or authorised service providers to authorised waste management or recycling facilities. Material recovery, reuse and recycling will be prioritised to minimise disposal to landfill.

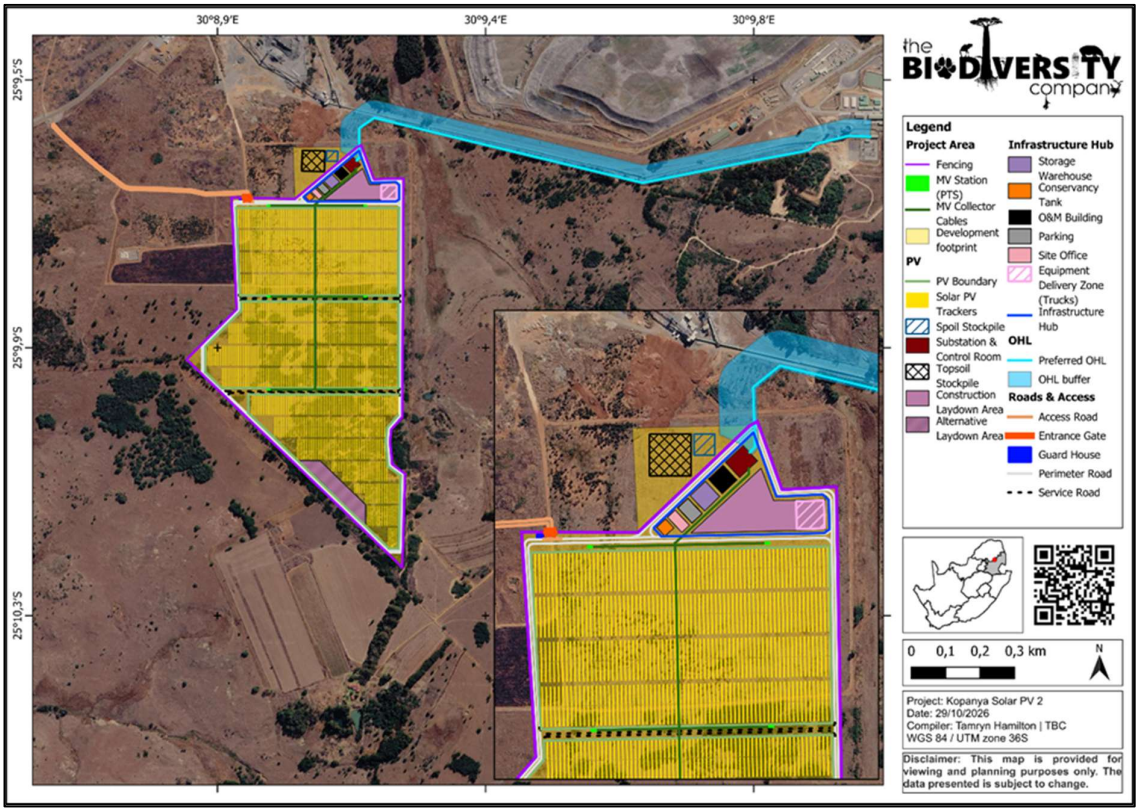


Figure 1-1 Map illustrating the layout of the proposed Project components

1.2.3 Project Area

The Project area is also approximately 14 km south east of the R540 regional road, 26 km south east of R36 regional road and 29 km north east of the R37 regional road. The surrounding land uses include mining activities, agricultural practices, and watercourses.

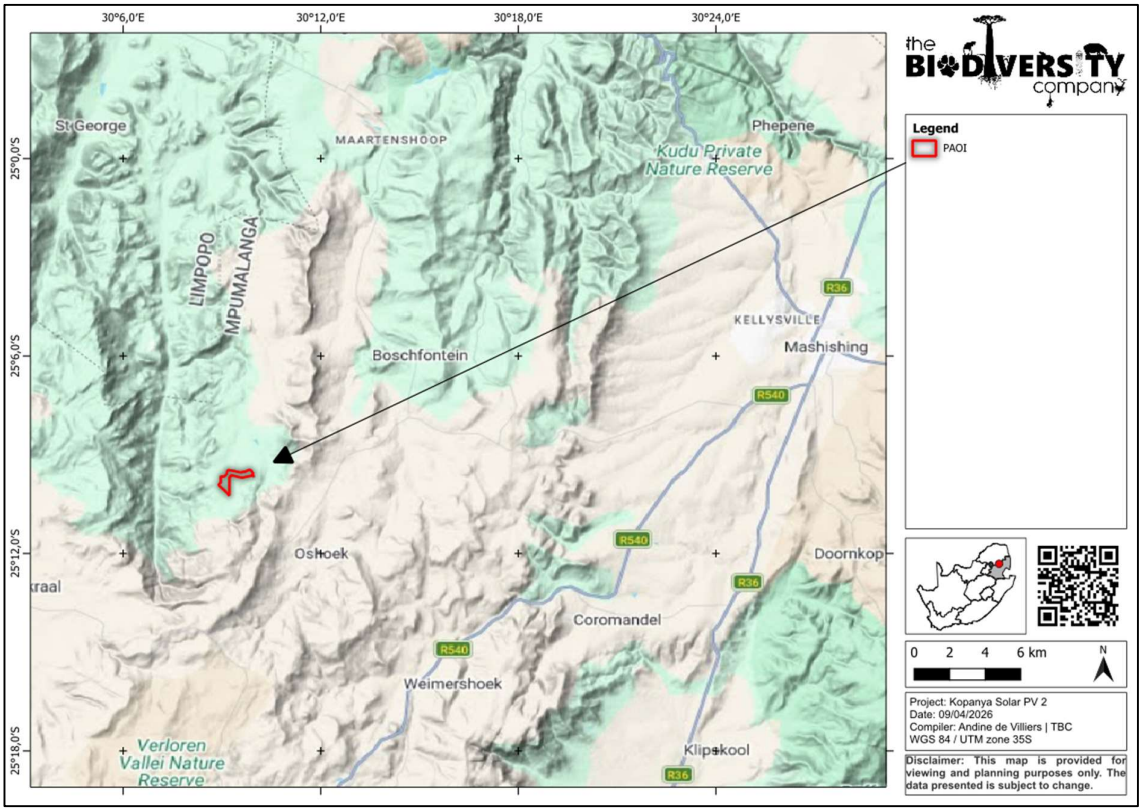


Figure 1-2 Spatial context of the proposed Project

1.3 Scope of Work

The approach of this assessment is based on the protocols compiled by van Tol *et al*., (2021) and issued by the Department of Water and Sanitation (DWS). According to these protocols, the following two steps are required for this level of hydropedology assessment:

1. Identification of dominant hillslopes; and
2. Conceptualise hillslope hydrological responses.

For impact assessments associated with activities that pose significant threats on the interflow volumes of a landscape or activities that are expected to drastically change the dynamics of a landscape (i.e., open cast mining), four steps are required. For those activities that only include minor impacts (i.e., installation of a pipeline or infrastructure), only the first two steps are required. Therefore, considering the intensity of the proposed Project activities, only the first two steps are relevant to this assessment.

Renewable energy facilities, such as solar facilities, require a basic hydropedological assessment because of their potential risk to local wetland functions based on hydropedological hillslope behaviour (see Appendix: Decision Tree for When and the Type of Hydropedological Assessment Required).

1.4 Assumptions and Limitations

The following aspects were considered as limitations:

- Only the slopes affected by the proposed Project have been assessed;
- It has been assumed that the extent of the Project area provided by the responsible party is accurate; and

- The Global Positioning System used for ground truthing is accurate to within 5 m. Therefore, the observation soil site's delineation plotted digitally may be offset by up to 5 m to either side.

2 Literature Review

2.1 Hydropedological Flow Paths

Given that hydropedology is a relatively new field, a short literature review has been added on this interdisciplinary research field. This literature is an excerpt from van Tol *et al*., (2017).

Soil physical properties and hydrology play significant roles in the fundamentals of hydropedology. Physical properties including porosity, hydraulic conductivity, infiltration etc., determine micro preferential flow paths through a soil profile. The hydrology in turn is responsible for the formation of various morphological processes in soil, including mottling, colouration, and the accumulation of carbonate.

These processes are used to construct models illustrating subsurface flow paths, storage, and interconnection between these flow paths. Hydropedology can therefore be used for a variety of functions. These functions include process-based modelling, digital soil mapping, pollution control management, impact of land use change on water resources, wetland protection, characterising ground and subsurface flows as well as wetland protection and rehabilitation, of which the latter will be the main focus during this report (see Figure 2-1) as they support effective water-resource management in relation to wetlands and subsurface flows..

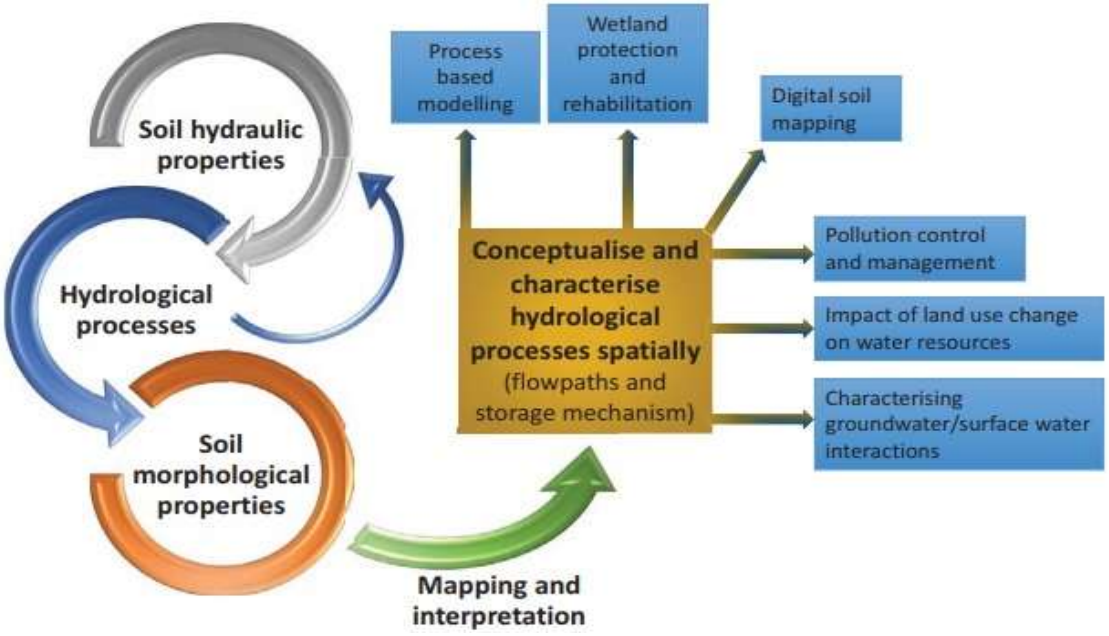


Figure 2-1 Illustration of the interactive nature of hydropedology and its potential applications (van Tol et al., 2017)

As can be seen in Figure 2-2, the hydropedological behaviour of soil types can differ significantly. Figure 2-2 (a) illustrates a typical red coloured soil (top- and subsoil). This soil type will typically have a vertical flow path throughout the soil profile. Water will therefore infiltrate the topsoil and freely drain into the profile to such an extent that the water rapidly reaches the bedrock. After reaching this layer, water will penetrate the ground water source or be transported horizontally towards lower laying areas. This soil type is known as a recharge soil, given its ability to recharge ground and surface water sources.

Figure 2-2 (b) illustrates interflow soils. Lateral flows are dominant in this soil type and occurs due to differences in the hydraulic conductivity of soil horizons. The "sp" soil horizon restricts vertical

movement and promotes lateral flows at the A/B interface. The lighter colour in this profile indicates leaching which is caused by lateral flows which often occurs on top of a bedrock layer due to the impermeable nature thereof. Mottles often occur above this impermeable layer due to fluctuating water levels, see the magnified illustration in Figure 2-2 (b-i).

Figure 2-2 (c) illustrates responsive soil. This hydropedological soil type is characterised (in this case) by a dark topsoil and a grey coloured subsoil. Other indicators include mottling and gleying. These soil types are saturated for very long periods. Therefore, rainfall is unlikely to infiltrate this layer and would likely be carried off via overland flow and are mostly fed by lateral subsurface flows. Shallow soils are equally responsive in the sense that the soil profile will rapidly be saturated during precipitation, after which rainfall will be carried off by means of overland flows.

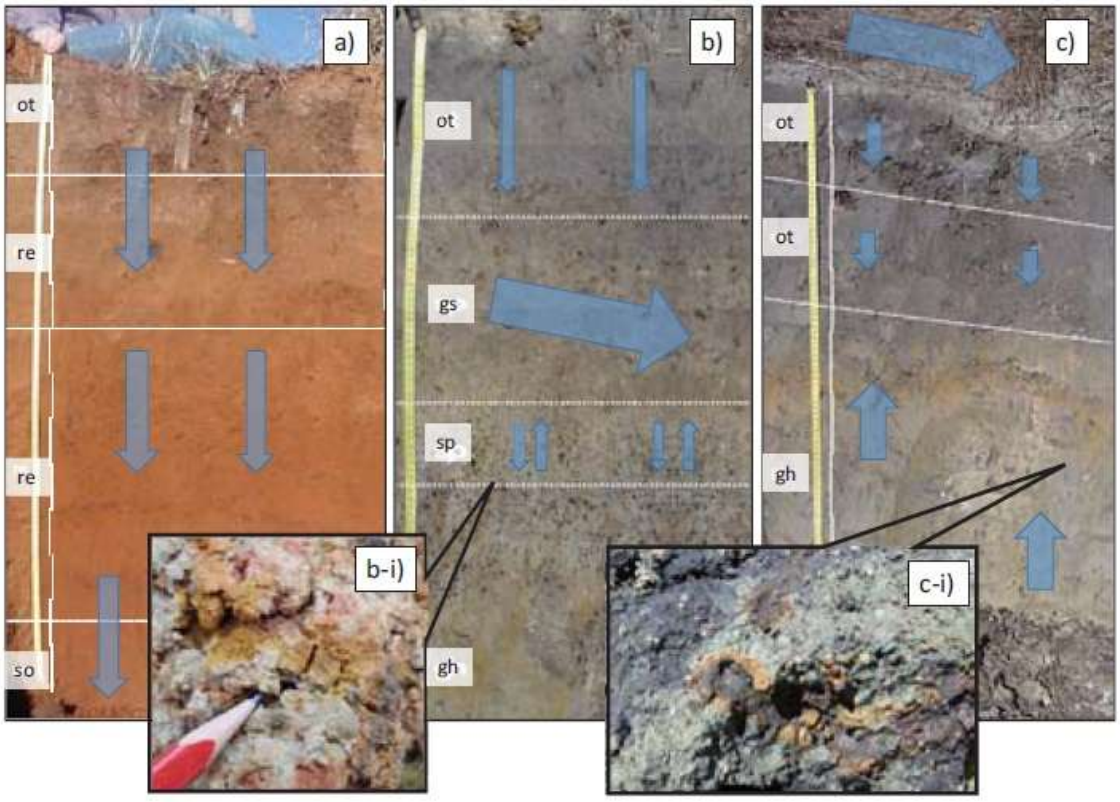


Figure 2-2 Illustration of different hydropedological soil types (van Tol et al., 2017)

A typical example of the hydropedological processes through a hillslope is illustrated in Figure 2-3. In this example, a recharge soil type is located at the upper reaches of the slope. Rainfall infiltrates this soil type and percolates vertically towards the bedrock. Water then, infiltrates into this bedrock given the permeability thereof and could now recharge groundwater or flow down-gradient towards soils in lower lying positions. The second soil type (the interflow zone) indicates lateral flows at the A/B interface and again at the soil/bedrock interface which feeds the responsive zone. The responsive zone is then simultaneously fed by lateral subsurface flows and ground water recharge.

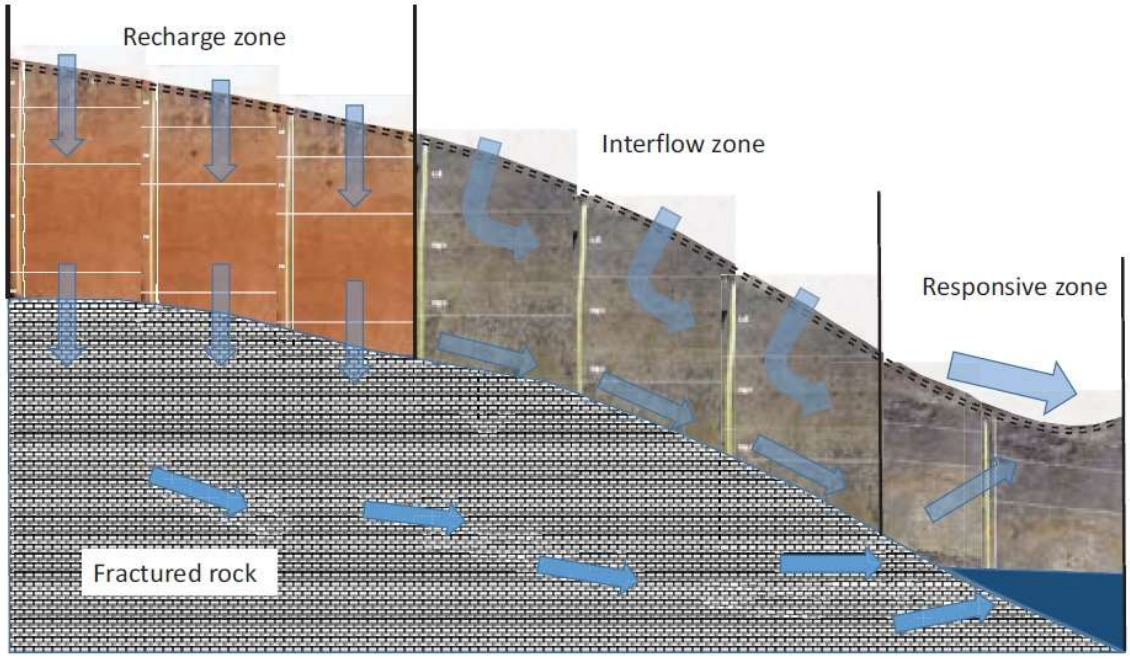


Figure 2-3 Illustration of different hydropedological soil types (van Tol et al., 2017)

The methodology of van Tol *et al.,* (2017) has since been updated to include a "stagnant" hydropedological type. According to van *Tol et al.,* (2019), four different hydropedological types exist, namely Recharge, Interflow, Responsive and Stagnating hydropedological types. These soil types are divided into seven subgroups depending on the morphology of the relevant soil form. The latest addition to this methodology, as mentioned, is known as a stagnating hydropedological type.

This soil type is characterised by restrictive movement of water through profiles (both laterally and vertically) and is dominated by evapotranspiration. The A- and B-horizon of such a soil type usually has a high permeability with morphological indicators indicating very little movement through the profile. Lime and iron concretions as well as cementation of silica are typical indicators of such a soil form.

3 Methodology

3.1 Desktop Assessment

The following information sources were considered for the desktop assessment:

- Aerial imagery (Google Earth Pro);
- Land Type Data (Land Type Survey Staff, 1972 - 2006);
- Topographical river line data;
- Contour data (5 m); and
- Mucina & Rutherford (2006).

3.2 Field Procedure

The slopes within the Project area have been assessed during the desktop assessment to identify possible transects (Figure 3-1) that will represent typical terrain and soil distribution patterns. These locations were then altered slightly during the survey depending on the extent of vegetation, slopes,

access, and any features that will improve the accuracy of data acquired. Eight (8) representative transects were sampled with a hand soil auger. Each sampling point was augured to a minimum depth of 1.2 m where possible depending on the profile depth or to the available parent material substratum layer. Hillslopes were selected based on the available varying land types of terrain units with the sub-basin catchment of influence. Each representative hillslope transects had three (3) sampling sites, at the crest (TMU1-2), midslope (TMU 3-4) and valley bottoms (TMU 5). It is worth noting that, spacing between the sampling sites is variable, the only important part is that the points must coincide with any sampling area within the three (3) respective terrain units (crest, midslope and footslope/Vallely bottom). Soils were classified to their soil family level following the Soil Classification Working Group, (2018). Wetland delineation data was used to identify areas receiving water from the representative hillslopes in the catchment of influence.

3.2.1 Identification of Soil Types and Hydrological Soil Types

Soil types have been identified according to the South African soil classification system (Soil Classification Working Group, 2018) (see Figure 4-9) after which the link between soil forms and hydropedological response were established (van Tol & Le Roux, 2019), and the soils regrouped into various hydropedological soil types as shown in Table 3-1 and the revised updated hydropedological soil types (van Tol and Bouwer, 2024) in Table 3-2.

Table 3-1 Hydrological soil types of the studied hillslopes (van Tol et al., 2019)

Hydrological soil type	Description	Subgroup	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with limited contribution to evapotranspiration or deep freely drained soils with significant contribution to evapotranspiration.	Shallow	
		Deep	
Interflow (a/b)	Duplex soils where the textural discontinuity facilitates build-up of water in the topsoil. Duration of drainable water depends on rate of Evapotranspiration (ET), position in the hillslope (lateral addition/release) and slope (discharge in a predominantly lateral direction).	A/B	
Interflow (soil/bedrock)	Soils overlying relatively impermeable bedrock. Hydromorphic properties signify temporal build of water on the soil/bedrock interface and slow discharge in a predominantly lateral direction.	Soil/Bedrock	
Responsive (shallow)	Shallow soils overlying relatively impermeable bedrock. Limited storage capacity results in the generation of overland flow after rain events.	Shallow	
Responsive (saturated)	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation excess.	Saturated	
Stagnating	In these soils outflow of water is limited or restricted. The A and/or B horizons are permeable but morphological indicators suggest that recharge and interflow are not dominant. These includes soils with carbonate accumulations in the subsoil, accumulation and cementation by silica, and precipitation of iron as concretions and layers. These soils are frequently observed in climate regions with a very high evapotranspiration demand. Although infiltration occurs readily, the dominant hydrological flow path in the soil is upward, driven by evapotranspiration.		

Table 3-2 Revised hydrological soil types of the representative hillslopes (van Tol et al and Bouwer, 2024)

Hydrological soil type	Description		Subgroup	Symbol
Recharge	Soils without any morphological indication of saturation. Vertical flow through and out the profile into the underlying bedrock is the dominant flow direction. These soils can either be shallow on fractured rock with limited contribution to evapotranspiration or deep freely drained soils with significant contribution to evapotranspiration.	These soils can either be shallow on fractured rock with limited contribution to evapotranspiration	Shallow	
		Deep freely drained soils which can contribute significantly to evapotranspiration	Deep	
		Soils with high clay contents and low conductivity	Slow	
Interflow	Three types of interflow soils occur, those where interflow is dominant at the A/B horizon interface, those where interflow is dominant at the soil/bedrock interface and those with morphological indicators of periodic saturation, but low hydraulic conductivities will limit significant flow through these soils.	This type occurs in duplex soils where the textural discontinuity facilitates build-up of water in the topsoil	shallow	
		Freely drained soils overly relatively impermeable bedrock. Hydromorphic properties signify periodic saturation associated with a water table at the soil bedrock/interface	Deep	
		Actual flow volumes and lateral transport is minimal as most of the water is either stagnant or evapotranspirated before it could make a significant contribution to streams or wetlands in lower lying positions.	Slow	
Responsive	Soils with morphological evidence of long periods of saturation. These soils are close to saturation during rainy seasons and promote the generation of overland flow due to saturation excess.	These soils 'respond' quickly to rain events and typically generate overland flow. These soils can either be shallow and overly relatively impermeable bedrock, with limited storage capacity which is quickly exceeded following a rain event	Shallow	
		They are soils with morphological indications of long periods of saturation. Since these soils are close to saturation during the rainy season additional precipitation will typically flow overland due to saturation excess	Wet	
		Soils with crusts or very low surface infiltration rates will promote overland flow due to infiltration excess, also known as Hortonian overland flow.	Hortonian	

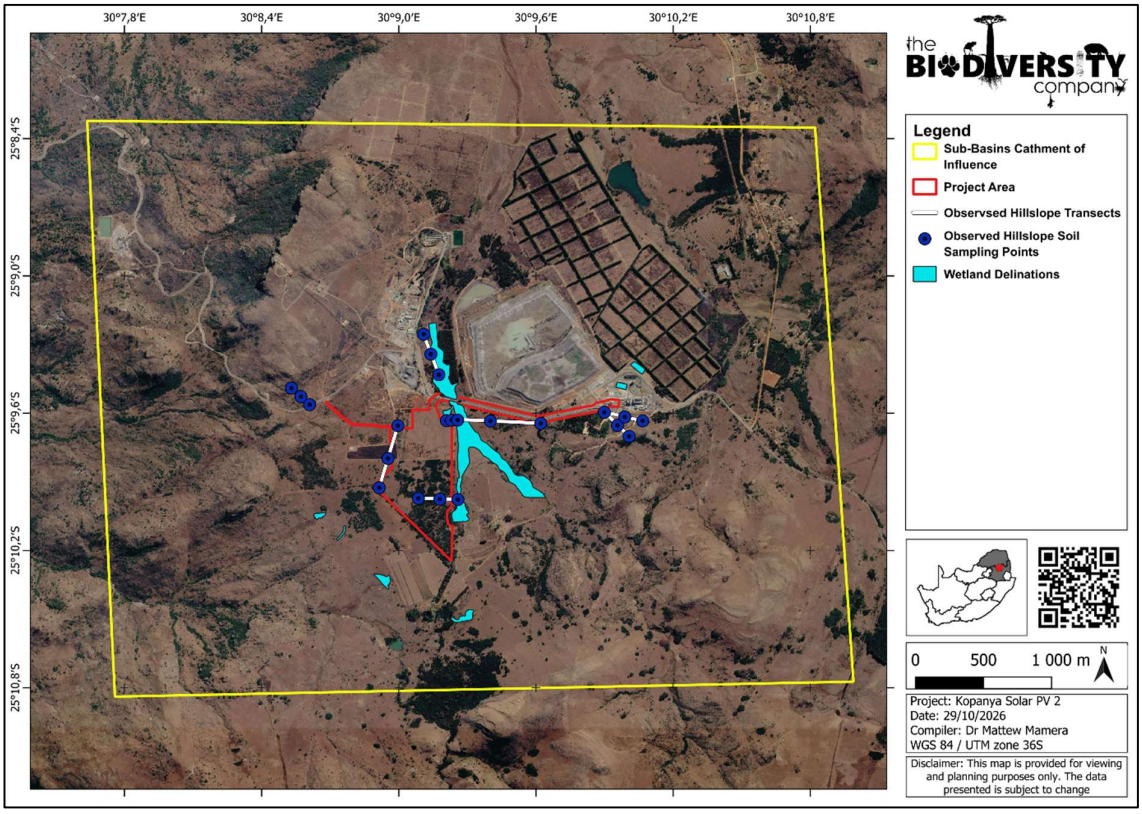


Figure 3-1 Transects and Observation Sites

4 Results and Discussions

4.1 Desktop Information

4.2 Climate

The Project area falls within the Lydenburg Montane Grassland, Sekhukhune Montane Grassland and Sekhukhune Montane Bushveld vegetation (see Figure 4-1). It is characterised with summer rainfall, with very dry winters. The proposed Project area falls within the summer rainfall regime with the Mean Average Precipitation) from about 720 millimetres (mm) in the east to 600 mm in the west, much of the rain falling in the form of thunderstorms in summer from November to January. Mean daily temperature ranges from a minimum of 2.8 degrees Centigrade (ºC) in winter to a maximum of 24.9 ºC in summer. Daily temperatures vary considerably at different localities, with higher temperatures on the plains and lower temperatures on higher-lying plateaus (Mucina & Rutherford, 2006; and South African National Biodiversity Institute, 2006- 2024; see Figure 4-1).

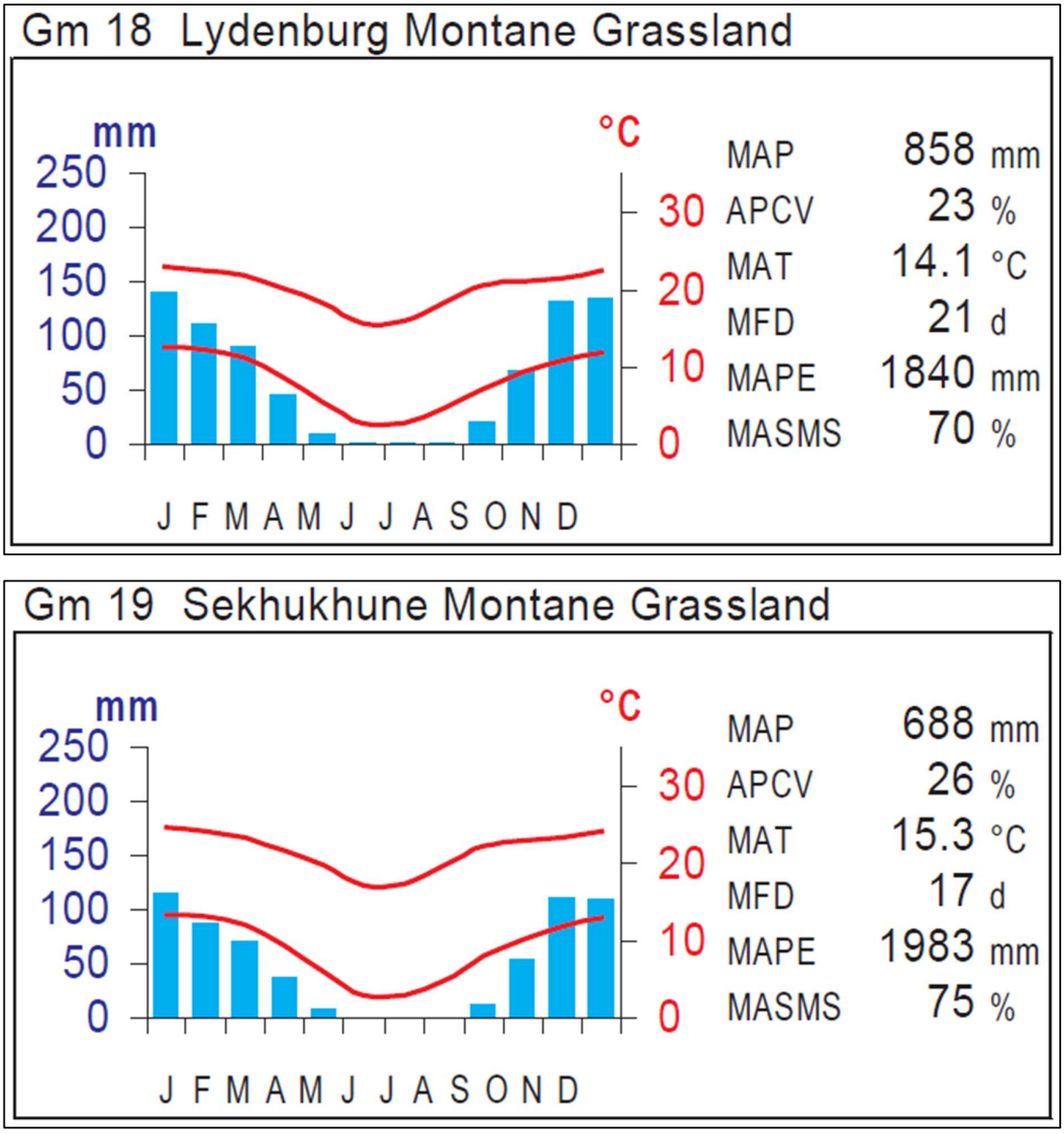


Figure 4-1 Summarised climate for the region (Mucina & Rutherford, 2006)

4.2.1 Vegetation

The proposed Project area falls within the Lydenburg Montane Grassland, Sekhukhune Montane Grassland and Sekhukhune Montane Bushveld vegetation. The proposed Project area falls within the Mpumalanga Province. In the region has continuous undulating norite hills in the Roossenekal region, from Stoffberg in the south, northwards through Mapochs Gronde to Schurinksberg in the north, with Steelpoort River in the west. The area has an altitude ranging 1 300 to 1 960 m (Mucina & Rutherford, 2006).

The landscape features mainly include major chains of hills which transect the area and have a north-south orientation, creating moderately steep slopes with predominantly eastern and western aspects. Large norite boulders and stones cover the shallow soils on the hillsides. Dense, sour grassland occur on slopes of mountains and undulating hills, with scattered clumps of trees and shrubs in sheltered habitats. Turf and clay soils characterise the open plains between the chains of hills and culminate in

an open plain in the Stoffberg area. Dense, tall grassland is found on the plains and encroachment by indigenous or invasion by alien microphyllous tree species is common in places (Mucina & Rutherford, 2006).

4.2.2 Geology and Soils

The geology of the area overlies the mafic intrusive rocks of the Upper and Main Zones of the Rustenburg Layered Suite, which is economically the most important part of the Bushveld Igneous Complex (Vaalian Erathem). Substrates of the undulating hills are generally heterogeneous rocky areas with miscellaneous soil types and those of the southern plains have diagnostic horizons that are vertic, melanic or red-structured. The dominant soil forms in this geology have high clay content and include Arcadia, Mayo, Milkwood, Mispah, Shortlands and Steendal. The dominant land type includes Ea land type which covers 40% of the area with minor occurrences of Ib and Ab.

According to the land type database (Land Type Survey Staff, 1972 - 2006) the transects relevant to the proposed Project are located in the Ab 29, Ac 74, Ac 75, Fa 327, Fa 343, Ib 31 and Ib 154 land types. The Ab 29, Ac 74 and Ac 75 land type mainly consist of Arcadia, Bonheim, Hutton, Shortlands, Clovelly and Katspruit soil forms with the occurrence of bare rocks and other soils within the landscape. The Fa 327, Fa 343 land types are commonly characterised with Hutton, Oakleaf, Glenrosa and Willowbrook soil forms with rocky areas as well as other soils. The Ib 31 and Ib 154 land types are commonly characterised with Clovelly, Swartland, and Katspruit soil forms with rocky areas as well as other soils also occurring in the terrain according to the Soil Classification Working Group, (1991). The Ab and Ac land type is characterised by red-yellow apedal, freely drained soils with dystrophic and/or mesotrophic properties. The Fa land types are characterised by Glenrosa and/or Mispah forms (other soils may occur); lime rare or absent in upland soils but generally present in low-lying soils. The Ib land types are characterised with miscellaneous land classes and soils with rocky areas. The relevant land types of terrain units for the Ab 29, Ac 74, Ac 75, Fa 327, Fa 343, Ib 31 and Ib 154 land types are presented below.

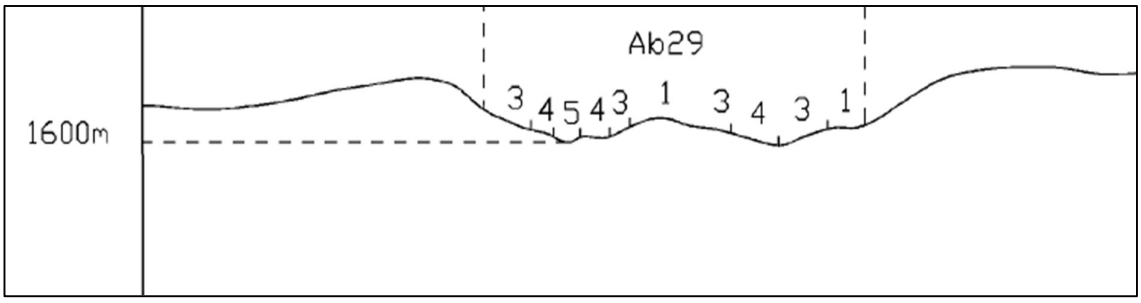


Figure 4-2 Illustration of land type Ab 29 terrain units (Land Type Survey Staff, 1972 - 2006)

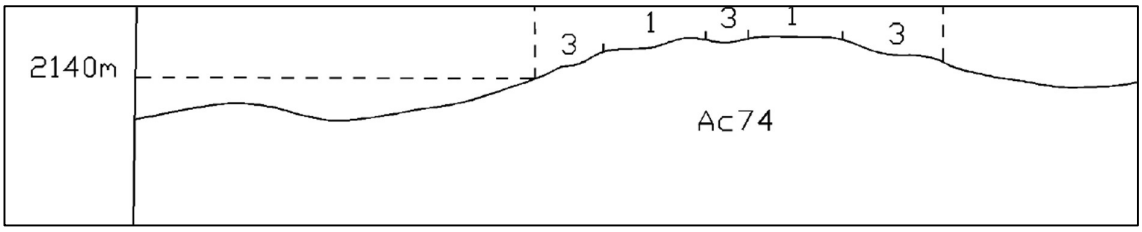


Figure 4-3 Illustration of land type Ac 74 terrain units (Land Type Survey Staff, 1972 - 2006)

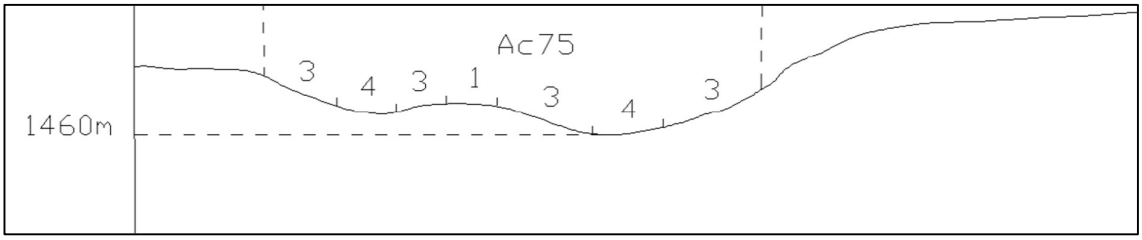


Figure 4-4 Illustration of land type Ac 75 terrain units (Land Type Survey Staff, 1972 - 2006)

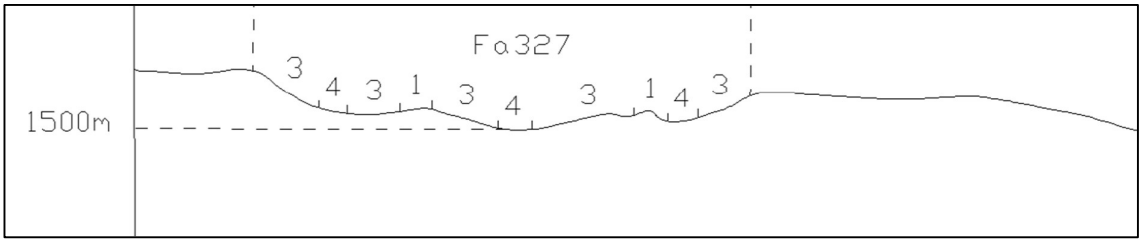


Figure 4-5 Illustration of land type Fa 327 terrain units (Land Type Survey Staff, 1972 - 2006)

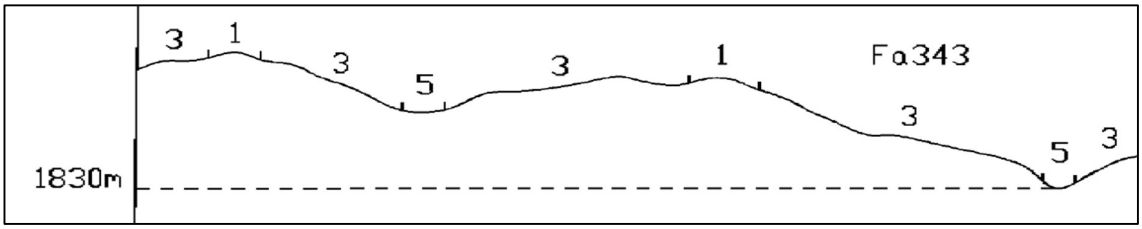


Figure 4-6 Illustration of land type Fa 343 terrain units (Land Type Survey Staff, 1972 - 2006)

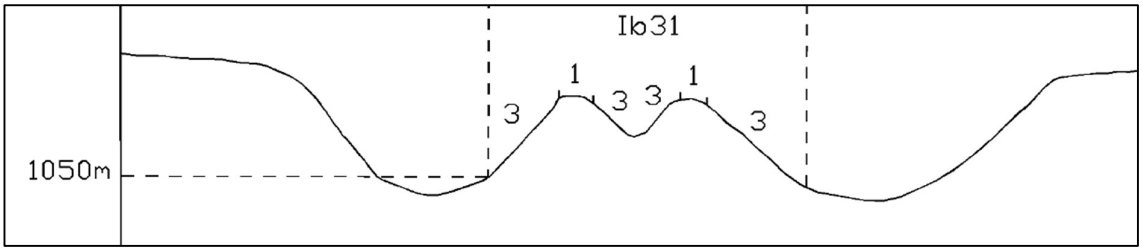


Figure 4-7 Illustration of land type Ib 31 terrain units (Land Type Survey Staff, 1972 - 2006)

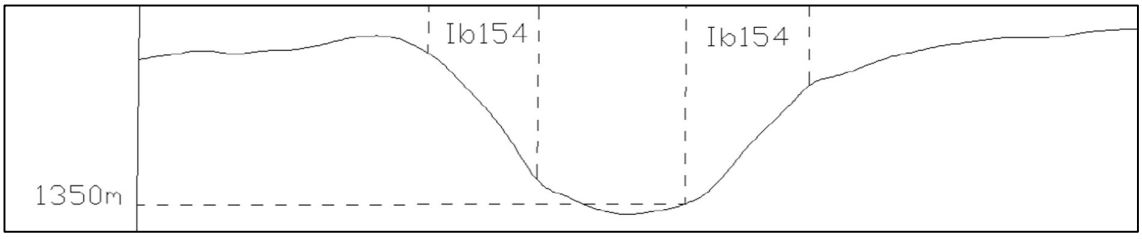


Figure 4-8 Illustration of land type Ib 154 terrain units (Land Type Survey Staff, 1972 - 2006)

Table 4-1 Soils expected at the respective terrain units within the Ab 29 land type (Land Type Survey Staff, 1972 – 2006)

Terrain Units							
1 (10%)		**3 (45%)**		**4 (40%)**		**5 (5%)**	
Shortlands	55%	Hutton	50%	Bare Rocks	80%	Arcadia	70%
Hutton	25%	Shortlands	40%	Shortlands	10%	Bonheim	30%
Bare Rocks	20%	Bare Rocks	10%	Bonheim	10%		

Table 4-2 Soils expected at the respective terrain units within the Ac 74 land type (Land Type Survey Staff, 1972 – 2006)

Terrain Units					
1 (60%)		**3 (35%)**		**5 (5%)**	
Clovelly	30%	Clovelly	35%	Katspruit	70%
Bare Rocks	20%	Bare Rocks	25%	Cartref	20%
Mispah	15%	Hutton	20%	Bare Rocks	10%
Glenrosa	15%	Mispah	15%		
Hutton	15%	Glenrosa	10%		
Cartref	5%	Cartref	5%		

Table 4-3 Soils expected at the respective terrain units within the Ac 75 land type (Land Type Survey Staff, 1972 – 2006)

Terrain Units							
1 (10%)		**3 (50%)**		**4 (35%)**		**5 (5%)**	
Hutton	50%	Hutton	55%	Hutton	50%	Bonheim, Willowbrook	60%
Glenrosa	20%	Glenrosa	20%	Clovelly	20%	Oakleaf	30%
Clovelly	15%	Clovelly	10%	Shortlands	10%	Bonheim	10%
Shortland	10%	Shortlands	10%	Oakleaf	10%		
Bare Rocks	5%	Bare Rocks	5%	Bonheim	10%		

Table 4-4 Soils expected at the respective terrain units within the Fa 327 land type (Land Type Survey Staff, 1972 – 2006)

Terrain Units							
1 (15%)		**3 (63%)**		**4 (20%)**		**5 (2%)**	
Bare Rocks	30%	Glenrosa	25%	Hutton	30%	Oakleaf	30%
Glenrosa	20%	Bare Rocks	20%	Shortlands	25%	Valsrivier	25%
Clovelly	15%	Shortlands	15%	Glenrosa	10%	Bonheim	20%
Shortland	15%	Mispah	15%	Clovelly	10%	Swartland	10%
Mispah	15%	Clovelly	10%	Oakleaf	10%	Bare Rocks	5%
Hutton	5%	Hutton	10%	Bare Rocks	5%	Glenrosa	5%

	Clovelly	10%	Mispah	5%	Mispah	5%
	Swartland	5%	Swartland	5%		

Table 4-5 Soils expected at the respective terrain units within the Fa 343 land type (Land Type Survey Staff, 1972 – 2006)

Terrain Units					
1 (20%)		**3 (75%)**		**5 (5%)**	
Bare Rocks	40%	Bare Rocks	30%	Willowbrook	50%
Glenrosa	30%	Glenrosa	25%	Cartref	15%
Hutton	10%	Hutton	20%	Swartland	15%
Clovelly	10%	Clovelly	15%	Bare Rocks	10%
Cartref	10%	Cartref	5%	Glenrosa	5%
		Swartland	5%	Clovelly	5%

Table 4-6 Soils expected at the respective terrain units within the Ib 31 land type (Land Type Survey Staff, 1972 – 2006)

Terrain Units					
1 (25%)		**3 (70%)**		**5 (5%)**	
Bare Rocks	80%	Bare Rocks	65%	Swartland	40%
Swartland	20%	Swartland	25%	Bonheim	40%
				Bare Rocks	20%

Table 4-7 Soils expected at the respective terrain units within the Ib 154 land type (Land Type Survey Staff, 1972 – 2006)

Terrain units					
1 (50%)		3 (45%)		4 (5%)	
Clovelly	35%	Clovelly	35%	Katspruit	30%
Hutton	15%	Mispah	15%	Stream beds	30%
Avalon	15%	Cartref	10%	Wasbank, Cartref	15%
Mispah	15%	Hutton	10%	Longlands	15%
Bare Rock	5%	Avalon	10%	Swartland	10%
Cartref	5%	Glenrosa	5%		
Glenrosa	5%	Wasbank	5%		
Glencoe	5%	Longlands	5%		

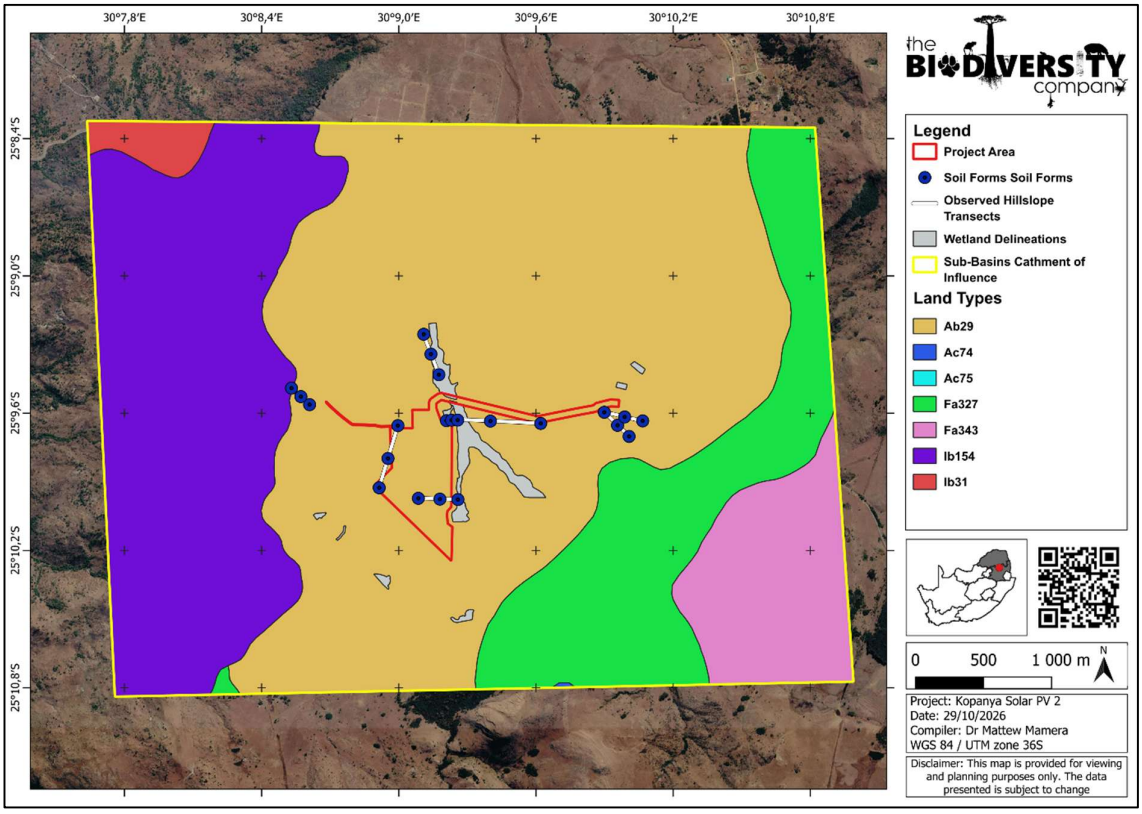


Figure 4-9 Land types present within the proposed Kopanya Solar PV 2 Project`s surroundings

4.3 Identified Soil Forms

The following soil forms were identified on-site whilst surveying the relevant transects:

- Tubatse (Orthic topsoil on top of a neocutanic horizon with a hard rock layer below);
- Hutton (Orthic topsoil on top of a thick red apedal horizon);
- Nkonkoni (Orthic topsoil on top of a red apedal horizon with a lithic horizon below);
- Vaalbos (Orthic topsoil on top of a red apedal horizon with a hard rock below);
- Glenrosa (Orthic topsoil on top of a lithic horizon);
- Mispah (Orthic topsoil on top of a hard rock substratum); and
- Katspruit (Orthic topsoil on top of a gley horizon);

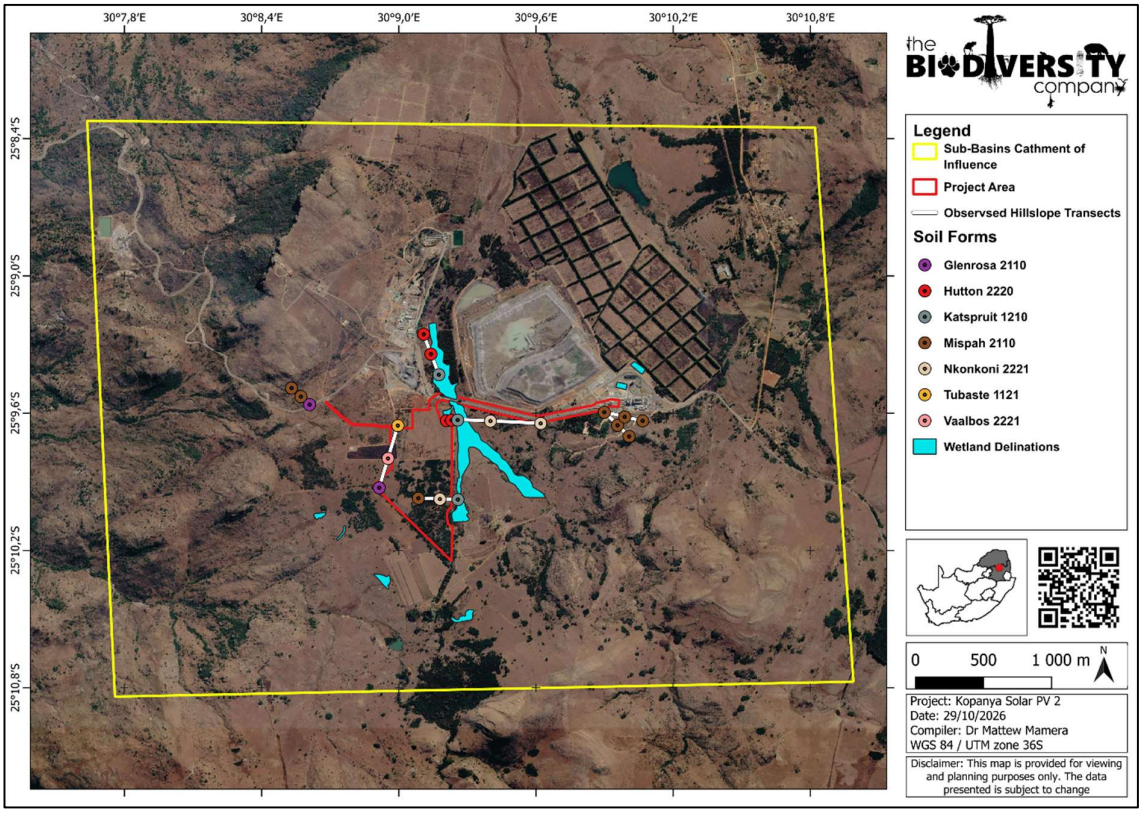


Figure 4-10 Soil forms and the respective soil families identified within representative hillslope transects

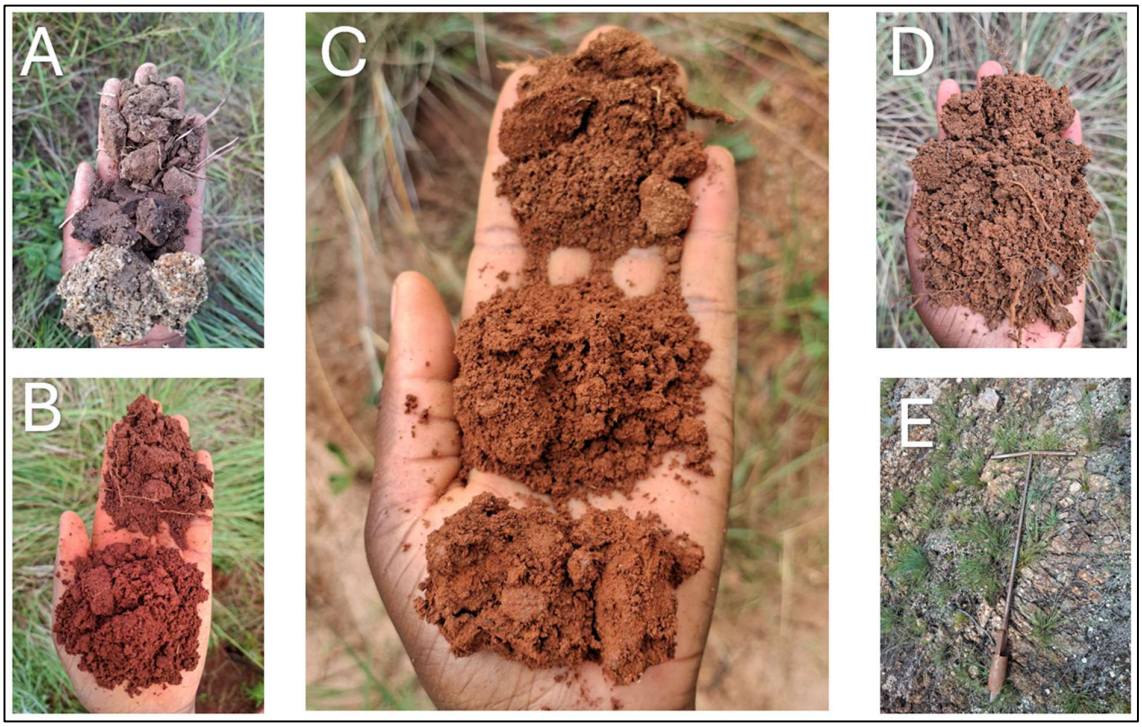


Figure 4-11 Diagnostic soil horizons identified on-site: A) Orthic topsoil with a neocutanic horizon. B-C) Orthic topsoil with a red apedal horizon. D) Orthic topsoil with a lithic horizon. E) Orthic topsoil with a hard rock layer below

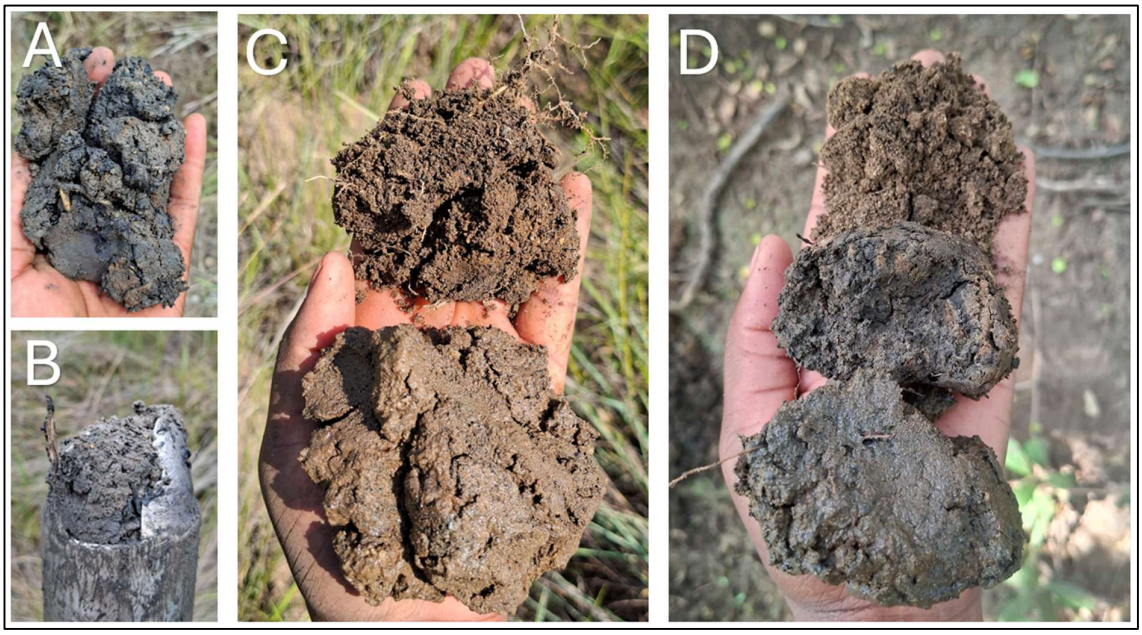


Figure 4-12 Diagnostic soil horizons identified on-site: A-D) Orthic topsoil with a with gley subsurface horizons

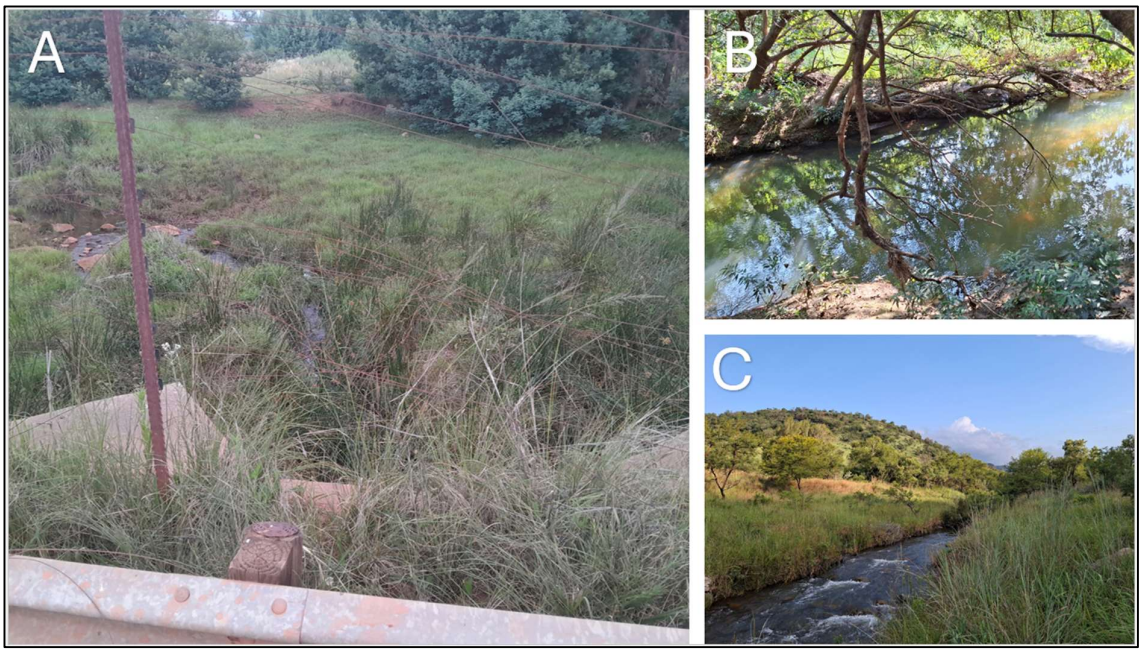


Figure 4-13 Diagnostic soil horizons identified on-site: A-C) Examples of surface return/overland flows and lateral flows pathways

4.4 Hillslope Hydrology

The survey was conducted to obtain information regarding the soil morphology to their respective soil family levels and hydropedological flow paths relevant to the hillslope by means of several

representative transects (see Table 4-8). The hillslope hydrology of slopes intersected by the proposed Project and associated infrastructure are characterised by their distinct hydropedological patterns. The majority of the slopes for the first distinctive hydropedological patterns are characterised by recharge (shallow) (see Figure 4-14) hydropedological types. These patterns occur from the crest to the valley bottom merging to a watercourse.

The second distinctive hydropedological patterns are characterised with recharge (slow, shallow, and deep) (Figure 4-15). These patterns occur from the crest to the midslope with recharge (shallow) transecting to recharge (deep) to the lower midslope transecting to recharge (slow) in the valley bottom section merging to the watercourse. The third to fourth distinctive hydropedological patterns are characterised with recharge (shallow and deep) and responsive (wet) (Figure 4-16 to Figure 4-17). These patterns occur from the crest to the lower midslope with a recharge (shallow or deep) type transecting to responsive (wet) in the valley bottom section merging to the watercourse. Restrictions in the water flow occurs within the responsive soils due to the presence of a high clay content and partially or unfractured parent material (see Figure 4-16 to Figure 4-17).

Table 4-8 Identified hillslope dominant soil forms and hydropedological groups

Terrain Morphological Unit (TMU)							
1&2		3		4		5	
Soil form	**Hydroped**	**Soil form**	**Hydroped**	**Soil form**	**Hydroped**	**Soil form**	**Hydroped**
Mispah 2110	Recharge (Shallow)	Mispah 2110	Recharge (Shallow)	Mispah 2110	Recharge (Shallow)	Mispah 2110	Recharge (Shallow)
Mispah 2110	Recharge (Shallow)	Mispah 2110	Recharge (Shallow)	Mispah 2110	Recharge (Shallow)	Mispah 2110	Recharge (Shallow)
Nkonkoni 2221	Recharge (Deep)	Nkonkoni 2221	Recharge (Deep)	Nkonkoni 2221	Recharge (Deep)	Katspruit 1210	Responsive (Wet)
Hutton 2220	Recharge (Deep)	Hutton 2220	Recharge (Deep)	Hutton 2220	Recharge (Deep)	Katspruit 1210	Responsive (Wet)
Mispah 2110	Recharge (Shallow)	Vaalbos 2221	Recharge (Deep)	Vaalbos 2221	Recharge (Deep)	Tubatse 1121	Recharge (Slow)
Glenrosa 2110	Recharge (Shallow)	Hutton 2220	Recharge (Deep)	Hutton 2220	Recharge (Deep)	Katspruit 1110	Responsive (Wet)
Hutton 2220	Recharge (Deep)	Hutton 2220	Recharge (Deep)	Hutton 2220	Recharge (Deep)	Katspruit 1210	Responsive (Wet)
Glenrosa 2110	Recharge (Shallow)	Mispah 2110	Recharge (Shallow)	Mispah 2110	Recharge (Shallow)	Mispah 2110	Recharge (Shallow)

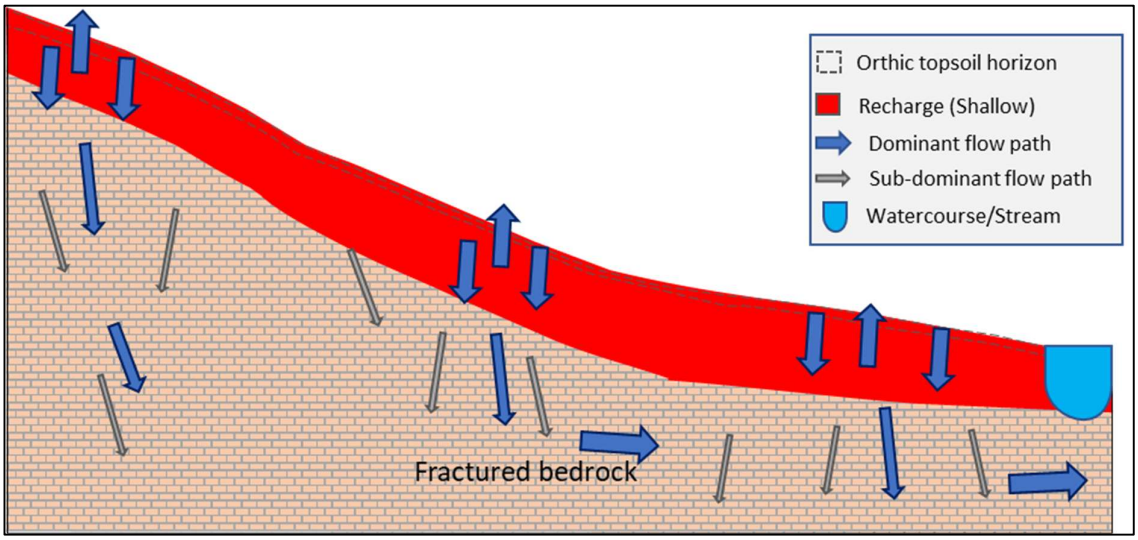


Figure 4-14 ***Hillslope hydrology one of four of the distinct hydropedological patterns prior to construction of the proposed Kopanya Solar PV 2 Project and associated infrastructure***

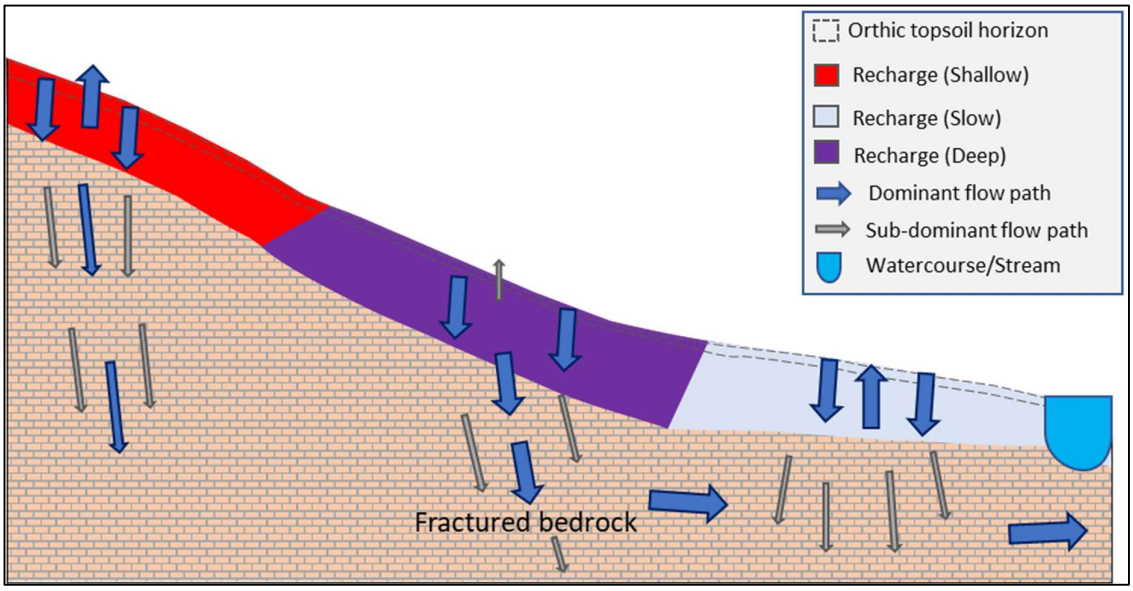


Figure 4-15 ***Hillslope hydrology two of four of the distinct hydropedological patterns prior to construction of the proposed Kopanya Solar PV 2 Project and associated infrastructure***

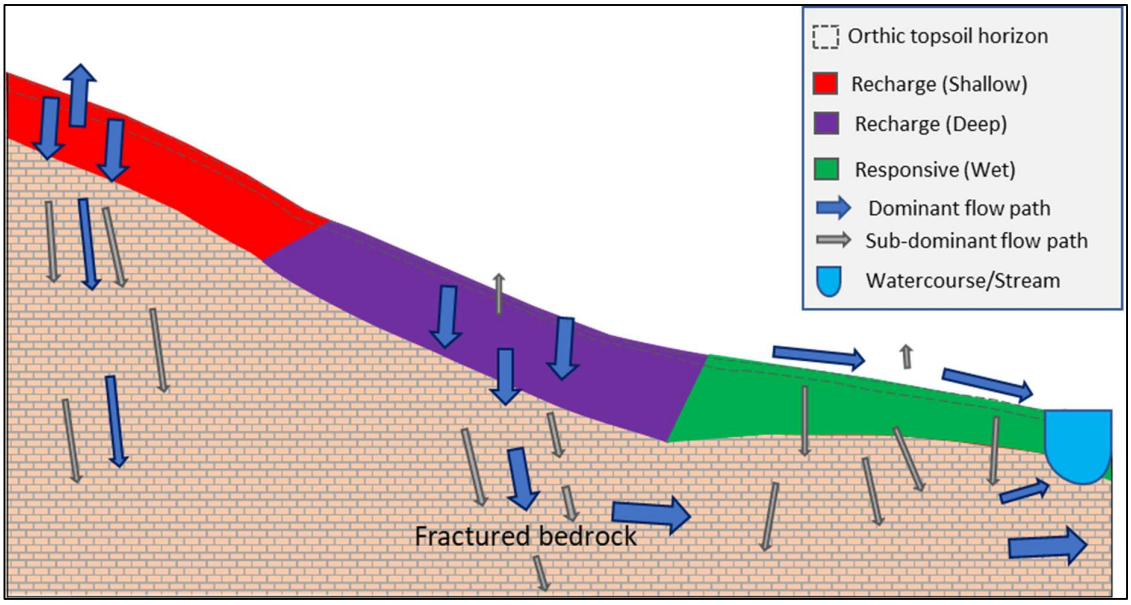


Figure 4-16 ***Hillslope hydrology three of four of the distinct hydropedological patterns prior to construction of the proposed Kopanya Solar PV 2 Project and associated infrastructure***

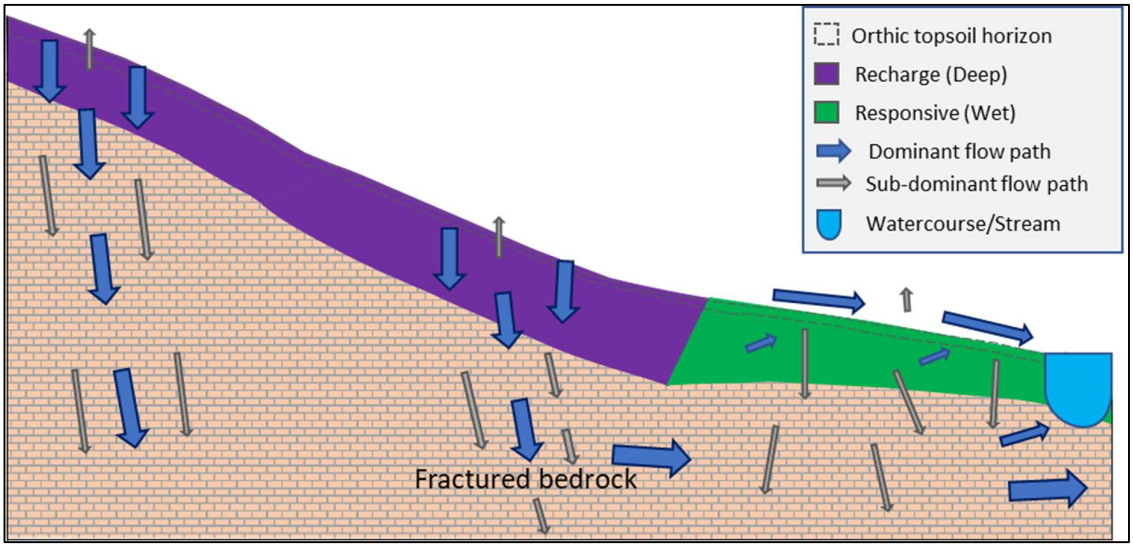


Figure 4-17 Hillslope hydrology four of four of the distinct hydropedological patterns prior to construction of the proposed Kopanya Solar PV 2 Project and associated infrastructure

The shallow Glenrosa and Mispah soil forms soils and deep Hutton, Nkonkoni, and Vaalbos soil forms identified on-site are characterised with well drained profiles. The Glenrosa soil forms consist of an orthic topsoil with a lithic horizon below. The Mispah soil forms consist of an orthic topsoil with a hard rock substratum below. The Hutton soil forms consist of an orthic topsoil with a thick red apedal horizon below. The Nkonkoni soil forms consist of an orthic topsoil with a red apedal horizon with a lithic horizon below. The Vaalbos soil forms consist of an orthic topsoil with a red apedal horizon with a hard rock layer below. Clear horizons of apedal horizons were evident and visible in the profile. These profiles are characterised by extremely high permeability soil hydraulic conductivity (Ks) rates, including the lower lithic horizon which can also be available below the B1 subsurface horizon in most cases. The Ab 29, Ac 74, Ac 75, Fa 327, Fa 343, Ib 31 and Ib 154 land types are commonly characterised with these soils from the crest to the lower midslope areas.

No signs of leaching or oxidation/reduction processes were identified throughout the soil profiles, which, together with the high Ks emphasises rapid vertical recharge of the groundwater storage as being the dominant flow path.

The valley bottom regions are characterised by recharge (slow) and predominately responsive (wet) hydropedological types. The Ac 74, Ac 75, Fa 327, Fa 343, Ib 31 and Ib 154 land types are commonly characterised with these soils in the footslope or valley bottom landscapes areas. Areas are characterised by recharge (slow) hydropedological types commonly have an increase in clay contents in the B1 horizon with low conductivity; volume of water flow is low due to the textural discontinuity resulting in surface stagnations. If the evaporative demand is higher most of the water is lost through evaporation processes. The soils associated to these areas include Tubatse soil forms with a neocutanic B1 horizon.

Neocutanic horizons are characterised with young weakly-structured subsurface layers with variations in the soil matrix. The horizon is commonly associated to the processes of transportation of materials usually colluvial or alluvial origins in the valley bottoms or flats terrains and river terraces that have been subjected to an intermediate stage of pedogenic changes. The colour differences in the neocutanic horizon are usually caused by illuvial material that coats weak structural units (Soil Classification Working Group, 2018).

The soil form relevant to the responsive (Wet) hydropedological types, observation point is that of the Katspruit soil forms. The Katspruit soil forms are characterised by gley horizon as the subsoil, which is indicative of prolonged/permanently saturated soils which result in the formation of "responsive soils." Responsive soils will be subject to overland/return flow during precipitation events (due to the naturally high-water content which will ensure rapid saturation). Between rainfall events, these soil forms will steadily feed watercourses and will lose moisture by means of Evapotranspiration (ET).

Gley horizons that are well developed and have homogenous dark to light grey colours with smooth transitions. Stagnant and reduced water over long periods is the main factor responsible for the formation of a gley horizon and could be characterised by green or blue tinges due to the presence of a mineral called Fougerite which includes sulphate and carbonate complexes. Even though grey colours are dominant, yellow, and/or red striations can be noticed throughout a gley horizon. The structure of a gley horizon mostly is characterised as strong pedal, with low hydraulic conductivities due to high clay content (clayey texture), although sandy gley horizons are also known to occur. The gley soil form commonly occurs at the toe of hillslopes (or benches) where lateral water inputs (subsurface) are dominant and the underlaying geology is characterised by a low hydraulic conductivity. The gley horizon usually is second in diagnostic sequence in shallow profiles yet is known to be lower down in sequence and at greater depths (Soil Classification Working Group, 2018).

4.5 Conceptual Impact Prediction

The proposed Project will have acceptable impacts on the hydropedology behaviour of most relevant hillslopes, due to the position of the development area and associated infrastructure like the bifacial solar panels, racking and tracking systems, electrical infrastructure and grid connection, offices, or buildings, parking areas, blasting (shallow rock for cable trenches and building footings), fence, road, conservancy tank (sewage to be taken to the municipal works), supporting infrastructure and services and associated infrastructure (crest, lower and midslope). The total catchment area affected per hydropedological group was quantified, with recharge soils comprising the largest proportion of the impacted hectares (approximately 2391 ha), while a smaller fraction of the footprint intersects responsive-wet soils (approximately 72 ha), primarily in valley-bottom positions.

The following hydrological flows are expected from the representative hillslopes:

1. In the upper crest areas (Figure 4-18), vertical flows are expected to remain dominate due to the presence of recharge soils such as the recharge shallow (Mispah and Glenrosa soil forms) and recharge deep (Hutton, Nkonkoni and Vaalbos soil forms). The presence of the solar panels, associated infrastructure and construction activities will have minimal interception to the vertical flows;

2. The vertical flows will eventually become sub-dominate in the fracture or semi-permeable parent material; lateral flows will also occur towards the midslope areas. If the evaporation process is high some of the water will be lost especially on the available recharge shallow from the topsoil layers.

3. In areas with exposed bare rocky areas (Figure 4-18 to Figure 4-20), overland flow or surface runoff will occur following rainfall events which contributes towards the midslope and lower areas in the landscape. Blasting effects can also promote widen of rock fractures which will result in increased vertical flows from these surface overland flows towards groundwater stores.

4. In some of the lower midslope and the valley bottoms with recharge (slow) hydropedological type (see Figure 4-19), with the Tubatse soil forms will result in overland flows or some lateral flows occurring due to the increased clay contents, recharging both groundwater storages and watercourses or wetlands below. Some lateral flows from the proposed PV activities will also contribute on the surface flows towards the wetlands (artificial or natural) or watercourse. Some interception of these lateral flows can occur from the cable trenches or building footings. Lateral

flow discontinuity can occur; this will eventually become vertical flows. Panel drip lines, compacted access routes, hardstanding and drainage outlets may concentrate surface runoff and reduce diffuse infiltration. During the rainy periods, some of the rain will be intercepted by the solar panels and surface overland flows will be prominent, recharging the wetland areas. Some of the stagnant surface water flows may be lost through evaporation as percolation will be slow in these soils due to lower conductivity as the clay contents increase over time.

5. The other transects with the responsive (Wet) hydropedological types (i.e., Katspruit soil forms) predominant in the valley bottom (Figure 4-18 and Figure 4-20), are characterised with dominate surface overland flows or runoff recharging wetlands and watercourses. These areas act as responsive receptors recharging the groundwater stores. Also, these areas have a high tendency to promote towards available water resources when developed. The proposed conservancy tank should avoid these areas as any potential sewer leakages or spill can cause contaminate migration of feacal bacteria such as *E.coli* or feacal coliforms towards water resources.

6. In the landscape, percolation effects can occur into either a fractured bedrock or semi-permeable layer, even though the effects are usually sub-dominate recharging the groundwater stores for the catchment.

The proposed Project and associated infrastructure located within the available recharge hydropedological type is not expected to affect the hillslope hydrology in any manner. Flow changes can occur in the lateral flows due to increased water regimes and underlying restrictive impermeable layers which can disconnect these lateral flows. Surface sealing from the proposed infrastructure due to compaction can reduce some of the flows and infiltration. These effects are however expected to have acceptable impact towards the total streamflow or total deductible water regime losses of sensitive receptors (downstream rivers and wetlands) and groundwater storage. Changes in water regime stores will be minimally impacted, even though some changes will continue as some of these surface water is diverted through storm water drainages, which requires good water regime management. Measures which can promote infiltration and reduce surface overland flows will result in the addition of the potential water regime losses back in the catchment.

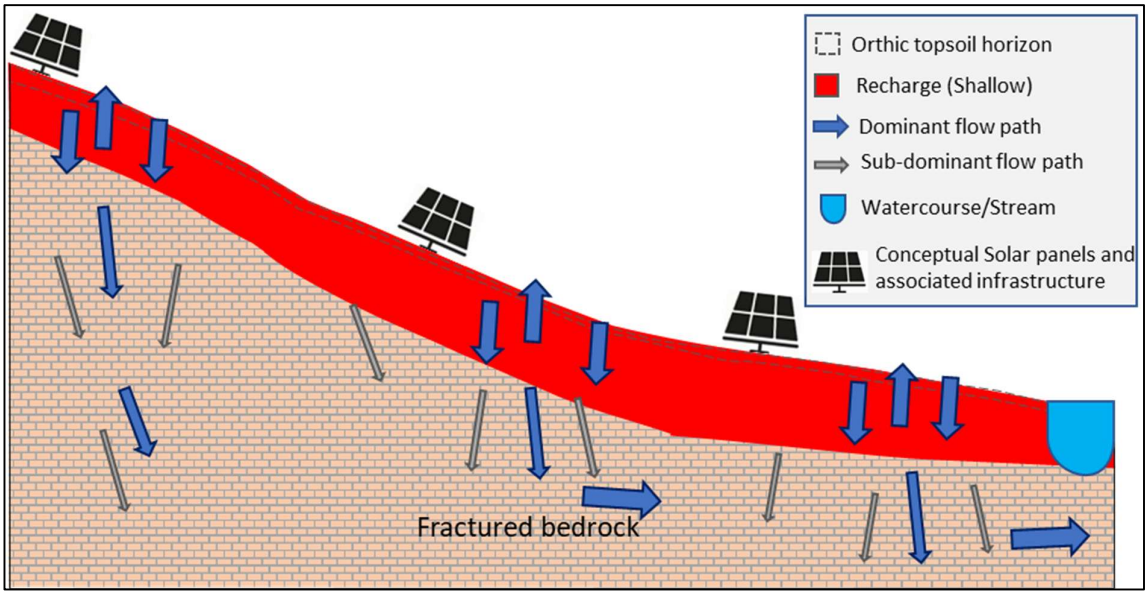


Figure 4-18 Hillslope hydrology one of four of the distinct hydropedological patterns after the construction of the Kopanya Solar PV 2 Project and associated infrastructure

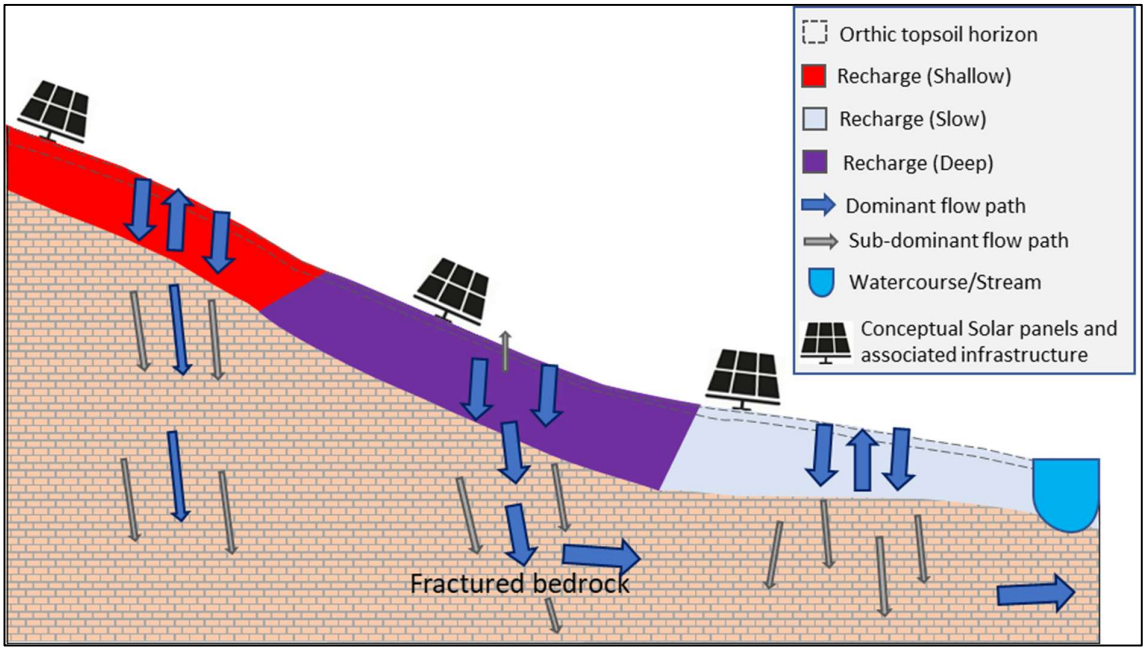


Figure 4-19 Hillslope hydrology two of four of the distinct hydropedological patterns after the construction of the Kopanya Solar PV 2 Project and associated infrastructure

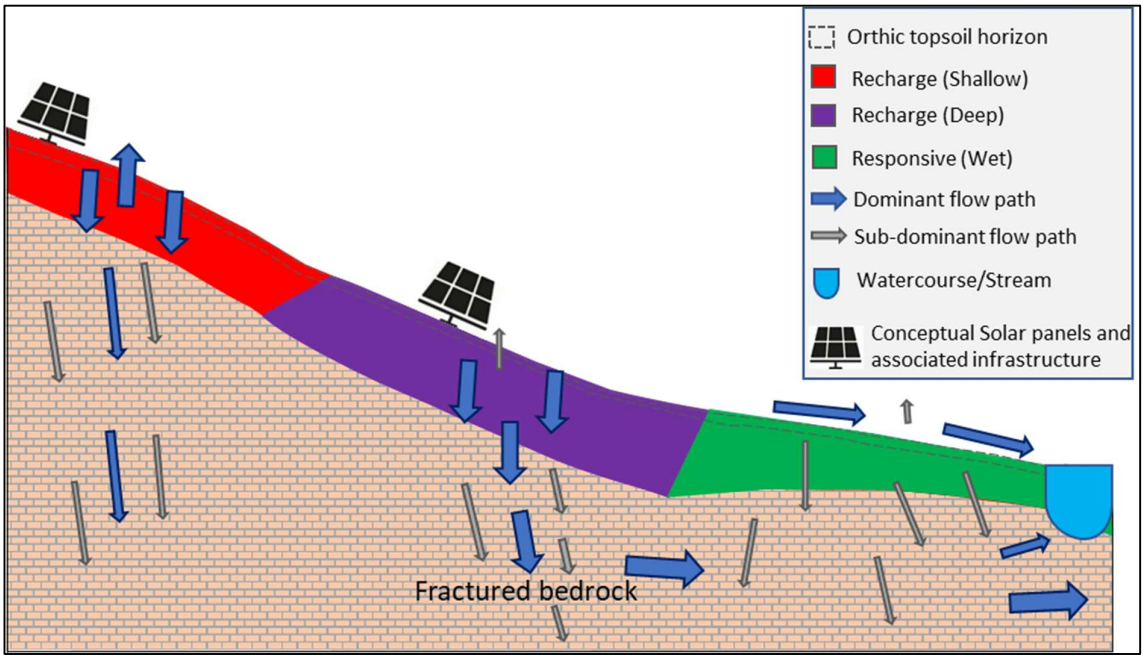


Figure 4-20 Hillslope hydrology three of four of the distinct hydropedological patterns after the construction of the Kopanya Solar PV 2 Project and associated infrastructure

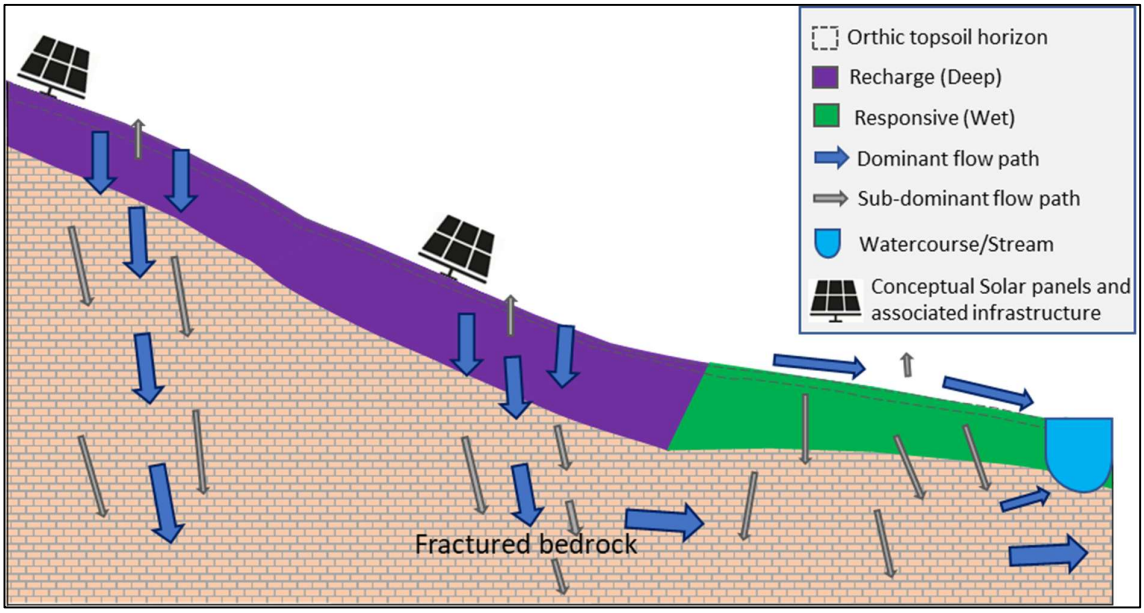


Figure 4-21 Hillslope hydrology four of four of the distinct hydropedological patterns after the construction of the Kopanya Solar PV 2 Project and associated infrastructure

4.6 Impact Assessment

4.6.1 Construction and Operation Phase

The expected impacts on the catchment water regimes were assessed following the GCS (2026) impact matrix methodology. Soil erosion, sedimentation, or overland flows can occur due to increased traffic on the surface during the construction phase of the new infrastructure and operation of the existing infrastructure or activities within the proposed mining right area which can also result in compaction and surface sealing. Overland flow and potential erosion of terrestrial and watercourse or channels soils can occur which can lead to loss of fertile topsoil. Soil erosion from the existing infrastructure can also contribute to water pollution and siltation of rivers though minimal as mitigation measures have already been implemented. Surface sealing will also promote head cutting instreams and loss of fertile topsoil. Paved areas will intercept lateral flow paths (i.e., areas like parking or roads) and remove connectivity between recharge zones and lateral flow zones. Alteration of this flow path will likely change the water regimes negatively, even though the impact should be acceptable with an estimated loss of water recharge between 1%-3%. The proposed Project area for the operation phase will have a negative low impact post mitigation. These effects are manageable as the post mitigation has been scored low for overland flows and potential soil erosion.

4.6.1.1 Construction phase

Table 4-9 Impact assessment of erosion due to increased overland flow on the environment

Activity Which May Cause the Impact	Pre- Mitigation							Post Mitigation							Confidence
	Duration	Extent	Potential for impact on irreplaceable resources	Severity	Consequence	Probability	Significance	Duration	Extent	Severity	Potential for impact on irreplaceable resources	Consequence	Probability	Significance	
Construction of the PV will lead to erection of panel stands, blasting, trenches, building footings, fence, and roads which can cause compaction, soil erosion, also spills from the conservancy tank and leaks from the machinery	3	3	1	-2	-14	2	-28	2	2	-1	1	-5	2	-10	High

Table 4-10 Impact assessment of potential decrease in subsurface lateral flow and return flow on the environment

Activity Which May Cause the Impact	Pre- Mitigation							Post Mitigation							Confidence
	Duration	Extent	Potential for impact on irreplaceable resources	Severity	Consequence	Probability	Significance	Duration	Extent	Severity	Potential for impact on irreplaceable resources	Consequence	Probability	Significance	
Construction of the PV will lead to erection of panel stands, blasting, trenches, building footings, fence, and roads which can cause compaction, soil erosion, also spills from the conservancy tank and leaks from the machinery	3	3	1	-2	-14	2	-28	2	2	-1	1	-5	2	-10	High

4.6.1.2 Operation phase

Table 4-11 Impact assessment of erosion due to increased overland flow on the environment

Activity Which May Cause the Impact	Pre- Mitigation							Post Mitigation							Confidence
	Duration	Extent	Potential for impact on irreplaceable resources	Severity	Consequence	Probability	Significance	Duration	Extent	Severity	Potential for impact on irreplaceable resources	Consequence	Probability	Significance	
Operation of the PV will lead to surface runoff, soil compaction, soil erosion, potential hydrocarbon or sewer spills, and leaks from the machinery	2	2	1	-2	-10	2	-20	1	2	-1	1	-4	2	-8	High

Table 4-12 Impact assessment of potential decrease in subsurface lateral flow and return flow on the environment

Activity Which May Cause the Impact	Pre- Mitigation							Post Mitigation							Confidence
	Duration	Extent	Potential for impact on irreplaceable resources	Severity	Consequence	Probability	Significance	Duration	Extent	Severity	Potential for impact on irreplaceable resources	Consequence	Probability	Significance	
Operation of the PV will lead to surface runoff, soil compaction, soil erosion, potential hydrocarbon or sewer spills, and leaks from the machinery	4	3	1	-2	-16	2	-32	1	3	-1	1	-5	2	-10	High

4.6.2 Decommissioning and Closure Phase

The phase will include closure and ceasing of the PV modules, PV panels, and associated supporting infrastructure (concrete footings and below ground electrical cables) and associated activities. Some of the infrastructure will be removed from the site for decommissioning, this will be done with specialist on the site. Increased traffic will occur on-site, though the effects are expected to be minimal and

manageable and mitigation measures will already be implemented. These effects are manageable as the post mitigation has been scored low.

Table 4-13 Impact assessment of erosion due to increased overland flow on the environment

Activity Which May Cause the Impact	Pre- Mitigation							Post Mitigation							Confidence
	Duration	Extent	Potential for impact on irreplaceable resources	Severity	Consequence	Probability	Significance	Duration	Extent	Severity	Potential for impact on irreplaceable resources	Consequence	Probability	Significance	
Closure of the PV will lead to increased traffic, surface runoff, compaction, soil erosion, spills, and leaks from the machinery	2	2	1	-2	-10	2	-20	1	2	-1	1	-4	1	-4	High

Table 4-14 Impact assessment of potential decrease in subsurface lateral flow and return flow on the environment

Activity Which May Cause the Impact	Pre- Mitigation							Post Mitigation							Confidence
	Duration	Extent	Potential for impact on irreplaceable resources	Severity	Consequence	Probability	Significance	Duration	Extent	Severity	Potential for impact on irreplaceable resources	Consequence	Probability	Significance	
Closure of the PV will lead to increased traffic, surface runoff, compaction, soil erosion, spills, and leaks from the machinery	2	3	1	-2	-12	2	-24	1	2	-1	1	-4	2	-8	High

4.6.3 Mitigation Measures

Mitigations are recommended for proposed activities and associated infrastructure. Subsurface drainage can also allow the roof water from the associated infrastructure to percolate and re-infiltrate. Overland flow management practices such as mulching and landscape terracing and revegetation are also important within the development area to reduce surface runoffs. With respect to hydrocarbons or

sanitation systems leakages or spills need to be fixed and ensure measures are in place to prevent future leakages. Measures like contacting the responsible authorities immediately for sewage associated with sanitation systems and having response guidelines. Implement robust measures for associated pipelines for hydrocarbons or sewer, like safety monitoring, early warning systems, and emergency action plans to protect downstream communities.

The following measures can promote infiltration, and percolation flows during the Project construction and operation:

The following measures can promote infiltration and percolation flows:

- Minimise soil compaction and keep the soil covered with residue and vegetative cover;
- Infiltration basin or trench only where necessary can minimise surface overflows or runoffs and allow water that runs off from roofs to settle and re-infiltrate;
- Establish vegetated buffer strips and grassed waterways around surface buildings and solar PV infrastructure to filter runoff and protect water bodies from contamination;
- Prevent flood damage or concentration of runoff;
- Preserve the natural and beneficial functions of the natural drainage system downstream;
- Preserve and enhance stormwater quality;
- Attenuate the difference between pre- and post-development flows;
- Divert stormwater and surface runoff from buildings, roads, and parking areas via green engineering stormwater management dissipation infrastructure, wherever possible;
- Prevent disposal of wastewater into the catchment system or surrounding areas; and
- Adhering to the recommended footprint buffers and wetland buffers as proposed by the wetland specialist for the proposed Project area should be sufficient to reduce the deductible water losses in the catchment. Also prevent any location of sanitation systems in responsive soils and discharge of untreated potential wastewater into the catchment as responsive saturated soils (mostly associated with the valley bottoms or along water channels) have a high tendency to promote contaminant (i.e., Bacteria and inorganic elements) migrations towards water resources.

5 Conclusion

Four (4) hillslope pattern types which were identified, includes the presence of recharge (slow, shallow, and deep), and responsive (shallow and wet) hydropedological types. The transects align with the Ab 29, Ac 74, Ac 75, Fa 327, Fa 343, Ib 31 and Ib 154 land types, commonly characterised with shallow soils with some rocky areas from the crest to the lower midslope areas and saturated soils. The observed upper hillslope crest areas are characterised with vertical flows due to the presence of recharge shallow and deep hydropedological types. The midslope sections are also characterised by recharge shallow and deep hydropedological types with vertical. Surface runoffs or water stagnation can also promote the occurrence of evaporation effects as water will be lost from the topsoil horizons or surface runoffs. During the rainy season surface overland flow behaviour will occur towards the lower landscape areas. The lower midslope towards the valley bottom areas have recharge slow and responsive (wet) hydropedological types, with most areas with wetlands characterised by responsive (wet) types dominated with surface overland flows recharging wetlands and watercourses in the catchment.

The assessment demonstrates that the majority of the proposed development footprint is situated on recharge-dominated hillslopes, with supporting evidence showing that most affected soils are well-drained recharge types such as Mispah, Glenrosa, Hutton, Nkonkoni, and Vaalbos. The total catchment area affected per hydropedological group was quantified, with recharge soils comprising the largest proportion of the impacted hectares (approximately 2391 ha), while a smaller fraction of the footprint intersects responsive-wet soils (approximately 72 ha), primarily in valley-bottom positions. The proportion of recharge soils affected is significantly higher than that of responsive soils, indicating that the project's direct influence on sensitive hydropedological zones is limited. The expected change in runoff and recharge is minor, with modelling and field data indicating a reduction in recharge of approximately 1%–3%, and only a marginal increase in surface runoff, both of which are not anticipated to materially alter total streamflow or broader catchment functioning. Downstream receptors, particularly wetland-associated and valley-bottom soils, are identified as the most sensitive, but the predicted impacts on these areas remain low after mitigation. Overall, the evidence supports the conclusion that the Kopanya Solar PV 2 Project can be authorised, as the impacts on flow paths and catchment water regimes are minimal to acceptable post-mitigation, and can be sustainably managed through appropriate design, siting, and operational controls.

The proposed Project and associated infrastructure will require mitigation measures being implemented due to impacts expected on some of the identified hillslopes in the assessment area. Some changes, though minimal in water regime stores can occur with an estimated loss of water recharge between 1%-3%, which can require mitigations. Measures which can promote infiltration should continue which will result in the addition of the water regimes back in the catchment. Flow impediment can be managed well to further minimise saturation conditions and surface return flows to promote subsurface groundwater recharge and storage. Valley bottom soils are responsive hydromorphic soils due to long periods of saturation. Usually, developments should avoid such areas with responsive (wet) hydropedological soil types mostly associated to and found in areas like wetlands which act as water regime receptors for the water balance in the hillslopes` catchment as most of the supporting infrastructure already exists. These soils also have a high tendency to promote migration of inorganic (chemical elements including hydrocarbons) and organic (faecal bacteria) from a pollution source towards water resources in the catchment. The proposed conservancy tank should avoid these areas as any potential sewer leakages or spill can cause contaminate migration of feacal bacteria such as *E.coli* or feacal coliforms towards water resources.

5.1 Impact Statement

The proposed activity for the proposed Project and associated infrastructure should be authorised, as the hydropedological impacts are acceptable and manageable with proper mitigation measures in place.

Key Findings:

- Most hillslopes are dominated by recharge (shallow and deep) soils, supporting groundwater recharge.
- Some areas (especially wetlands) are sensitive and prone to contaminant migration.

The overall impact is medium but becomes low after mitigation.

Positive Impacts:

- Recharge soils help maintain groundwater and streamflow.

Negative Impacts:

- Minimal disruption to hillslope hydrology if mitigation is implemented.
- Some alteration of water regimes and flow paths.

Conditions for Authorisation:

- Implement the mitigation measures, contained in this report for the solar PV activities.
- Avoid development in the delineated wetland area and buffer.

Management measures for these systems will ensure that adequate water deducted from the catchment as runoff will be re-applied into the system which can minimise losses from the total deductible regimes as most of the hillslopes have responsive soils. Application of good quality water will promote lateral flows associated with these hydropedological groups. Improved water quality in the area is important to minimise pollutant migration. Hydrocarbons or effluent leakages migrations should be immediately fixed or minimised, and the affected areas mitigated to protect human health and the environment. From a hydropedological perspective, the proposed monitoring will be sufficient for water flows and groundwater recharge receptors.

5.2 Specialist Opinion

From a hydropedological perspective, changes in water regimes will be minimal, the impact of the development on hydropedological flow paths, post mitigation would be acceptable, and the impacts can be managed sustainably.

6 References

Land Type Survey Staff. (1972 - 2006). Land Types of South Africa: Digital Map (1:250 000 Scale) and Soil Inventory Databases. Pretoria: ARC-Institute for Soil, Climate, and Water.

Mamera M and van Tol JJ. Application of Hydropedological Information to Conceptualise Pollution Migration From Dry Sanitation Systems in the Ntabelanga Catchment Area, South Africa. *Air, Soil and Water Research*. 2018;11. doi:10.1177/1178622118795485

Mucina, L., & Rutherford, M. C. (2006). The Vegetation of South Africa, Lesotho, and Swaziland. Strelitzia 19. Pretoria: National Biodiversity Institute.

Minnesota Pollution Control Agency (MPCA). (2019). Design criteria for stormwater ponds. In Minnesota stormwater manual.

National Pollutant Discharge Elimination System (NPDES). 2021. Stormwater Best Management Practice. Wet Detention Ponds. EPA-832-F-21-031BB

Soil Classification Working Group. (1991). Soil Classification A Taxonomic system for South Africa. Pretoria: The Department of Agricultural Development.

Soil Classification Working Group. (2018). Soil Classification A Taxonomic system for South Africa. Pretoria: The Agricultural Research Council.

Van Tol, J.J., Le Roux, P.A.L. & Hensley, M. 2013. Pedological criteria for estimating the importance of subsurface lateral flow in E horizons in South African soils. *Water SA* (39):1

Van Tol, J.J., Le Roux, P.A.L., Lorentz, S.A., Hensley, M. 2013. Hydropedological classification of South African hillslopes. Vadose Zone Journal.

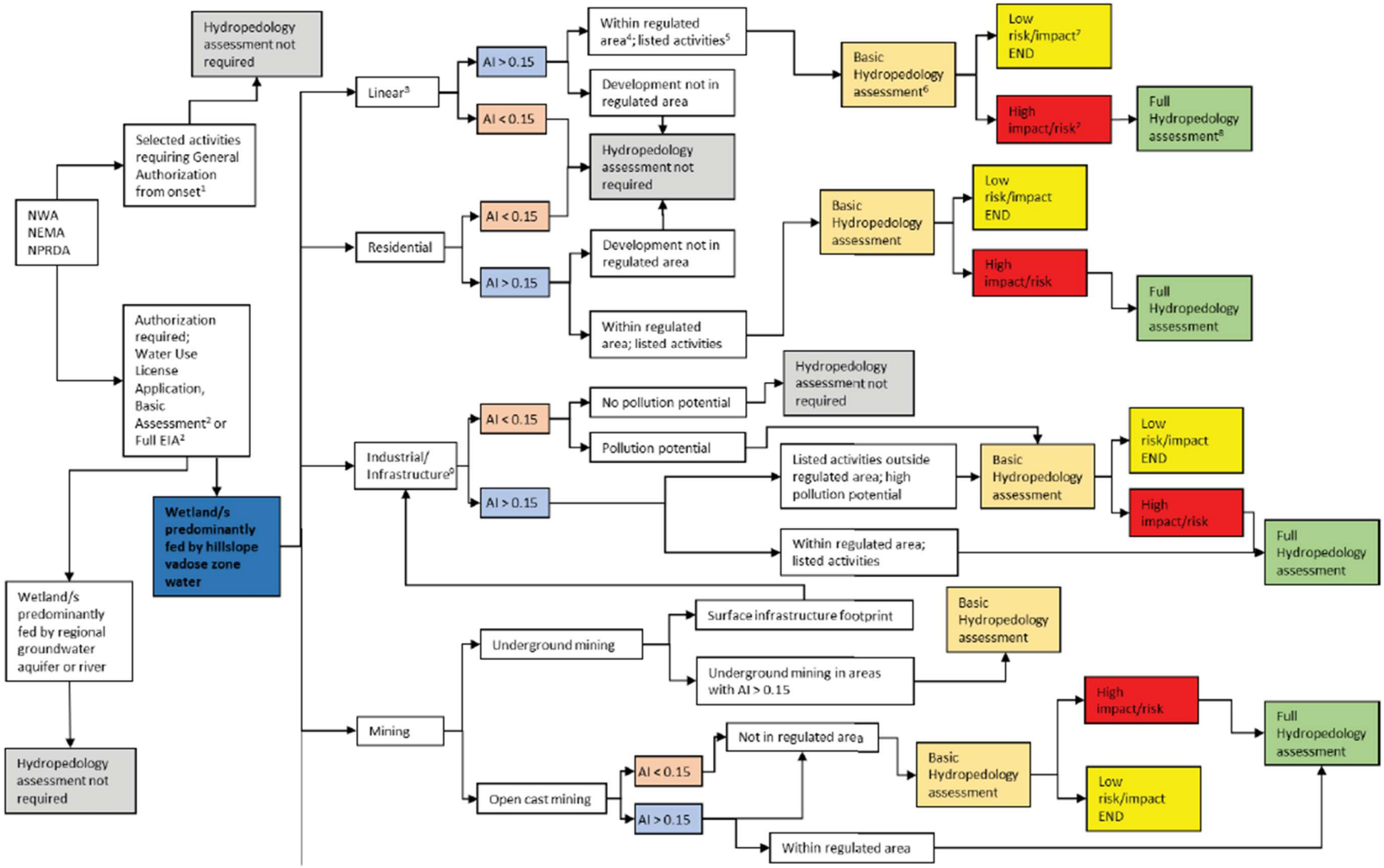
Van Tol, J., Le Roux, P. & Lorentz, S. 2017. The science of hydropedology- Linking soil morphology with hydrological processes. *Water Wheel* 16(3).

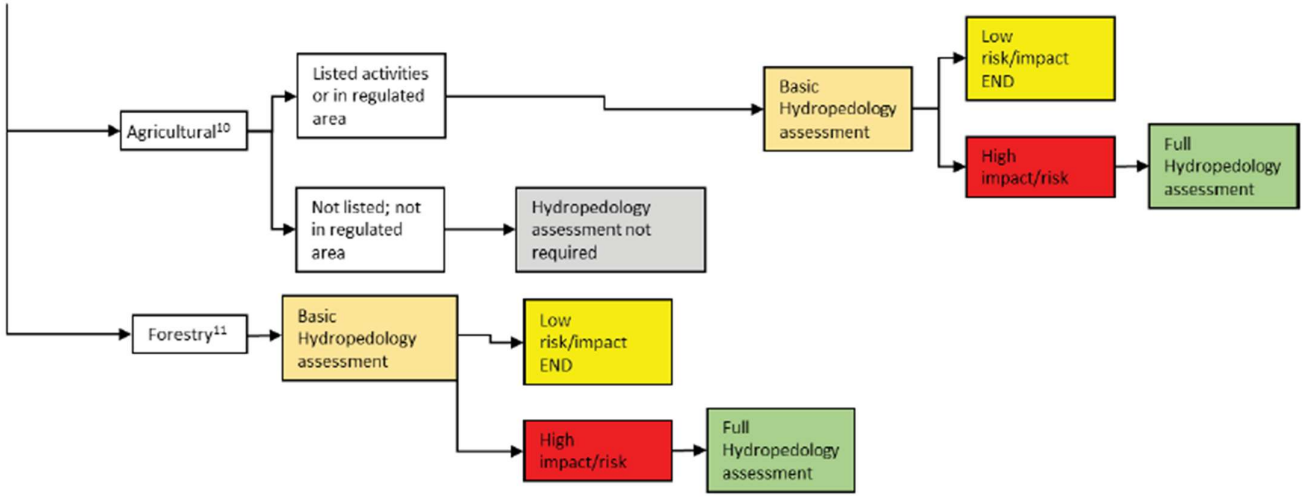
Van Tol, J.J. & Le Roux, P.A.L., 2019. Hydropedological grouping of South African soil forms. South African Journal of Plant and Soil.

Van Tol., JJ., Bouwer, D., and Le Roux, P.A.L. 2021. Guideline for hydropedological assessments and minimum requirements.

Van Tol., JJ and D Bouwer, 2024. Hydropedology of South African soil forms and families. Water SA 50(2) 236–245 / Apr 2024.

7 Appendix A: Decision Tree for When and the Type of Hydropedological Assessment Required




Agricultural[10]
Listed activities or in regulated area
Not listed; not in regulated area
Hydropedology assessment not required
Basic Hydropedology assessment
Low risk/impact END
High impact/risk
Full Hydropedology assessment
Forestry[11]
Basic Hydropedology assessment
Low risk/impact END
High impact/risk
Full Hydropedology assessment

8 Appendix B: Specialist Declaration

DECLARATION

I, Matthew Mamera, declare that:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 48 and is punishable in terms of Section 24F of the Act.



Dr Matthew Mamera

Soil Scientist

The Biodiversity Company

November 2026

9 Appendix C: Curriculum Vitae



Matthew Mamera

Pr Sci Nat 116356 +27 785 772 668 matthew@thebiodiversitycompany.com

PROFILE SUMMARY

Environmental and ecological specialist with 10 years' consulting experience, with international working experience. Specialist experience in project exploration, mining, engineering, hydropower, renewable energy, and private sector developments. Project management of national and international multi-disciplinary projects. Provides specialist guidance, technical support, and facilitation for compliance with in-country legislative requirements and international lender standards. Registered Pr Sci Nat with the South African Council for Natural Scientific Professions and the Soil Science Society of South Africa.

PERSONAL INFO

Nationality: South African Permanent Residence
Date of birth: 31 October 1988

EXPERIENCE

- Environmental Impact Assessments (EIA)
- Soil taxonomic classification (SA forms and WRB groups)
- Soil Hydropedology, Agricultural and Land contamination assessments
- Soil Carbon credits

SKILLS

- ✓ Soil and Soil Hydropedology Assessments
- ✓ Agricultural, soil and water contamination Assessments
- ✓ Rehabilitation
- ✓ Monitoring & Management Plans

LANGUAGES

English – Proficient
Zulu, Xhosa, Ndebele, Sotho – Conversational
Afrikaner - Basic



Signed: Dr Matthew Mamera

ACADEMIC QUALIFICATIONS

University of the Free State (2021): Doctor of Philosophy (PhD) - Soil Science:
Title: *Assessing pollution and managing faecal sludge through biochar applications in Phuthaditjhaba, South Africa.*

University of the Fort Hare (2018): Master of Science (MSc) - Soil Science:
Title: *Pollution potential of on-site dry sanitation systems associated with the Mzimvubu Water Project, Eastern Cape, South Africa.*

University of the Fort Hare (2015): Bachelor of Science Honours *Cum laude* (Hons) – Soil Science

University of the Fort Hare (2001 - 2004): Bachelor of Science Agriculture in Soil Science. Majors: Soil Science.

PROFESSIONAL EXPERIENCE

Mar 2022 – Present	**The Biodiversity Company** Soils Unit Manager / Soil & Soil Hydropedology
Feb 2018 – Dec 2020	**University of the Free State** Junior Researcher, lecturer / Soil Science
Jan 2015 – Dec 2017	**University of Fort Hare** Junior Research, Tutor / Soil Science

INTERNATIONAL EXPERIENCE

Angola, Botswana, Namibia, Zambia, South Africa