

FINAL REPORT

HYDROPEDOLOGICAL ASSESSMENT FOR THE VOLSPRUIT OPENCAST MINING PROJECT

For:

**San Oosthuizen
EcoPartners (Pty) Ltd**

By:

Wetland Consulting Services (Pty.) Ltd.



Wetland Consulting Services (Pty.) Ltd. 1998/017216/07
P.O. Box 72295
Lynnwood Ridge
Pretoria
0040

First Floor, Building 1
Eulophia Corner
Perseus Office Park
38 Genl. van Reyneveld Street
Pretoria

Tel: +27 12 349 2699
Fax: +27 12 349 2993
E-mail: info@wetcs.co.za
Website: www.wetcs.co.za

August 2023

Reference: - W2022_005

DOCUMENT SUMMARY DATA

Project: **Hydropedological Assessment for the Volspruit Opencast Mining Project**

CLIENT: **EcoPartners (Pty) Ltd**

CONTACT DETAILS: **San Oosthuizen**
 EcoPartners (Pty) Ltd
 177 Weltevreden Road
 Berario
 Johannesburg
 2195
 Tel: (011) 431 2251
 san@ecopartners.co.za

CONSULTANT: **Wetland Consulting Services (Pty) Ltd**

CONTACT DETAILS: **Johannes Hachmann**
 PO Box 72295
 Lynnwood Ridge
 0040
 Telephone number: (012) 349 2699
 E-mail: johannesh@wetcs.co.za

TABLE OF CONTENTS

1.	INTRODUCTION AND SCOPE OF WORK	2
1.1	Introduction	2
1.2	rationale for the scope of work	2
2.	DETAILS OF SPECIALIST	3
2.1	DETAILS OF THE SPECIALIST WHO PREPARED THE REPORT	3
2.2	EXPERTISE OF THE Specialist	3
2.2.1	<i>Qualifications of the Specialist</i>	3
2.2.2	<i>Past Experience of the Specialist</i>	3
2.2.3	<i>CV OF THE Specialist</i>	3
3.	DECLARATION OF INDEPENDENCE	4
4.	SCOPE, PURPOSE, APPROACH AND METHODOLOGY	5
4.1	STUDY AREA - LOCATION	5
4.2	Scope of work	5
4.3	Approach, Methodology	6
4.3.1	<i>Collation of existing information</i>	6
4.3.2	<i>Hydropedological assessment</i>	7
5.	ASSUMPTIONS AND LIMITATIONS	7
6.	RESULTS	8
6.1	Climate	8
6.2	Terrain	8
6.3	Geology	9
6.4	hydrology of the nyl river	9
6.5	Soil classification	10
6.6	Cross section profiles	10
6.6.1	<i>Cross Section 1</i>	11
6.6.2	<i>Cross Section 2</i>	11
6.6.3	<i>Cross Section 3</i>	12
6.6.4	<i>Cross Section 4</i>	12
6.6.5	<i>Cross Section 5</i>	12
6.6.6	<i>Cross Section 6</i>	12
6.6.7	<i>Cross Section 7</i>	12
6.7	HYDROPEDOLOGICAL response units	20
6.8	Conceptual hydrological understanding	20
6.9	Likely impacts to the hydrology of the floodplain due to the proposed mining and associated infrastructure	21
6.9.1	<i>Operational Phase</i>	22

6.9.2	Post Closure Phase	22
-------	--------------------	----

7.	CONCLUSION AND RECOMMENDATIONS	23
-----------	---------------------------------------	-----------

8.	REFERENCES	25
-----------	-------------------	-----------

APPENDIX A		26
-------------------	--	-----------

INDEMNITY AND CONDITIONS RELATING TO THIS REPORT

The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge as well as available information. The report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken and Wetland Consulting Services (Pty.) Ltd. and its staff reserve the right to modify aspects of the report including the recommendations if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.

Although Wetland Consulting Services (Pty.) Ltd. exercises due care and diligence in rendering services and preparing documents, Wetland Consulting Services (Pty.) Ltd. accepts no liability, and the client, by receiving this document, indemnifies Wetland Consulting Services (Pty.) Ltd. and its directors, managers, agents and employees against all actions, claims, demands, losses, liabilities, costs, damages and expenses arising from or in connection with services rendered, directly or indirectly by Wetland Consulting Services (Pty.) Ltd. and by the use of the information contained in this document.

This report must not be altered or added to without the prior written consent of the author. This also refers to electronic copies of this report which are supplied for the purposes of inclusion as part of other reports, including main reports. Similarly, any recommendations, statements or conclusions drawn from or based on this report must make reference to this report. If these form part of a main report relating to this investigation or report, this report must be included in its entirety as an appendix or separate section to the main report.

1. INTRODUCTION AND SCOPE OF WORK

1.1 INTRODUCTION

Wetland Consulting Services (Pty.) Ltd. (WCS) was appointed by San Oosthuizen from EcoPartners to undertake a hydropedological assessment of the area affected by the opencast mining and associated infrastructure associated with the proposed Volspruit Project, with an emphasis on a section of the Nylsvley floodplain. The proposed mine is located adjacent to the Nyl River floodplain approximately 20 km south-west of Mokopane in the Limpopo Province. This assessment entails a conceptual hydropedological study which will be used to inform an Integrated Water Use License Application (IWULA) application for the proposed mining project. The need for this study arises from the recently established requirement from the Department of Water and Sanitation (DWS) to conduct a hydropedological study (Van Tol et al., 2021) for any development or mining potentially having an impact on wetlands or other water resources.

1.2 RATIONALE FOR THE SCOPE OF WORK

Mining related impacts on watercourses, especially when an opencast pit is proposed in close proximity to wetlands, as is the case with the proposed mining activity in this study, generally require a hydropedological assessment at the most detailed level according to the document “Guideline for Hydropedological Assessments and Minimum Requirements” (Van Tol *et al.*, 2021). The most detailed level (“Step 4: Quantification of hydropedological fluxes”) typically involves the use of a hydrological model to simulate the flows under the current conditions and under the mining scenario to quantify flow losses to wetlands and watercourses. However, although the north pit is in very close proximity to the floodplain, this hydropedological assessment was conducted at a conceptual level only (“Step 1: Identification of the representative hillslope/s” and “Step 2: Conceptualize hillslope hydropedological responses”).

The rationale supporting this more conceptual approach is based on the understanding derived from the existing studies already undertaken for this proposed mine. These include soils, geotech, hydrogeology, surface water flooding, and general surface hydrology studies. The findings of these studies, indicate that the floodplain is not in contact with the regional or any perched groundwater body. Instead, groundwater is situated several meters below the surface of the floodplain. This suggests that the floodplain is predominantly driven by surface water and not by groundwater or interflow. It is therefore likely that any hydrological modelling that places emphasis on interflow will not provide meaningful results in terms of the floodplain at this particular site.

2. DETAILS OF SPECIALIST

2.1 DETAILS OF THE SPECIALIST WHO PREPARED THE REPORT

Table 1 Details of the Specialist

Project Consultancy	Wetland Consulting Services (Pty.) Ltd.
Company Registration	1998/017216/07
Professional Affiliation	South African Council for Natural Scientific Professions (SACNASP) 116815/17
Contact Person	Mr Johannes Hachmann
Physical Address	Perseuor Park, Building 1 (Eulophia Corner), First Floor, Eastern Wing, 38 Genl van Reyneveld Street, Pretoria
Postal Address	P O Box 72295, Lynnwood Ridge, 0040
Telephone Number	+27 12 349 2699
Fax Number	+27 12 349 2993
E-mail	johannesh@wetcs.co.za

2.2 EXPERTISE OF THE SPECIALIST

2.2.1 Qualifications of the Specialist

Johannes Hachmann holds the following degrees:

- BSc [Environmental Natural Science] - Albert Ludwig University Freiburg, Germany.
- MSc [Hydrology] - Free University Amsterdam, Netherlands

Johannes Hachmann holds a Professional Registration with SACNASP since 2017 – 116815/17. He is registered in the field of Water Resource Science.

2.2.2 Past Experience of the Specialist

Johannes Hachmann, Hydrologist, has a professional working experience of 9 years working for Wetland Consulting Services (Pty.) Ltd.

2.2.3 CV OF THE Specialist

A summarised CV of the Specialist is attached as APPENDIX A to this report.

3. DECLARATION OF INDEPENDENCE

I, **Johannes Hachmann**, as the appointed specialist hereby declare/affirm the correctness of the information provided as part of the application, and 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
- am aware that it is an offence in terms of Regulation 48 to provide incorrect or misleading information and that a person convicted of such an offence is liable to the penalties as contemplated in section 49B(2) of the National Environmental Management Act, 1998 (Act 107 of 1998).



Signature of the specialist

Wetland Consulting Services (Pty.) Ltd.

Name of company

14 August 2023

Date

4. SCOPE, PURPOSE, APPROACH AND METHODOLOGY

4.1 STUDY AREA - LOCATION

The location of the proposed Volspruit Project with opencast pit and associated infrastructure is shown in **Figure 1**. The study area falls within the quaternary catchment A61E.

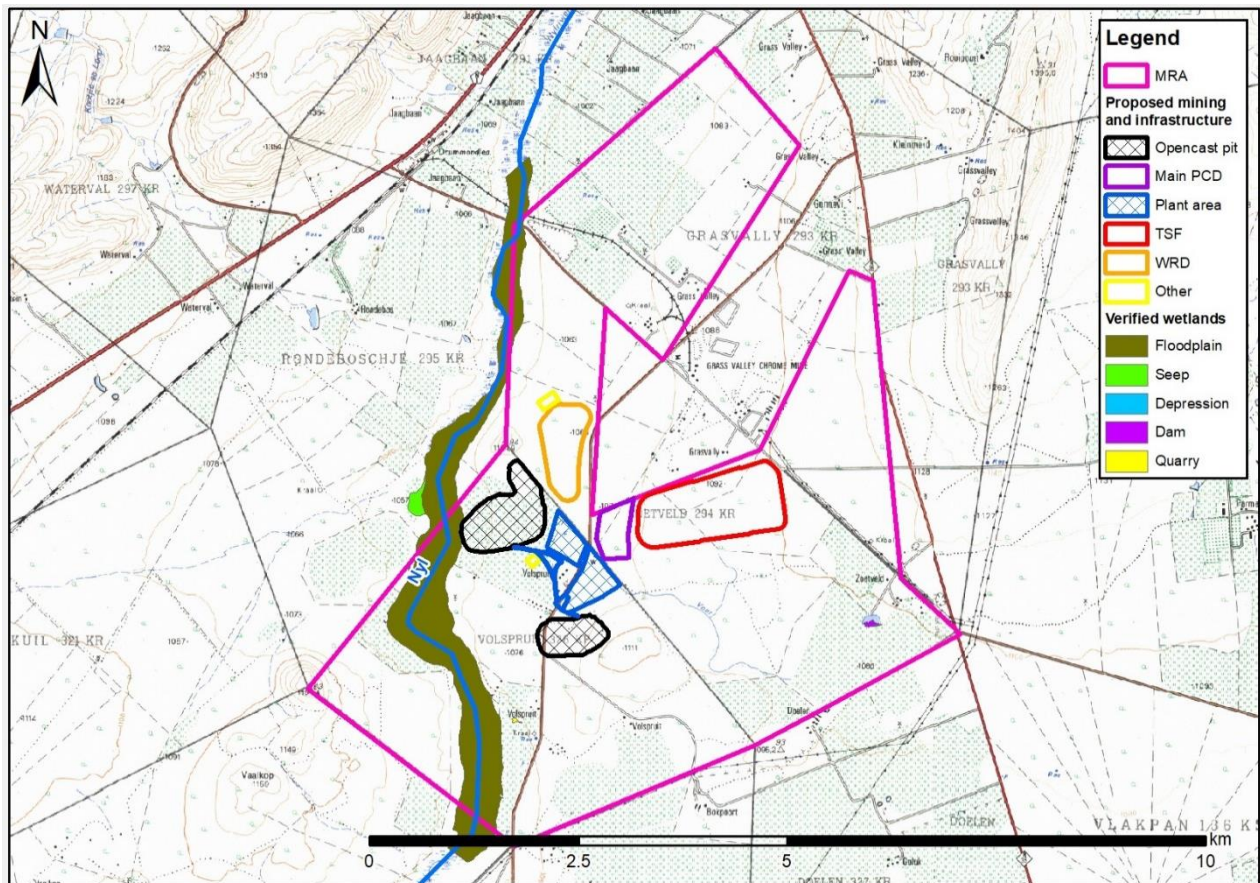


Figure 1 Map showing the location of the study area.

4.2 SCOPE OF WORK

The Volspruit Project proposes to establish a new mining operation according to the activities shown in **Figure 2**. The proposed mining will be undertaken by means of opencast mining. The surface infrastructures will include of the following:

- Main Pollution Control Dam (PCD);
- Waste Rock Dump (WRD);
- Plant area;
- Tails Stacking Facility (TSF);
- Small PCD's (Other); and
- Opencast mining pits.

The purpose of this report is to provide a conceptual hydrological assessment for both the current conditions (pre-mining) and the envisaged conditions during mining (using the estimated worst-case scenario during mining), focussing on the following key considerations:

- Hydrology of the floodplain section with the study area and associated wetlands within areas affected by the proposed activities;
- Hydrological flow drivers for current conditions and conditions likely occurring during mining ;
- Impact to the hydrological flow drivers of the floodplain and associated wetlands as a result of mining (impacted state); and
- Recommendations on how to mitigate these impacts where possible.

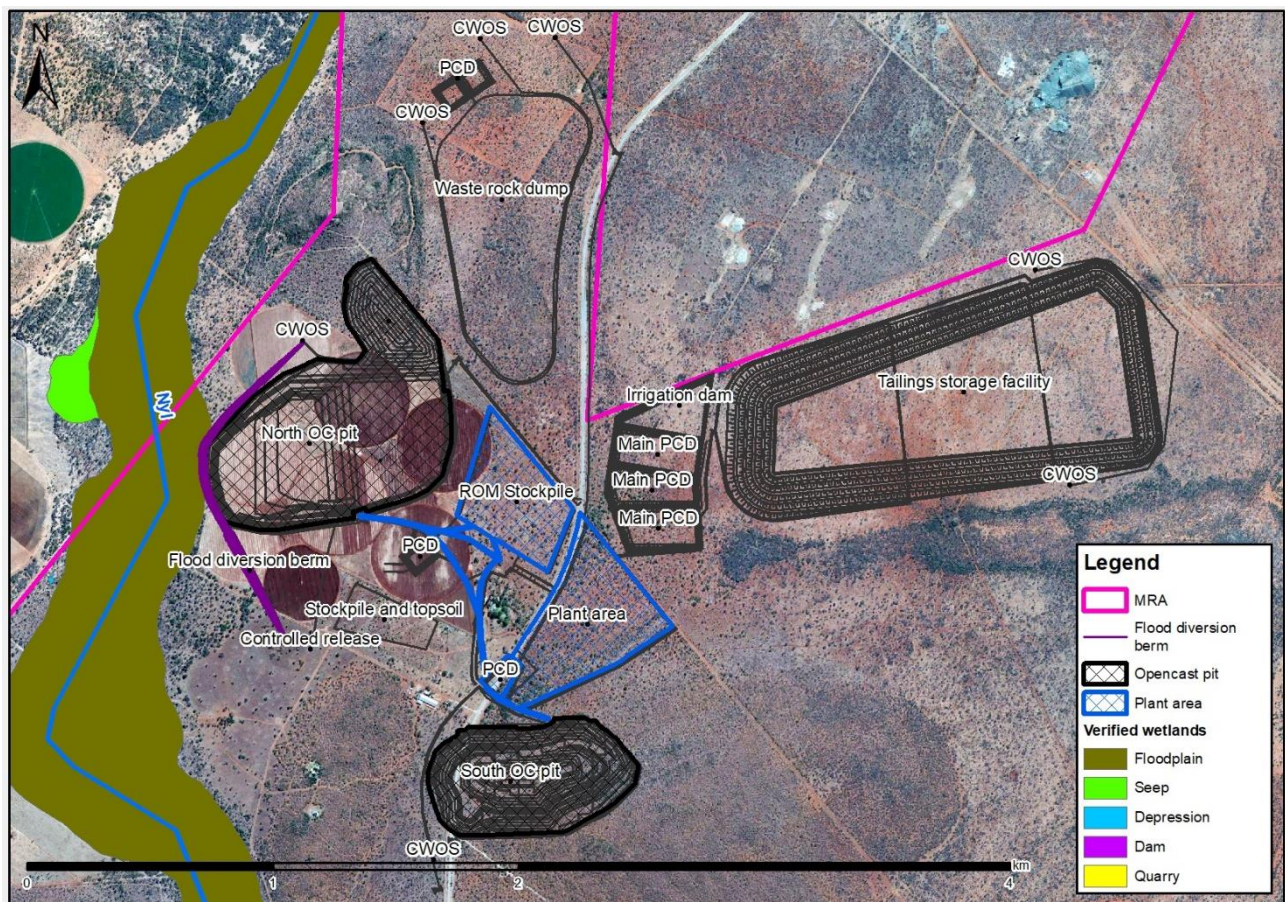


Figure 2 Map showing the proposed mining activity footprint in relation to the amended Mining Rights Area (MRA), wetlands and the Nyl River floodplain. CWOS = Clean Water Outlet Structures, PCD = Pollution Control Dam and OC = Open Cast.

4.3 APPROACH, METHODOLOGY

4.3.1 Collation of existing information

The following studies were reviewed to form a baseline understanding of the study area specifically in regard to the local geology, soils and hydrogeology:

- Claassens, Andries. Date unknown. *Report on the Soil Survey and Land Capability Classification of the Farms Volspruit and Zoetveld. Soil Science and Plant Nutrition Consultant. Specialist report.*
- GEO Pollution Technologies – Gauteng (Pty) Ltd. 2014. *Summary of the Geohydrological Report for the proposed Volspruit Mine (North- and South Pit) near Mokopane, Limpopo Province. Specialist report with reference EsVol-13-447f.*
- GEO Pollution Technologies – Gauteng (Pty) Ltd. 2022. *Groundwater Specialist Study Update for Proposed Volspruit Mining Project. Specialist report with reference EPVOL-21-6722.*
- Tanner, Dominique, Iain McDonald, R.E. Jock Harmer, Duncan D. Muir, Hannah S.R. Hughes. 2019. *A record of assimilation preserved by exotic minerals in the lowermost platinum-group element deposit of the Bushveld Complex: The Volspruit Sulphide Zone. Lithos, Volumes 324–325, Pages 584-608, ISSN 0024-4937.*
- WCS Scientific, 2022. *Wetland Assessment Report for the Volspruit Mine Project, Limpopo Province. Report reference 1430b/2021*

4.3.2 Hydropedological assessment

A conceptual hydropedological assessment provides insight into hydrological processes by interpreting soil morphological properties. These soil observations were used as a proxy for the characterisation of hydrological processes with an emphasis on flow drivers within the hillslope and for wetland systems specifically. Once the flow drivers of the systems in their current conditions are established, predictions can be made informing how these may change after the execution of the proposed mining activities. Both possible negative and positive impacts were identified and described conceptually. This assessment was performed on a hillslope scale whereby the links between the catchments and respective wetlands were described and assessed with an emphasis on the areas where impacts associated with the mining activities are likely to occur.

Soil transects were hand augured perpendicular to the slope in order to characterise soil hydraulic properties in areas most likely affected by the proposed mining and infrastructure activities. Soil texture was estimated on site and used to derive the hydraulic characteristics of the soils using hydropedo transfer lookup tables (Rawls et al., 1982). Typical soil hydropedological parameters were recorded to classify soils into recharge, interflow and responsive soils. In addition, two double ring infiltrometer tests were conducted in order to better understand the infiltration rate and therefore the likelihood of surface runoff generation during high intensity storm events. This forms the basis for informing the understanding of hydrological flow drivers feeding the wetlands.

5. ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitation related to this study apply:

- This report has been prepared for the particular purpose outlined in the Introduction and Scope of Work above and no responsibility is accepted for the use of this report, in whole or in part, in any other context or for any other purpose.
- This assessment was based on the project description and proposed development and activity descriptions as detailed and illustrated in this report.
- In addition, it is recognised that the passage of time may affect the information and assessment provided in this report. WCS's opinions are therefore based upon the information that was made available to WCS and which existed at the time of compiling this report.

- It was assumed that the floodplain wetland within the study area footprint is primarily surface water driven with limited or no interflow and groundwater component. Quantifying the flows to the floodplain by means of detailed hydrological modelling has therefore been excluded from the scope of work of this proposal.
- Usually a hydrological modelling approach is required when impacts to water resources due to opencast mining need to be determined (Van Tol et al., 2021). It was assumed that a hydrogeological assessment on a conceptual level would be sufficient to provide meaningful results with regards to impacts on the floodplain.
- No test pits were dug as part of this study, instead all soil observations were made by using a hand auger with extensions to reach depths of refusal where possible. This proved both suitable and adequate for the purpose of this study as most of the soils within the study area were shallow and in isolated spots soil depth up to 2.7 mbgl were encountered as the maximum depth.
- The frequency of soil observations for each transect was altered on site at the discretion of the specialist. Some areas were sampled more frequently while other areas less frequently based on the observed heterogeneity in the respective catena. While this approach can potentially lead to unforeseen knowledge gaps that can affect the accuracy of the findings, it was deemed adequate for the purpose of this study given the relatively uniform nature of the soils within the study area.
- No hydrological modelling was performed as part of this study.
- This report needs to be seen as part of a larger suite of studies undertaken for the proposed mining activity/operation, and the results and findings must be understood and interpreted within the context, findings and recommendations of these other studies. This report therefore serves to provide additional information pertaining to the existing suite of studies.

6. RESULTS

6.1 CLIMATE

The climate in the study area falls under the BSh category which is hot arid steppe or veld (Kottek et. al., 2006). The rainfall is lower than the potential evapotranspiration throughout the year. The mean annual rainfall for the area is about 548 mm and the potential annual evapotranspiration is between 1 700 and 1 800 mm per annum (Bailey and Pitman, 2016a).

6.2 TERRAIN

The proposed mining and associated infrastructure are situated on a hillslope adjacent to the Nyl River floodplain (**Figure 3**). The hillslope between the isolated hill-tops (koppies) to the north and south of the main infrastructure can be characterised as a relatively uniformly gently sloping slope that is steepest at the crest (top of Cross-section 1) and flattens out towards to the footslope where the gradient becomes flatter towards the floodplain. The isolated hills within the area have much steeper slopes than the general terrain in the area.

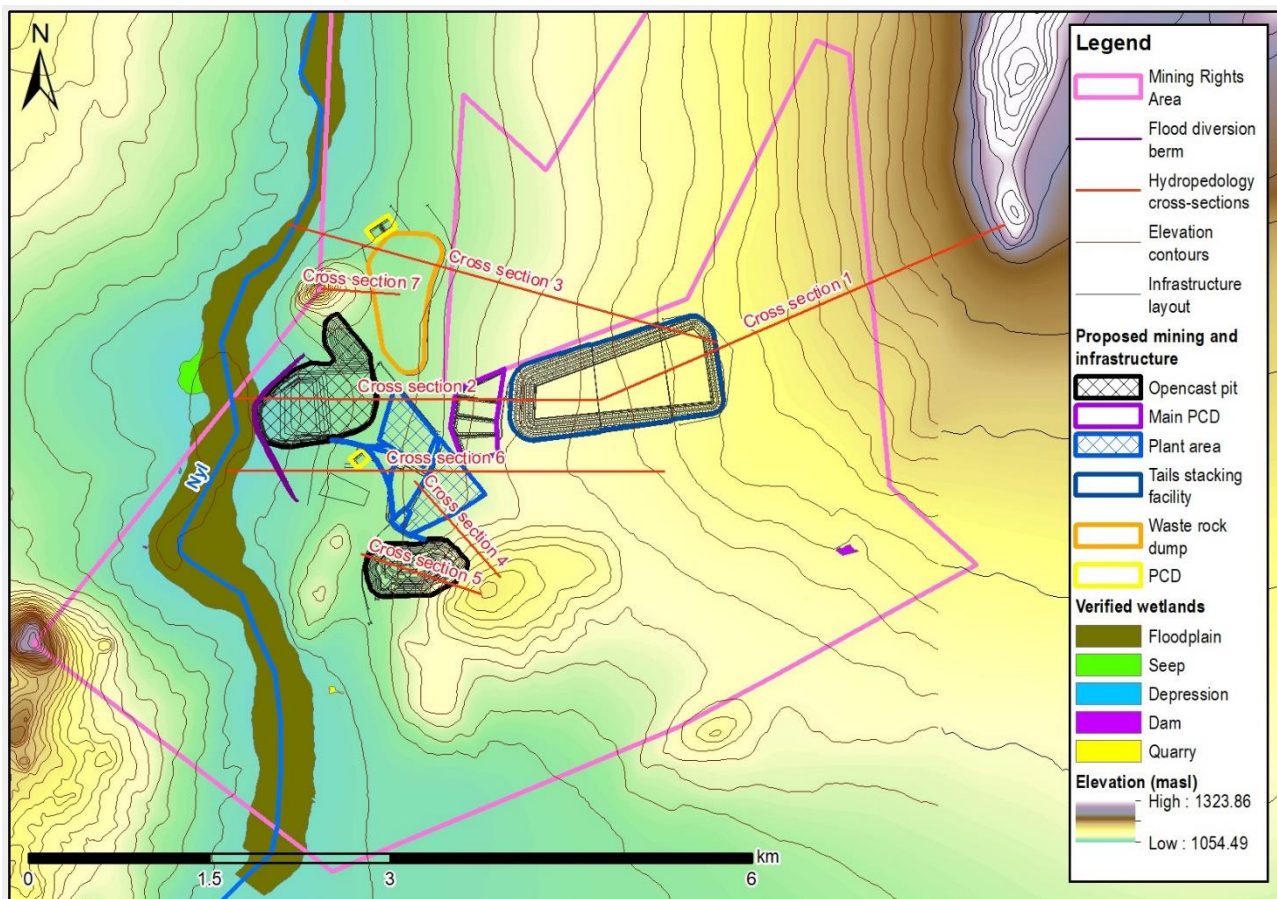


Figure 3 Map showing the surface terrain in relation to the proposed infrastructure and mining with the hydropedology transects (cross-sections) in relation to the floodplain and associated wetlands.

6.3 GEOLOGY

The study area falls within the northern Bushveld Igneous Complex and more specifically belongs to the Lower Zone of the Bushveld Complex. Transvaal Supergroup rocks are situated below the Lower Zone Rocks. The ore body targeted by the Volspruit Mining Expansion Project is hosted within the Platinum Group Elements (PGE) more specifically Pyroxenite, serpentinized harzburgite and chromitite layers.

6.4 HYDROLOGY OF THE NYL RIVER

EScience Associates (2014) have conducted a hydrological modelling study of the Nyl River with emphasis on the likely impacts of the proposed mining activity to the river discharge within the Nyl River. The study has concluded that the Nyl River at the outlet of quaternary catchment A61E2 has no flow for 90 % of the time (between 2005 and 2014) making this an ephemeral river. The study concludes that the artificially lowered groundwater table along the Nyl River floodplain is a contributing factor for the lack of baseflow. Interflow losses to the lowered groundwater table is being mentioned as the reason as to why 'interflow' cannot reach the floodplain but instead flows into the below lying aquifer. The study predicts that the river discharge from quaternary catchment A61E2 will decrease by 4.25 % under the proposed mining scenario due to increased transmission losses.

The increased transmission losses are predicted to occur due to the mining induced further lowering of the groundwater table.

6.5 SOIL CLASSIFICATION

As part of this assessment the soil forms were determined at each sampling/observation site and have been interpolated throughout the study area. A map showing the soil forms is shown in **Figure 4**. The study area is dominated by Glenrosa and Nkonkoni soils both showing the weathering of the soil's parent material at the bottom of the soil profile. In some areas the Mispah soil form could replace the Glenrosa soil form where the lithic horizon is less pronounced. However the strong weathering throughout the study area was the reason why the Glenrosa soil form occurs more commonly than the Mispah soil form.

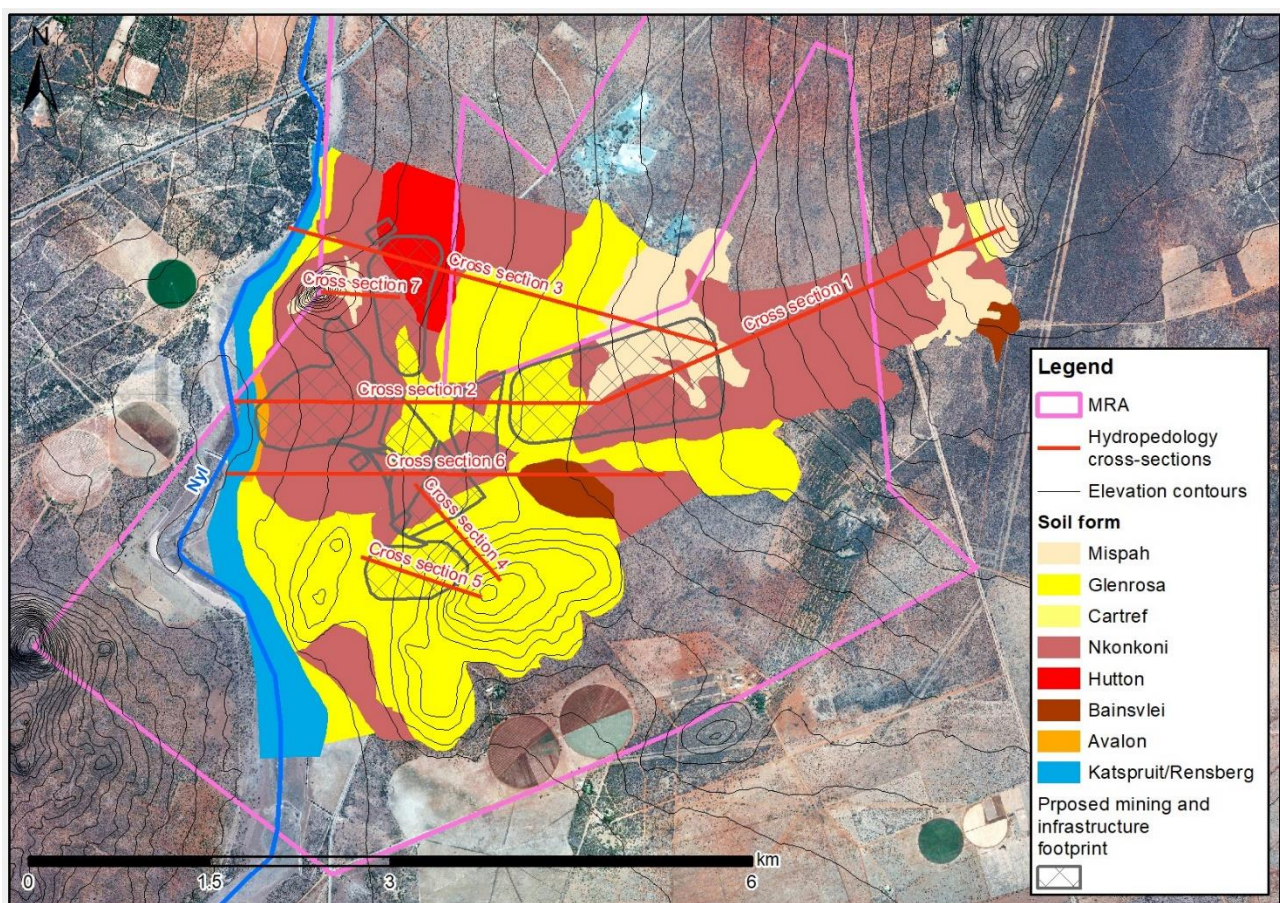


Figure 4 Map showing the soil forms within the study area as well as hydropedological transects, 5 m elevation contours, the mining rights areas, and the proposed mining and infrastructure footprint.

6.6 CROSS SECTION PROFILES

In total 7 cross sections (see **Figure 5**) were used to represent the different parts within the study area. Each transect is described with an emphasis on hydrology which in turn is conceptually based on the findings of the hydropedological assessment. The cross sectional profiles are shown in **Figure 6** to **Figure 12** below.

6.6.1 Cross Section 1

The crest of this hillslope (**Figure 6**) is characterised by a steep rocky ridge with very little to no soil cover classified as the Mispah (Ms) soil form. This section is responsive where most rainfall would be generated into surface runoff. At the foot of the rocky outcrop ridge there is a relatively short section with Cartref (Cf) soils showing signs of interflow. A band of rocky outcrops where the Harzburgite rocks occur at surface or under very shallow A-horizon is followed by deep well drained Nkonkoni (Nk) soils with a soil depth of up to 2.7 m below ground level (mbgl). This portion is characterised by dark red soils above strongly weathered bedrock allowing for high rates of infiltration and vertical movement of water through the fractured rock representing recharge soils. The soils were generally shallower towards the lower end of Cross Section 1. Cross Section 1 ends at the midslopes and is continued with Cross Section 2.

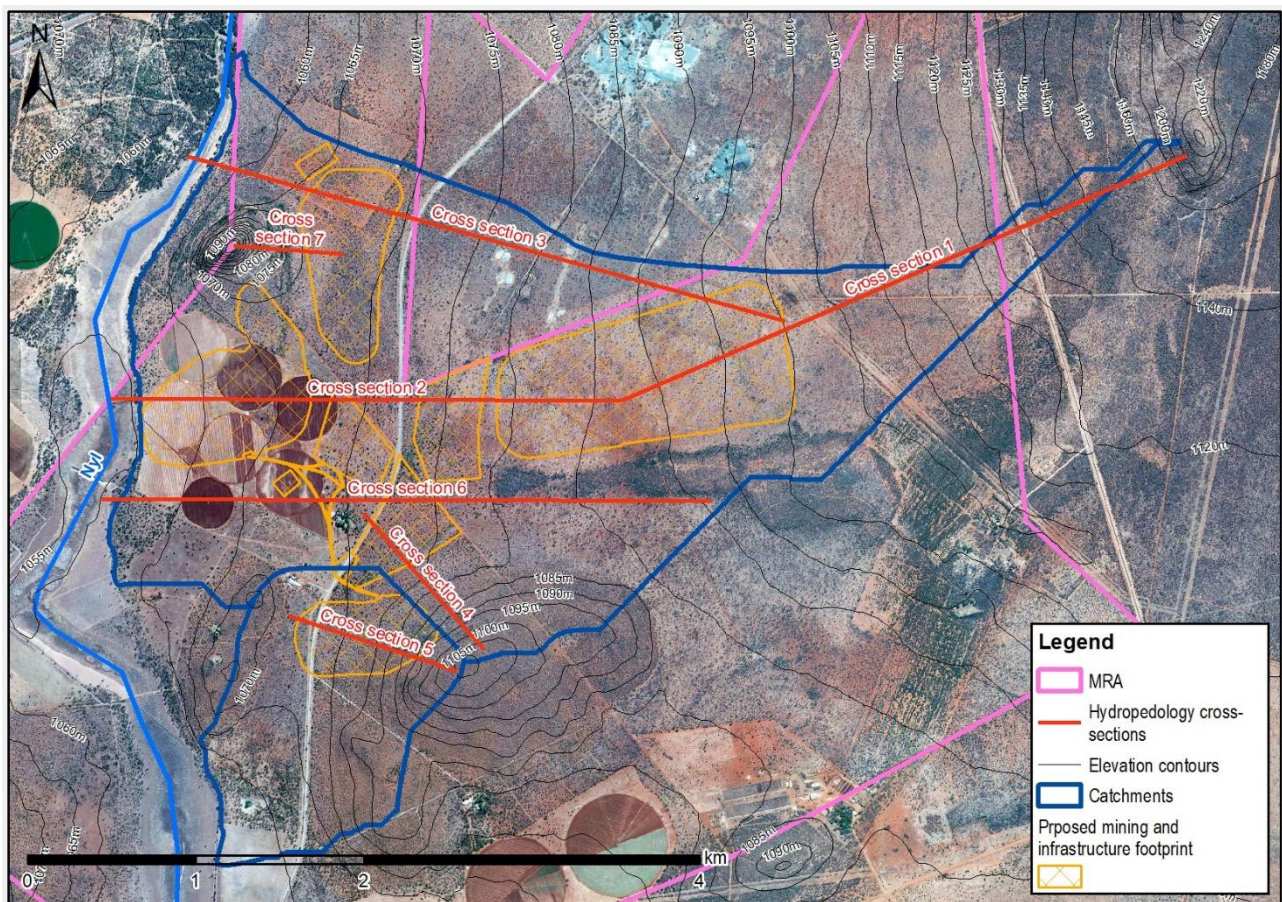


Figure 5 Map showing the location of the cross sectional profiles use for the hydrogeological assessment in relation to the surface water catchment of the study area, proposed mining and associated infrastructure and surface topography.

6.6.2 Cross Section 2

This cross section (**Figure 7**) starts at the midslopes which are dominated by shallow relatively well drained Glenrosa (Gs) soils and ends at the Nyl River floodplain. The shallow Glenrosa soils showed high chroma and are underlain by strongly fractured and weathered bedrock allowing for high groundwater recharge. A limited amount of surface runoff is expected to be generated during high intensity rainfall events due to the shallow soil depth. The soil depth increases to about 1.6 mbgl towards the footslope of the hillslope. Here soils consist of the Nkokoni (Nk) soil form and showed

high chroma similar to what is typically found in Hutton soils indicating good drainage and infiltration of these soils. No signs of saturated conditions were found. A narrow band of Avalon (Av) soils follows before the soils change to Katspruit (Ka) and Rensburg in the floodplain. The clay rich soils within the floodplain prevent sub-surface water movement either laterally or horizontally causing saturated conditions in the soil profile during wet conditions. The soils within the floodplain are poorly drained due to their low hydraulic conductivity and are therefore responsive in nature.

6.6.3 Cross Section 3

Cross Section 3 (**Figure 8**) is similar to Cross Section 2. It also contains a shallow responsive section at the midslopes and towards the footslope the soil depth increases, consisting of well drained recharge soils. The poorly drained Mishpah (Ms) soils at the top of the cross section generate surface runoff during storm events. The lack of distinct interflow towards the footslope and towards the floodplain indicates that the groundwater level is likely below the depth of the soil. The Hutton (Hu) and Nkoknoi (Nk) soil forms found towards the lower part of the cross section were more than 1.6 m deep and are likely to be well drained.

6.6.4 Cross Section 4

This cross section (**Figure 9**) depicts the slope off a local hill situated at the southern side of the study area. This hill (koppie) mostly consists of very shallow soils with the soil forms Mispah (Ms) and Glenrosa (Gs). Towards the footslope the soils change into Nkokono (Nk) and gradually increase with depth. The high infiltration capacity of the lower lying soils likely absorbs most surface runoff generated by the shallow soils on the hill. There are no signs of drainage lines at the footslopes adjacent to the hill.

6.6.5 Cross Section 5

This cross section (**Figure 10**) is very similar to Cross Section 4 with the expectation of the lack of deeper soils at the footslope. The lack of a B-horizon makes for a uniform soil form of Glenrosa (Gs) throughout the slope. The hydropedological response is likely to be similarly uniform as the soils towards the footslope are expected to be well drained despite their shallow depth. The deep red colour of the soil suggests that there are no saturated conditions for any prolonged periods.

6.6.6 Cross Section 6

Cross Section 6 (**Figure 11**) proceeds from gently sloping midslopes to the Nyl River floodplain. The soils on the mid to lower parts are well drained moderately deep and are classified as Nkokoni (Nk) soils. The soils show reduced conditions towards the bottom of the cross section at the intersection between terrestrial and wetland soils. The change between recharge soils and responsive soils is relatively sudden with a lack of interflow soils between them. This suggests that saturated conditions within the sandy soil do not occur long enough or frequently enough to develop any signs of interflow. It is likely that the groundwater level is too low to allow for saturated conditions to develop close to the soil.

6.6.7 Cross Section 7

This cross section (**Figure 12**) is similar to Cross Section 4 with the only difference being the deep recharge soils at the footslopes. Here soils reached a depth of greater than 1.6 mbgl.

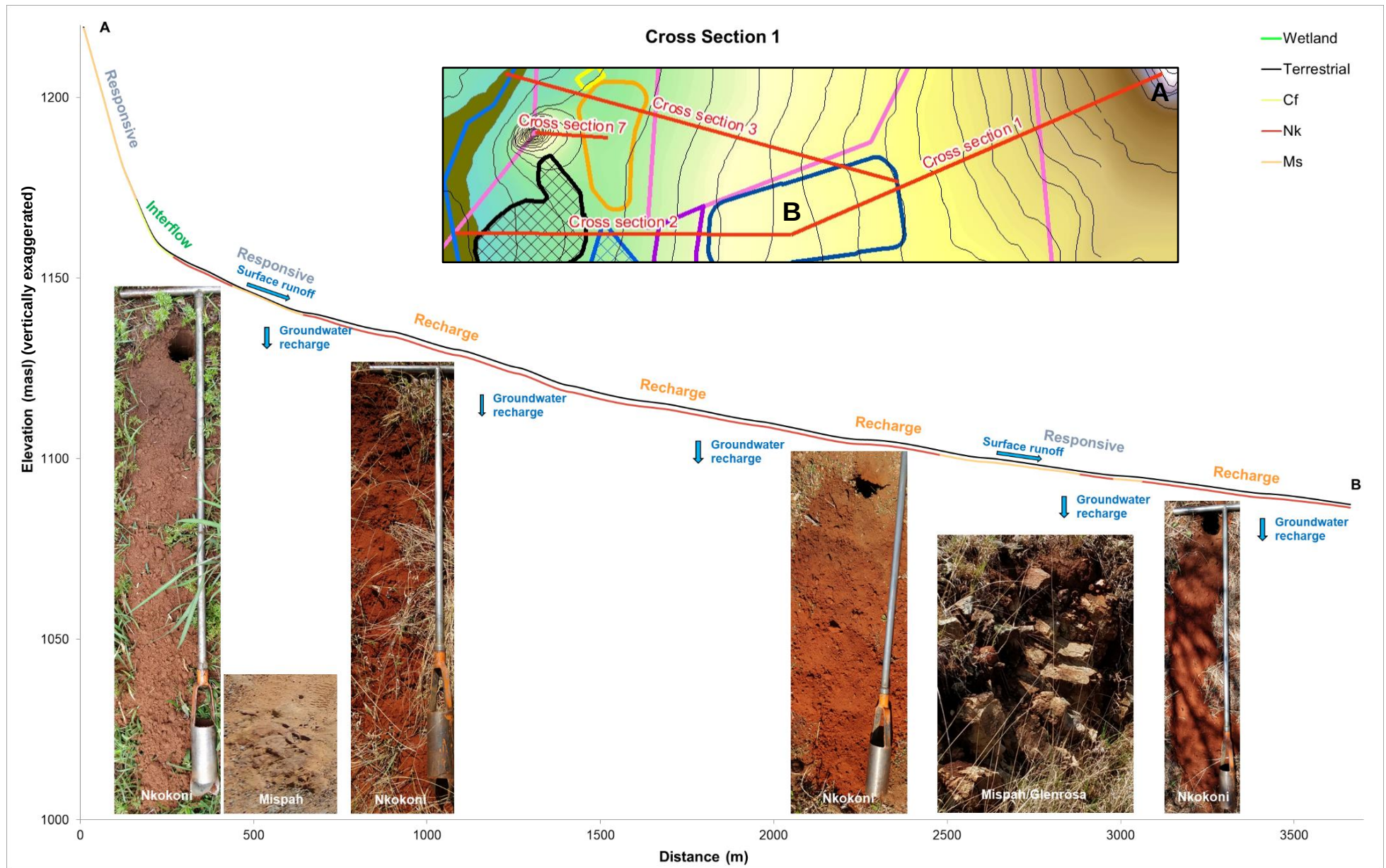


Figure 6 Cross section profile 1 showing terrain, soil forms, soil depth, hydropedological response units, representative soil profiles and conceptual hydrology.

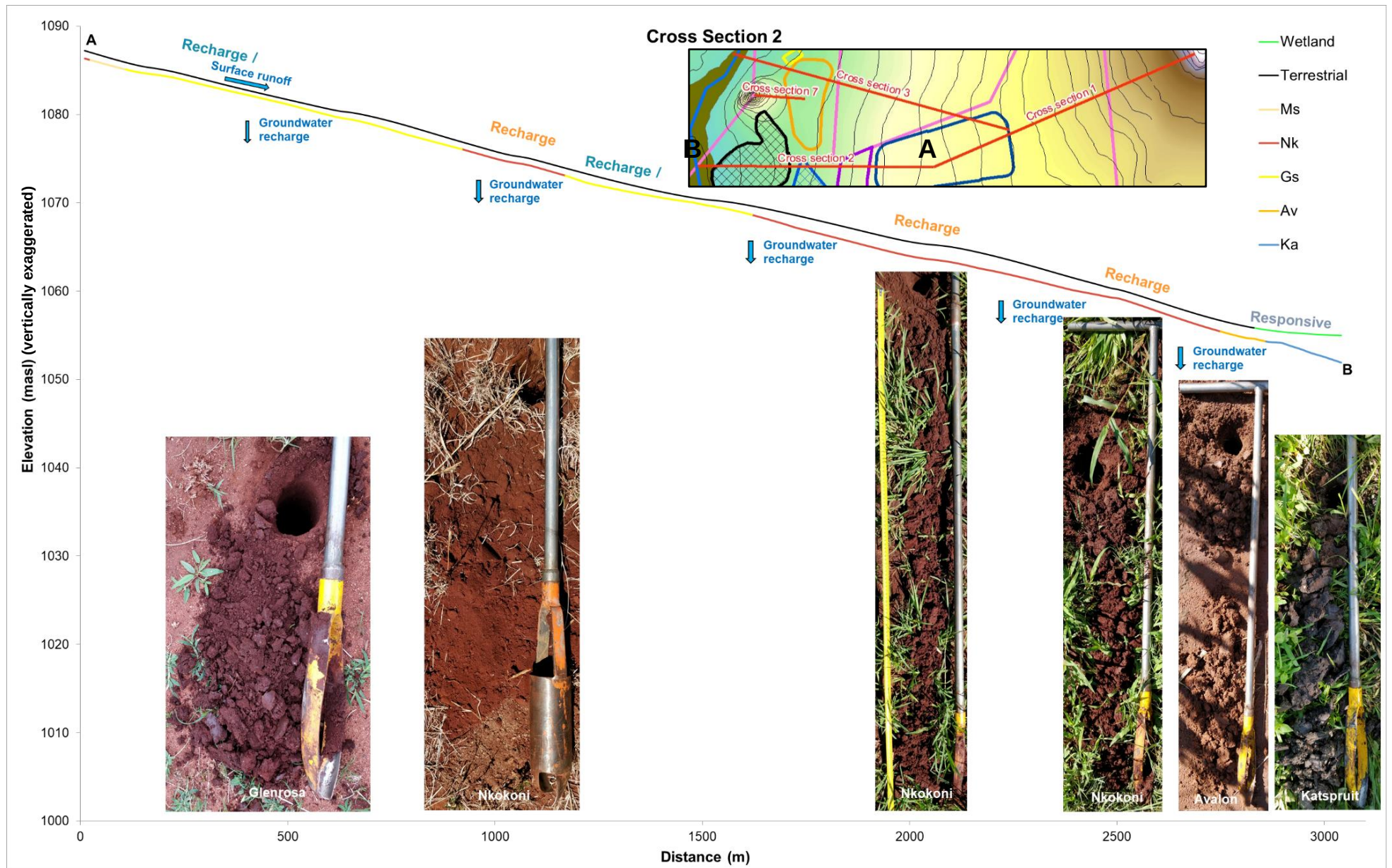


Figure 7 Cross section profile 2 showing terrain, soil forms, soil depth, hydrogeological response units, representative soil profiles and conceptual hydrology.

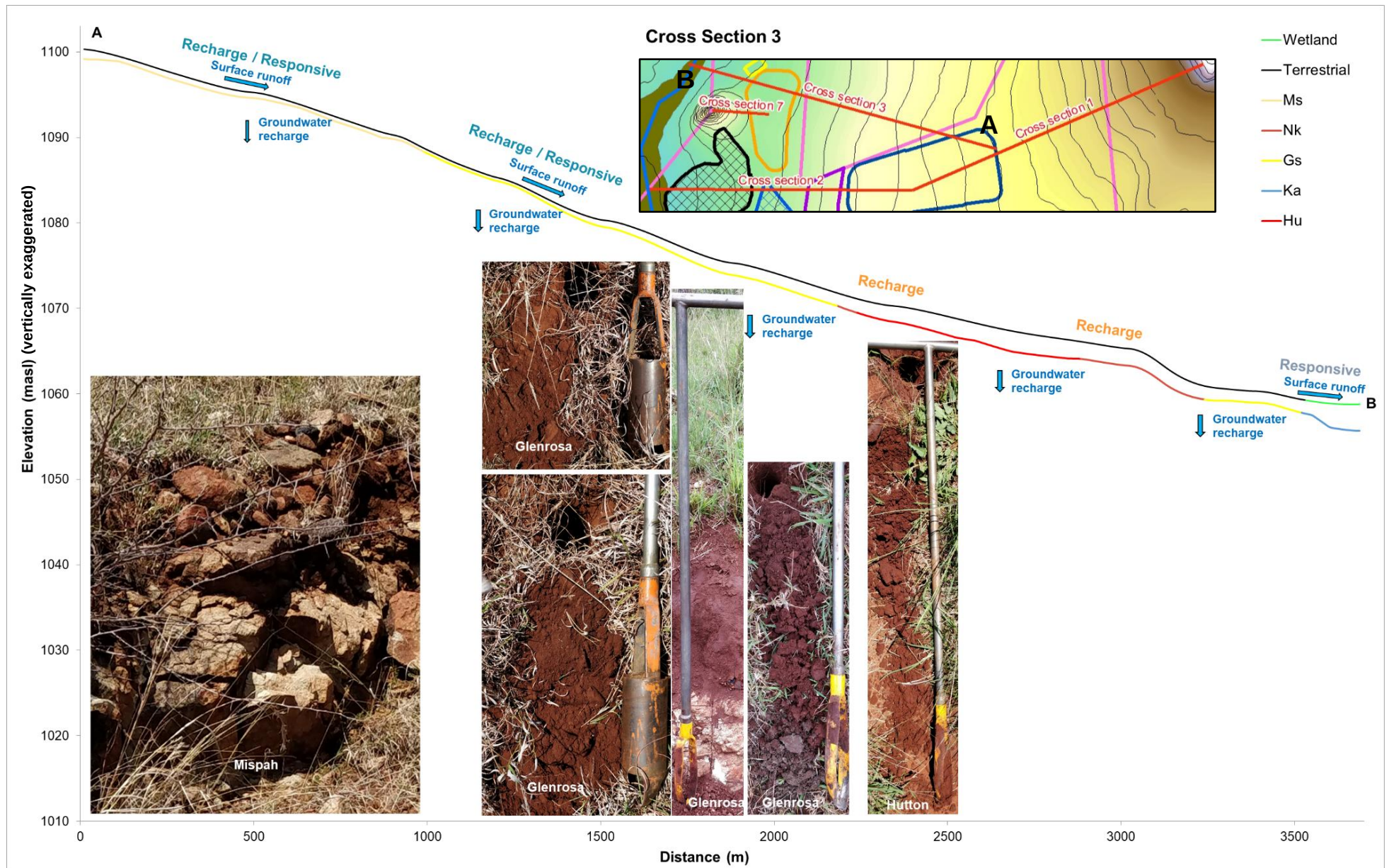


Figure 8 Cross section profile 3 showing terrain, soil forms, soil depth, hydropedological response units, representative soil profiles and conceptual hydrology.

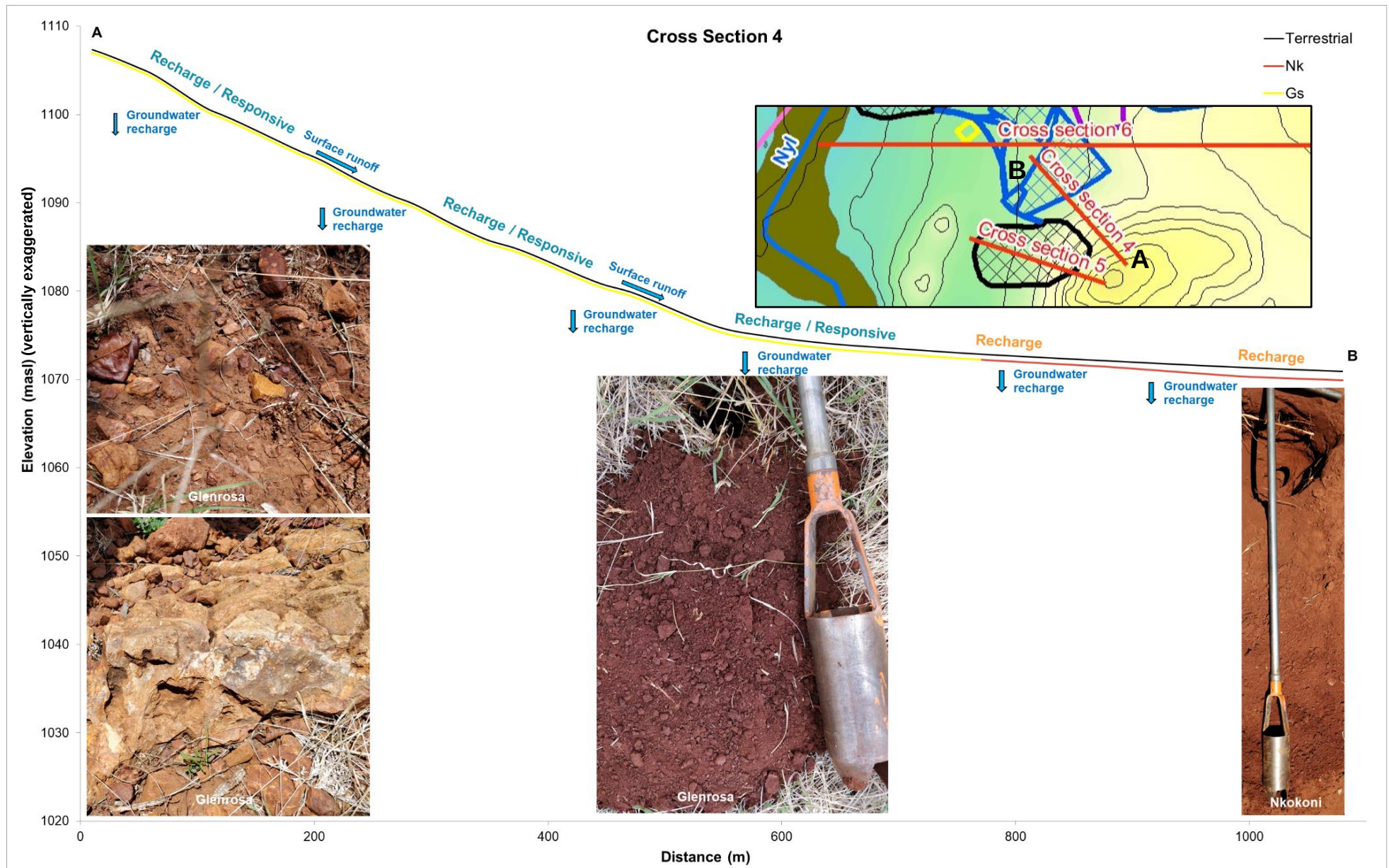


Figure 9 Cross section profile 4 showing terrain, soil forms, soil depth, hydrological response units, representative soil profiles and conceptual hydrology.

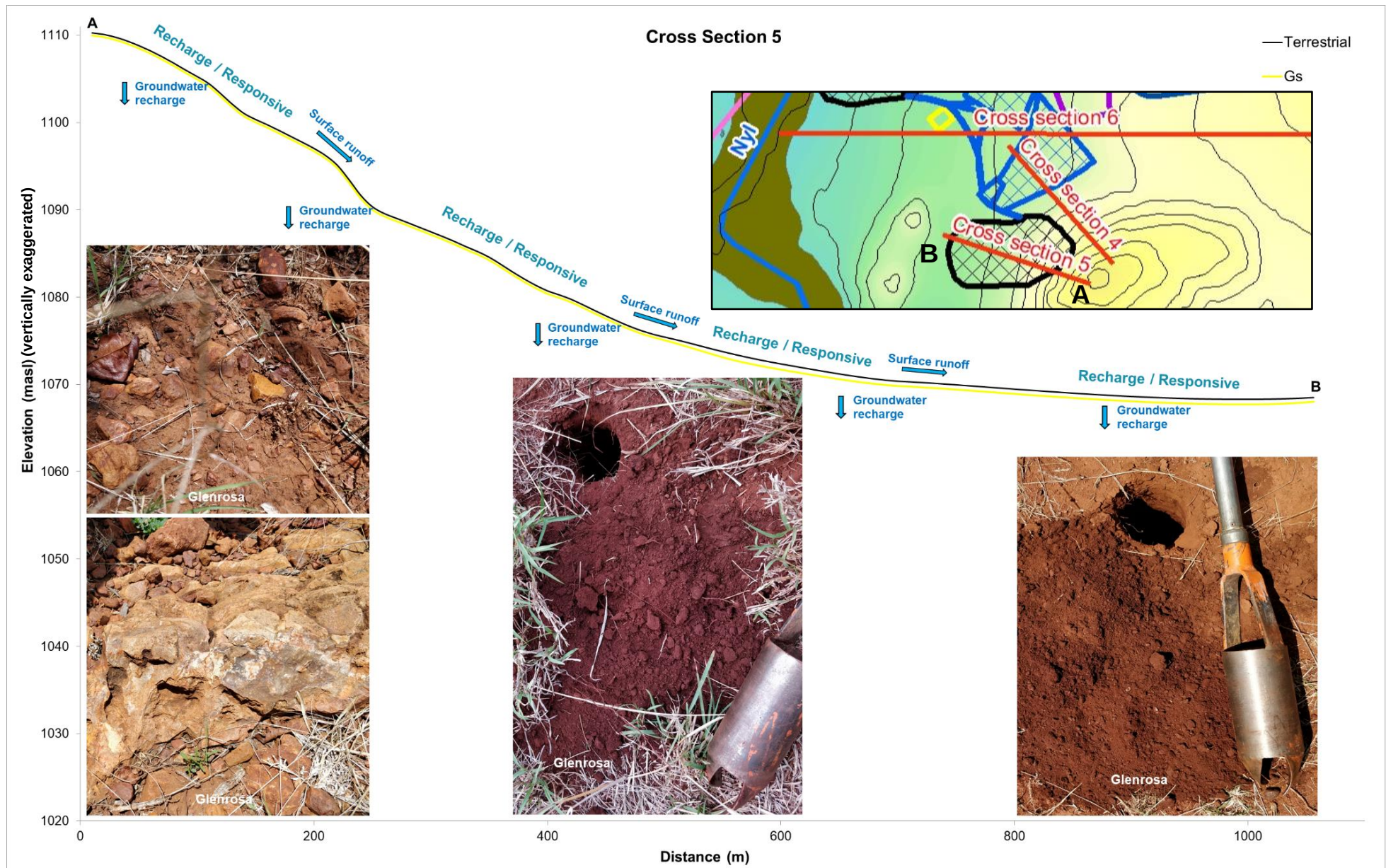


Figure 10 Cross section profile 5 showing terrain, soil forms, soil depth, hydropedological response units, representative soil profiles and conceptual hydrology.

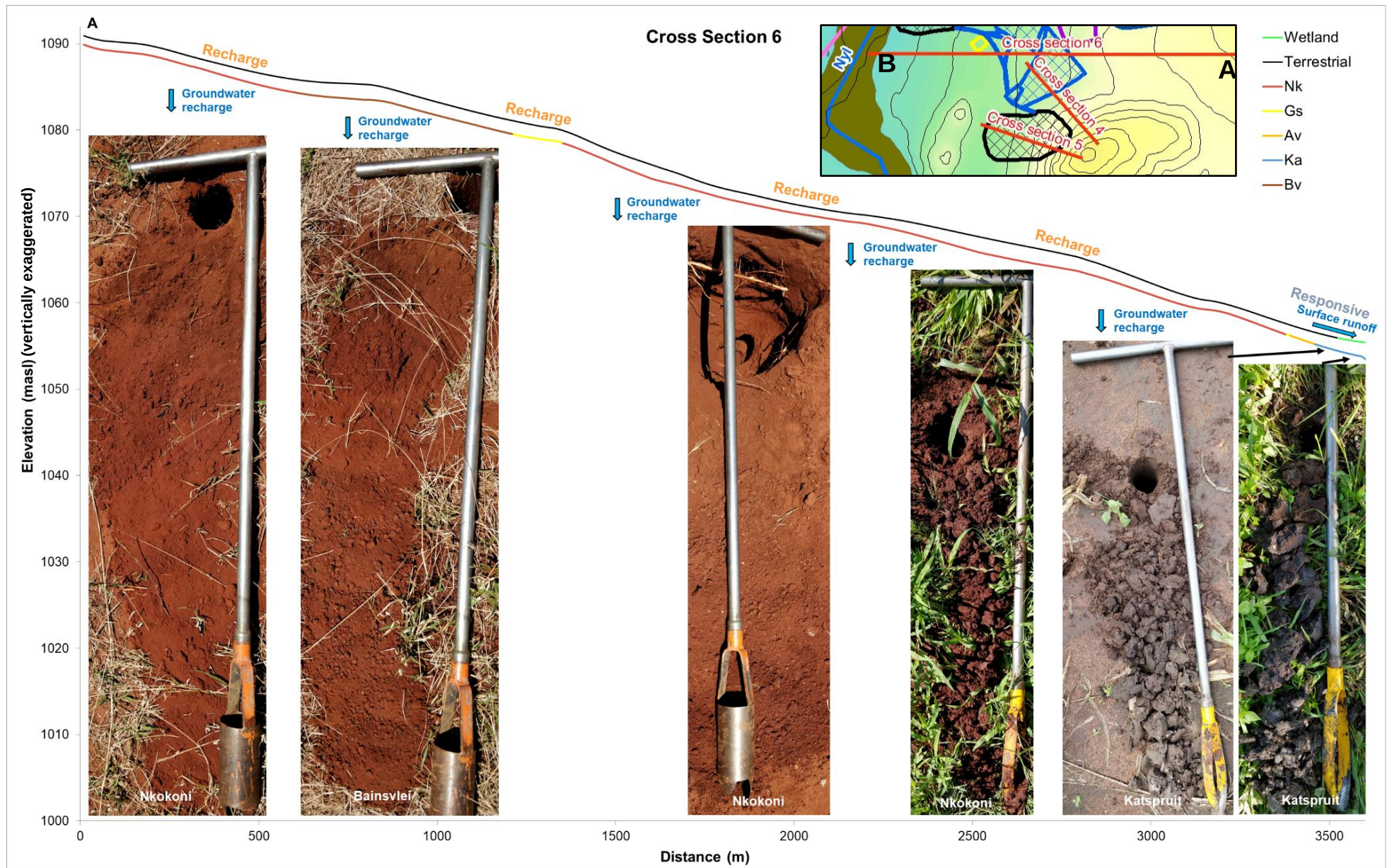


Figure 11 Cross section profile 6 showing terrain, soil forms, soil depth, hydropedological response units, representative soil profiles and conceptual hydrology.

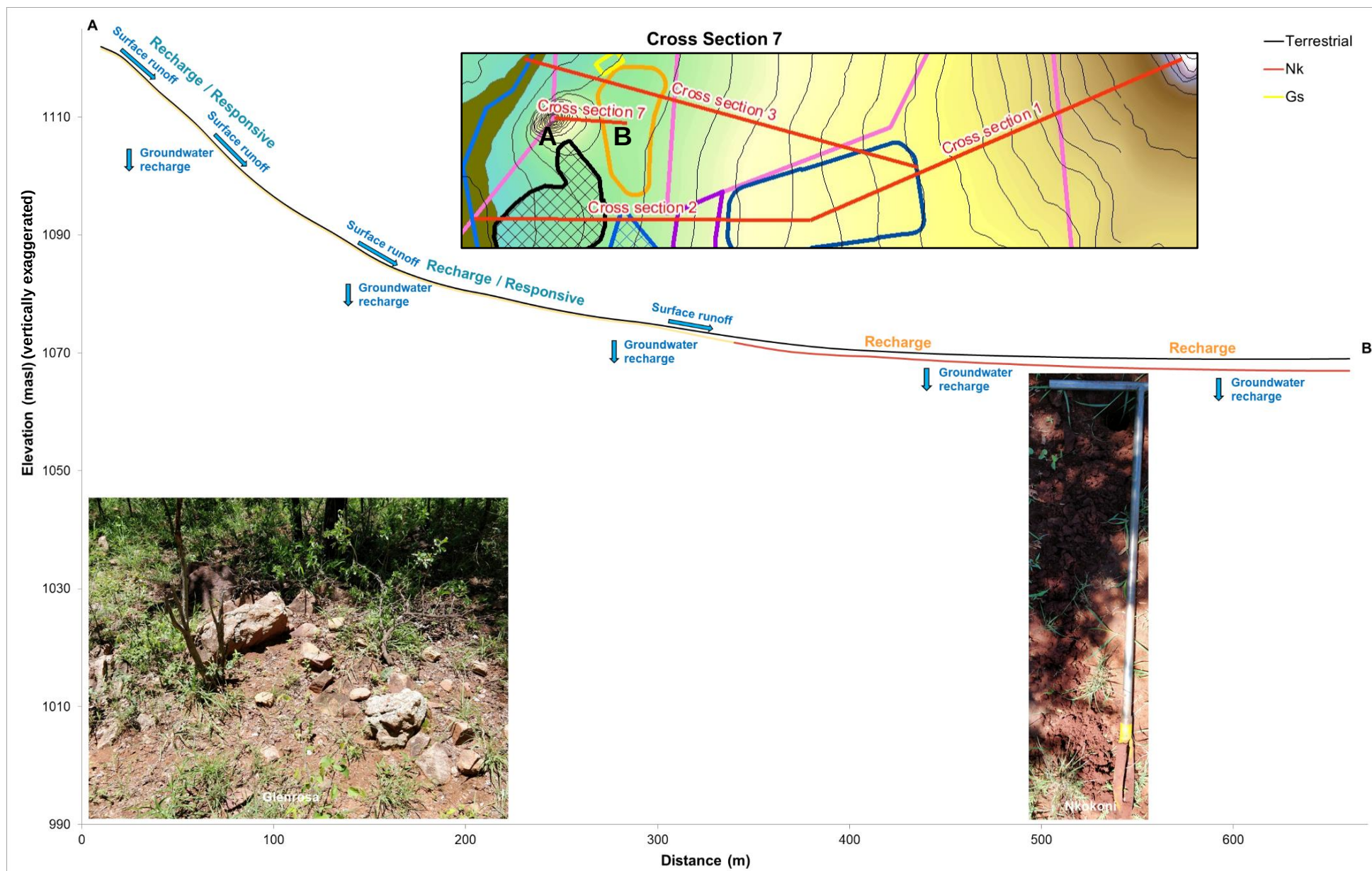


Figure 12 Cross section profile 7 showing terrain, soil forms, soil depth, hydropedological response units, representative soil profiles and conceptual hydrology.

6.7 HYDROPEDOLOGICAL RESPONSE UNITS

The hydrogeological response units provide an insight into the hydrology conceptually and are shown in **Figure 13**. The study area mainly consists of recharge and recharge/responsive soils. The only exception are some steep rocky outcrops at the upper end of the catchment as well as the floodplain consisting of responsive soils. There was a notable lack of interflow soils indicating that water does not flow laterally within the soil profile but instead either infiltrates into the parent material and percolates to the below-lying aquifer as groundwater recharge or for shallow soils resulting in surface runoff (responsive soils). Soils found within the study area that had the responsive component also showed relatively high infiltration rates indicating that they had both responsive as well as recharge properties. Only certain areas show predominantly responsive characteristics such as the floodplain as well as some rocky areas mostly at the very top of hillslopes.

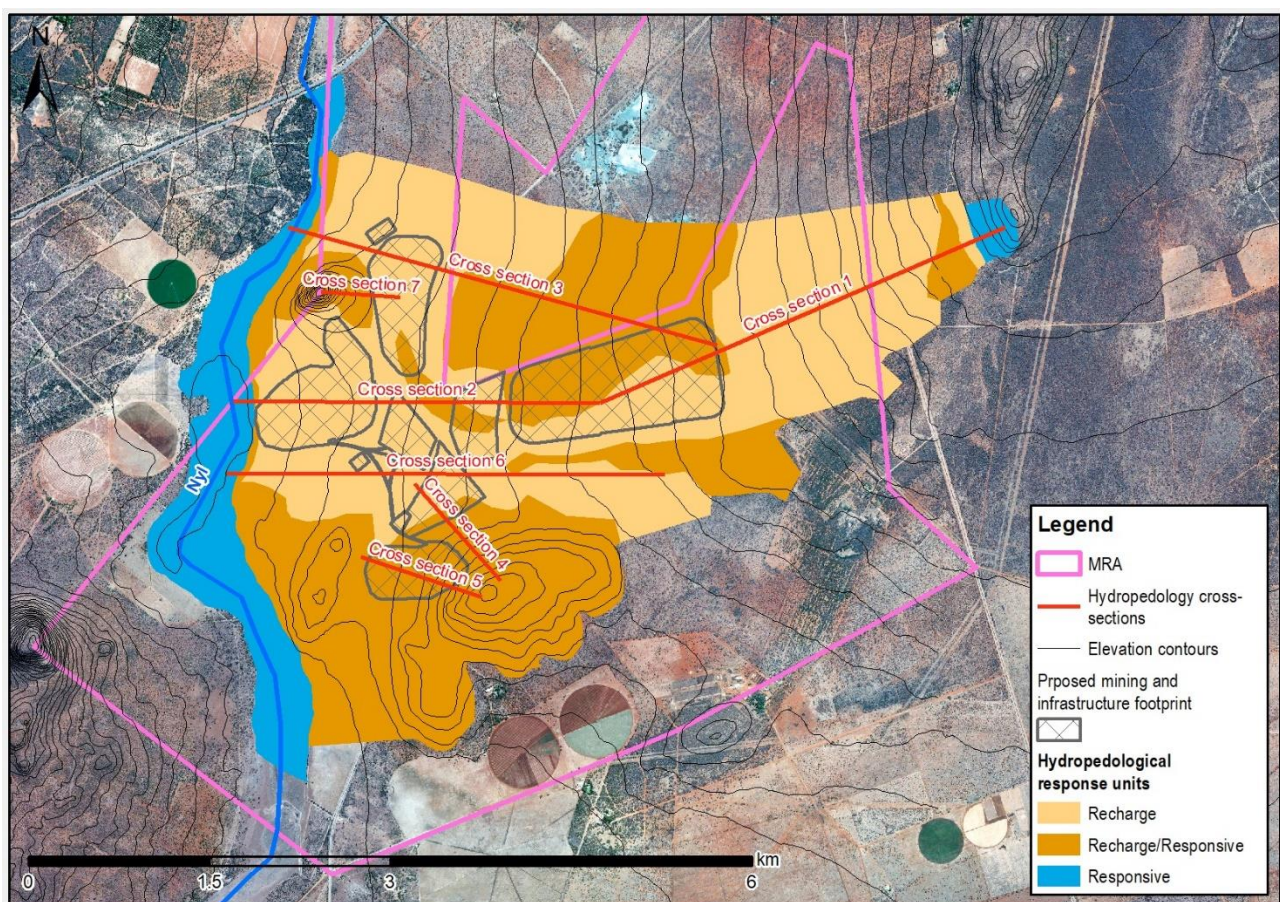


Figure 13 Map showing the approximate layout of the hydrogeological response units within the study area including hydrogeological transects, 5 m elevation contours, the mining rights areas as well as the proposed mining and infrastructure footprint.

6.8 CONCEPTUAL HYDROLOGICAL UNDERSTANDING

The study area is dominated by soils with high infiltration capacity and a high proportion of groundwater recharge due to the sandy nature of the soils and high degree of fractures and weathering in the soil's parent material. Soils with a high clay content were only found in the

floodplain wetland and also occur in the extreme south of the study area associated with the Springbokvlaakte Thronveld. Soil water movement was found to be predominantly vertical with a distinct lack of signs of horizontal water movement (interflow) despite the high hydraulic conductivity of the soils in general. This is most likely due to the general absence of water impeding layers in the soil and below-lying bedrock combined with a groundwater level generally below the bottom of the soil. This is true even in the vicinity of the floodplain and several meters below the soil surface directly below the floodplain within the thick clay layer (GEO Pollution Technologies, 2022). In a more recent studies (Geo Pollution Technologies, 2022 and GPT, 2023) groundwater levels were monitored near the floodplain between about 2010 and 2019 and it was shown that the groundwater levels never reached the surface within the monitoring boreholes for the duration of the monitoring period.

The floodplain section within the study area is therefore understood to be mainly driven by surface runoff generated upstream of the study area. The eastern hillslope adjacent to the floodplain (study area) is only expected to marginally contribute water to the floodplain in the form of surface runoff during high intensity rainfall events. This is however not expected to be an important hydrological driver to the floodplain as this surface runoff is likely to be limited to rare only occurring during very high intensity rainfall events. Such surface runoff occurs predominantly as sheet flow, with no drainage lines or watercourses identified within the hillslope.

The groundwater assessment study (GPT, 2023) has shown that it is unlikely that the floodplain within the section adjacent to the study area near the north pit is in contact with the groundwater table under climatically average conditions and under the currently present groundwater levels. It is important to note that the aquifer in the general area is subject to water abstraction for irrigation purposes and it is likely that the groundwater levels are being lowered as a result. The artificially lowered groundwater levels result in transmission losses i.e. surface water from within the floodplain percolating to the below lying aquifer. These losses are likely low withing the clay rich floodplain soils as these have a low hydraulic conductivity. In comparison the transmission losses are expected to be higher when the flooding extent exceeds the clay rich floodplain soils where permeability is higher. It is important to note that during large floods where flooding takes place beyond the clay rich soils and into the adjacent sandy terrestrial soils the loss through transmission losses is relatively small compared to the large volume floodwater mostly originating from the upstream catchment. It is possible that the local transmission losses will reduce the flooding extent and duration slightly under this scenario.

It is possible that the groundwater levels could rise several meters during extreme wet years with exceptionally high rainfall and as a result with exceptionally high groundwater recharge. Under these conditions the transmission losses would be lower and if the groundwater would reach the surface, then transmission losses would diminish. However in these wet conditions the floodplain would be subjected to above normal flooding from the upstream catchment and as a result any additional water from groundwater would not likely make a significant relative contribution to the floodplain's hydrology.

6.9 LIKELY IMPACTS TO THE HYDROLOGY OF THE FLOODPLAIN DUE TO THE PROPOSED MINING AND ASSOCIATED INFRASTRUCTURE

6.9.1 Operational Phase

Since the general hillslope within the study area is not the primary, or even a significant, hydrological driver for the floodplain, it is unlikely that proposed mining and associated infrastructure will significantly reduce the amount of water feeding the floodplain from the study area. The opencast mining operation will further lower the groundwater levels underneath the floodplain due to the proposed opencast pits and the associated dewatering (GPT, 2023). The proposed infrastructure will likely reduce the groundwater recharge in some areas. Since the floodplain under average climatic conditions does not likely receive groundwater under the current conditions, it is unlikely that the change in groundwater dynamics will have an impact on the floodplain as the floodplain is currently not in contact with the aquifer.

The hydrological work conducted by EScience (2014) concluded that the mining induced lowering of the groundwater table results in a decrease in river baseflow and increased river transmission losses. River baseflow is however not affected by the lowered groundwater level as there is no interaction between the groundwater and river water during baseflow conditions. This is further substantiated by the hydropedological assessment conducted as part of this study which has found no evidence of interflow within the soil profile near the floodplain. Signs of interflow would be evident if interflow occurred historically before groundwater abstraction took place, however, the soils do not show significant signs of interflow. Transmission losses would occur during flooding events where the flood waters would extend beyond the clay rich soils within the floodplain where the floodwater is able to infiltrate into the sandy soils which have a relatively high permeability. This likely results in slightly reduced flooding extent and duration. Based on the groundwater level recordings from between 2013 and 2019 it is evident that the groundwater levels did not reach the surface adjacent of the floodplain near the proposed open cast north pit. For areas where the groundwater is currently well below the floodplain soils it is unlikely that a further lowering of the groundwater table will result in increased transmission losses. However for areas where the floodplain is still in contact with the blow lying aquifer the groundwater lowering will increase transmission losses during flooding.

The likely negative impacts to the affected section of floodplain from a hillslope hydrology perspective as a result of the proposed mining and infrastructure are:

- Capturing of surface runoff effectively reducing the catchment area of the floodplain associated with the study area by 2.04 km² which is 16.87 % of the study area (Erudite. 2019). The overall catchment reduction of the floodplain is by far lower (approximately 0.1 %) taking into consideration that the overall catchment size (approximately 1 900 km²) is much larger than the study area; and
- Possible erosion risk by capturing and re-directing clean water upslope of dirty water areas and subsequently releasing such stormwater lower down in the landscape as concentrated flows. These flow concentrations could lead to soil erosion and sediment mobilisation.

6.9.2 Post Closure Phase

Post closure the groundwater levels will return to the pre-mining conditions about 12 years following rehabilitation for the area of the North Pit (GPT, 2023). This assumes that no abstractions for irrigation will take place post closure. Some surface alterations such as the discard dumps will likely remain in the landscape post closure and will affect the surface runoff characteristics, however their impacts to the overall hillslope hydrology will be likely relatively minor.

7. CONCLUSION AND RECOMMENDATIONS

A hydrogeological assessment has been conducted to provide a holistic picture of the local (within the study area) hillslope hydrology and to identify whether or not this likely contributes to the flow drivers of the Nyl River floodplain on site. Furthermore the potential impacts with respect to the hillslope hydrology contribution to the floodplain due to the proposed opencast mining and associated infrastructures were assessed and discussed.

The general hillslope hydrology can be characterised as groundwater recharge dominated soils with limited to no signs of lateral water movement within the soil profile. Areas with shallow soils are expected to be responsive during high intensity rainfall events, however the generated surface runoff is unlikely to contribute significantly to the floodplain. In most areas the surface runoff will be absorbed by the deep sandy soils adjacent to the floodplain or the lower gradient near the floodplain will prevent the surface runoff from reaching the floodplain in most storm events. The hillslope is generally lacking a drainage network further indicating that the surface hydrology from the local adjacent hillslope (eastern bank of the floodplain within the study area) is not a significant flow driver to this section of the floodplain. The groundwater levels within and in the vicinity of the floodplain in the study area are below the soil profile and also unlikely to contribute a significant amount of water to the floodplain under current conditions, which is primarily driven by flood water from the upstream catchment outside the study area.

The proposed mining and infrastructure activities are unlikely to have a significant negative impact on the flow drivers of the affected section of the floodplain, particularly in the context of the findings related to the conceptual hillslope hydrology. There are a number of potential small impacts to the floodplain from a hillslope hydrology perspective which are mostly related to a relative reduction of catchment area due to capturing of water in dirty water areas, changing the infiltration characteristics by sealing surfaces creating more surface runoff and the potential erosion risk during high intensity rainfall events due to flow concentration caused by capturing and redirecting of flows from the upslope clean water catchment areas.

The following recommendations are made in order to mitigate some of the potential hillslope flow related impacts to the affected section of the floodplain:

- Minimise the extent of hardened surfaces and dirty water areas on site;
- Capture and divert surface runoff upslope of any proposed mining or infrastructure area and release the captured surface runoff into the below lying environment in a controlled manner considering erosion risks in order to minimise the catchment area loss;
- Ensure effective isolation of dirty water areas to prevent contamination of surface runoff and groundwater. Potential contaminants stored on site (e.g. hydrocarbons) must be stored on impervious hardened areas to prevent contamination of groundwater. Dirty water collection infrastructure must be effectively isolated to prevent groundwater contamination, including through the provision of liner systems where necessary;
- Clean water management infrastructure should be constructed as vegetated swales and protected against erosion;
- Implement a groundwater quality monitoring strategy as per the recommendations of the groundwater specialist;

- Release of clean surface water generated within any infrastructure areas into the below-lying environment in a controlled manner considering erosion risks and potential water quality issues from these areas. Discharge areas must be located on vegetated recharge soils to allow for infiltration and recharge of groundwater. No discharge should be allowed directly onto the floodplain wetland;
- Assess the surface water inflow reductions utilising the existing surface water modelling results based on the clean/dirty water separation areas in order to quantify the impact to the floodplain under average flow conditions, not only for the 1:2, to 1:100 year flooding event;
- Detailed flow and flood monitoring (depth, extent, duration, frequency) must be implemented for the floodplain on site as soon as possible and maintained throughout the Life of Mine;
- At least 2 transects of shallow piezometer boreholes (minimum 3 per transect) should be established along the floodplain edge downslope of each proposed opencast pit to monitor shallow groundwater levels and any interflow that may occur

8. REFERENCES

- Bailey A.K., Pitman W.V. 2016a.** Water resources of South Africa, 2012 Study (WR2012), WR2012 study executive summary. Water Research Commission, Gezina, WRC Report TT 683/16, 58pp.
- Bailey A.K., Pitman W.V. 2016b.** Water resources of South Africa, 2012 study (WR2012), Book of maps. Water Research Commission, Gezina, WRC Report TT 685/16, 90pp.
- Bailey and Pitman Water Resources (Pty) Ltd, Bailey A.K., Pitman W.V. 2021.** Hydrological Analysis of the Nylsvlei A61 Tertiary Catchment. Draft Report.
- Claassens, Andries. Date unknown.** Report on the Soil Survey and Land Capability Classification of the Farms Volspruit and Zoetveld. Soil Science and Plant Nutrition Consultant. Specialist report.
- EScience Associates (Pty) Ltd. 2014.** Nyl River Hydrological Modelling. Final Draft Report.
- Erudite. 2019.** Sylvania Platinum Ltd, Volspruit PGM Project, Northern and Southern Pit, Stormwater Management Plan. Report reference P5015 Rev A.
- GEO Pollution Technologies – Gauteng (Pty) Ltd. 2014.** Summary of the Geohydrological Report for the proposed Volspruit Mine (North- and South Pit) near Mokopane, Limpopo Province. Specialist report with reference EsVol-13-447f.
- GEO Pollution Technologies – Gauteng (Pty) Ltd. 2022.** Groundwater Specialist Study Update for Proposed Volspruit Mining Project. Specialist report with reference EPVOL-21-6722.
- GPT. 2023.** Groundwater Specialist Study Update for Volspruit Mining Project. Specialist report with reference EPVOL-23-9279.
- Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006.** World Map of the Köppen-Geiger climate classification updated. Meteorol. Z., 15, 259-263. DOI: 10.1127/0941-2948/2006/0130.
- Middleton B.J. and Bailey A.K. 2009.** Water Resources of South Africa, 2005 study. Water Research Commission Report Number TT 380/08, Water Research Commission, Pretoria, South Africa.
- Rawls, W.J., Brakensiek, D.L. and Saxton, K.E. 1982.** Estimation of Soil Water Properties. Transactions of the ASAE. American Society of Agricultural Engineers, St. Joseph, Michigan, USA.
- Soil Classification Working Group, 2018.** Soil Classification: A Natural and Anthropogenic System for South Africa. ARC-Institute for Soil, Climate and Water, Pretoria.
- Tanner, Dominique, Iain McDonald, R.E. Jock Harmer, Duncan D. Muir, Hannah S.R. Hughes. 2019.** A record of assimilation preserved by exotic minerals in the lowermost platinum-group element deposit of the Bushveld Complex: The Volspruit Sulphide Zone. Lithos, Volumes 324–325, Pages 584-608, ISSN 0024-4937.
- Van Tol, J.J., Bouwer, D. & Le Roux, P.A.L., 2021.** Guideline for Hydropedological Assessments and Minimum Requirements. Provided by the DWS.

APPENDIX A

Johannes Hachmann Summarised *Curriculum Vitae*

Date of Birth:	1982-05-29	Profession:	Hydrologist
Passport Number:	C486G3N24	Nationality:	German
Postal address:	PO Box 72295 Lynnwood Ridge Pretoria 0040	Tel:	(012) 349 2699
		Fax:	(012) 349 2993
		Cell:	073 658 9065
		E-mail:	johannesh@wetcs.co.za
Academic History:	2005 - BSc [Environmental Natural Science] - Albert Ludwig University Freiburg, Germany 2012 - MSc [Hydrology] - Free University Amsterdam, Netherlands		
Professional Affiliations:	SACNASP: Water Resource Science (116815/17) WISA: Member of Water Institute of South Africa (Reg. number 30425) South African Wetland Society (Reg. number R87XH0HU)		
Employment record:	2013 – Present day: Ecohydrologist: Wetland Consulting Services (Pty.) Ltd. 2009 – 2012: Research Assistant: Free University Amsterdam		

Selected project experience over the past 9 years:

- Wetland hydrology specialist input as part of Preliminary Determination of the Reserve and Resource Class for selected Wetlands in Quaternary Catchments B11A and B11B; for SRK on behalf of the Department of Water and Sanitation;
- Wetland hydrology specialist as part of the Preliminary Determination of the Reserve and Resource Class for selected Wetlands in Quaternary Catchments B12B, B12C and X11C; for Golder Associates Africa on behalf of the Department of Water and Sanitation;
- Wetland hydrology specialist input as part of the Preliminary Determination of the Reserve and Resource Class for selected Wetlands in Quaternary Catchments B20F and B20G; for Anglo American Inyosi Coal on behalf of the Department of Water and Sanitation;
- Wetland hydrology specialist input as part of the Preliminary Determination of the Reserve and Resource Class for selected Wetlands in Quaternary Catchment B11G; for Jones & Wagener Consulting Engineers on behalf of the Department of Water Affairs;
- Wetland hydrological specialist inputs for a component of a project entitled: Identification of wetland processes impacting water resources at catchment scale; Together with the Council for Scientific and Industrial Research (CSIR); for the Water Research Commission (WRC);
- Various hydrological studies assessing and quantifying development related impacts on pans, wetlands, streams and rivers;
- Hydrological Monitoring: Installation of Hydrological and Meteorological Monitoring Equipment and Training of Government Personnel in Lesotho for a German consultancy company on behalf of the Gesellschaft fuer Internationale Zusammenarbeit (GIZ), Germany;
- Pan – Ecohydrological modelling of a pan to inform conceptual wetland buffer for Sebata Institute;
- Hydrological modelling of hillslope seepage wetlands and buffer determination to ensure wetland functionality for Golder Associates Africa;
- Hydrological modelling and scenario assessment of a pan at a proposed coal mine for Glencore on behalf of the Department of Water and Sanitation;
- Various specialist studies related to hydrological modelling informing the impacts on water resources.