SURFACE WATER HYDROLOGY

GEOGRAPHIC INFORMATION SYSTEMS (GIS) BASED DESKTOP SURFACE WATER HYDROLOGICAL ASSESSMENT FOR KLEI MINERALE (PTY) LTD FOR THE APPLICATION OF A PROSPECTING RIGHT ON PORTIONS 36, 37, 38, 39, 40 AND 41 OF THE FARM BOEKENHOUTKLOOF 315 JR, PRETORIA

Report number: SPS-REP-186-17-18

Submitted to:

Wika Esterhuizen

Klei Minerale (Pty) Ltd.

Email: wika@sabrix.co.za

November 2017

"Your Partner in Calculating Environmental Solutions"

ENVASS

ENVIRONMENTAL ASSURANCE (Pty)Ltd





PROVIDING
ENVIRONMENTAL
SOLUTIONS
SINCE 2004

DOCUMENT CONTROL	
Document Title	GIS-based desktop surface water hydrological assessment for the application of a prospecting right on portions 36, 37, 38, 39, 40 and 41 of the Farm Boekenhoutkloof 315 JR, Pretoria
Report Number	SPS-REP-186-17-18
Version	0.0
Date	December 2017
Submitted to	Wika Esterhuizen SHE Advisor Klei Minerale (Pty) Ltd. wika@sabrix.co.za
Distribution	Klei Minerale (Pty) Ltd. Environmental Assurance (Pty) Ltd.

QUALITY CONTROL			
	Originated By	**Reviewed By**	**Approved By**
Name	Johan P. Nortje Pr.Sci.Nat	DuToit Wilken	Carl Schoeman Pr.Sci.Nat
Designation	Environmental Consultant and Specialist	Senior Operations Manager	Environmental Consultant and Projects Coordinator
Signature			
Date	09-12-2017	11-12-2017	13-12-2017

DISCLAIMER

DECLARATION OF OBJECTIVENESS

I, **Johan P. Nortje,** in my capacity as a specialist consultant and registered professional environmental scientist, hereby declare that I:

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of this project, other than remuneration for the work performed in terms of the National Environmental Management Act 107 of 1998;
- Have and will not have vested interest in the proposed activity nor will I engage myself in any conflicting interest associated with this project;
- I undertake to disclose and provide to the competent authority any material or information at my disposal regarding this project as required in terms of National Environmental Management Act 107 of 1998;
- Based on the information provided to me by the client and in addition to information obtained during the course of this study, I have presented the results and conclusion with regard to this project to the best of my professional ability;
- I reserve the right to modify aspects pertaining to this study should additional information become available through ongoing research and further work on this field;
- I undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study;
- I am duly qualified and experienced to undertake the work at hand;
- I am compulsorily and legally registered as a Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) with registration number 400166/17.
- I am bound by and committed to the professional and ethical Code of Conduct of the SACNASP.

Johan P. Nortje, Pr.Sci.Nat (SACNASP Registration: 400166/17)

Specialist	Affiliation	Relevant expertise
Johan P. Nortje	Environmental Assurance (Pty) Ltd. SACNASP SAGIC	B.Sc (Biological Science) (NWU), B.Sc (Hons) (NWU) (Environmental Science), practical environmental scientific experience – work as consultant at ENVASS. Compulsorily and legally registered with SACNASP to conduct work on this project.

EXECUTIVE SUMMARY

Environmental Assurance (Pty) Ltd – hereafter referred to as ENVASS, was appointed by Klei Minerale (Pty) Ltd to undertake a surface water hydrology assessment on Portions 36, 37, 38, 39, 40 and 41 of the Boekenhoutkloof 315 JR (see Figure 2), City of Tshwane Metropolitan Municipality in the Gauteng Province: The study area is located 13 km northwest of the Pretoria CBD and between Akasia and Atteridgeville. The aim of this report is to contextualise the general study area in terms of surface water hydrology and will provide the proposed prospecting activity with general information on possible surface water hydrological impacts including preventative mitigation measures.

Hydrology is concerned with the natural water cycle and is the earth science of water on or near the land surface. Prospecting can impact on surface water hydrology through the introduction of structures and by disturbing the natural characteristics of a watercourse and its catchment. Watercourses may be affected by direct runoff from the mining area itself. As a result, the natural magnitude, direction and timing of flood events can become significantly altered. Alterations to surface water hydrology could have associated implications for the local ecology, society and economy.

This report presents the assessment, through Geographic Information System (GIS) analysis, of surface water hydrological features on the Farm Boekenhoutkloof and possible impacts associated with the proposed prospecting. Recommendations (as mitigation measures) to avoid or reduce impacts of the proposed prospecting on the hydrology of local watercourses and/or drainage lines are provided.

The study area falls within the A21H Quaternary Catchment that forms part of the Crocodile (West) and Marico Management Area. The closest major river to the study area is the Swartspruit, a perennial river flowing roughly 1.5 km to the south of the area. To the north of the Boekenhoutkloof proposed prospecting area is the Magaliesberg. The mountain forms a separation between two catchment areas. As the gradient of the site is toward the south of the Magaliesberg, no impacts on surface water (explicitly excluding groundwater) in the northern catchment area is envisioned.

The hydrologic functions ran for a digital elevation model (DEM) created from the 1:50000 topographical map series data of South Africa (grid reference 2528) showed that no major streams were expected to accumulate through or near the site. Please refer to the methodologies utilised in Section 4 for context on how flow accumulation was determined. Data obtained from the Department of Water and Sanitation (DWS, 2017) showed that the Swartspruit (a former tributary of the Crocodile River (West) and now confluence with the Hartbeespoort Dam) has its origin +- 1.5 km south of the outer boundary of the Boekenhoutkloof proposed prospecting area.

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF FIGURES

LIST OF ABBREVIATIONS AND ACCRONYMS

CTMM	City of Tshwane Metropolitan Municipality
DEM	Digital Elevation Model
GIS	Geographic Information Systems
LUDS	Land Use Decision Support Tool
MAMSL	Meters Above Mean Sea Level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NEMA	National Environmental Management Act
PES	Present Ecological State
SMP	Stormwater Management Plan
TEMP	Temperature
USEPA	United States Environmental Protection Agency
WMA	Water Management Area
WUL	Water Use Licence

1. INTRODUCTION

Environmental Assurance (Pty) Ltd – hereafter referred to as ENVASS, was appointed by Klei Minerale (Pty) Ltd to undertake a surface water hydrology assessment on Portions 36, 37, 38, 39, 40 and 41 of the Boekenhoutkloof 315 JR (see Figure 2), City of Tshwane Metropolitan Municipality in the Gauteng Province. The study area is located 13 km northwest of the Pretoria CBD and between Akasia and Atteridgeville. The aim of this report is to contextualise the general study area in terms of surface water hydrology and will provide the developers with general information on possible surface water hydrological impacts including preventative mitigation measures.

Hydrology is concerned with the natural water cycle and is the earth science of water on or near the land surface. Prospecting can impact on surface water hydrology through the introduction of structures or excavations and by disturbing the natural characteristics of a watercourse and its catchment. Watercourses may be affected by direct runoff from the mining area itself. As a result, the natural magnitude, direction and timing of flood events can become significantly altered. Alterations to surface water hydrology could have associated implications for the local ecology, society and economy.

Impacts on hydrology are intrinsically linked to hydrogeology, water quality, geomorphology and freshwater ecology (see an illustration of how surface water hydrology is typically linked with other environmental aspects in the figure below).

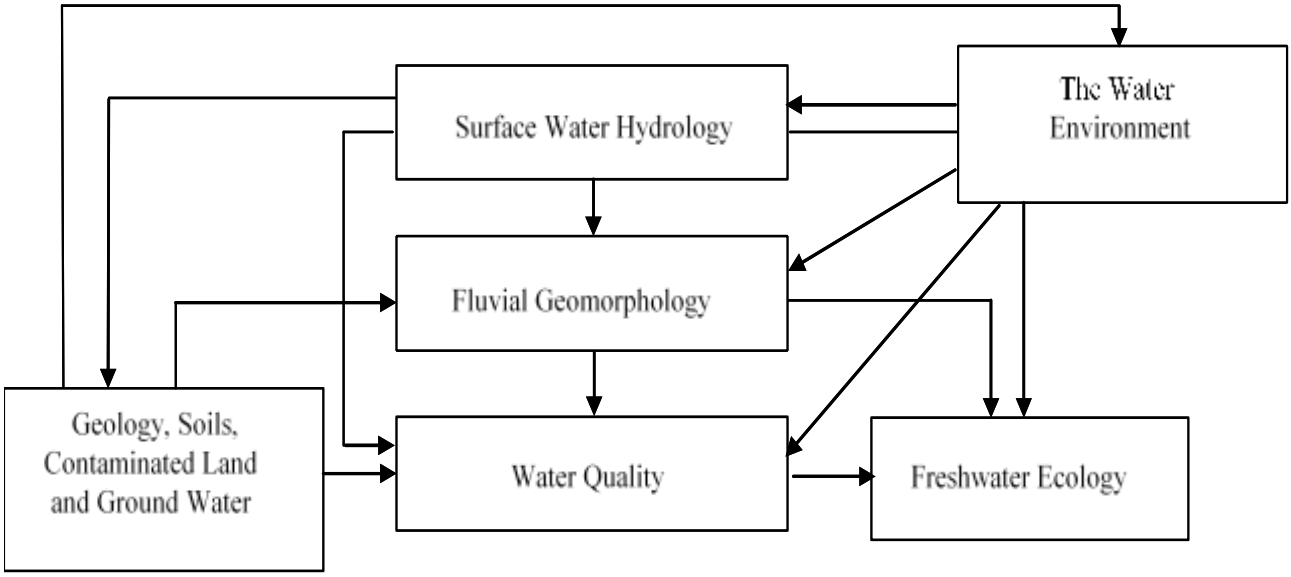

Figure 1: Typical interrelationship of surface water hydrology with other environmental aspects

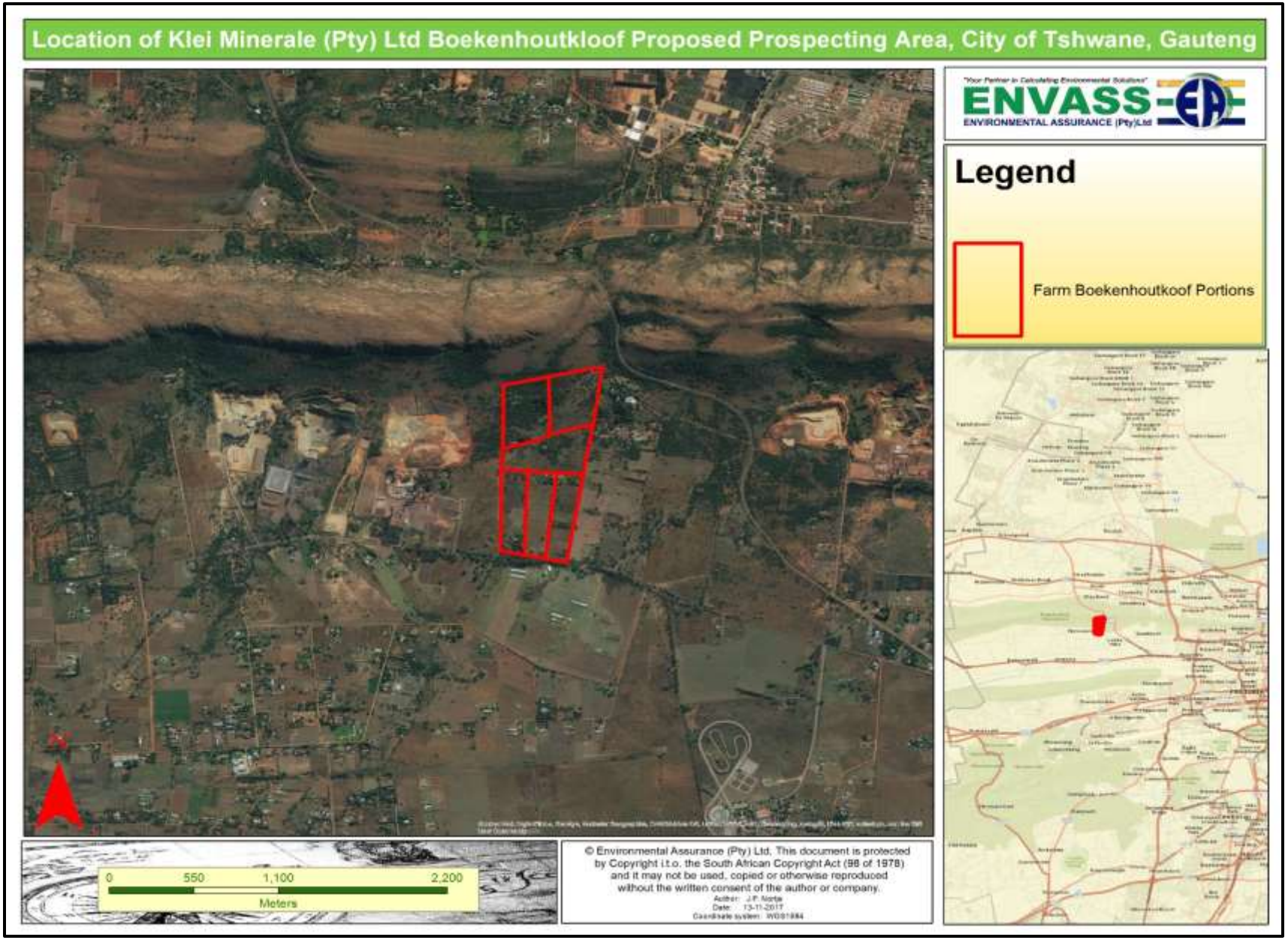

Figure 2: Locality map of the surveyed study area.

2. SCOPE OF WORK

This report presents the assessment, through Geographic Information System (GIS) analysis, of surface water hydrological features on the Farm Boekenhoutkloof and possible impacts of prospecting. Recommendations (as mitigation measures) to avoid or reduce impacts of the proposed prospecting on the hydrology of local watercourses and/or drainage lines are provided.

3. LEGISLATION AND GUIDELINES

The following legislation, standards and guidelines have been taken into account:

3.1. The Constitution of South Africa, 1996 (Act No. 108 of 1996) [as amended]

Section 24

Environment - Everyone has the right- [Constitution of the Republic of South Africa, 1996 (No. 108 of 1996)]

(a) to an environment that is not harmful to their health or well-being; and
(b) to have the environment protected, for the benefit of present and future generations through reasonable legislative and other measures that-

i) prevent pollution and ecological degradation;
ii) promote conservation; and
iii) Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

The proposed development has the potential to harm the environment and may, in different ways, pose a risk to the health and wellbeing of people, if impacts are not prevented, mitigated or managed correctly. The Applicant has the overall responsibility to ensure that the rights of people in terms of Section 24 of the Constitution is protected in terms of the proposed development activity.

3.2. National Water Act, 1998 (Act 36 of 1998)

Provides for the protection of the quality of water and water resources in South Africa and provides for the establishment of Water Management.

3.3. The National Environmental Management Act, 1998 (Act No. 107 of 1998) [as amended]

Section 28 (1)

Duty of Care and responsibilities to minimise, prevent and remediate environmental degradation. The applicant is the developer and overall responsibility of the developer of the proposed prospecting area rests with the proponent, especially in terms of liabilities associated with the operational phase.

3.4. National Policy / Guidelines

National policy and guidelines applicable to surface water management includes:

- South African Water Quality Guidelines, First Edition, 1996 – These guidelines set out the minimum water quality requirements for a range of water quality parameters for each water user.
- Development of a Waste Discharge Charge System: Framework Document. Second Edition, 2000 – Provides a framework for the implementation of a system to charge for water use such as the discharge of waste that impacts on water resources.
- Framework for a Water Quality Management Performance Assessment System: (WQMPAS), First Edition, 2000 – Reports results on an initial investigation into a performance management system to enable a more effective WQPMAS in future.
- Best Practice Guidelines for the mining sector, DWAF 2006, 2008 dealing with aspects of DWA's water management hierarchy and deals with integrated mine water management, pollution prevention and minimisation of impacts, water reuse and reclamation and water treatment.
- Best Practice Guidelines for the mining sector, DWAF 2006, 2008 dealing with general water management strategies, techniques and tools which could be applied cross – sectorial and deals with storm water management, water and salt balances, water monitoring systems, impact prediction.
- Best Practice Guidelines for the mining sector, DWAF 2006-2008 dealing with specific mining activities and addresses the prevention and management of impacts from small scale mining, water management for Mine Residue Deposits, pollution control dams, water management for surface mines, and water management for underground mines.

4. GIS-BASED HYDROLOGIC FUNCTION METHODOLOGIES

- The first step in any of the hydrologic modelling tools in ArcGIS is to fill the elevation grid. One starts with a surface that has no sinks. Sinks are areas of internal drainage, that is, areas that do not drain out anywhere. The reason that sinks need to be filled in is because a drainage network is built that finds the flow path of every cell, eventually off the edge of the grid. If cells do not drain off the edge of the grid, they may attempt to drain into each other, which will lead to an endless processing loop.

- Determining the direction of flow. To calculate a drainage network or watersheds, a grid must exist that is coded for the direction in which each cell in a surface drains. Flow direction is important in hydrologic modelling because in order to determine where and how a landscape drains, it is necessary to determine the direction of flow for each cell in the landscape.
- Determining flow accumulation (streams). Flow accumulation is the next step in hydrologic modelling. Watersheds are defined spatially by the geomorphological property of drainage. In order to generate a drainage network, it is necessary to determine the ultimate flow path of every cell on the landscape grid. Flow accumulation is used to generate a drainage network, based on the direction of flow of each cell. By selecting cells with the greatest accumulated flow, we are able to create a network of high-flow cells. These high-flow cells should lie on stream channels and at valley bottoms. The results from flow accumulation modelling is then verified against existing streams data to ensure accuracy of the models.
- The next step in the process is to determine the catchment areas for each stream modelled. This can either be done manually or automatically. For the purposes of this study, the catchment delineation was first done automatically and then compared with existing data. Should the result from automatic delineation differ too much from existing data, the delineation would have to be done manually. Catchment areas can be automatically delineated using the Basin command in ArcGIS. Pour points are automatically selected from where the grid drains at its edges, and catchments are delineated. Automatic watershed delineation uses a flow accumulation value which is specified. ArcGIS searches for cells at the edge of the grid that have this amount of flow accumulation, and turns these cells into pour points.

5. BACKGROUND INFORMATION

5.1. Location & Physical Environment

The closest city to the study area is Pretoria, located about 13 km to the southeast. The suburbs of Akasia is located about 4 km northeast of the area demarcated for prospecting and Atteridgeville 6 km to the south. The study area falls within the City of Tshwane Metro Municipality in the Gauteng Province. In terms of vegetation, the study area falls within the Grassland Biome, Central Bushveld Bioregion and Moot Plains Bushveld vegetation unit. A small section along the northern boundary of the study area falls on Gold Reef Mountain Bushveld.

The Grassland Biome covers approximately 28% of South Africa. According to Mucina & Rutherford (2006), the conservation status for Moot Plains Bushveld is considered vulnerable. The conservation target for this vegetation unit is 19% and about 13% is conserved in in the Magaliesberg Nature Reserve. Moot Plains Bushveld is found in the North-West and Gauteng Provinces, with the main belt occurring immediately south of the Magaliesberg from the Selons River Valley in the west to Pretoria in the east. A narrow belt is also found immediately north of the Magaliesberg and Daspoort mountain ranges from Rustenburg in the west to the Crocodile River in the east. Cultivation, urban and built-up areas have transformed about 28% of this vegetation unit. Erosion in these areas is generally very low.

Gold reef Mountain Bushveld, on the other hand, is found in the North-West, Gauteng, Free State and Mpumalanga Provinces and occurs along the quartzite ridges of the Magaliesberg from Boshoek and Koster in the west to Bronkhorstspruit in the east. Other areas include the west-east ridges of the Witwatersrand, the inner ridges of the Vredefort Dome and part of the Suikerbosrand and hills around Heidelberg. In terms of conservation, Gold Reef Mountain Bushveld is considered least threatened with a conservation target of 24%. About 22% is conserved mainly in the Magaliesberg Nature Reserve and a small portion in other nature reserves. Cultivation, urban and built-up areas transformed about 15% and erosion is generally very low (Mucina & Rutherford 2006).

The average elevation for Moot Plains Bushveld varies between 1050 and 1450 MASL, while the elevation for Gold Reef Mountain Bushveld varies between 1200 and 1750 MASL. The average elevation of the project area is 1320 MASL and it is noted that the northern boundary is more elevated as it borders the Magaliesberg.

The study area falls within the summer rainfall region and the average annual rainfall is roughly 573 mm per year. The average maximum temperature for the study area ranges from 18.3 ºC in June to 27.5 ºC in January. The lowest temperatures occur during July when an average of 1.7 ºC is reached during the night (SA Explorer accessed 24/10/2017).

The study area falls within the A21H Quaternary Catchment that forms part of the Crocodile (West) and Marico Management Area. The closest major river to the study area is the Swartspruit, a perennial river flowing roughly 1.5 km to the south of the area demarcated for prospecting.

5.2. Project description

The area demarcated for the prospecting of Shale/Brick Clay, Clay, Silica Sand, Sand and Aggregate covers an area of approximately 60.428 ha (Table 1 & Figure 3). Prospecting will initially consist of a high-level desktop study and potential desktop resource evaluation. Activities will include studying previous drilling, trenching, sampling and exploration data. Historical data and existing maps will be studied as well. Should the results of the desktop study be favourable, further exploration drilling, trenching and resource estimations will be performed on selected sites.

Table 1: Property name & coordinates

Property	Portion	Map Reference (1:50 000)	Coordinates
Boekenhoutkloof 315 JR	36	2528CA	S: -25.688399 E: 28.063330
Boekenhoutkloof 315 JR	37	2528CA	S: -25.687947 E: 28.066328
Boekenhoutkloof 315 JR	38	2528CA	S: -25.691207 E: 28.064781
Boekenhoutkloof 315 JR	39	2528CA	S: -25.694705 E: 28.062592
Boekenhoutkloof 315 JR	40	2528CA	S: -25.694705 E: 28.064234
Boekenhoutkloof 315 JR	41	2528CA	S: -25.694800 E: 28.065400

6. LIMITATIONS AND ASSUMPTIONS

- The steps that were followed for modelling hydrologic characteristics in the area are based on freely obtainable national topographic map series data (1:50000) (NGI, 2017). This data is meant to be accurate on a rough scale, whereas the Boekenhoutkloof Mine of Klei Minerale is much smaller in area and consequently on a finer scale. This means that only high-level hydrological functions for an area of the scale 1:50000 could be ran as finer scale data is not currently publicly available.
- To obtain finer-scaled data, a surveyor needs to be appointed to survey and create data (topographical information containing z-values or height values in metre).

7. RESULTS AND FINDINGS

- To the north of the Boekenhoutkloof proposed prospecting area is the Magaliesberg. The mountain forms a separation between two catchment areas. As the gradient of the site is toward the south of the Magaliesberg, no impacts on surface water (explicitly excluding groundwater) in the northern catchment area is envisioned.
- The hydrologic functions ran for a digital elevation model (DEM) created from the 1:50000 topographical map series data of South Africa (grid reference 2528) showed that, based on elevation data, no major streams were expected to accumulate through or near the site.
- Data obtained from the Department of Water and Sanitation (DWS, 2017) showed that the Swartspruit (a former tributary of the Crocodile River (West) and now confluencing with the Hartbeespoort Dam) has its origin +- 1.5 km south of the outer boundary of the Boekenhoutkloof proposed prospecting area.

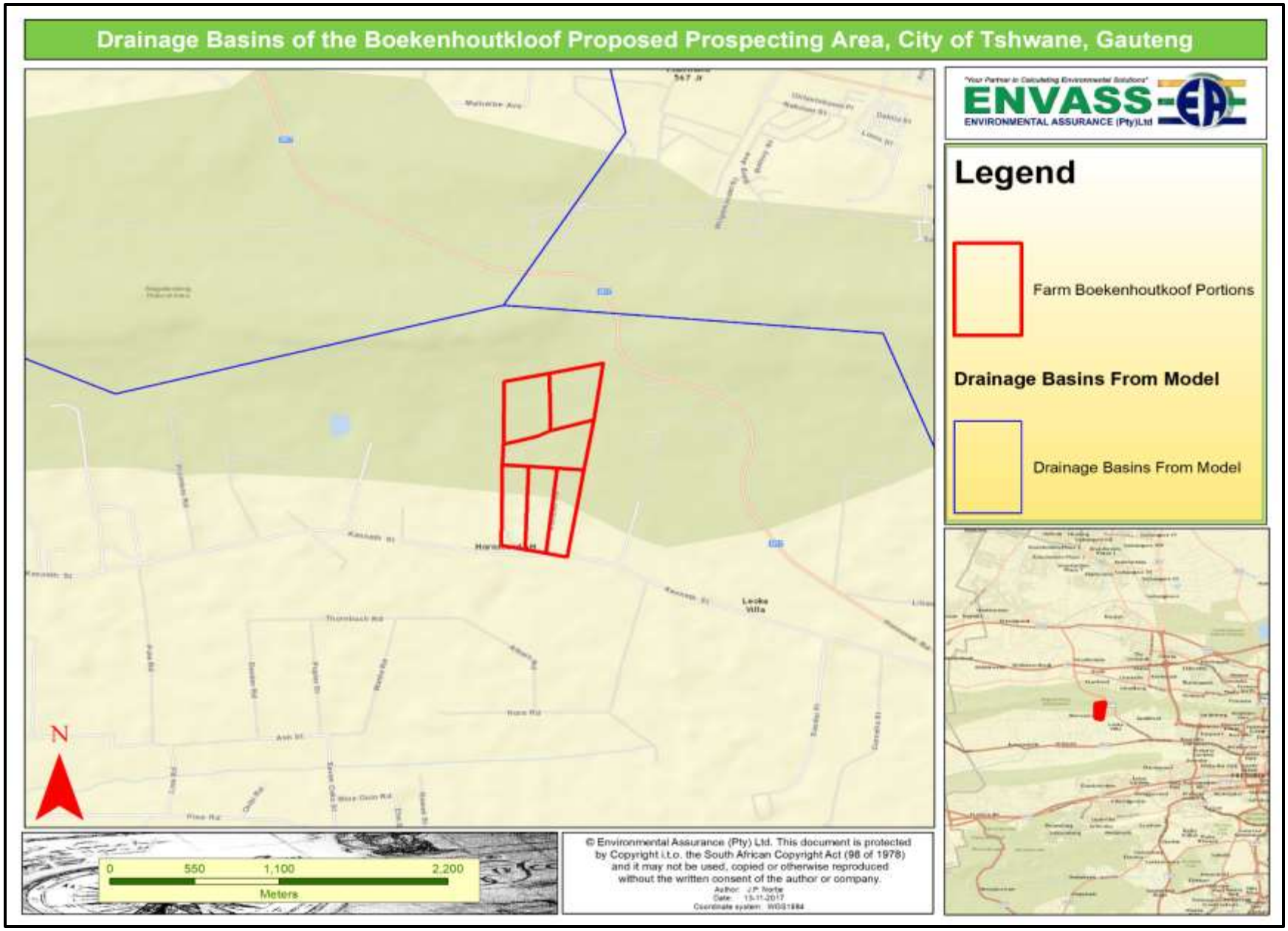

Figure 3: Drainage basins from hydrologic modelling

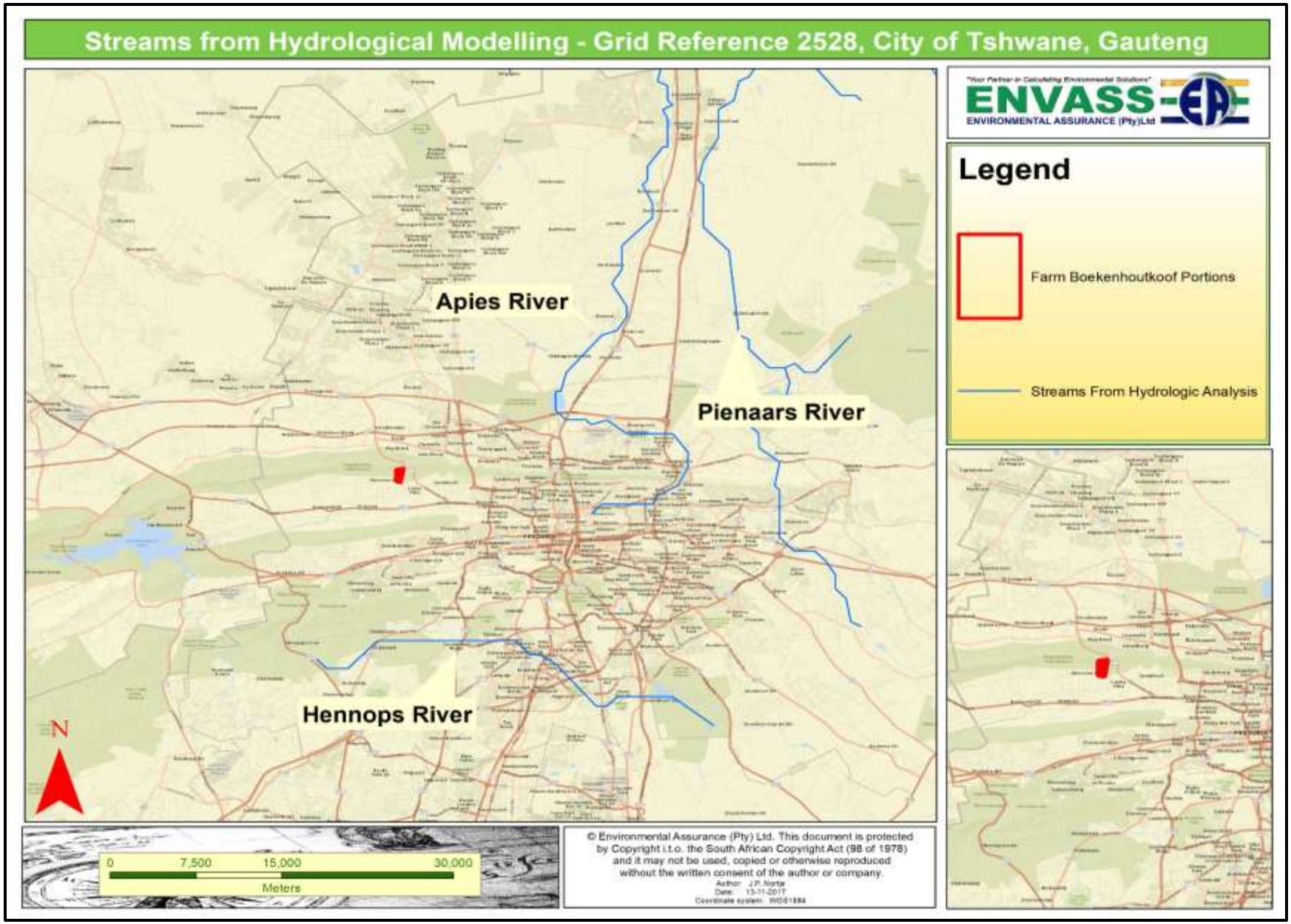

Figure 4: Streams (flow accumulation) from hydrologic modelling

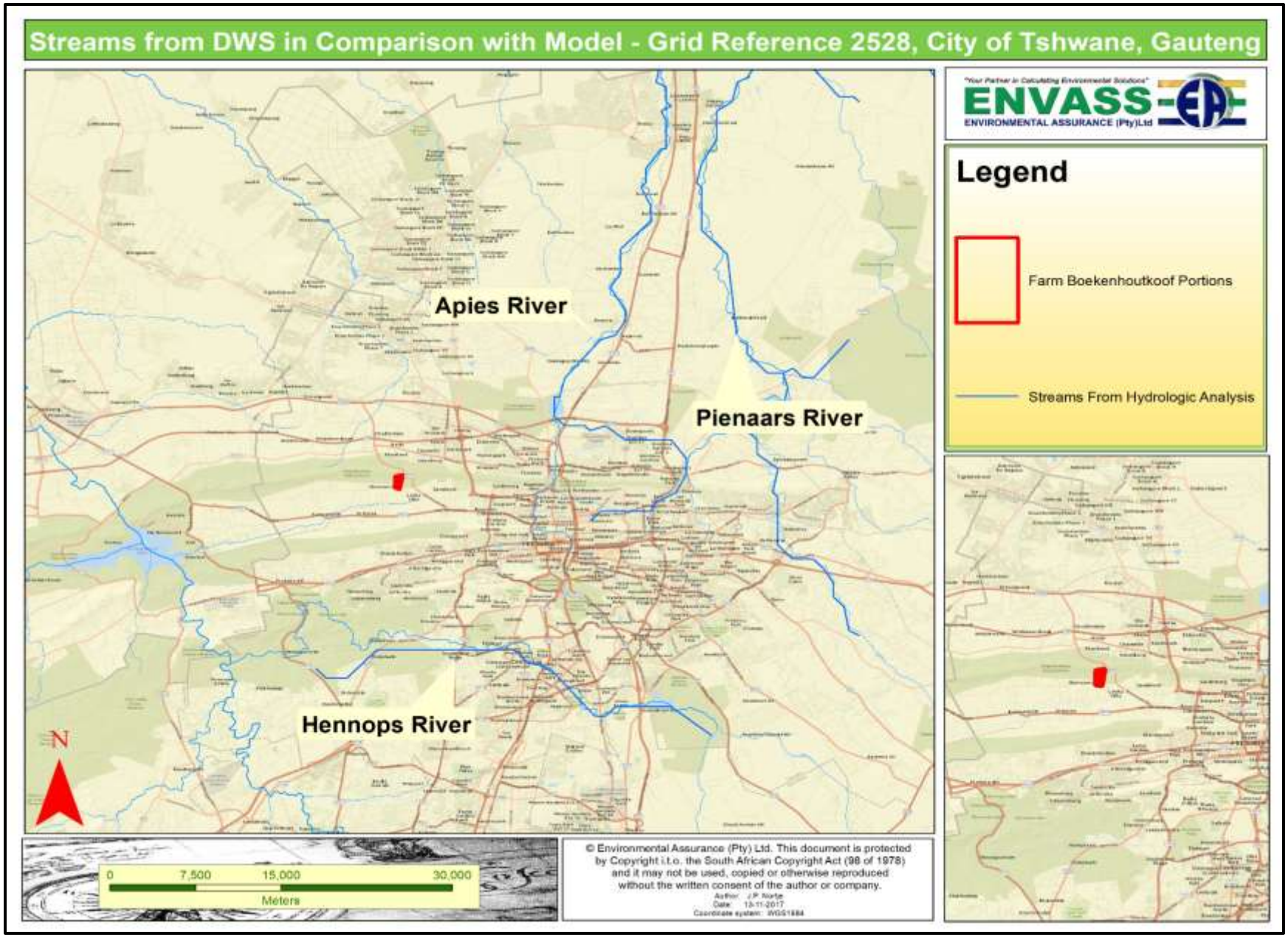

Figure 5: Streams from hydrologic modelling in comparison with actual streams (DWS, 2017)

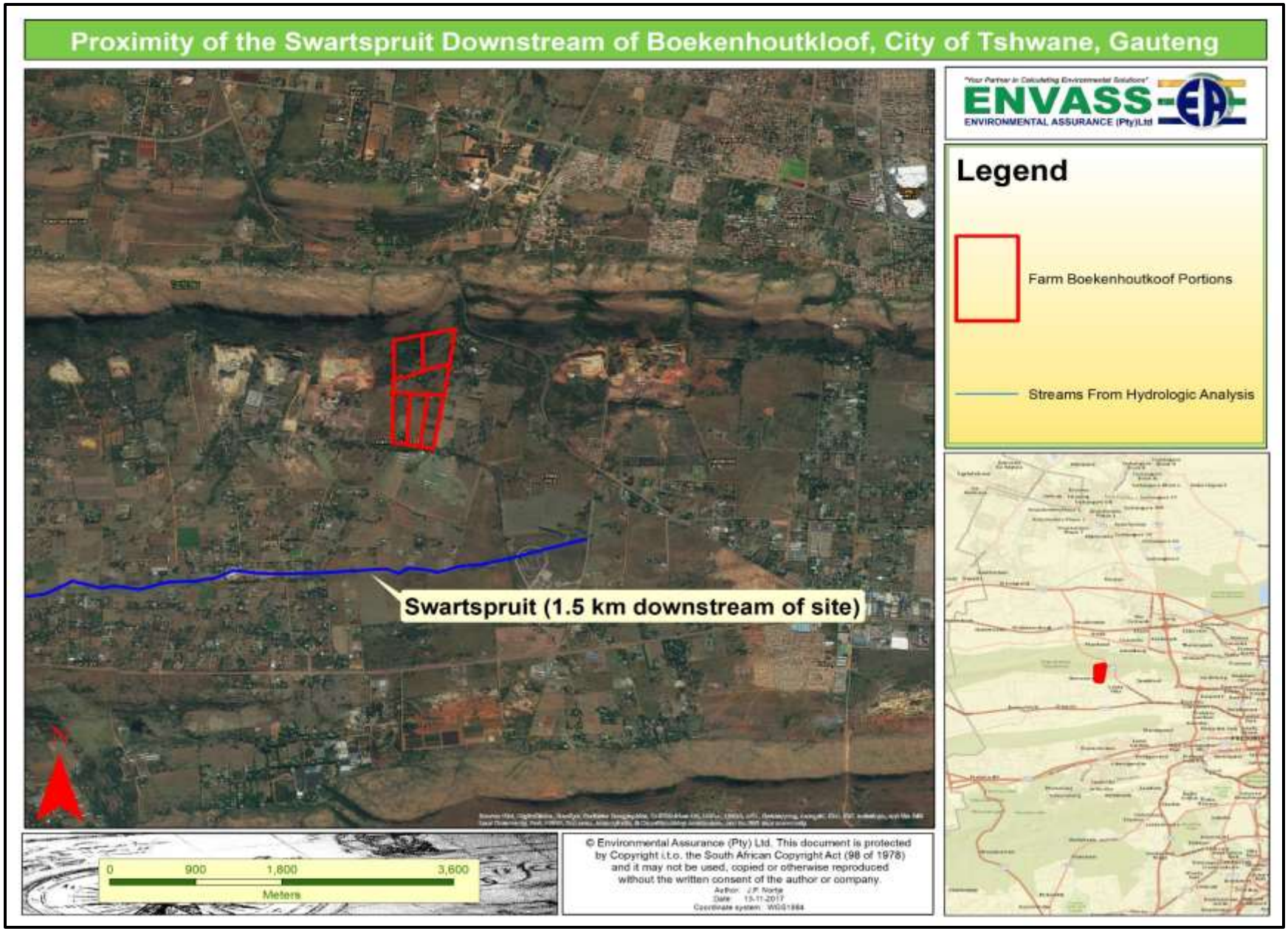

Figure 6: Proximity of the Swartspruit to the proposed prospecting area

8. INFORMATION FOR A STORMWATER MANAGEMENT PLAN

Klei Minerale (Pty) Ltd should make all effort to separate clean and dirty water on the site of the proposed prospection activities. A stormwater management plan (SMP) is recommended for this purpose. Please see information derived from this assessment that may assist in compiling a SMP for the site:

Clean and Dirty Catchment Identification and Separation:

- Stormwater will flow from north to south based on GIS results (basin delineation and flow accumulation);
- Clean stormwater will likely be generated to the east of the site (considering the area to the east is less disturbed);
- Dirty storm water is likely generated to the east of the site from the open cast mine on other portions of Boekenhoutkloof.
- The life of mine (LOM) of the opencast clay mine to the west of the site will influence the short to long-term water quality of runoff in the proposed area. The SMP should be planned accordingly.

9. CONCLUSION

The study area falls within the A21H Quaternary Catchment that forms part of the Crocodile (West) and Marico Management Area. The closest major river to the study area is the Swartspruit, a perennial river flowing roughly 1.5 km to the south of the area demarcated for prospecting. To the north of the Boekenhoutkloof proposed prospecting area is the Magaliesberg. The mountain forms a separation between two catchment areas. As the gradient of the site is toward the south of the Magaliesberg, no impacts on surface water (explicitly excluding groundwater) in the northern catchment area is envisioned.

The hydrologic functions ran for a digital elevation model (DEM) created from the 1:50000 topographical map series data of South Africa (grid reference 2528) showed that, based on elevation data, no major streams were expected to accumulate through or near the site. Data obtained from the Department of Water and Sanitation (DWS, 2017) showed that the Swartspruit (a former tributary of the Crocodile River (West) and now flowing into the Hartbeespoort Dam) has its origin +- 1.5 km south of the outer boundary of the Boekenhoutkloof proposed prospecting area.

10. RECOMMENDATIONS

From the results, findings and conclusion of this study, the proposed recommendations that follow for the area, are aimed at the management and prevention of impacts on surface water hydrology. Please note that these recommendations are for the attention of the environmental control officer (ECO) on site and that further recommendations from an engineer may be required.

- A Stormwater Management Plan (SMP) to be developed for the collective area under prospecting (or the existing SMP updated, where applicable for present and future activities) and should include the management of stormwater during

excavation, as well as the installation of temporary stormwater and erosion control measures during prospection followed up by rehabilitation of the area.

- Temporary stormwater management systems (such as sand bags) will be installed to prevent stormwater from entering or exiting the area under prospection, which could result in silt laden surface water from draining into the valley south of the Magaliesberg below (origin of the Swartspruit in close proximity).
- The area under prospection's slopes should be profiled to ensure that they are not subjected to excessive erosion but capable of drainage run-off with minimum risk of scrub (hydrologic action by water that causes erosion). A maximum gradient of 1:3 is recommended.
- If necessary, temporary diversion channels should be constructed ahead of the emplacement areas and stockpiles (if relevant) to intercept clean run-off and divert it around disturbed areas into the natural drainage system downstream (down gradient) of the area under prospection.
- All existing mined areas (where works are taking place) will be rehabilitated to control erosion and sedimentation over the surface area of the location under prospection.
- Existing vegetation must be retained as far as possible to minimise erosion problems.
- Rehabilitation of the area under prospection shall be planned and completed (after conclusion of the prospecting activities) in such a way that the run-off water (if any) will not cause erosion.
- Visual inspections shall be done on a regular basis with regard to the stability of the temporary water control structures, erosion and siltation (if required).
- Sediment-laden run-off from cleared areas should be prevented from entering rivers and streams;
- No river or surface water may be affected by silt emanating from the area under prospection (especially aimed at prevention of siltation of the nearby Swartspruit).

These measures and recommendations should be included in the Environmental Management Programme.

Respectfully submitted,

J.P. Nortje, Pr.Sci.Nat
Electronic Copy Signed

11. REFERENCES

Department of Water Affairs and Forestry (2008). Best Practice Guideline G3: Water Monitoring System.

Kunz, R (2004). Daily Rainfall Data Extraction Utility, Version 1.4.

Middleton, B.J. and A.K. Bailey. (2009). Water Resources of South Africa, 2005 Study. (WR2005). WRC Report No's 380/08, 381/08, 382/08. Water Research Commission. Pretoria.

Midgley, D.C., Pitman W.V. and Middleton, B.J. (1994). Surface Water Resources of South Africa.

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

SANRAL (2006). The South African National Road Agency Limited. Drainage Mannual, 5th Edition, fully Revised

Smithers JC and Schulze RE. (2003) Design rainfall and flood estimation in SA (Regionalisation of rainfall statistics for design flood estimation), Water Research Commission Report No1060/1.

Weather-and-climate.com

Winfinder.com