Palaeontological Impact Assessment for the proposed Prospecting Rights application by Khwara Manangese (Pty) Ltd on Farm Eersbegint 703, northeast of Hotazel, Northern Cape Province

Desktop Study

For

SLR

29 October 2019

Prof Marion Bamford
Palaeobotanist
P Bag 652, WITS 2050
Johannesburg, South Africa
Marion.bamford@wits.ac.za

Expertise of Specialist

The Palaeontologist Consultant is: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 30 years research; 22 years PIA studies

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by SLR Consulting, Johannesburg, South Africa. The views expressed in this report are entirely those of the author and no other interest was displayed during the decision making process for the Project.

Specialist: Prof Marion Bamford

Signature: MKBamford

Executive Summary

A palaeontological Impact Assessment was requested for the proposed prospecting rights application and drilling of ten cores on Farm Eersbegint 703, To comply with the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), a desktop Palaeontological Impact Assessment (PIA) was completed for the proposed project.

Khwara Manganese (Pty) Ltd “Khwara” proposes to conduct prospecting activities for Iron Ore and Manganese in respect of Portion 43 (Eersbegint) of Farm 703 Black Rock in the Joe Morolong Local Municipality, located in the John Taolo Gaetsewe District Municipality, Northern Cape Province (see attached figures). The prospecting activities will include non-invasive and invasive activities. Non-invasive activities will comprise analysing existing core, ground penetrating radar and hand held ground magnetic mapping. Invasive activities would comprise drilling of ten prospecting boreholes on the farm. The property is 27km North West of Hotazel.

The proposed site lies on the Quaternary aged Kalahari Group Aeolian sands that are very unlikely to preserve fossils because they are windblown (Aeolian) sands. The northeastern part of the farm lies on Dwyka tillites and shales however only Dwyka mustones are known to preserve any fossils. Beneath the sands are likely to be the non-fossiliferous Hotazel Formation manganese and banded iron Formation deposits. Nonetheless, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no palaeontological site visit is required and only if the geologist or responsible person on site finds potential fossils should a palaeontologist be asked to assessed their scientific value.

Table of Contents

1. Background

Khwara Manganese (Pty) Ltd “Khwara” proposes to conduct prospecting activities for Iron Ore and Manganese in respect of Portion 43 (Eersbegint) of Farm 703 Black Rock in the Joe Morolong Local Municipality, located in the John Taolo Gaetsewe District Municipality, Northern Cape Province (see attached figures). The prospecting activities will include non-invasive and invasive activities. Non-invasive activities will comprise analysing existing core, ground penetrating radar and hand held ground magnetic mapping. Invasive activities would comprise drilling of ten prospecting boreholes on the farm. The property is 27km North West of Hotazel.

A Palaeontological Impact Assessment was completed for the Eersbegint 703 Prospecting Rights Application in order to comply with the South African Heritage Resources Agency (SAHRA) in terms of Section 38(8) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999) (NHRA), and is reported herein.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (2017)

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	**Relevant section in report**
ai	Details of the specialist who prepared the report	Appendix B
aii	The expertise of that person to compile a specialist report including a curriculum vitae	Appendix B
b	A declaration that the person is independent in a form as may be specified by the competent authority	Page 1
c	An indication of the scope of, and the purpose for which, the report was prepared	Section 1
ci	An indication of the quality and age of the base data used for the specialist report: SAHRIS palaeosensitivity map accessed – date of this report	Yes
cii	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5
d	The date and season of the site investigation and the relevance of the season to the outcome of the assessment	N/A
e	A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2
f	The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Section 4
g	An identification of any areas to be avoided, including buffers	N/A
h	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	N/A

i	A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 5
j	A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 4
k	Any mitigation measures for inclusion in the EMPr	Appendix A
l	Any conditions for inclusion in the environmental authorisation	N/A
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	N/A
nii	If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	N/A
o	A description of any consultation process that was undertaken during the course of carrying out the study	N/A
p	A summary and copies if any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A

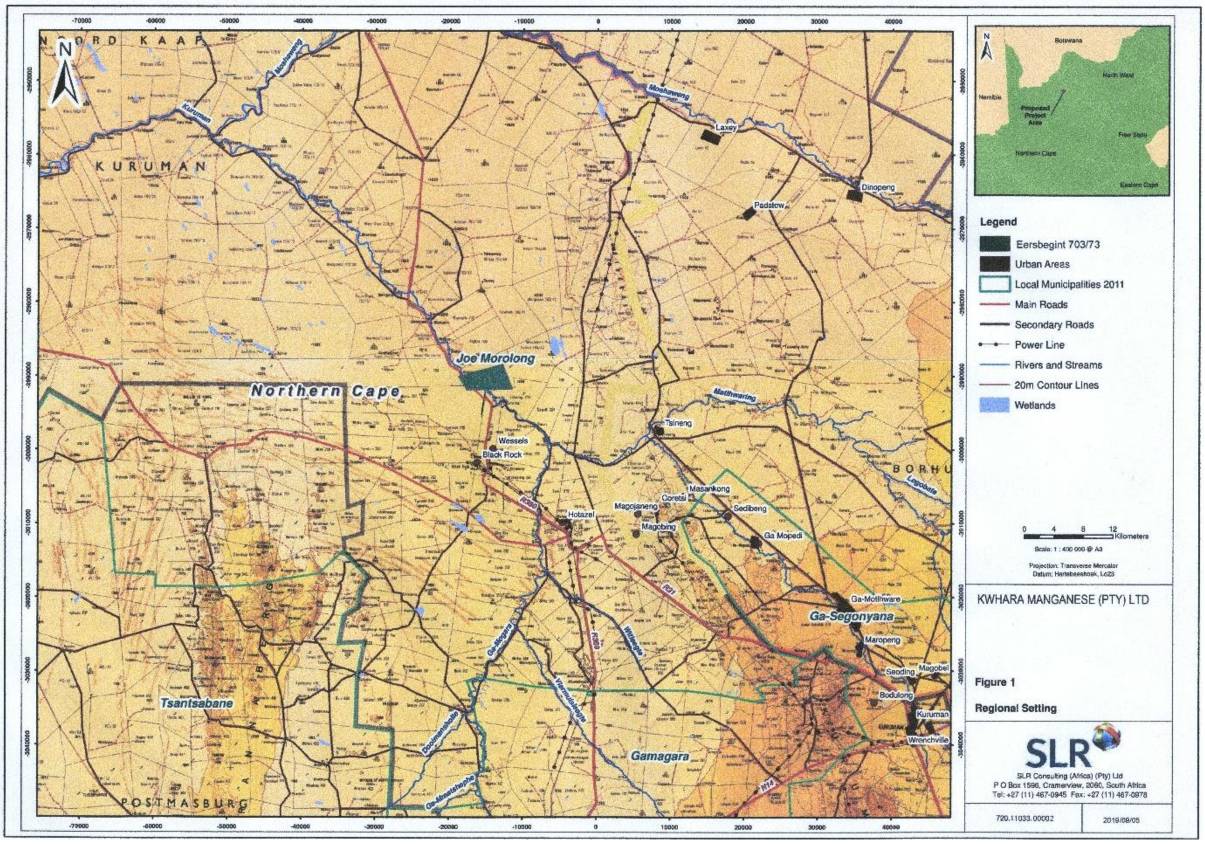

Figure 1: Google Earth map of the proposed prospecting rights project on Farm Eersbegint 703, northeast of Hotazel with the sections shown in dark green.

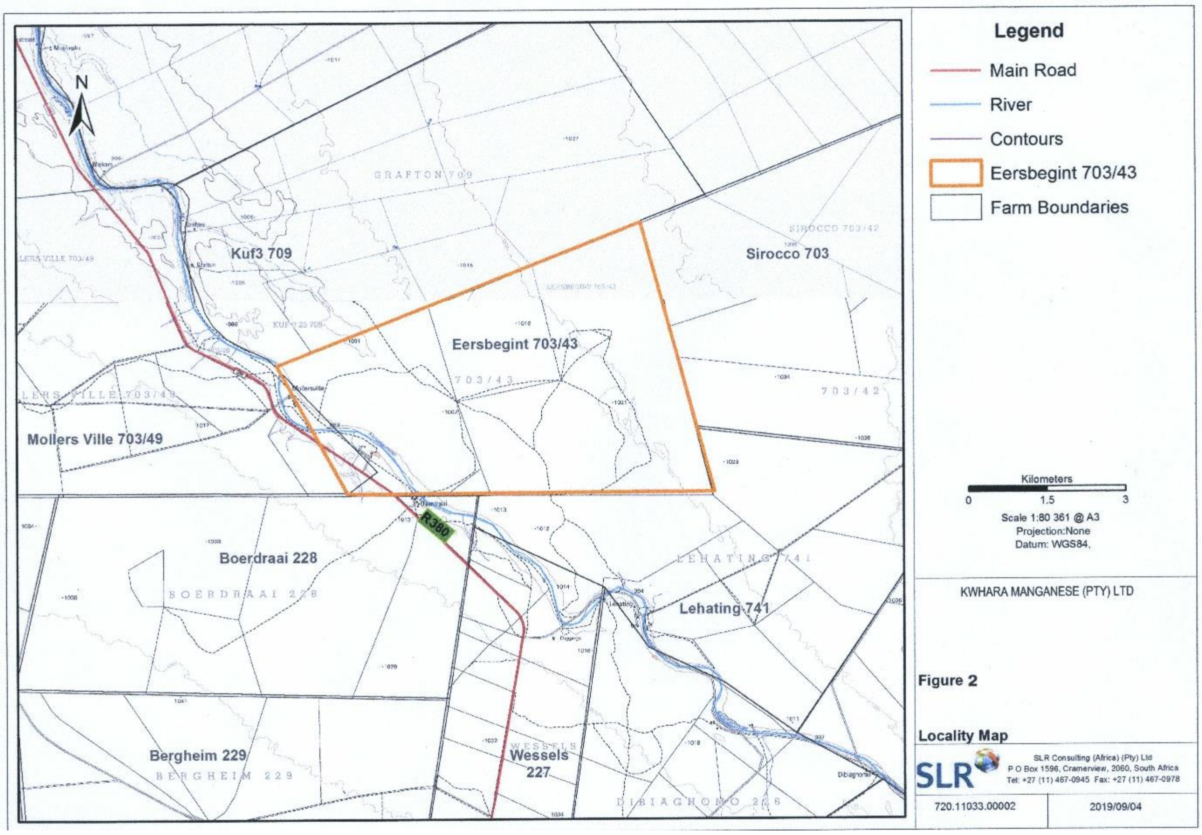

Figure 2: Map showing the farm boundaries. Eersbegint 703 is indicated in the red rectangle. Map supplied by SLR.

2. Methods and Terms of Reference

The Terms of Reference (ToR) for this study were to undertake a PIA and provide feasible management measures to comply with the requirements of SAHRA.

The methods employed to address the ToR included:

1. Consultation of geological maps, literature, palaeontological databases, published and unpublished records to determine the likelihood of fossils occurring in the affected areas. Sources included records housed at the Evolutionary Studies Institute at the University of the Witwatersrand and SAHRA databases;
2. Where necessary, site visits by a qualified palaeontologist to locate any fossils and assess their importance (*not applicable to this assessment*);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*not applicable to this assessment*); and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a representative sample collected (*not applicable to this assessment*).

3. Geology and Palaeontology

i. Project location and geological context

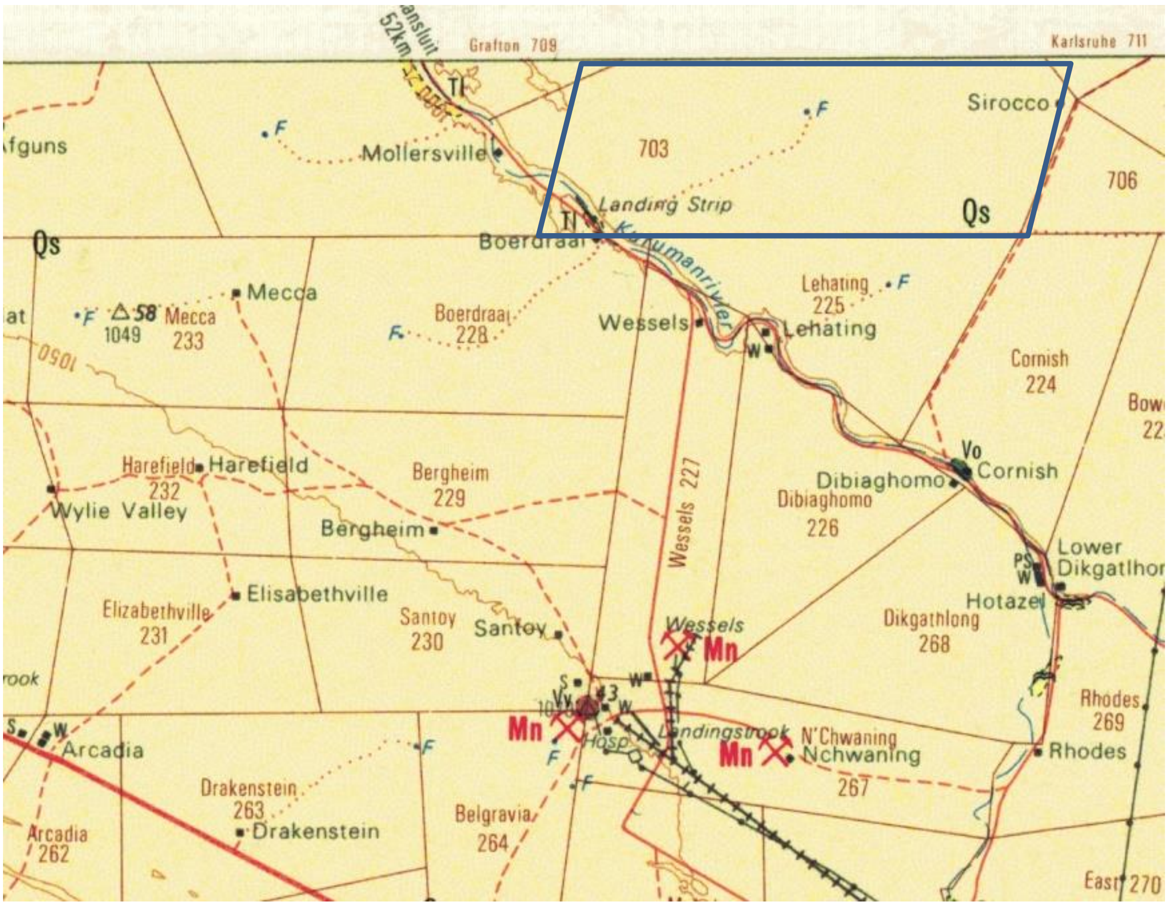

Figure 3: Geological map of the area around the farm Eersbegint 703, northwest of Hotazel. The location of the proposed project is indicated within the blue rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map Kuruman 2722, 1977.

There is a discrepancy in the two geological maps with the southern section of the Farm Eersbegint shown in Figure 3 form the Kuruman 2722 map from 1977, and the northern corner of the farm shown in Figure 4 from the older map Morokweng 2622 from ca 1972

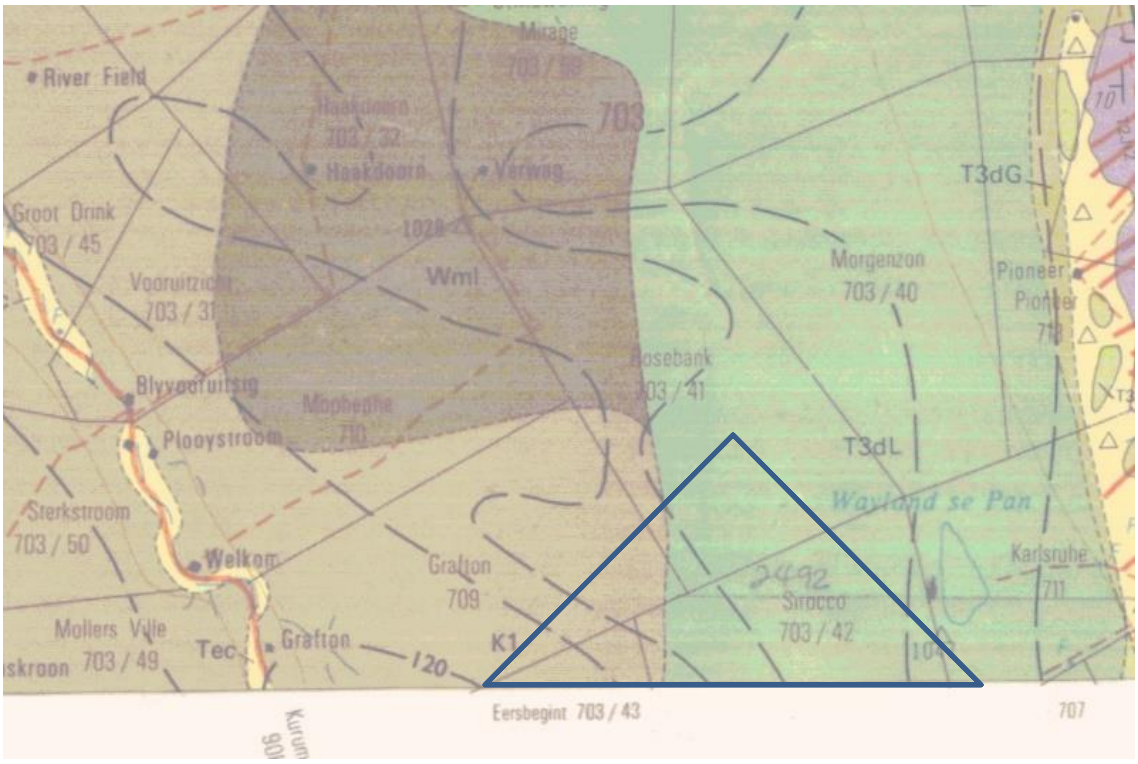

Figure 4: Geological map of the northern part of Farm Eersbegint 703 as shown on Geological Survey Morokweng 2622, ca 1972.

Table 2: Explanation of symbols for the geological map and approximate ages (Eriksson et al., 2006. Johnson et al., 2006). SG = Supergroup; Fm = Formation; Ma = million years; grey shading = formations impacted by the project.

Symbol	Group/Formation	Lithology	Approximate Age
Qs	Kalahari sands,	Alluvium, sand,	Quaternary, ca 2,5 Ma to present
K1	Dwyka Group, Karoo SG	Brown shale and tillites	Upper Carboniferous to Early Permian ca 300 Ma
T3dL	Daspoort Stage, Pretoria Group, Transvaal SGG	Green lava	Ca 2150 Ma

The Kalahari Manganese Field (KMF) is hosted by the ca 2200 Million year old Hotazel Iron Formation of the Postmasburg Group of the Transvaal Supergroup in the Griqualand West area of the Northern Cape Province of South Africa (Figure 4 from Beukes et al., 2016). The Geological map only shows the surface geology but the more recent and more detailed map from Beukes et al. (2016) shows that the farm Eersbegint 703, just north of Black Rock, is underlain by the Hotazel and Beaumont Formations (Postmasburg Group, Transvaal Supergroup, approximately 2394 Million years old; Eriksson et al., 2006).

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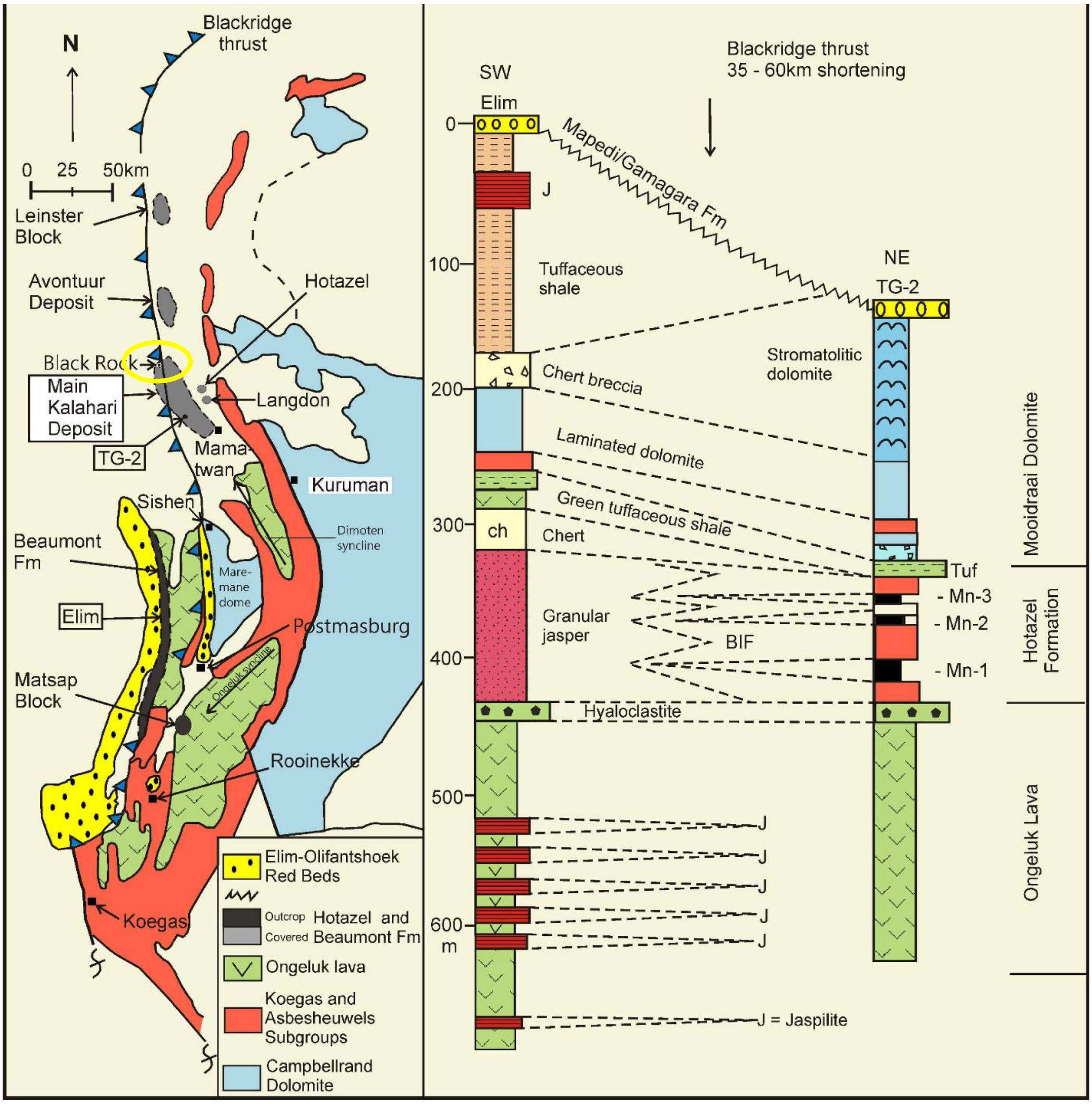

4. (a) Regional map of the Transvaal Supergroup in Griqualand West showing the distribution of the Kalahari Manganese Field and Black Ridge thrust fault. (b) Schematic diagram indicating lateral interfingering of the Hotazel and Mooidraai formations of the KMF on the Kaapvaal Craton to the east, in the footwall of the Black Ridge thrust fault with the Beaumont Formation to the west off the craton in the hangingwall of the thrust (from Cairncross and Beukes, 2013).

Figure 4: From Beukes et al., (2016), as described above, with the location of Eersbegint 703 shown in yellow.

The Hotazel Formation is composed of Manganese deposits and Banded Iron Formation (BIF) (Beukes et al., 2016). According to Eriksson et al., (2006) the Hotazel Formation has volcanic-exhalative manganese.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 5. The site for prospecting and target of the project are the potential manganese and Iron deposits of the Hotazel Formation. The manganese is of volcanic origin so does not preserve any fossils (Esiksson et al., 2006). Banded Iron Formations were formed by the free oxygen released by photosynthesising microbes in warm shallow seas that was absorbed by the iron, but no fossils are preserved in the BIF (Astrup et al., 1998).

The overlying Kalahari sands have a minor potential of preserving fossil because they are the right age, Quaternary (Plumstead, 1969). However, the sands are windblown (Aeolian) in this part of the country. It is very unlikely that any fossils would be entrained in the sands and they would not be in primary context but would have been transported from another area. Only more robust fossils, such as silicified wood fragments or bones would be able to survive the transport by wind. Based on the older Morokweng geological map (Figure 4) the northern part of the farm is overlain by Dwyka tillites and green lavas of the Daspoort Formation

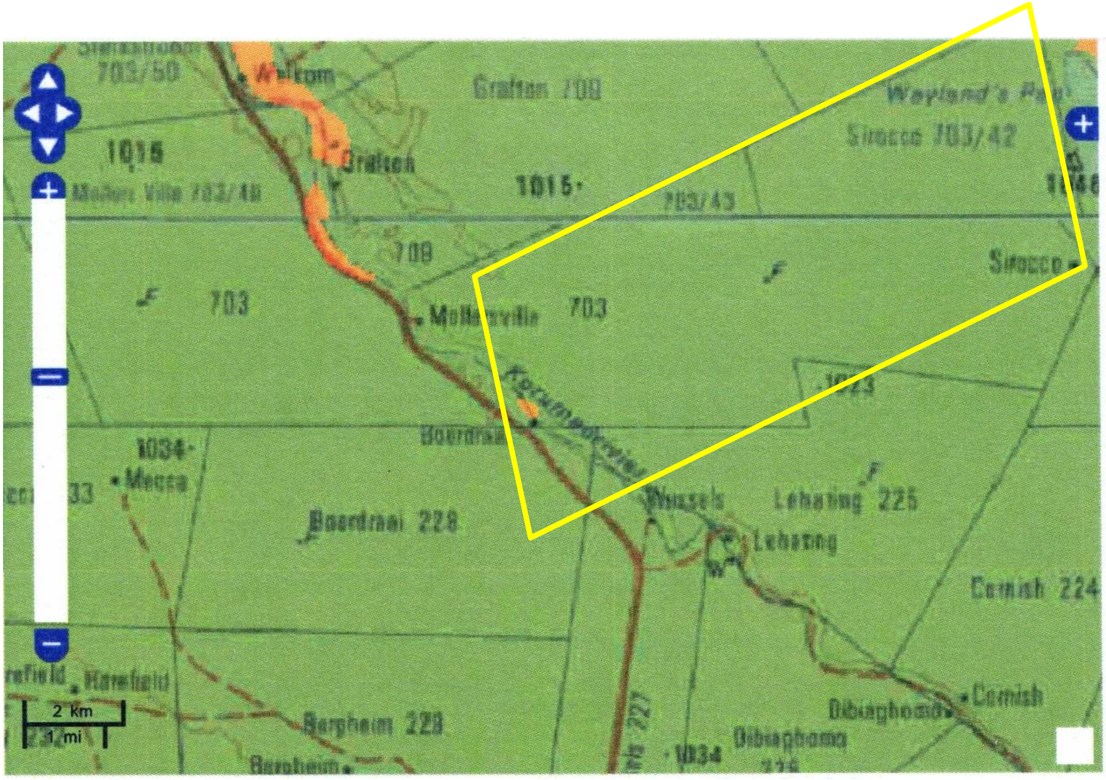

Figure 5: SAHRIS palaeosensitivity maps for the site for the proposed prospecting activities on Farm Eersbegint 703, shown within the yellow rectangle. Colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Dwyka Group tillites are unlikely to preserve fossils, only the mudstones have preserved any fossils and these tend to be rare and fragmented (Johnston et al., 2006).

The Dwyka Group is made up of seven facies that were deposited in a marine basin under differing environmental settings of glacial formation and retreat (Visser, 1986, 1989; Johnson et al., 2006). In the north these are called the Mbizane Formation, and the Elandsvlei Formation in the south. Described below are the seven facies (Johnson et al., 2006 p463-465):

The massive diamictite facies comprises highly compacted diamictite that is clast-poor in the north. It was deposited in subaqueous or subglacial positions.
The stratified diamictite comprises alternating diamictite, mudrock, sandstone and conglomerate beds. They are interpreted as being rapidly deposited, sediment gravity flows but with some possible reworking of the subglacial diamictites.

The massive carbonate-rich diamictite facies is clast-poor and was formed by the rainout of debris, with the carbonate probably originating by crystallisation from interstitial waters.
The conglomerate facies ranges from single layer boulder beds to poorly sorted pebble and granule conglomerates. The boulder beds are interpreted as lodgement deposits whereas the poorly sorted conglomerates are a product of water-reworking of diamicton by high-density sediment gravity flows.
The sandstone facies were formed as turbidite deposits.
The mudrock with stones facies represents rainout deposits in the distal iceberg zone.
The **mudrock facies** consists of dark-coloured, commonly carbonaceous mudstone, shale or silty rhythmite that was formed when the mud or silt in suspension settled. This is the only fossiliferous facies of the Dwyka Group.

The Dwyka *Glossopteris* flora outcrops are very sporadic and rare. Of the seven facies that have been recognised in the Dwyka Group fossil plant fragments have only been recognised from the mudrock facies. They have been recorded from around Douglas only (Johnson et al., 2006; Anderson and McLachlan 1976) although the Dwyka Group exposures are very extensive. Jurassic Dolerites do not contain fossils as they are igneous intrusives.

The Daspoort Formation in this area, according to the geological map, is comprised of green lavas. Lavas are volcanic and do not preserve fossils.

From the SAHRIS map above the area is indicated as moderately sensitive (green) so a desktop assessment has been completed for the project.

4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in **Error! Reference source not found.**:

Definition of SIGNIFICANCE	**Significance = consequence x probability**
Definition of CONSEQUENCE	**Consequence is a function of intensity, spatial extent and duration**

Criteria for ranking of the INTENS ITY of environmental	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional
	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.
	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community
	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)
Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART B: DETERMINING CONSEQUENCE

EXTENT

A part of the site/property	Whole site	Beyond the site, affecting neighbours	Local area, extending far beyond site.	Regional/ National
VL	**L**	**M**	**H**	**VH**

INTENSITY = VL

Very long	VH	Low	Low	Medium	Medium	High
Long term	H	Low	Low	Low	Medium	Medium
Medium term	M	Very Low	Low	Low	Low	Medium
Short term	L	Very low	Very Low	Low	Low	Low
Very short	VL	Very low	Very Low	Very Low	Low	Low
INTENSITY = L						
Very long	VH	Medium	Medium	Medium	High	High
Long term	H	Low	Medium	Medium	Medium	High
Medium term	M	Low	Low	Medium	Medium	Medium
Short term	L	Low	Low	Low	Medium	Medium
Very short	VL	Very low	Low	Low	Low	Medium
INTENSITY = M						
Very long	VH	Medium	High	High	High	Very High
Long term	H	Medium	Medium	Medium	High	High
Medium term	M	Medium	Medium	Medium	High	High
Short term	L	Low	Medium	Medium	Medium	High
Very short	VL	Low	Low	Low	Medium	Medium
INTENSITY = H						
Very long	VH	High	High	High	Very High	Very High
Long term	H	Medium	High	High	High	Very High
Medium term	M	Medium	Medium	High	High	High
Short term	L	Medium	Medium	Medium	High	High
Very short	VL	Low	Medium	Medium	Medium	High

DURATION	Very long	VH	High	High	Very High	Very High	Very High
	Long term	H	High	High	High	Very High	Very High
	Medium term	M	Medium	High	High	High	Very High
	Short term	L	Medium	Medium	High	High	High
	Very short	VL	Low	Medium	Medium	High	High

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	VH	Very Low	Low	Medium	High	Very High
	Probable	H	Very Low	Low	Medium	High	Very High
	Possible/ frequent	M	Very Low	Very Low	Low	Medium	High
	Conceivable	L	Insignificant	Very Low	Low	Medium	High
	Unlikely/ improbable	VL	Insignificant	Insignificant	Very Low	Low	Medium
			VL	L	M	H	VH
			CONSEQUENCE				

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.

Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.

Pre-mitigation
Intensity = L
Extent = VL
Duration = VH
Probability = VL

Post-mitigation (collection of any fossils)
Intensity = VL
Extent = VL
Duration = VL
Probability = VL

Based on the nature of the project, surface activities may impact upon the fossil heritage only if preserved in the development footprint and this has a low probability. The geological structures suggest that the rocks are either much too old to contain fossils. Furthermore, the surface material to be cored through is loose Aeolian sand and this does not preserve fossils. Since there is an extremely small chance that fossils may have been entrained and transported in the sand and may be disturbed, a Fossil Chance find protocol has been added to this report. If fossils are found and collected then there will be NO impact on the fossil heritage. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely low.

5. Assumptions and uncertainties

Based on the geology of the area and the palaeontological record as we know it, it can be assumed that the formation and layout of the manganese deposits, banded iron formation and Aeolian sands are typical for the country and do not contain fossil plant, insect, invertebrate and vertebrate material. The Aeolian sands of the Quaternary period would not preserve fossils.

6. Recommendation

Based on experience and the lack of any previously recorded fossils from the area, it is extremely unlikely that any fossils would be preserved in the loose sands of the Quaternary. Nonetheless, a Fossil Chance Find Protocol should be added to the EMPr: if fossils are found once coring has commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample.

7. References

Astrup, J., Tsikos, H., 1998. Manganese. In: M.G.C. Wilson and C.R. Anhaeusser (Eds). The Mineral Resources of South Africa: Handbook. Council for Geosciences 16, p. 450-460.

Beukes, N.J., Swindell, E,W.P., Wabo, H., 2016. Manganese deposits of Africa. Episodes, 39(3), 1-33. DOI: 10.18814/epiiugs/2016/v39i2/95779.

Erikssen, P.G., Altermann, W., Hartzer, F.J., 2006. The Transvaal Supergroup and its pre-cursors. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. pp 237-260.

Johnson, M.R., van Vuuren, C.J., Visser, J.N.J., Cole, D.I., Wickens, H.deV., Christie, A.D.M., Roberts, D.L., Brandl, G., 2006. Sedimentary rocks of the Karoo Supergroup. In: Johnson, M.R., Anhaeusser, C.R. and Thomas, R.J., (Eds). The Geology of South Africa. Geological Society of South Africa, Johannesburg / Council for Geoscience, Pretoria. Pp 461 – 499.

Plumstead, E.P., 1969. Three thousand million years of plant life in Africa. Geological Society of southern Africa, Annexure to Volume LXXII. 72pp + 25 plates.

Visser, J.N.J., 1986. Lateral lithofacies relationshipsin the glacigene Dwyka Formationin the western and central parts of the Karoo Basin. Transactions of the Geological Society of South Africa 89, 373-383.

Visser, J.N.J., 1989. The Permo-Carboniferous Dwyka Formation of southern Africa: deposition by a predominantly subpolar marine icesheet. Palaeogeography, Palaeoclimatology, Palaeoecology 70, 377-391.

8. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations and coring begin.

1. The following procedure is only required if fossils are seen on the surface and when excavations/coring commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (plants, insects, bone, coal) should be put aside in a suitably protected place. This way the mining activities will not be interrupted.
3. Photographs of similar fossil plants must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 1.5). This information will be built into the EMP’s training and awareness plan and procedures.

4. Photographs of the putative fossils can be sent to the palaeontologist for a preliminary assessment.
5. If there is any possible fossil material found by the developer/environmental officer/miners then the qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumps where feasible.
6. Fossil plants or vertebrates that are considered to be of good quality or scientific interest by the palaeontologist must be removed, catalogued and housed in a suitable institution where they can be made available for further study. Before the fossils are removed from the site a SAHRA permit must be obtained. Annual reports must be submitted to SAHRA as required by the relevant permits.
7. If no good fossil material is recovered then no site inspections by the palaeontologist will not be necessary. A final report by the palaeontologist must be sent to SAHRA once the project has been completed and only if there are fossils.
8. If no fossils are found and the excavations have finished then no further monitoring is required.

Appendix A – Examples of fossils from the Quaternary

Figure 7: Examples of silicified woods that might have been entrained in the aeolian sands.

Figure 8: Examples of Quaternary and modern bones found in loose sediments.

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
September 2019

I) Personal details

Surname	:	**Bamford**
First names	:	**Marion Kathleen**
Present employment	:	Professor; Director of the Evolutionary Studies Institute. Member Management Committee of the NRF/DST Centre of Excellence Palaeosciences, University of the Witwatersrand, Johannesburg, South Africa-
Telephone	:	+27 11 717 6690
Fax	:	+27 11 717 6694
Cell	:	082 555 6937
E-mail	:	marion.bamford@wits.ac.za ; marionbamford12@gmail.com

ii) Academic qualifications

Tertiary Education: All at the University of the Witwatersrand:
1980-1982: BSc, majors in Botany and Microbiology. Graduated April 1983.
1983: BSc Honours, Botany and Palaeobotany. Graduated April 1984.
1984-1986: MSc in Palaeobotany. Graduated with Distinction, November 1986.
1986-1989: PhD in Palaeobotany. Graduated in June 1990.

iii) Professional qualifications

Wood Anatomy Training (overseas as nothing was available in South Africa):
1994 - Service d'Anatomie des Bois, Musée Royal de l'Afrique Centrale, Tervuren, Belgium, by Roger Dechamps
1997 - Université Pierre et Marie Curie, Paris, France, by Dr Jean-Claude Koeniguer
1997 - Université Claude Bernard, Lyon, France by Prof Georges Barale, Dr Jean-Pierre Gros, and Dr Marc Philippe

iv) Membership of professional bodies/associations

Palaeontological Society of Southern Africa
Royal Society of Southern Africa - Fellow: 2006 onwards
Academy of Sciences of South Africa - Member: Oct 2014 onwards
International Association of Wood Anatomists - First enrolled: January 1991
International Organization of Palaeobotany – 1993+
Botanical Society of South Africa
South African Committee on Stratigraphy – Biostratigraphy - 1997 - 2016
SASQUA (South African Society for Quaternary Research) – 1997+
PAGES - 2008 –onwards: South African representative
ROCEEH / WAVE – 2008+
INQUA – PALCOMM – 2011+onwards

vii) Supervision of Higher Degrees

All at Wits University

Degree	Graduated/completed	Current
Honours	7	0
Masters	10	4
PhD	12	5
Postdoctoral fellows	10	3

viii) Undergraduate teaching

Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 25 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 2-8 students per year.

ix) Editing and reviewing
Editor: Palaeontologia africana: 2003 to 2013; 2014 – Assistant editor
Guest Editor: Quaternary International: 2005 volume
Member of Board of Review: Review of Palaeobotany and Palynology: 2010 –
Cretaceous Research: 2014 -

Review of manuscripts for ISI-listed journals: 25 local and international journals

x) Palaeontological Impact Assessments

Selected – list not complete:

- Thukela Biosphere Conservancy 1996; 2002 for DWAF
- Vioolsdrift 2007 for Xibula Exploration
- Rietfontein 2009 for Zitholele Consulting
- Bloeddrift-Baken 2010 for TransHex
- New Kleinfontein Gold Mine 2012 for Prime Resources (Pty) Ltd.
- Thabazimbi Iron Cave 2012 for Professional Grave Solutions (Pty) Ltd
- Delmas 2013 for Jones and Wagener
- Klipfontein 2013 for Jones and Wagener
- Platinum mine 2013 for Lonmin
- Syferfontein 2014 for Digby Wells
- Canyon Springs 2014 for Prime Resources
- Kimberley Eskom 2014 for Landscape Dynamics
- Yzermyne 2014 for Digby Wells
- Matimba 2015 for Royal HaskoningDV
- Commissiekraal 2015 for SLR
- Harmony PV 2015 for Savannah Environmental
- Glencore-Tweefontein 2015 for Digby Wells
- Umkomazi 2015 for JLB Consulting
- Ixia coal 2016 for Digby Wells
- Lambda Eskom for Digby Wells
- Alexander Scoping for SLR
- Perseus-Kronos-Aries Eskom 2016 for NGT
- Mala Mala 2017 for Henwood
- Modimolle 2017 for Green Vision
- Klipoortjie and Finaalspan 2017 for Delta BEC
- Ledjadja borrow pits 2018 for Digby Wells
- Lungile poultry farm 2018 for CTS
- Olienhout Dam 2018 for JP Celliers
- Isondlo and Kwasobabili 2018 for GCS

- Kanakies Gypsum 2018 for Cabanga
- Nababeep Copper mine 2018
- Glencore-Mbali pipeline 2018 for Digby Wells
- Remhoogte PR 2019 for A&HAS
- Bospoort Agriculture 2019 for Kudzala
- Overlooked Quarry 2019 for Cabanga
- Richards Bay Powerline 2019 for NGT
- Eilandia dam 2019 for ACO

xi) Research Output

Publications by M K Bamford up to June 2018 peer-reviewed journals or scholarly books: over 140 articles published; 5 submitted/in press; 8 book chapters.
Scopus h index = 27; Google scholar h index = 32;
Conferences: numerous presentations at local and international conferences.

xii) NRF Rating

NRF Rating: B-2 (2016-2020)
NRF Rating: B-3 (2010-2015)
NRF Rating: B-3 (2005-2009)
NRF Rating: C-2 (1999-2004)