Palaeontological Impact Assessment for the proposed Eskom West Rand Strengthening Project Phase 2 Pluto Substation to Westgate Substation, Gauteng Province

Site Visit (Phase 2) Report

Prepared for

RESOLUTE ENVIRONMENTAL SOLUTIONS

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Expertise of Specialist

The Palaeontologist Consultant is: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, ASSAf
Experience: 32 years research; 24 years PIA studies

Declaration of Independence

This report has been compiled by Professor Marion Bamford, of the University of the Witwatersrand, sub-contracted by Archaeological and Heritage Services Africa (Pty) Ltd, Pretoria, 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: 

Executive Summary

A palaeontological Impact Assessment was requested for the routes proposed routes and corridors between Pluto Substation and Westgate Substation as part of Eskom's West Rand Strengthening Project Phase 2 project (SAHRA Case Id: 15179). Part of the southern route is on potentially fossiliferous rocks of the Malmani Subgroup.

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 site visit Palaeontological Impact Assessment (PIA) was completed for the proposed project by Marion Bamford on 12th September 2021.

Pluto Substation and environs are on the Black Reef Formation (Transvaal Supergroup) while Westgate Substation is on non-fossiliferous rocks of the Turffontein Subgroup (Central Rand Group, Witwatersrand Supergroup). The southern route (Corridor 3) between Pluto and Westgate substations required a site visit palaeontological assessment because much of it lies on very highly sensitive rocks of the Malmani Subgroup (Transvaal Supergroup) that could preserve trace fossils: stromatolites. The western one third of the route from Pluto Substation is on ploughed agricultural lands, the central third is on ploughed and abandoned agricultural land and the eastern one third to Westgate Substation is on abandoned agricultural land that is listed as "natural", as well as disturbed mine property.

No fossils were seen on the privately-owned ploughed land, that had very restricted access. Open veld occurs along and to the west of the R28 and this was surveyed on foot. No rocky outcrops and no trace fossils such as stromatolites were found. Even the open fields are very disturbed from previous agriculture and current dumping of rubbish. Combining the site visit observations with a desktop assessment of the geology and palaeontology of the three routes, the central route (Corridor 2) is the preferred route because the rocks are ancient and non-fossiliferous. The North route (Corridor 1) is also partially on fossiliferous rocks of the Malmani Subgroup but on agricultural lands. The southern route (Corridor 3) is along a larger proportion of potentially fossiliferous rocks but fossils were not found. Nonetheless, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological assessment is required. As far as the palaeontology is concerned, the project should be authorised along any of the three proposed routes.

Table of Contents

1. Background

As part of a long term project to increase and improve the supply of electricity from Eskom for mining, industrial and domestic use, the West Rand Strengthening Phase 2 project is being planned. The line-in-line-out (LILO) for four large existing substations (SS) will have new poles, namely Pluto SS (west), Westgate SS (north), Princess SS (east) and Taunus SS (south), see Figure 1. There are three alternative routes being considered between the substations with wide corridors (Figure 2).

A desktop Palaeontological Impact Assessment (Butler in Smeyatsky and Kitto, 2019) has already been done but the Interim Comment from SAHRA (Case Id: 15179) noted that a site visit was required for the potentially very highly sensitive rocks of the Malmani Subgroup along the southern route between Pluto SS and Westgate SS.

In this report the palaeosensitivity of the four substations is reviewed, and the three proposed routes between Pluto SS and Westgate are reviewed and the southern route was visited because it is on the Malmani Subgroup rocks that could preserve trace fossils such as stromatolites.

A Palaeontological Impact Assessment is required for the proposed southern route alternative because it lies on very highly sensitive rocks according to the SAHRIS palaeosensitivity map. In order to comply with the regulations of 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 site visit and survey (Phase 2) Palaeontological Impact Assessment (PIA) was completed for the proposed project and is reported herein.

Table 1: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (amended 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	Page 1
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 for fossils
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	Section 6
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;	Sections 1, 6
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	Section 8
m	Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 8, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6
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	Section 6
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 four substations in relation to each other, Pluto SS (west). Westgate SS (north), Princess SS (east) and Taunus SS (south).

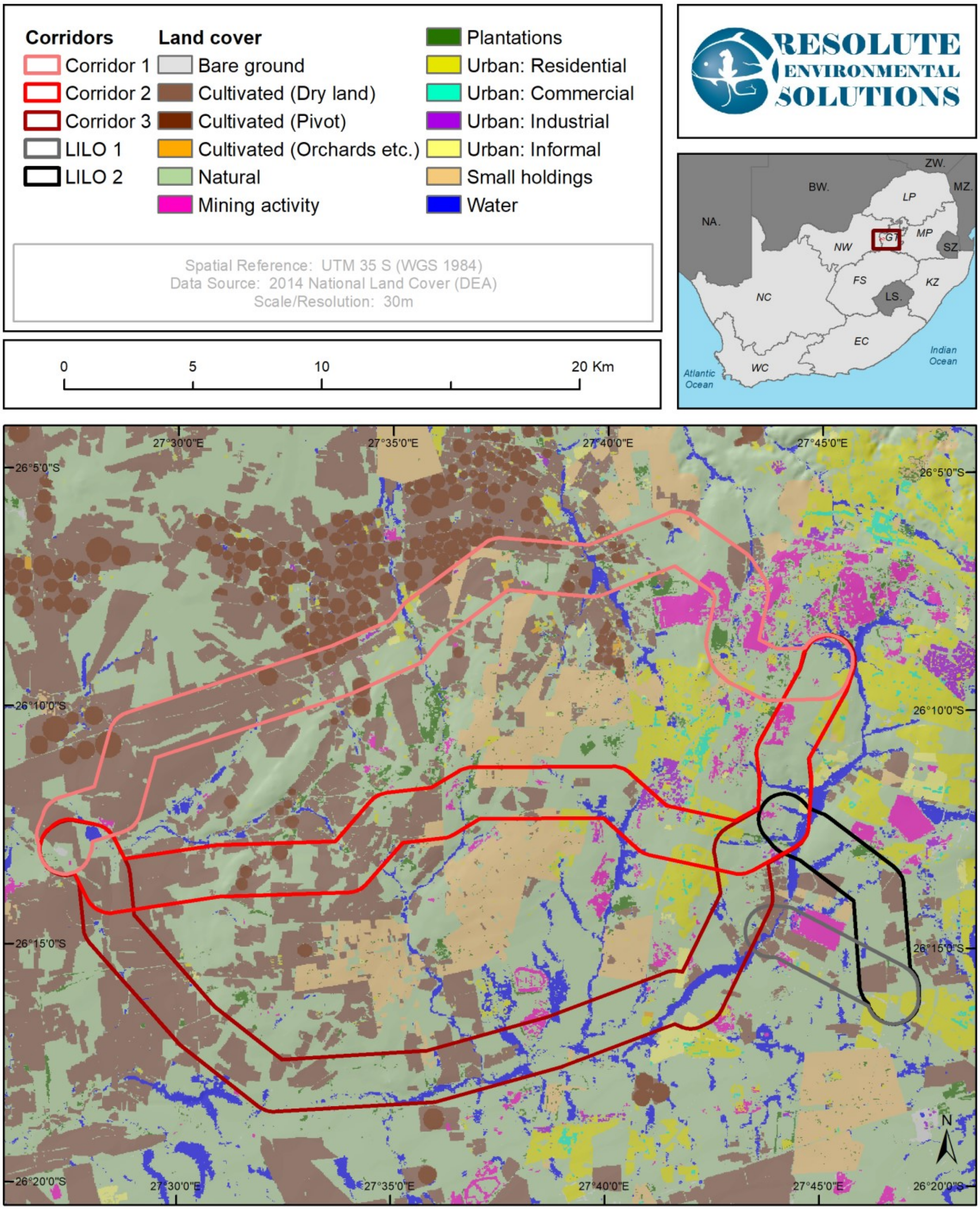


Figure 2: National Land Cover map from Resolute Environmental showing the proposed routes between the substations. Corridor 1 (pink) = northern route; Corridor 2 (red) = central route; Corridor 3 (brown) = southern route.

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 (as reported herein, and collect or rescue fossils if required);
3. Where appropriate, collection of unique or rare fossils with the necessary permits for storage and curation at an appropriate facility (*as indicated in section 4 below)*; and
4. Determination of fossils' representivity or scientific importance to decide if the fossils can be destroyed or a just a representative sample collected and housed in a recognised repository.

3. Geology and Palaeontology

i. Project location and geological context

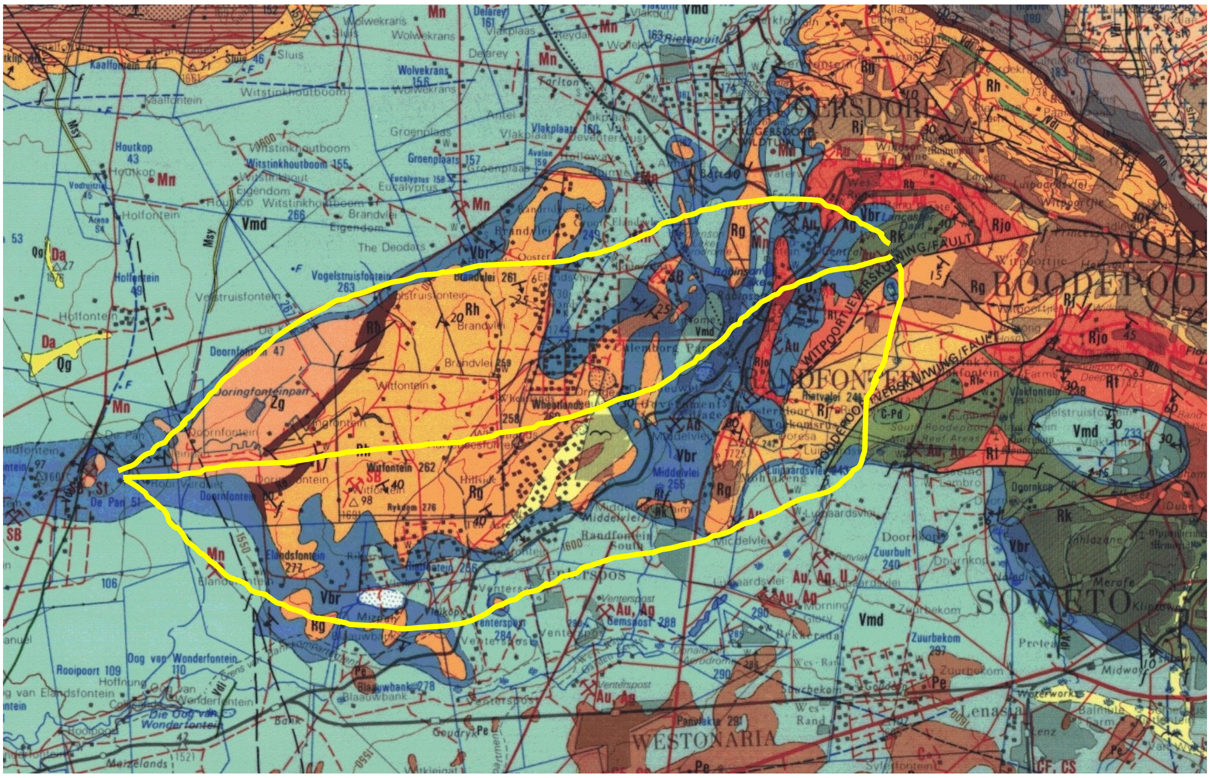


Figure 3: Geological map of part of the West Rand including the substations and rough routes (see later figures for accurate routes. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2626 West Rand - Parys.

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

Symbol	Group/Formation	Lithology	Approximate Age
Q	Quaternary	Alluvium, sand, calcrete	Neogene, ca 2.5 Ma to present
Vm	Malmani SG, Chuniespoort Group, Transvaal SG	Dolomite, chert	Ca 2585 – 2480 Ma
Vbr	Black Reef Fm, Transvaal SG	Quartzite, conglomerate, shale	<2618 Ma
Rk	Klipriviersberg Group, Ventersdorp SG	Mafic lava, tuff, amygaloidal or porphyritic in places	2791 – 2779 Ma
Rt	Turffontein Subgroup, Central Rand Group, Witwatersrand SG	Quartzite, conglomerate, shale	Ca 2970 – 2714 >2970 Ma (Gumsley et al., 2020)
Rjo	Johannesburg Subgroup, Central Rand Group, Witwatersrand SG	Quartzite, conglomerate	>2790 Ma
Rj	Jeppestown Subgroup, West Rand Group, Witwatersrand SG	Shale, quartzite, conglomerate, amygdaloidal lava	>2790 Ma
Rg	Government Subgroup, West Rand Group, Witwatersrand SG	Quartzite, greywacke, conglomerate, shale, tillites, hornfels	>27890 Ma
Rh	Hospital Hill Subgroup, West Rand Group, Witwatersrand SG	Ferruginous shale, quartzite; banded ironstone	>2790 Ma
Zg	Basement granite	Granite, gneiss	>3500 Ma

The project is in the southern part of the Transvaal Basin that has the basal members of the Transvaal Supergroup, one part of the Ventersdorp Supergroup and the unconformably underlying rocks of the Witwatersrand Supergroup. The quartzites, conglomerates and shales of the Witwatersrand Supergroup were deposited in an epicontinental sea. His basin was subsequently flexed, squeezed, metamorphosed and mineralised (McCarthy). Although it is very important economically because of the gold mineralisation, the rocks are older than non-microscopic life forms, and the metamorphism would have destroyed any traces of early microbial life. The Klipriviersberg Group (Ventersdorp Supergroup) s composed of mafic lava and tuff from volcanic activity (Figure 3).

The Transvaal Supergroup rocks are a sequence of sedimentary and volcanic rocks that were deposited in the Transvaal Basin. Only the two basal members of this sequence occur in the area, the Black Reef Formation and the **Malmani Subgroup** (Figure 3, Table 2). Where there are good exposures (not this area) the Malmani Subgroup has been divided into five Formations: The Malmani Subgroup is up to 2000m thick and has been divided into five formations based on the composition of cherts, stromatolites, limestones and shales. At the base, overlying the Black Reef Formation, is the base is the Oaktree Formation that represents a transition from siliciclastic sedimentation to platform carbonates (Eriksson et al., 2006). It is composed of carbonaceous shales, stromatolitic dolomites and locally developed quartzites. Next is the Monte Christo Formation that has an erosive breccia base and continues with stromatolitic and oolitic platformal dolomites. Above that is the Lyttleton Formation that is composed of shales, quartzites and stromatolitic and dolomites. The overlying Eccles Formation includes a series of erosion breccias that locally contain gold deposits. This mineralisation has been attributed to hydrothermal remobilisation of fluids by the Bushveld complex (Eriksson et al., 2006). The topmost formation is the Frisco Formation that is composed mainly of stromatolitic dolomites but these become more shale rich towards the top of the sequence because of the deepening depositional environment.

Overlying most of the area are modern soils, and in the stream and river valleys there is Quaternary alluvium, soils and sands.

ii. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in Figure 4. The basement granite, gneiss, quartzites, conglomerates and volcanic rocks of the Witwatersrand and Ventersdorp Supergroups are too old and of the incorrect type to preserve fossils. Only the Black Reef Formation and the Malmani Subgroup dolomites might preserve trace fossils such as stromatolites.

Stromatolites are the trace fossils that were formed by colonies of green algae and blue-green algae (Cyanobacteria) that grew in warm, shallow marine settings. These algae were responsible for releasing oxygen via the photosynthetic process where atmospheric carbon dioxide and water, using energy from the sun, are converted into carbon chains and compounds that are the building blocks of all living organisms. The released carbon dioxide initially was taken up by the abundant reducing minerals to form oxides, e.g. iron oxide. Eventually free oxygen was released into the atmosphere and some was converted into ozone by the bombardment of cosmic rays. The ozone is critical for the filtering out of harmful ultraviolet rays.

Stromatolites are the layers upon layers of inorganic materials that were deposited during photosynthesis, namely calcium carbonate, magnesium carbonate, calcium sulphate and magnesium sulphate. These layers can be in the form of flat layers, domes or columns depending on the environment where they grew (Beukes, 1987). Some environments did not form stromatolites, just layers of limestone that later was converted to dolomite. The algae that formed the stromatolites are very rarely preserved, and they are microscopic so they can only be seen from thin sections studies under a petrographic microscope.

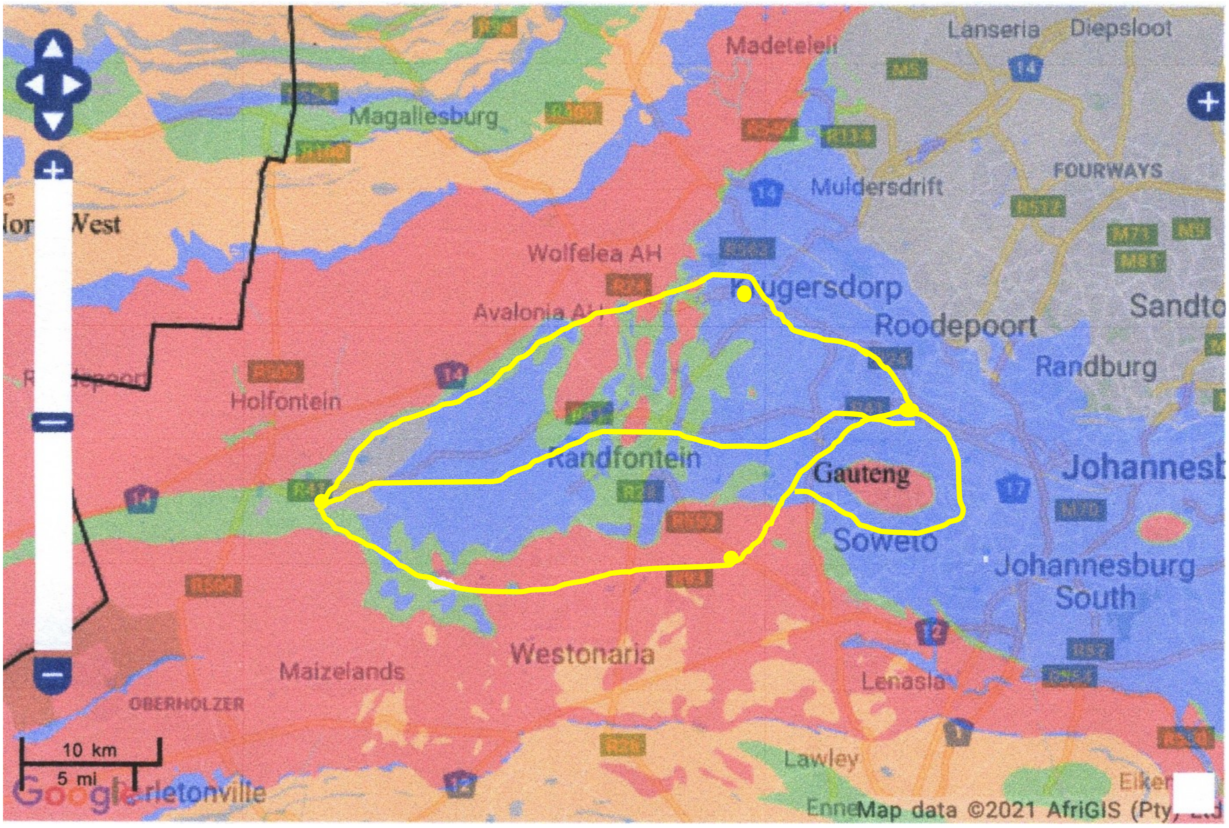
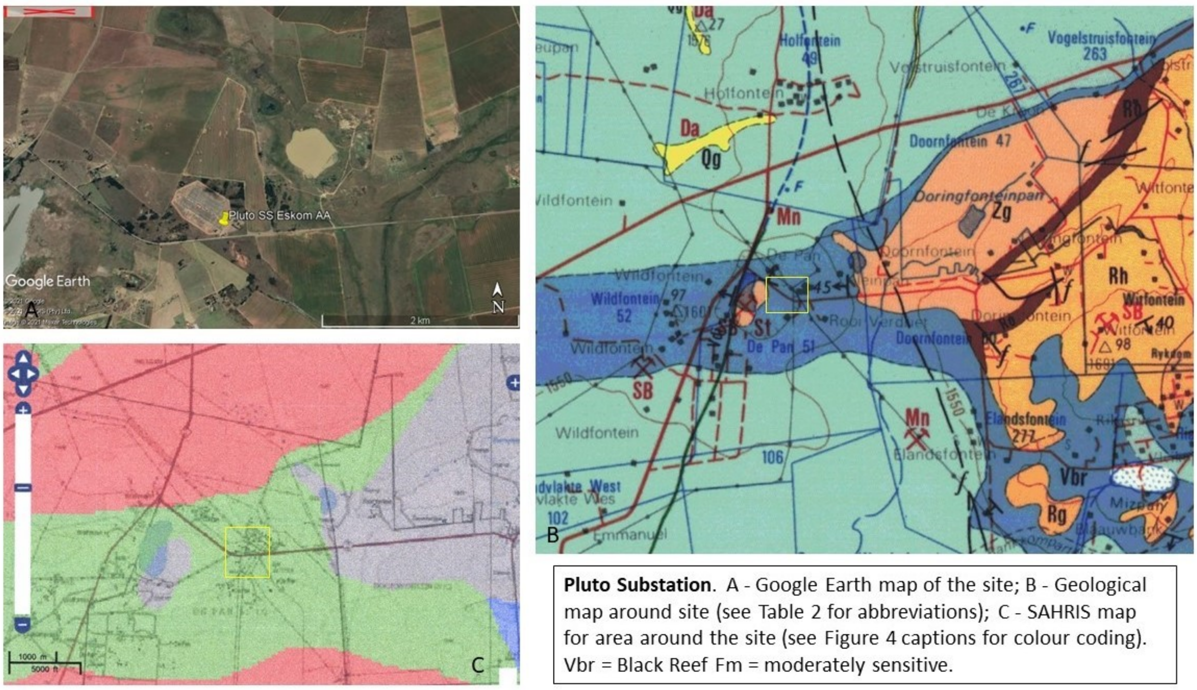
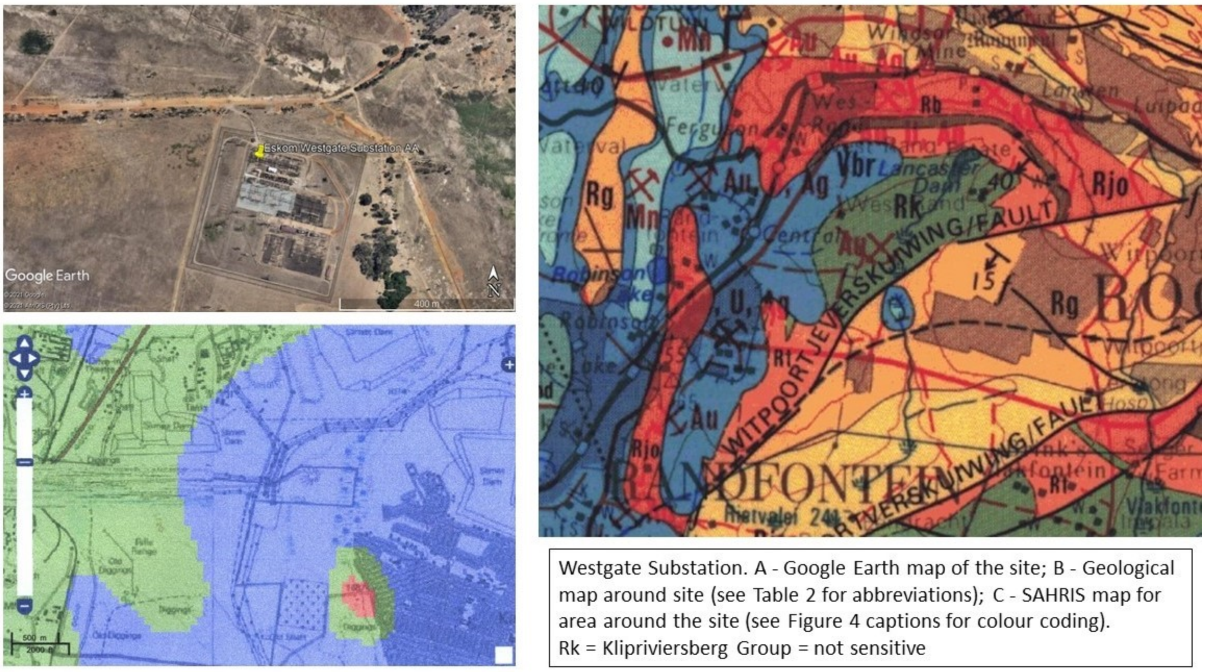


Figure 4: SAHRIS palaeosensitivity map for all the routes proposed West Rand Strengthening project Phase 2 shown by the lines with letters. N = northern route (Corridor 1); C = central route (Corridor 2); S = southern route (Corridor 3). Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.



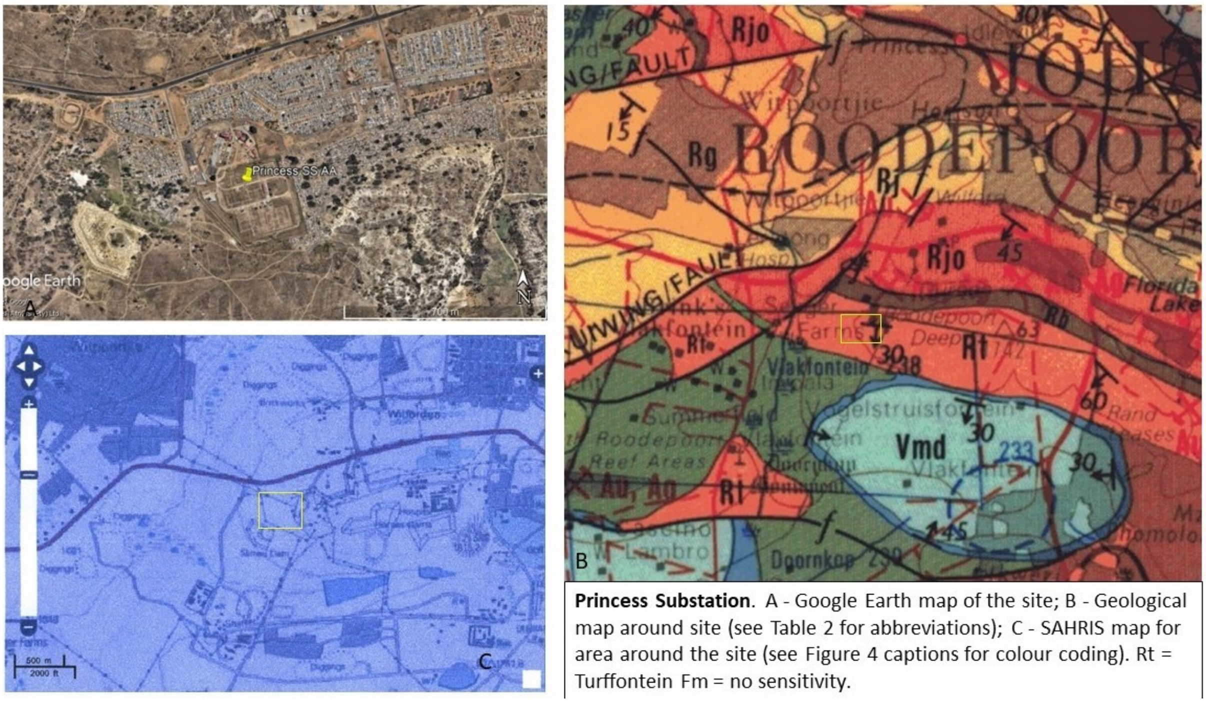
Pluto Substation. A - Google Earth map of the site; B - Geological map around site (see Table 2 for abbreviations); C - SAHRIS map for area around the site (see Figure 4 captions for colour coding). Vbr = Black Reef Fm = moderately sensitive.

Figure 5: Pluto Substation. A - Google Earth map of the site; B - Geological map around site (see Table 2 for abbreviations); C - SAHRIS map for area around the site (see Figure 4 captions for colour coding)



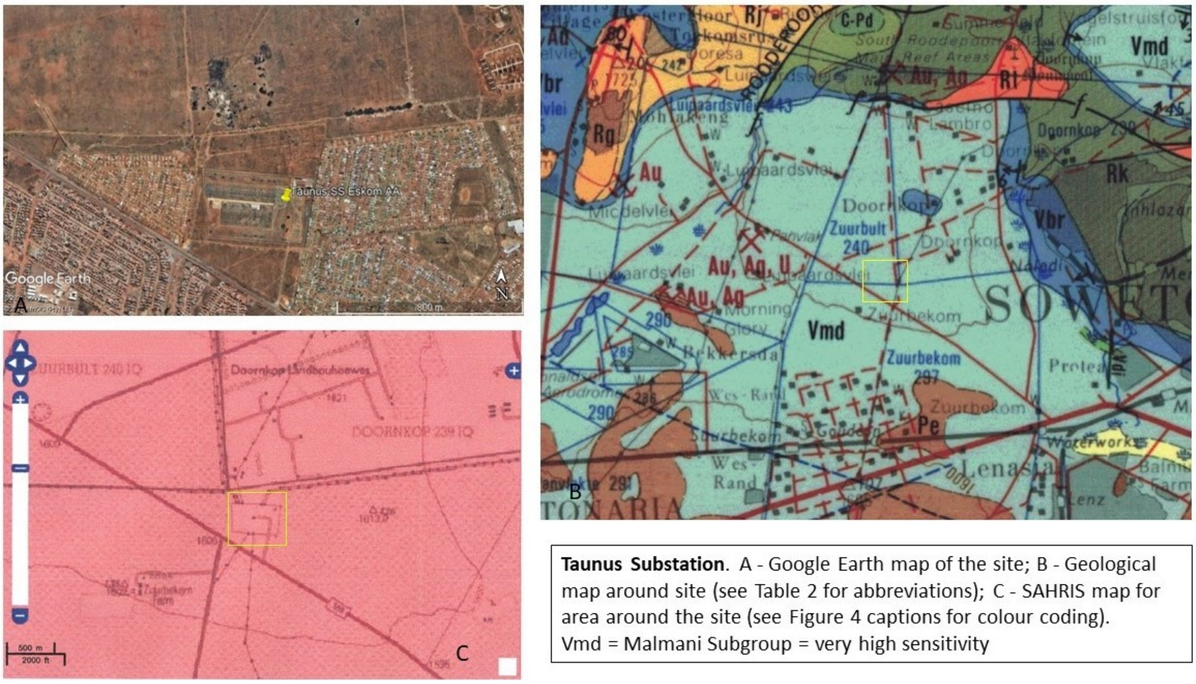
Westgate Substation. A - Google Earth map of the site; B - Geological map around site (see Table 2 for abbreviations); C - SAHRIS map for area around the site (see Figure 4 captions for colour coding). Rk = Klipriviersberg Group = not sensitive

Figure 6: Westgate Substation. A - Google Earth map of the site; B - Geological map around site (see Table 2 for abbreviations); C - SAHRIS map for area around the site (see Figure 4 captions for colour coding)



Princess Substation. A - Google Earth map of the site; B - Geological map around site (see Table 2 for abbreviations); C - SAHRIS map for area around the site (see Figure 4 captions for colour coding). Rt = Turffontein Fm = no sensitivity.

Figure 7: Princess Substation. A - Google Earth map of the site; B - Geological map around site (see Table 2 for abbreviations); C - SAHRIS map for area around the site (see Figure 4 captions for colour coding)



Taunus Substation. A - Google Earth map of the site; B - Geological map around site (see Table 2 for abbreviations); C - SAHRIS map for area around the site (see Figure 4 captions for colour coding).
Vmd = Malmani Subgroup = very high sensitivity

Figure 8: Taunus Substation. A - Google Earth map of the site; B - Geological map around site (see Table 2 for abbreviations); C - SAHRIS map for area around the site (see Figure 4 captions for colour coding).

Figure 9: Northern Route (Corridor 1) between Pluto Substation and Westgate Substation

Figure 10: Central Route (Corridor 2) between Pluto Substation and Westgate Substation

Figure 11: Southern Route (Corridor 3) between Pluto Substation (west) and Westgate Substation (east) with the potentially fossiliferous parts shown within the red rectangles (taken from Figure 4).

The westernmost and easternmost parts of the Southern route are on non-fossiliferous area and the central part is agricultural fields, and after visiting the area A (Figure 11) agricultural fields it was decided not to waste time on the same kind of non-productive site (i.e. between

Areas A and B of Figure 11). Area B had open fields and was visited – but very rapidly because there were many people wandering around and we did not feel safe.

Iii **Site visit observations**

A site visit and survey of the project area was completed on 12 September 2021 by Marion Bamford and a friend. In summary, farmlands were not accessible but were viewed from the roads, and furthermore, the ploughed or fallow soils have covered any relevant features. Photographs and observations were taken from the route but those from selected points are presented in Table 3, Figures 12 and 13.

Table 3: Site visit observations and relevant site photographs as indicated.

GPS coordinates	Observations	Figure
26°16’14” S 27°30’28”E	Area A Southwest of Pluto SS, along a provincial road Fields are lying fallow and have weeds or have been ploughed recently. No rocks, no rocky outcrops and no fossils were seen at all	12 A-D
26°17’33”S 27°33’01”E	R559 Dennyvale, small holdings, buildings and agriculture No rocks and no fossils seen	
26°17’20”S 27°38’34”E	Area B South of old mine dumps, van der Bijl Street Field lying fallow	
26°16’17”S 24°40’48”E	R28 heading north, open field on west side and a mine and dam on the east side. Field is abandoned but was ploughed previously. Lots of trash has been dumped here and people are wandering around. Has been burned recently and soils visible. No rocks and no fossils seen	13 A-D

Figure 12: Site photos for Area A – section of southern route (Corridor 1) southeast of Pluto SS (see Figure 11). A – Fallow field with soil and weed cover. B – view southwards over grassy field. C – recently ploughed field with no rocky outcrops. D – field with remnant of last season's crop.

Figure 13: Site photos for Area B – section of southern route (Corridor 1) southwest of Westgate SS (see Figure 11). A – abandoned field with sparse vegetation and no rocky outcrops. B – close-up of soils and burned grass. C – D – flat, previously ploughed field, now abandoned, no rocky outcrops.

4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in Table 4:

TABLE 4A: CRITERIA FOR ASSESSING IMPACTS

PART A: DEFINITION AND CRITERIA		
Criteria for ranking of the SEVERITY/NATURE of environmental impacts	**H**	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action.
	M	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints.
	L	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	L+	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	M+	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	H+	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
Criteria for ranking the DURATION of impacts	**L**	Quickly reversible. Less than the project life. Short term
	M	Reversible over time. Life of the project. Medium term
	H	Permanent. Beyond closure. Long term.
Criteria for ranking the SPATIAL SCALE of impacts	**L**	Localised - Within the site boundary.
	M	Fairly widespread – Beyond the site boundary. Local
	H	Widespread – Far beyond site boundary. Regional/ national
PROBABILITY (of exposure to impacts)	**H**	Definite/ Continuous
	M	Possible/ frequent
	L	Unlikely/ seldom

TABLE 4B: IMPACT ASSESSMENT

PART B: ASSESSMENT		
SEVERITY/NATURE	**H**	-
	M	-
	L	Soils do not preserve any fossils; so far there are no records from the Malmani Subgroup of stromatolites in this region so it is very unlikely that fossils occur on the site. The impact would be very unlikely.
	L+	-
	M+	-
	H+	-
DURATION	**L**	-
	M	-
	H	Where manifest, the impact will be permanent.
SPATIAL SCALE	**L**	Since the only possible fossils within the area would be trace fossils, stromatolites, in the Malmani Subgroup in dolomites, the spatial scale will be localised within the site boundary.
	M	-
	H	-

PART B: ASSESSMENT		
PROBABILITY	H	-
	M	-
	L	The site visit showed that there are no fossils in characteristic areas of the route. It is extremely unlikely that any fossils would be found in the loose sand and soils that will be excavated for pole foundations. Nonetheless, a Fossil Chance Find Protocol should be added to the eventual EMPr.

Based on the nature of the project, surface activities may impact upon the fossil heritage if preserved in the development footprint. The geological structures suggest that the rocks are the correct age and type to contain fossils, namely the dolomites of the Malmani Subgroup could have stromatolites. The site visit however, showed that there are no surficial dolomites or stromatolites.

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 dolomites are typical for the country and in some instances do contain trace fossils such as stromatolites. None was seen on the site visit, however, much of the area is farmland and so it has been disturbed and any rocks might have been removed. Open or 'natural' areas turned out to be abandoned fields so were previously disturbed, and are now being used as dumping sites. It is the considered opinion of the palaeontologist that the available sites are representative of the whole route. No rocks, or dolomites or fossil stromatolites were found. It is not known what is buried beneath the soils.

6. Recommendation

Based on experience and the lack of any fossils seen during the site visit, it is extremely unlikely that any fossils would be disturbed by the proposed project. No fossils would be found in the soils that will be excavated for poles or access roads. There is a very small chance that fossils (stromatolites of the Malmani Subgroup, Transvaal Supergroup) may occur in the rocks below the surface, so a Fossil Chance Find Protocol should be added to the EMPr. If fossils are found by the environmental officer, or other designated responsible person, once excavations have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample. As far as the palaeontology is concerned, the project should be authorised.

Summary

1. The substations are existing and are in built-up areas that are already disturbed.
2. LILO-1 and LILO-2 are in very disturbed areas and on non-fossiliferous rocks
3. Corridor 1 (northern) has only a short section on potentially fossiliferous rocks but the land is already ploughed or built-upon so there are no surface stromatolites.
4. Corridor 2 (central) is on non-fossiliferous rocks and the route is already very disturbed. This is the preferred route from the palaeontological aspect.

5. Corridor 3 (southern) is mostly on fossiliferous rocks but many parts are disturbed. The site visit showed that there are <u>no fossils along this route</u>.

As far as the palaeontology is concerned, there are no stromatolites along the southern route (Corridor 3), therefore the project should be authorised.

7. References

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8. Chance Find Protocol

Monitoring Programme for Palaeontology – to commence once the excavations / drilling activities begin.

1. The following procedure is only required if fossils are seen on the surface and when excavations/drilling for foundations commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (stromatolites,

plants, insects, bone, coal) should be put aside in a suitably protected place. This way the project activities will not be interrupted.

3. Photographs of similar fossils must be provided to the developer to assist in recognizing the fossil plants in the shales and mudstones (for example see Figure 14, 15). 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 or trace fossil material found by the developer / contractor /environmental officer then a qualified palaeontologist sub-contracted for this project, should visit the site to inspect the selected material and check the dumped material where feasible.
6. Trace fossils, 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 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: Exmples of trace fossils from the Malmani subgroup

Figure 14: Dolomite surface view – note there are no stromatolites and no fossils in this dolomite.

Figure 15: Stromatolites as seen from the surface. Scale = 12 cm.

Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD
January 2021

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	11	2
Masters	10	5
PhD	11	4
Postdoctoral fellows	10	4

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 –
Journal of African Earth Sciences: 2020 –

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
- Eastlands Residential 2019 for HCAC
- Fairview MR 2019 for Cabanga
- Graspan project 2019 for HCAC
- Lieliefontein N&D 2019 for Enviropro
- Skeerpoort Farm Mast 2020 for HCAC
- Vulindlela Eco village 2020 for 1World
- KwaZamakhule Township 2020 for Kudzala
- Sunset Copper 2020 for Digby Wells
- McCarthy-Salene 2020 for Prescali
- VLNR Lodge 2020 for HCAC
- Madadeni mixed use 2020 for Enviropro

xi) Research Output

Publications by M K Bamford up to July 2021 in peer-reviewed journals or scholarly books: over 150 articles published; 5 submitted/in press; 8 book chapters.
Scopus h-index = 29; Google scholar h-index = 36;
Conferences: numerous presentations at local and international conferences.