PHASE 1
PALEONTOLOGICAL IMPACT ASSESSMENT REPORT
APPLICATION FOR ENVIRONMENTAL AUTHORISATION

THE PROPOSED UPGRADING OF OLIFANTSPOORT AND EBENEZER WATER SUPPLY SCHEMES, PHASE 1 WITHIN THE JURISDICTION OF CAPRICORN AND MOPANI DISTRICT MUNICIPALITIES, LIMPOPO PROVINCE.

TSIMBA

ARCHAEOLOGICAL FOOTPRINTS (PTY) LTD

DEVELOPED FOR:	ON BEHALF OF :
Emvelo Quality and Environmental Consultant (PTY) Ltd	Lepelle Northern Water (SOC)

JULY : 2022

Prof Marion Bamford
Palaeobotanist
P Bag 652, WITS 2050
Johannesburg, South Africa

Expertise of Specialist

The Palaeontologist Consultant: Prof Marion Bamford
Qualifications: PhD (Wits Univ, 1990); FRSSAf, mASSAf
Experience: 33 years research and lecturing in Palaeontology
25 years PIA studies and over 300 projects completed

Declaration of Independence

I, _____ Marion Bamford **_____, declare that –**

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

Specialist: Prof Marion Bamford

Signature: 

Executive Summary

A Palaeontological Impact Assessment was requested for the upgrading of Olifantspoort and Ebenezer Water Supply Schemes, Phase 1 within the Jurisdiction of Capricorn and Mopani District Municipalities, Limpopo Province, that includes, upgrading of piping, pump stations, abstraction and a holding dam.

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 Phase 1 Palaeontological Impact Assessment (PIA) was completed for the proposed development.

The sites lie mostly on ancient granites and gneisses that do not preserve any fossils. Only the Lebowakgomo Pump station is on potentially fossiliferous rocks of the Timeball Hill Formation (Pretoria Group, Transvaal Supergroup) that might reserve trace fossils such as stromatolites or microbialites. Therefore, a Fossil Chance Find Protocol should be added to the EMPr. Based on this information it is recommended that no further palaeontological impact assessment is required unless fossils are found by the contractor, environmental officer or other designated responsible person once excavations or drilling activities have commenced. Since the impact will be low, as far as the palaeontology is concerned, the project should be authorised.

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1. Background

Lepelle Northern Water (SOC) intend to undertake the upgrades and refurbishment between Olifantspoort and Ebenezer Schemes' water conveyance and storage infrastructure. The scheme supplies potable water to the Polokwane Municipal area, and surrounding communities. Emvelo Quality and Environmental Consultant has been appointed to undertake a Scoping and EIR Process.

The Lepelle Northen Water (LNW) is a water service board supplying three regions in Limpopo Province, namely: Capricorn, Mopani, and Sekhukhune Region. For this application, the upgrades will only affect the water schemes within Capricorn and Mopani Regions, namely: Olifantspoort and Ebenezer Water Supply Schemes (WSS). The proposed upgrades of Olifantspoort and Ebenezer WSS have been one of the LNW priority projects, to ensure the sustainable water supply. Therefore, in terms of the environmental legal requirement, LNW will require an Environmental Authorisation (EA) prior to undertaking the water infrastructure upgrades. Consequently, the Environmental Impact Assessment (Scoping and EIR) process has commenced. This report is for the Palaeontological impact of the project.

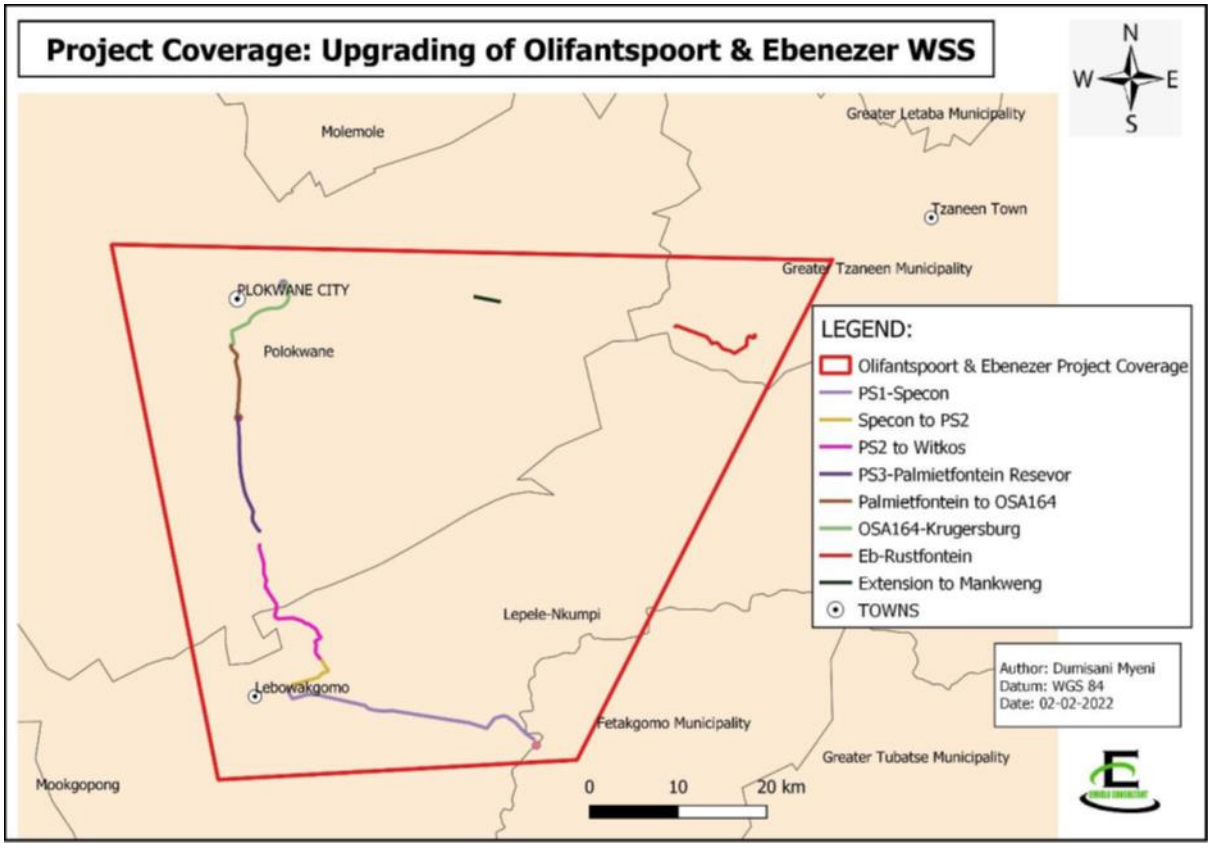


Figure 1. Coverage map for the Olifantspoort – Ebenezer Water Supply Scheme. Map taken from the BID document.

Project description (from the BID document)

The proposed upgrading of Olifantspoort Water Supply Scheme (WSS), Phase 1 from Olifantspoort WTW to Krugersburg Reservoirs, and Upgrading of Ebenezer Water Supply

Scheme, Phase 1 from Ebenezer Pumpstation to Rustfontein, and Mankweng reservoir off-take, will include the following components of the water conveyance and storage infrastructure. There are two main components to the project, the Olifantspoort WSS and the Ebenezer WSS:

Olifantspoort Water Supply Scheme:
The proposed upgrades Olifantspoort WSS water conveyance from Olifantspoort abstraction work to Krugersburg reservoirs is approximately 86km. The components of water conveyance and storage infrastructure are outlined below:

- The upgrading of Olifantspoort weir and raw water abstraction works;
- Construction of 200 000m^2 Olifantspoort off-channel storage dam with 5m embarkment height;
- Construction of 1600mmø raw water mains (350m from Olifantspoort abstraction to off- stream storage dam, and 450m from off-stream storage dam to Olifantspoort WTW);
- Refurbishment of the Olifantspoort WTW; Upgrading of the existing Olifantspoort WTW by constructing new 60 Mℓ/d module;
- Refurbishment of Pump Station (PS): PS1, PS2 and PS3; Upgrading of Specon Storage Reservoirs;
- Constructing a new pumpstations at PS1 (Olifantspoort WTW) and PS2 and PS3;
- Duplicate/dualisation of approximately 28.3km (800mmø) existing main by adding another (1500mmø) rising main from Olifantspoort WTW (PS1) to Specon;
- Duplicate/dualisation of approximately 23.6km (790mmø) existing main by adding another (1500mmø) main from Specon to PS2, and from PS2 Witkos Reservoir;
- Duplicate/dualisation of approximately ***14.6km*** (740mmø) existing main by adding another(1200mmø) main from Witkos Reservoir to PS3 and Palmietfontein Reservoir;
- Construction of new reservoirs at Witkos (30Mℓ) and Palmietfontein (50Mℓ);
- Construction of approximately ***8.5km*** (1200mmø) pumping main with pumping rate of (1900 ℓ/s) from Palmietfontein Reservoirs to OSA164;
- Construction of approximately ***11km*** (1200mmø) pumping main with pumping rate of (1900 ℓ/s) from OSA 164 to Krugersburg reservoirs.

Ebenezer Water Supply Scheme:
The proposed upgrades Olifantspoort WSS water conveyance for Ebenezer WSS is approximately ***13.5km***. The components of water conveyance comprise the following:

- The refurbishment of the Ebenezer WTW;
- Refurbishment and modifications to Ebenezer high-lift pump station;
- Construction of approximately11km (900mmø) new pumping main with a pumping rate of (1250ℓ/s), corresponding to 89 Mℓ /day from Ebenezer high-lift pump station to Rustfontein reservoirs complex;
- Extension of approximately 2.5km (600mmø) pumping main (Pipeline B) from Chamber GB73 to the Mankweng reservoir off-take.

Both of the proposed pipeline upgrades and refurbishment between Olifantspoort and Ebenezer Schemes' water conveyance and storage infrastructure merge to supply the

Polokwane Municipal Area. The total length of pipeline upgrade for these two schemes is approximately 99.5km.

Geographic locational context

The study area covers the region where the upgrades for water conveyance and storage infrastructure will take place, namely: Haenertsburg within Greater Tzaneen Local Municipality; Sekhukhune and Lebowakgomo within Lepelle-Nkumpi Local Municipality; Polokwane, Krugersburg and Mankweng within Polokwane Local Municipality, in Limpopo Province. Figures 1-2 provide the project location in relation to geographical context and project coverage. The project footprint covers the Polokwane Local Municipality, Lepelle-Nkumpi Local Municipality, and Greater Tzaneen Local Municipality, within Limpopo Province.

Site Context

The upgrades and refurbishment of Olifantspoort and Ebenezer Schemes' water conveyance and storage infrastructure will take place along Haenertsburg within Greater Tzaneen Municipality; Sekhukhune, Lebowakgomo and Mankweng within Lepelle-Nkumpi Municipality; Polokwane and surrounding communities along the water conveyance corridor within Polokwane Local Municipality, and will take place and be traversing the following localities: Dal Josaphat Farm, Mphahlele, Lebowakgomo Q, Lebowakgomo S, Syferkuil farm, Driefontein Farm, Bezuidenhout Lust farm, Patent farm, Majebas Kraal, Rustfontein Farm, Bochum Farm, Driekuil farm, Eindelik Farm, Hove Farm, Troutwaters AH, Haenertsburg Town and Townlands, Mankweng, Polokwane Game Reserve, and Krugersburg.

The locality maps in respect to the proposed upgrades of Olifantspoort and Ebenezer WSS water conveyance and storage infrastructure are presented below.

The Olifantspoort Off-Channel Storage and Olifants weir represented in figure 2 are situated within Koppieskraal, Portion 0. Farm No. 475, and Dal Josaphat Farm No. 461

The palaeontological report will be presented in three sections following the geographic maps supplied in the BID in the format outlined below, each comprising geographic map, geological map and SAHRIS palaeosensitivity map. The impact assessment for the whole project is in Section 4.

A: Olifantspoort Off-Channel Storage Dam and Olifantspoort Weir
Locality map – Figure 3; Geology map – Figure 4; SAHRIS map – Figure 5.
Table 2: Abbreviatiosn for symbols on geology maps (all).
B: Olifantspoort Supply Scheme Pumping Mains
Locality map – Figure 6; Geology map – Figure 7; SAHRIS map – Figure 8.
C: Ebenezer Supply Scheme Pumping Mains
Locality map – Figure 9; Geology map – Figure 10; Sahris map – Figure 11.

A Palaeontological Impact Assessment was requested for the Olifantspoort-Ebenezer WSS upgrade project. 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 Phase1 Palaeontological Impact Assessment (PIA) was completed for the proposed development and is reported herein.

Table 1: National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) and Environmental Impact Assessment (EIA) Regulations, 2014 (as amended) - Requirements for Specialist Reports (Appendix 6).

	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 2
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 6
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	Section 8, 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	Section 8, Appendix A
ni	A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6

	A specialist report prepared in terms of the Environmental Impact Regulations of 2017 must contain:	Relevant section in report
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	Sections 6, 8
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 of any comments that were received during any consultation process	N/A
q	Any other information requested by the competent authority.	N/A
2	Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	N/A

Figure 2: Google Earth map of the general area to show the relative land marks. The coverage of the Olifantspoort – Ebenezer WSS project is shown within the red polygon.

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 include 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.
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' retrospectivity 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

A: Olifantspoort Off-Channel Storage Dam and Olifantspoort Weir

The Olifantspoort Off-Channel Storage and Olifants weir represented in Figure 3 are situated within Koppieskraal, Portion 0. Farm No. 475, and Dal Josaphat Farm No. 461.

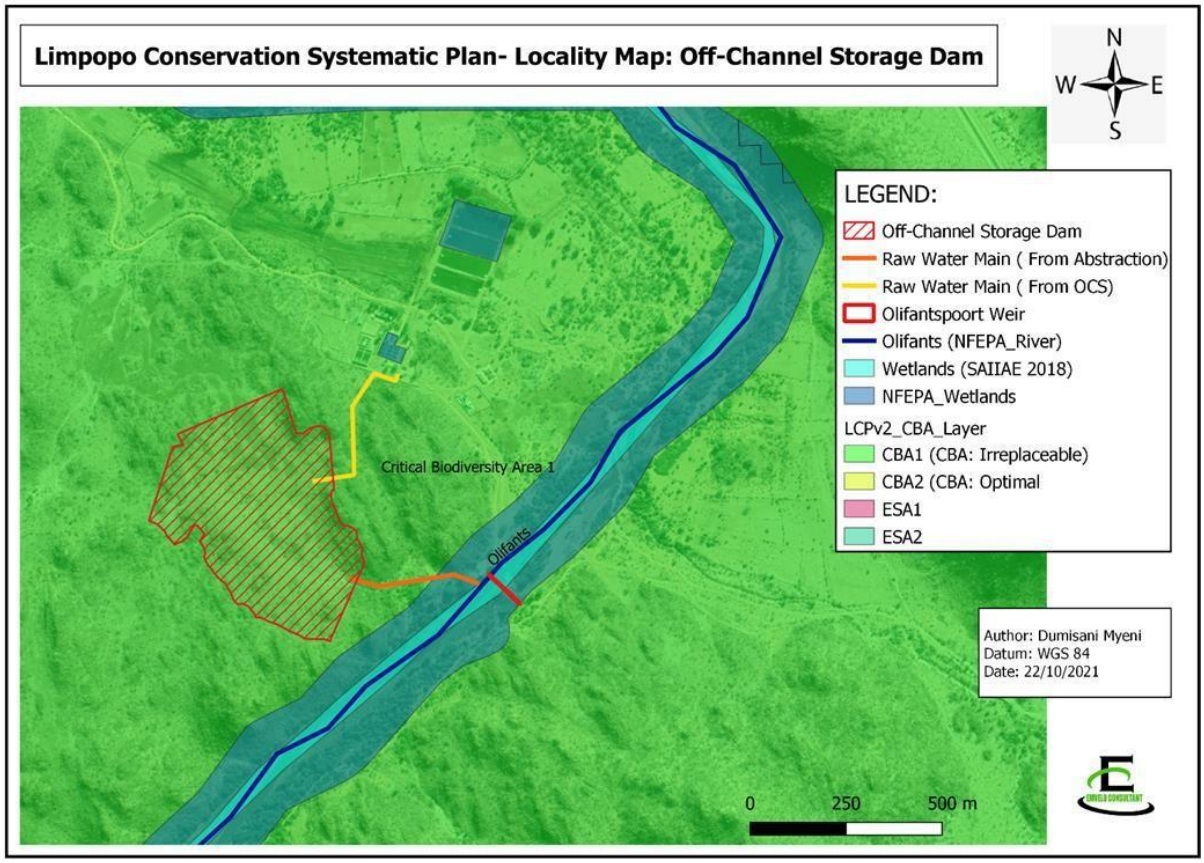


Figure 3: Olifantspoort Off-Channel Storage Dam and Olifantspoort Weir.

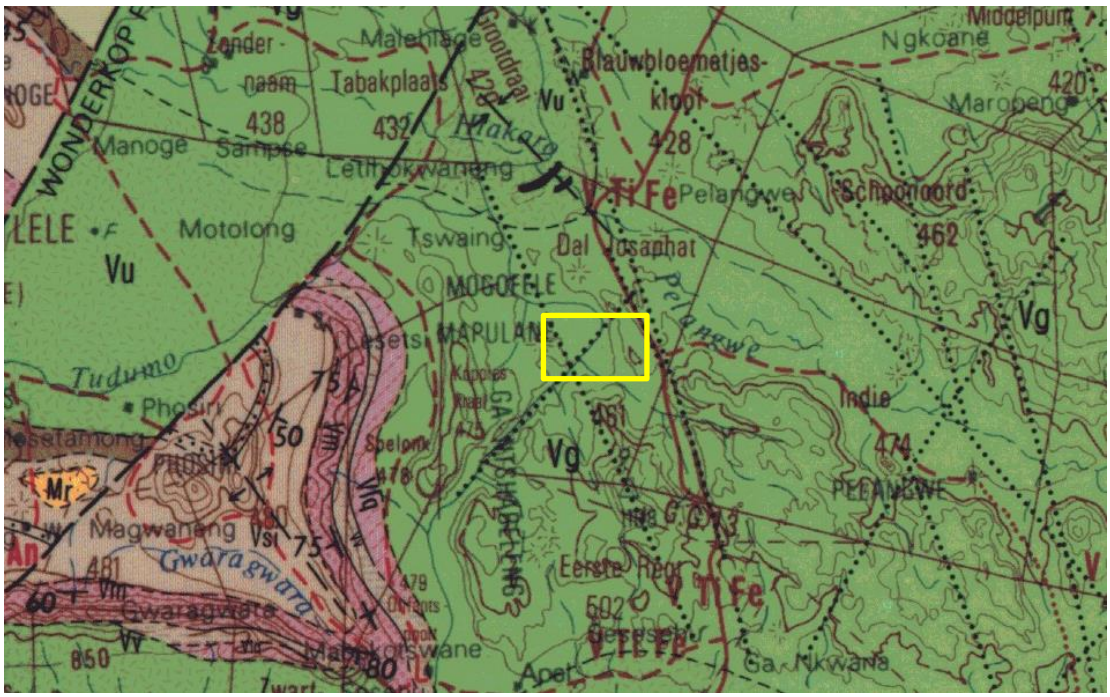


Figure 4: Geological map of the area around the Olifantspoort Off-Channel Storage Dam and Olifantspoort Weir. The location of the proposed project is indicated within the yellow rectangle. Abbreviations of the rock types are explained in Table 2. Map enlarged from the Geological Survey 1: 250 000 map 2428 Nylstroom.

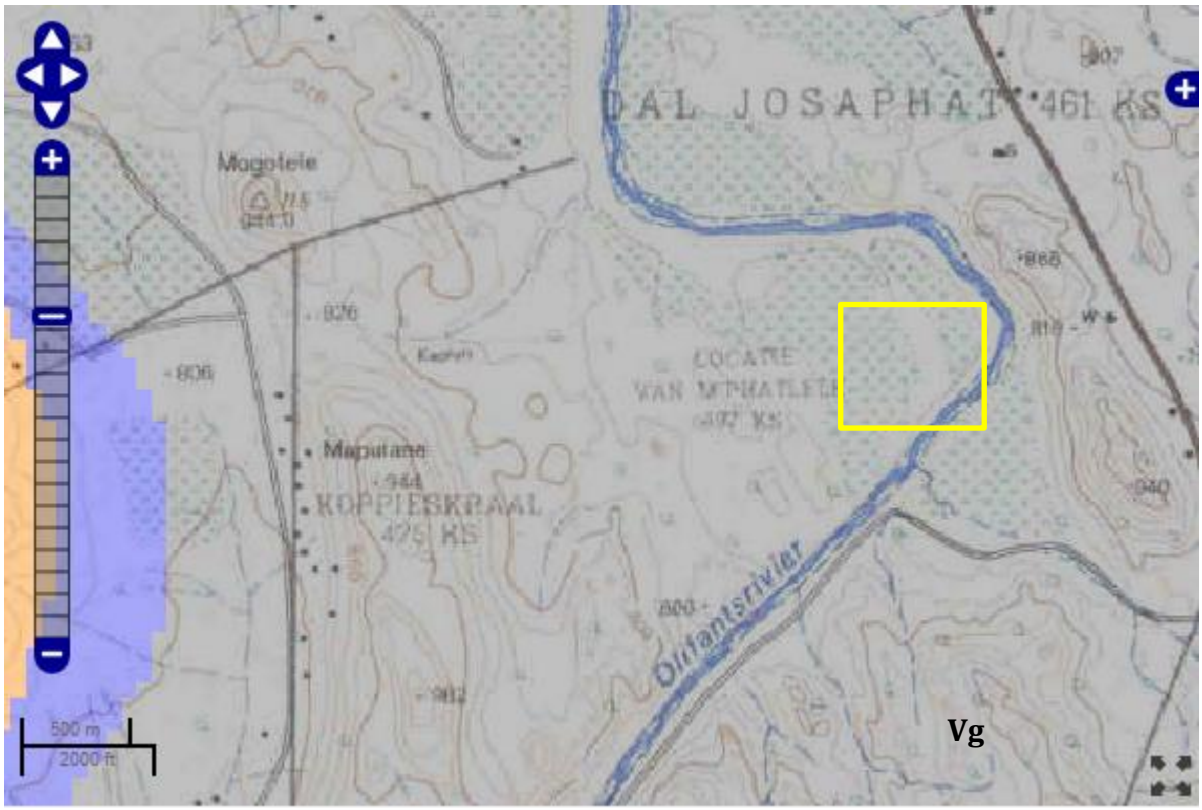


Figure 5: SAHRIS palaeosensitivity map for the Olifantspoort Off-Channel Storage Dam and Olifantspoort Weir shown within the yellow rectangle. Background colours indicate the following degrees of sensitivity: red = very highly sensitive; orange/yellow = high; green = moderate; blue = low; grey = insignificant/zero.

Table 2: Explanation of symbols for the geological maps and approximate ages (Eriksson et al., 2006. Johnson et al., 2006; Robb et al., 2006; Zeh et al., 2020). 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	Quaternary, ca 1.0 Ma to present
Tr-c	Clarens Fm, Stormberg Group, Karoo SG	Aeolian sands, sandstone	Late Triassic
Tr-e	Elliott Fm, Stormberg Group, Karoo SG	Shales. Sandstone, mudstone	Late Triassic
Vg	Gabbro Nortite, Rustenburg Layered Suite, Bushveld Igneous Complex intrusion	Gabbro, norite, pyroxenite, anorthosite, etc	Ca 2055 Ma
Vs	Selons River, Rooiberg Group, Transvaal SG	Volcanic rocks; quartzite xenoliths; sandstone and quartzite	Palaeoproterozoic
Vdi	Diabase	Intrusive volcanic dykes and sills	Post Transvaal SG
Vdr	Damwal Fm, Rooiberg Group, Transvaal SG	Volcanic rocks	Palaeoproterozoic

Symbol	Group/Formation	Lithology	Approximate Age
Vr	Rayton Fm, Pretoria Group, Transvaal SG	Quartzite, shale, subgreywacke	Palaeoproterozoic
Vdb	Dullstroom Fm, Pretoria Group, Transvaal SG	Volcanic rocks; pyroxene, hornfels	<2089 Ma
Vh	Houtenbek Fm, Pretoria Group, Transvaal SG	Quartzite, hornfels, limestone, chert	<2072 Ma
Vsq	Steenkampsberg Fm, Pretoria Group, Transvaal SG	Quartzite, subordinate shale	<2124 Ma
Vlq	Lakenvalei Fm, Pretoria Group, Transvaal SG	Quartzite, feldspathic quartzite, arkose	<2212 Ma
Vv	Vermont Fm, Pretoria Group, Transvaal SG	Hornfels, minor quartzite, limestone, chert	<2112 Ma
Vm	Magaliesberg Fm, Pretoria Group, Transvaal SG	Quartzite, minor hornfels	<2080 Ma
Vsi	Silverton Fm, Pretoria Group, Transvaal SG	Shale, carbonaceous in places, hornfels, chert	Ca 2202 Ma
Vdq	Daspoort Fm, Pretoria Group, Transvaal SG	Quartzite	<2240 Ma
Vst	Strubenkop Fm, Pretoria Group, Transvaal SG	Shale, in places ferruginous	Ca 2242 Ma
Vdw	Dwaalheuvel Fm, Pretoria Group, Transvaal SG	Quartzite, chert, jaspilite	<2242 Ma
Vha	Hekpoort Fm, Pretoria Group, Transvaal SG	Volcanic rocks	Ca 2224 Ma
Vb	Boshoek Fm, Pretoria Group, Transvaal SG	Quartzite	Ca 2266 Ma
Vt	Timeball Hill Fm Pretoria Group, Transvaal SG	Shale, siltstone, conglomerate in places; dotted = Quartzite	Ca 2316 – 2266 Ma
Vmd	Malmani SG, Chuniespoort Group, Transvaal SG	Dolomite, chert	Ca 2585 – 2480 Ma
Vbr	Black Reef Fm, Transvaal SG	Quartzite, conglomerate, shale	<2618 Ma
Vw	Wolkberg Group	Shale, mudstone, quartzite, volcanic rocks	>2168 Ma
Rt	Turfloop Granite	Granite	>2650 Ma
Rhr	Hout River Gneiss	Migmatite, gneiss, pegmatite	Ca 3282 Ma
Zpm	Mothuba Fm, Pietersburg Greenstone Belt, Murchison Sequence	Schist, amphibolite, serpentinite	Archaean >3100 Ma
Zg	Goudplaats Gneiss	Biotite hornblende gneiss	>3400 Ma

The whole project lies in the eastern part of the Kaapvaal Craton where the strata of the Transvaal Supergroup in the Transvaal Basin overlie the older basement rocks, in particular the Wolkberg Group and the even older intrusive granites and gneisses. The narrow Pietersburg Greenstone Belt is also present. Much younger rocks of the upper Karoo Supergroup, the Stormberg Group, unconformably overlie the old rocks. Very young sands and alluvium have been deposited in the river valleys.

The Olifantspoort Off-Channel Storage Dam and Olifantspoort Weir lie on the non-fossiliferous metamorphosed rocks of the Rustenburg Layered Suite, namely the gabbro and norite (Figure 4). This is indicated as grey in the SAHRIS palaeosensitivity map (Figure 5).

B: Olifantspoort Supply Scheme Pumping Mains

Approximately 86km of upgrades for Olifantspoort WSS' water conveyance and storage infrastructure from Olifants River (abstraction) to Krugersburg reservoirs (Figure 6), traverse the following localities: Koppieskraal, Voorspoed, Locatie Van M`Phatlele, Lebowakgomo-S, Lebowakgomo-Q, Uitloop, Schoonheid, Tsjuenispoort Oost, Staanplaats, Langkrans, Morgenzon, Block A, Tsjuenispoort West, Polokwane Metallurgical Complex, Beestekraal, Rietkolk, Palmietfontein, Du Preez Rust, Beestekraal, Weltevreden, Wildebeestkuil, Polokwane Town, Polokwane Game Reserve, Sterkloop, and Krugersburg (Figure 6).

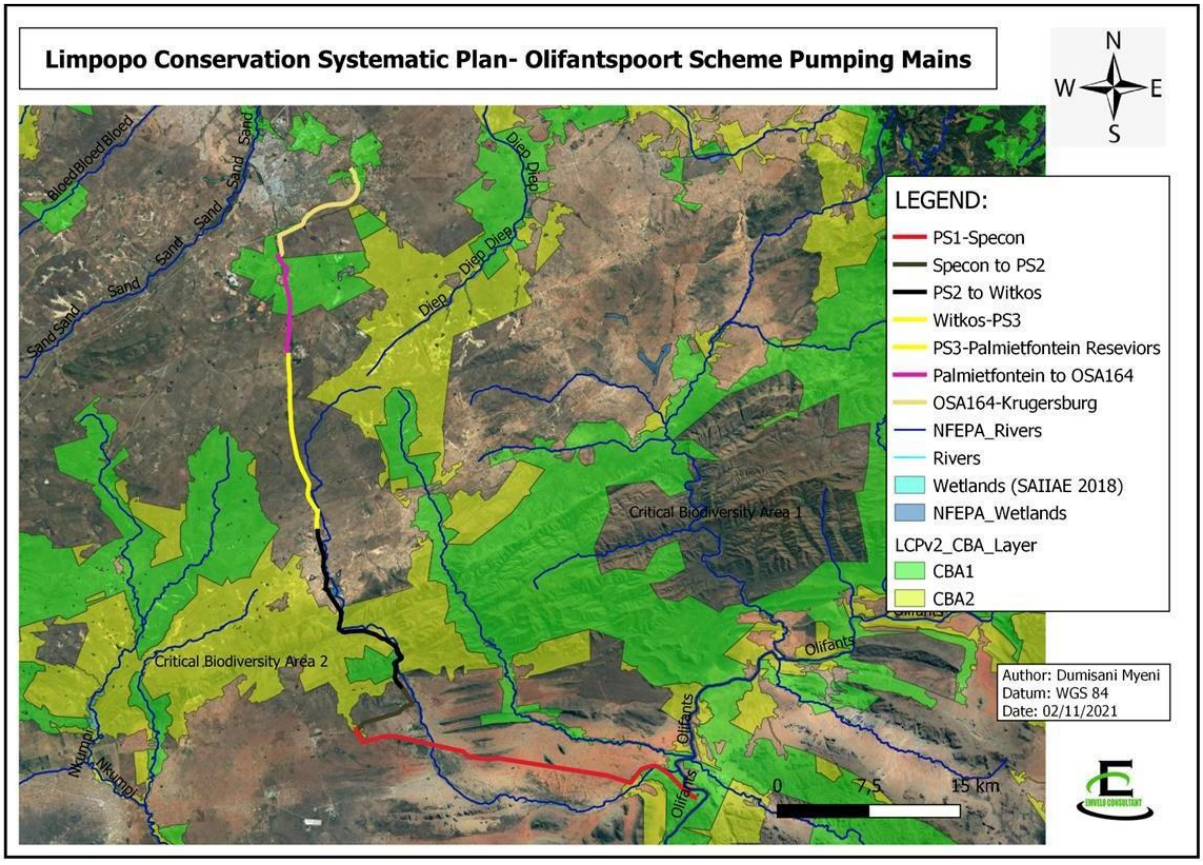


Figure 6: Map Showing Locality of Olifantspoort Supply Scheme Pumping Mains

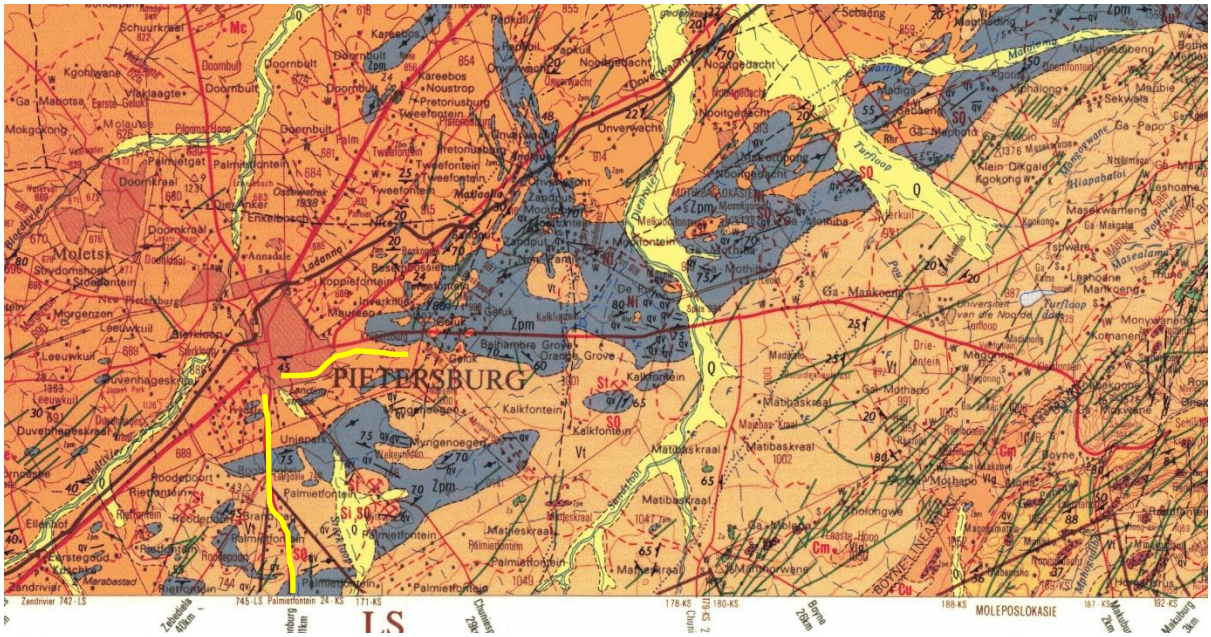


Figure 7: Geological map round Pietersburg (Polokwane) with the Krugersberg reservoir to the east and the main pipeline from the south to the city. See Table 2 for abbreviations. Geological Survey 1:250 000 map 2328 Pietersburg.

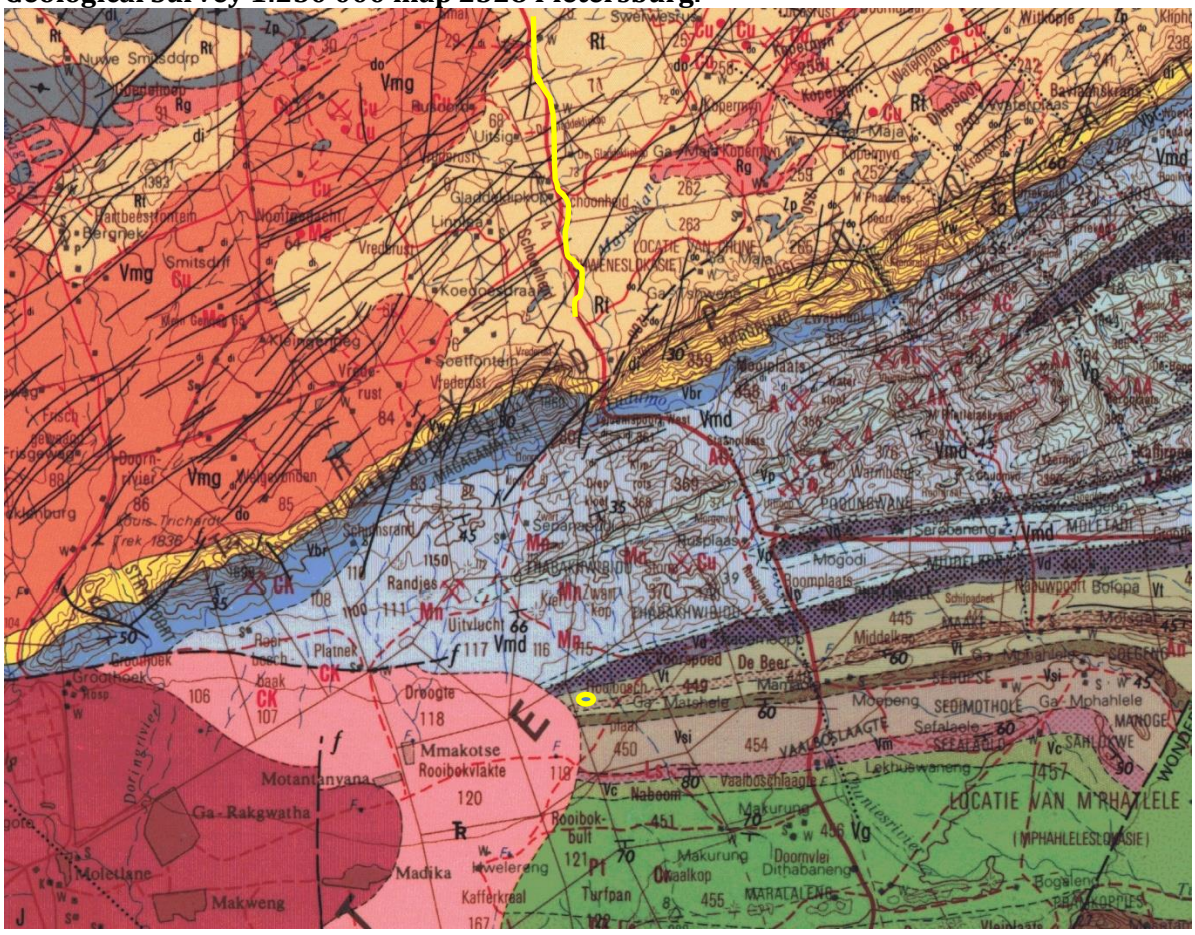


Figure 8: Geological map south of Pietersburg to Lebowakgomo with the Olifantspoort Supply Scheme Pumping Mains as shown in yellow. Geological Survey map 1:250 000 2428 Nylstroom. Symbols as in Table 2.

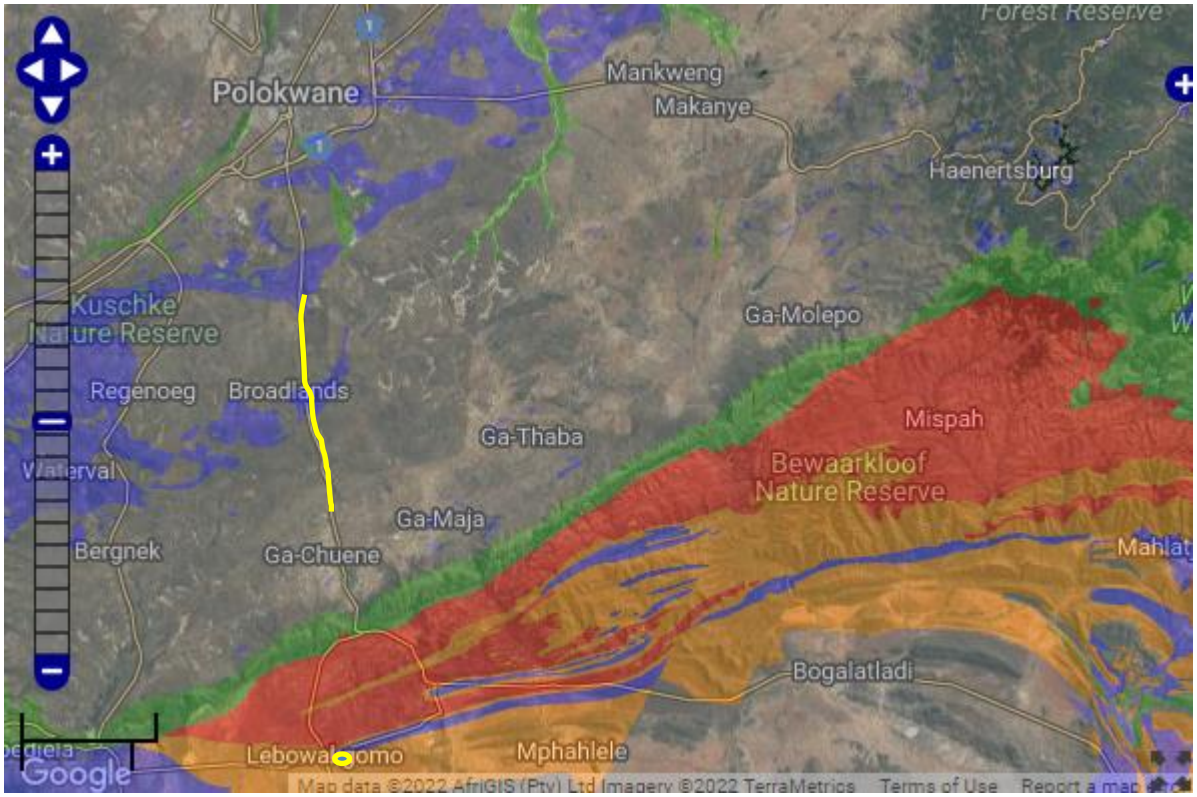


Figure 9: SAHRIS palaeosensitivity map for the Polokwane to Lebowakgomo pumping mains (Witkos) and in Lebowakgomo (yellow). Colour coding as in Figure 5.

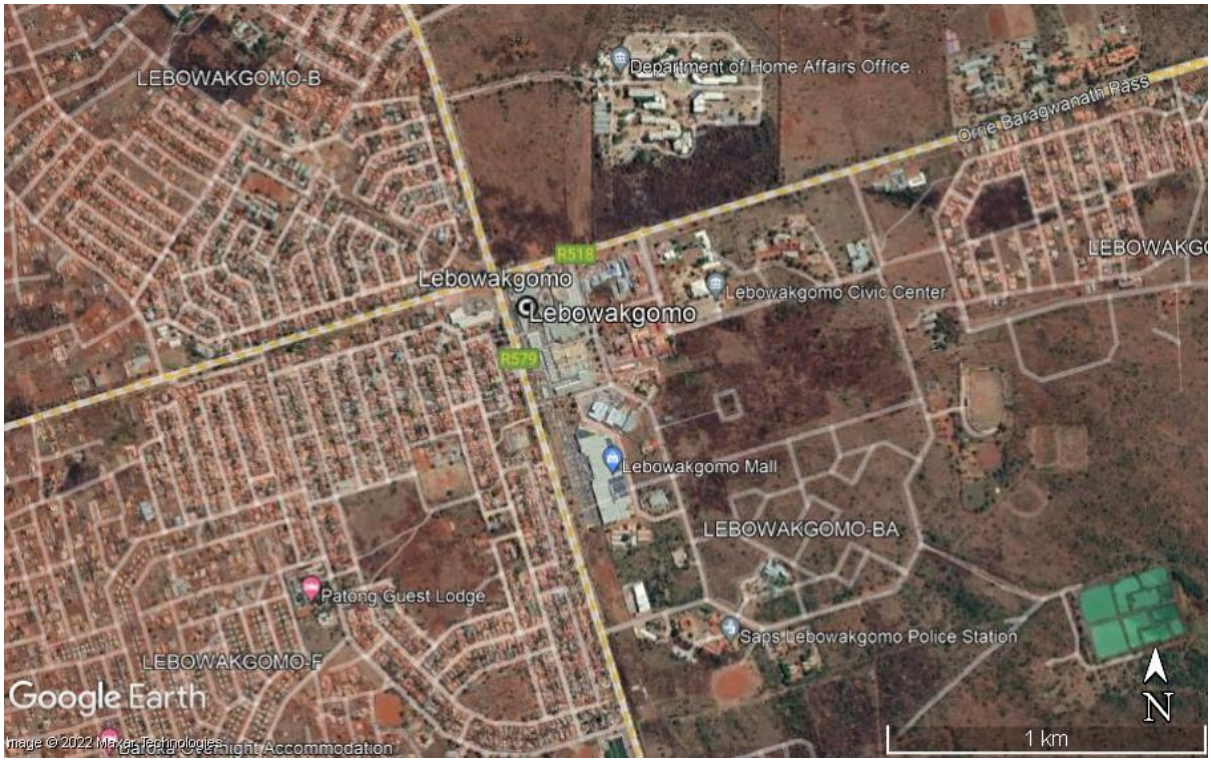


Figure 10: Google Earth Map of the Lebowakgomo Pump station.

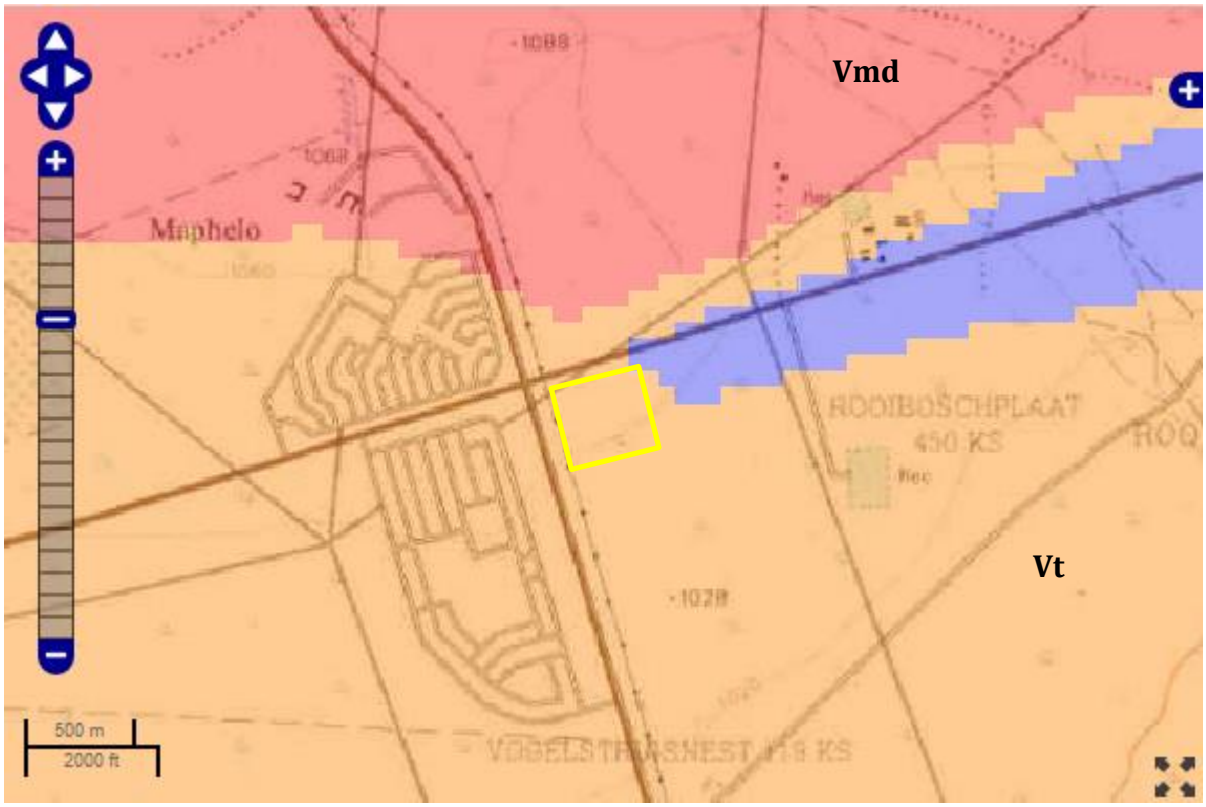


Figure 11: SAHRIS palaeosensitivity map for the Lebowakgamo pump station (yellow rectangle. Colour coding as in Figure 5.

The route from Polokwane southwards, including the Witkos pump and rising main is entirely on ancient non-fossiliferous rocks of the Turfloop Granite, and the Lebowakgomo pump station is on highly sensitive rocks of the Timeball Hill Formation (Pretoria Group, Transvaal Supergroup) that might have trace fossils such as microbial traces (microbialites or microbially induced sedimentary structures).

C: Ebenezer Supply Scheme Pumping Mains

Approximately 13.5km of upgrades for Ebenezer WSS' water conveyance from Ebenezer high lift pumpstation to Rustfontein reservoir complex, and extension from chamber GB73 to the Mankweng reservoir off-take (figure 4), traverse the following localities: Misty Crown, Driekuil, Hove, Bali-Will-Will, Rustfontein, Bochum, Eindelik, Rooiwal, Weighton, Stylbult, Haenertsburg Town and Townlands, Westwood, Allandale, Danallan, Nooitgedacht, Troutwaters AH, Driefontein, Syferkuil, and Bezuidenhout Lust.

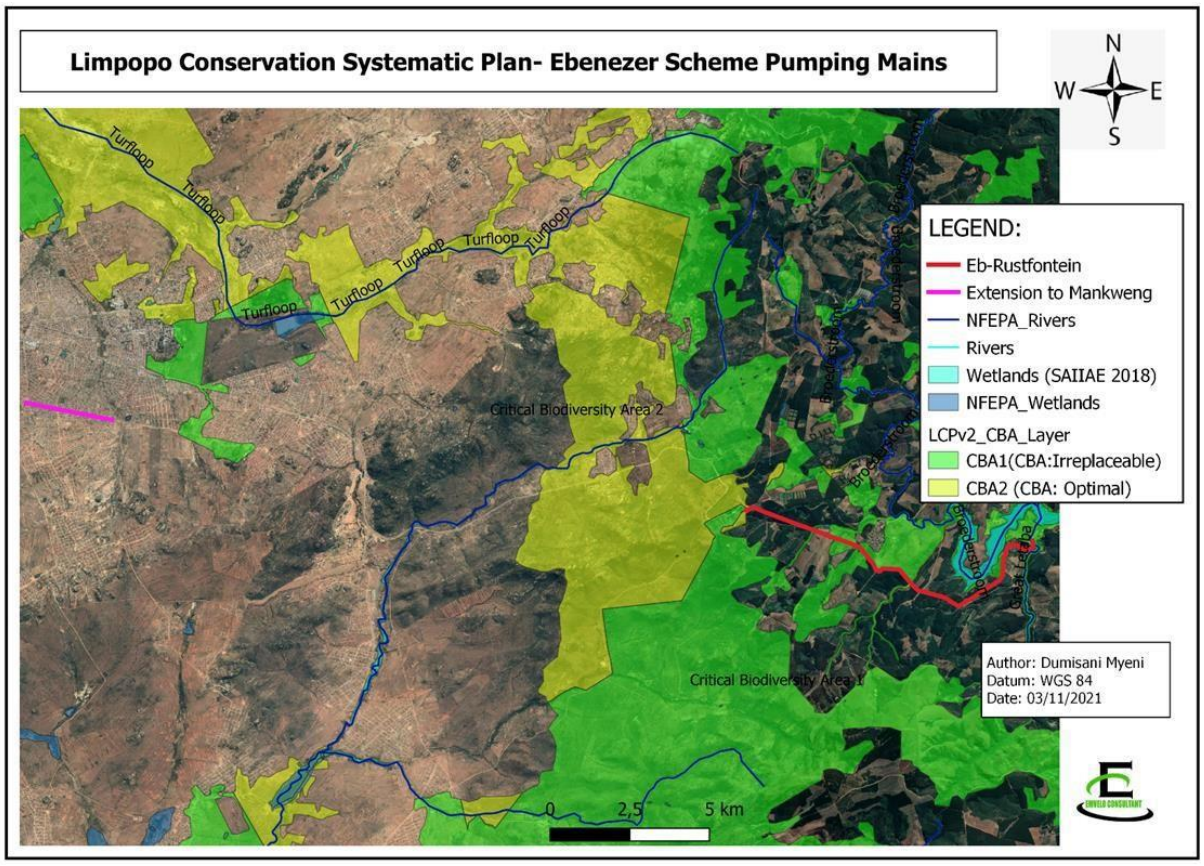


Figure 12: Map Showing Locality of Ebenezer Supply Scheme Pumping Mains.

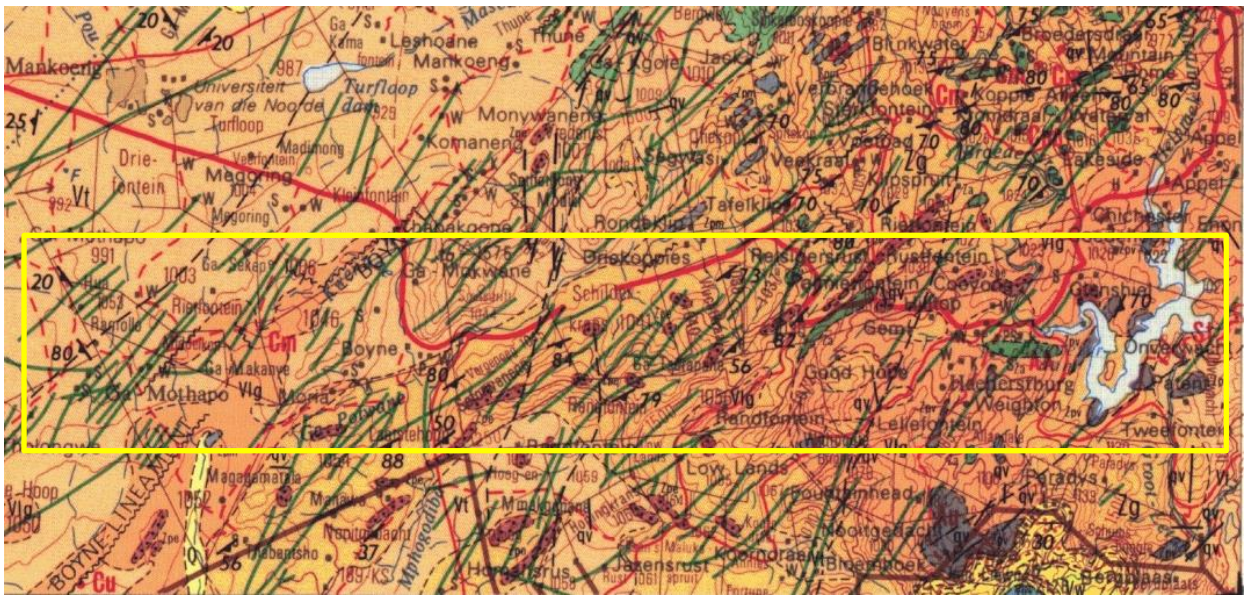


Figure 13: Geological map of the of Ebenezer Supply Scheme Pumping Mains route within the yellow rectangle. Geological Survey Map 1:250 000 2328 Pietersburg.

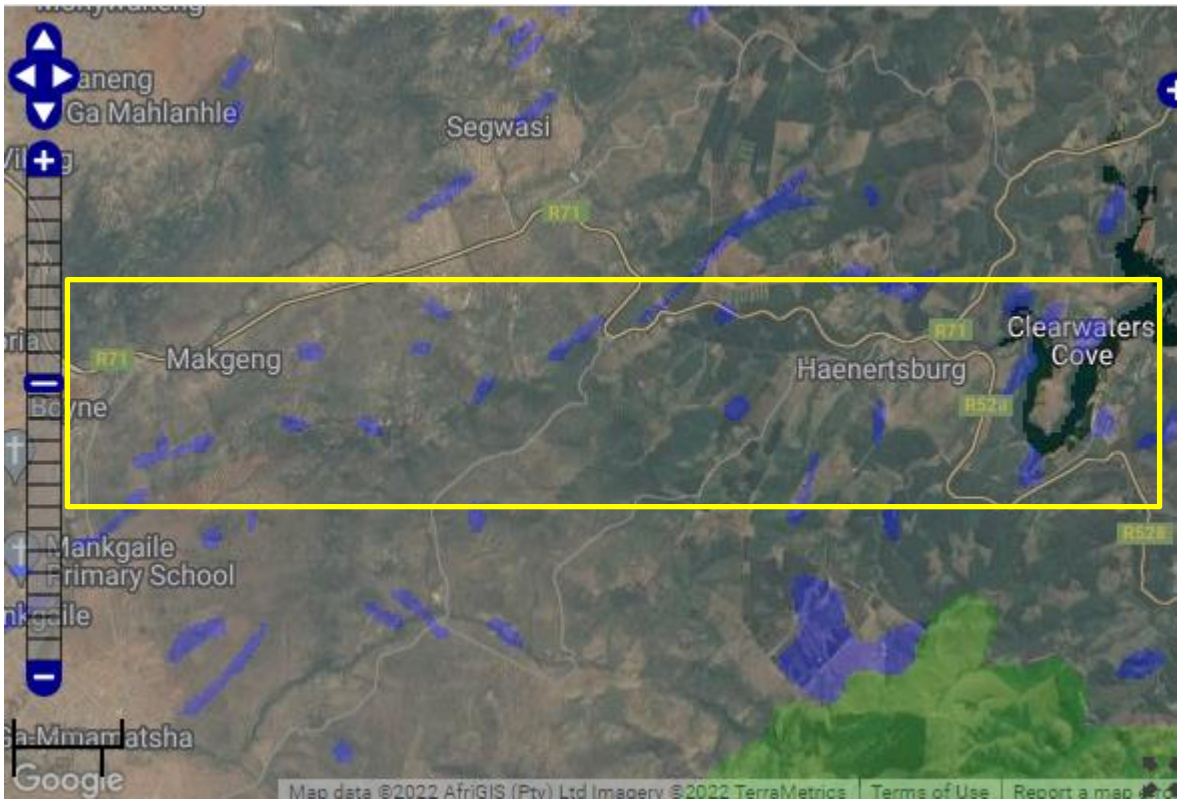


Figure 14: SAHRIS Palaeosensitivity map for the Ebenezer Supply Scheme Pumping Mains route within the yellow rectangle. Colour coding as for Figure 5.

The Ebenezer Supply Scheme Pumping Mains route is on non-fossiliferous rocks of the Goudplaats Gneiss. These are the oldest granites on the continent and since granites are of igneous origin they do not preserve any fossils within the yellow rectangle.

GENERAL GEOLOGY – whole area

The Late Archaean to early Proterozoic Transvaal Supergroup is preserved in three structural basins on the Kaapvaal Craton (Eriksson et al., 2006). In South Africa are the Transvaal and Griqualand West Basins, and the Kanye Basin is in southern Botswana. The Griqualand West Basin is divided into the Ghaap Plateau sub-basin and the Prieska sub-basin. Sediments in the lower parts of the basins are very similar but they differ somewhat higher up the sequences. Several tectonic events have greatly deformed the south western portion of the Griqualand West Basin between the two sub-basins

The Transvaal Supergroup comprises one of world's earliest carbonate platform successions (Beukes, 1987; Eriksson et al., 2006; Zeh et al., 2020). In some areas there are well preserved stromatolites that are evidence of the photosynthetic activity of blue green bacteria and green algae. These microbes formed colonies in warm, shallow seas.

In the Transvaal Basin the Transvaal Supergroup is divided into two Groups, the lower Chuniespoort Group and the upper Pretoria Group (with ten formations; Eriksson et al., 2006). The Chuniespoort Group is divided into the basal **Malmani Subgroup** that

comprises dolomites and limestones and is divided into five formations based on chert content, stromatolitic morphology, intercalated shales and erosion surfaces.

Making up the lower Pretoria Group are the **Timeball Hill** Formation and the Boshoek Formation. The Hekpoort, Dwaalheuwel, Strubenkop and Daspoort Formations form a sequence as the middle part of the Pretoria Group, Transvaal Supergroup, and represent rocks that are over 2060 million years old. The Hekpoort Formation is a massive lava deposit and is overlain by the Dwaalheuwel conglomerates, siltstone and sandstone (not present here). A hiatus separates the Strubenkop Formation slates and shales from the overlying quartzites of the Daspoort Formation. Upper Pretoria Group formations are the Silverton, Magaliesberg, Vermont, Lakenvalei, Nederhorst, Steenkampsberg and Houtenbek Formations

The Transvaal sequence has been interpreted as three major cycles of basin infill and tectonic activity with the first deep basin sediments forming the Chuniespoort Group, the second cycle deposited the lower Pretoria Group, and the sediments in this area are from the interim lowstand that preceded the third cycle. These sediments were deposited in shallow lacustrine, alluvial fan and braided stream environments (Eriksson et al., 2012).

i. Palaeontological context

The palaeontological sensitivity of the area under consideration is presented in separate figures of each of the three project areas. In summary, the volcanic rocks (granites, gneiss, gabbro, norite) do not preserve any fossils. Dolomites in the Malmani Subgroup might preserve stromatolites but this formation is not in the project sites. The Timeball Hill Formation might have microbial traces in the quartzites and shales because such trace fossils have been found in the younger Magaliesberg Formation (Bosch and Eriksson, 2006; Groenewald et al., 2014 PTR)

Bosch and Eriksson (2008) described crack-like features, vermiform structures and circular imprints resembling concretions or, possibly oncolites, that occur on sand sheet surfaces within the uppermost beds of the **Magaliesberg Formation**. They indicated two localities, one north of Pretoria, on the farm Baviaanspoort 330 JR and the other on the farm Rietvlei 518 JR, east of Pretoria. Leeuwpoort is northeast of Pretoria. The presence of such microbial mat-like features are found in epeiric marine tidally dominated coastline. The rhythmic alternation of water levels inherent in such settings can explain desiccation of microbial mats growing on the sandy substrates formed within the palaeoenvironment. In addition, the shifting loci of deposition were probably also related to braided fluvial inputs, through the medium of braid deltas (Bosch and Eriksson, 2008).

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.

Microbialites (sensu Burne and Moore, 1987) are organo-sedimentary deposits formed from interaction between benthic microbial communities (BMCs) and detrital or chemical sediments. In addition, microbialites contrast with other biological sediments in that they are generally not composed of skeletal remains. Archean carbonates mostly consist of stromatolites. These platforms could have been the site of early O2 production on our planet. Stromatolites are the laminated, organo-sedimentary, non-skeletal products of microbial communities, which may have included cyanobacteria, the first photosynthetic organisms to produce oxygen. Another type of trace fossil has been termed Microbially-induced sedimentary structures (MISS sensu Noffke et al., 2001) or simply 'fossil mats' (sensu Tice et al., 2011). These include swirls, rip-ups, crinkled surfaces and wrinkles that were formed by the mucus extruded by littoral algae or microbes and bound together sand particles. Davies et al. (2016) caution against the assumption that all such structures are microbially induced unless there is additional evidence for microbes in the palaeoenvironment.

Nonetheless, stromatolites and microbialites are accepted as trace fossils of algal colonies. MISS could be microbially or abiotically formed. The oldest stromatolites have been recorded from the Barberton Supergroup that was deposited between 3.55 to ca. 3.20 Ga, and stromatolites still form today in warm, shallow seas (Homan, 2019).

4. Impact assessment

An assessment of the potential impacts to possible palaeontological resources considers the criteria encapsulated in Table 3:

Table 3a: 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 3b: Impact Assessment

PART B: Assessment		
SEVERITY/NATURE	**H**	-
	M	-
	L	Volcanic rocks do not preserve fossils; so far there are no records from the Timeball Hill Fm of trace fossils (stromatolites, microbial traces) so it is very unlikely that fossils occur on the site. The impact would be negligible
	L+	-
	M+	-

PART B: Assessment		
	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 in the Timeball Hill Fm shales or quartzites, the spatial scale will be localised within the site boundary.
	M	-
	H	-
PROBABILITY	**H**	**-**
	M	**-**
	L	It is extremely unlikely that any fossils would be found in the loose soils and sands that cover the area or in the Timeball Hill shales or quartzites that will be excavated, Nonetheless, a Fossil Chance Find Protocol should be added to the eventual EMPr.

5. Discussion of findings

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 either much too old to contain fossils or the wrong type. No fossils were seen during the field survey although there are good exposures of the rocks. Since there is an extremely small chance that fossil bones or plant impressions may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely low. Furthermore, the material to be excavated is soil and this does not preserve fossils. Since there is an extremely small chance that fossils from the nearby Vryheid Formation may be disturbed a Fossil Chance Find Protocol has been added to this report. Taking account of the defined criteria, the potential impact to fossil heritage resources is extremely low.

Figure 1: Photograph of rocks and sediments from the Olifants River but no fossils preserved.

Figure 2:Witkos Reservoir : Some mudstones observed on the road reserve.

Figure 3:Red sands and with pebbles weathering out were observed in the road. No fossils.

Figure 4:View of an ant hill representing the various ant hills noted in the project area.

Figure 5: Scree slope but no fossils.

Figure 6:Biomantling and bioturbation, depositing excavated soil on the surface by ants

6. 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, sandstones, shales and sands are typical for the country and only some contain trace fossils (stromatolites and microbial traces). The sands of the Quaternary period would not preserve fossils.

7. 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 soils or ancient igneous rocks. Most of the project lies on non-fossiliferous rocks. Only the Lebowakagomo Pump station is on highly sensitive rocks of the Timeball Hill Formation but no fossils were found. There is a very small chance that trace fossils such as stromatolites or microbial structures may occur in the shales or quartzites of the Palaeoarchaean Timeball Hill Formation (Pretoria Group, Transvaal Supergroup) so a Fossil Chance Find Protocol should be added to the EMPr. If trace fossils are found by the contractor, environmental officer, or other responsible person once excavations for the Lebowakgomo Pump Station have commenced then they should be rescued and a palaeontologist called to assess and collect a representative sample. The impact on the palaeontological heritage would be low, therefore as far as the palaeontology is concerned, the project should be authorised.

8. References

Bosch, P., Eriksson, P., 2008. A note on two occurrences of inferred microbial mat features preserved in the c. 2.1 Ga Magaliesberg Formation (Pretoria Group, Transvaal Supergroup) sandstones, near Pretoria, South Africa. South African Journal of Geology 111, 251-262.

Burne, R.V., Moore, L.S., 1987. Microbialites; organosedimentary deposits of benthic microbial communities. Palaios 2(3), 241-254.

Davies, N.S., Liu, A.G., Gibling, M.R., Miller, R.F., 2016. Resolving MISS conceptions and misconceptions: A geological approach to sedimentary surface textures generated by microbial and abiotic processes Earth-Science Reviews 154, 210–246.

Eriksson, P.G., Altermann, W., Hartzer, F.J., 2006. The Transvaal Supergroup and its precursors. 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.

Eriksson, P.G., Bartman, R., Catuneanu, O., Mazumder, R., Lenhardt, N., 2012. A case study of microbial mats-related features in coastal epeiric sandstones from the Palaeoproterozoic Pretoria Group, Transvaal Supergroup, Kaapvaal craton, South Africa; the effect of preservation (reflecting sequence stratigraphic models) on the relationship between mat features and inferred palaeoenvironment. Sedimentary Geology 263, 67-75.

Homann. M., 2019. Earliest life on Earth: Evidence from the Barberton Greenstone Belt, South Africa. Earth Science Reviews 196, 102888.

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.

Noffke, N., Gerdes, G., Klenke, T. and Krumbein, W.E. (2001). Microbially induced sedimentary structures – a new category within the classification of primary sedimentary structures. Journal of Sedimentary Research, A71, 649-656.

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.

Robb, L.J., Brandl, G., Anhaeusser, C.R., Poujol, M., 2006. Archaean Granitoid Intrusions. 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 57-94.

Truswell, J.F., Eriksson, K.A., 1973. Stromatolitic associations and their palaeo-environmental significance: a reappraisal of a lower Proterozoic locality from the northern Cape Province, South Africa. Sedimentary Geology 10, 1–23.

Zeh, A., Wilson, A.H., Gerdes, A., 2020. Zircon U-Pb-Hf isotope systematics of Transvaal Supergroup – Constraints for the geodynamic evolution of the Kaapvaal Craton and its hinterland between 2.65 and 2.06 Ga. Precambrian Research 345, 105760. https://doi.org/10.1016/j.precamres.2020.105760

9. Chance Find Protocol

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

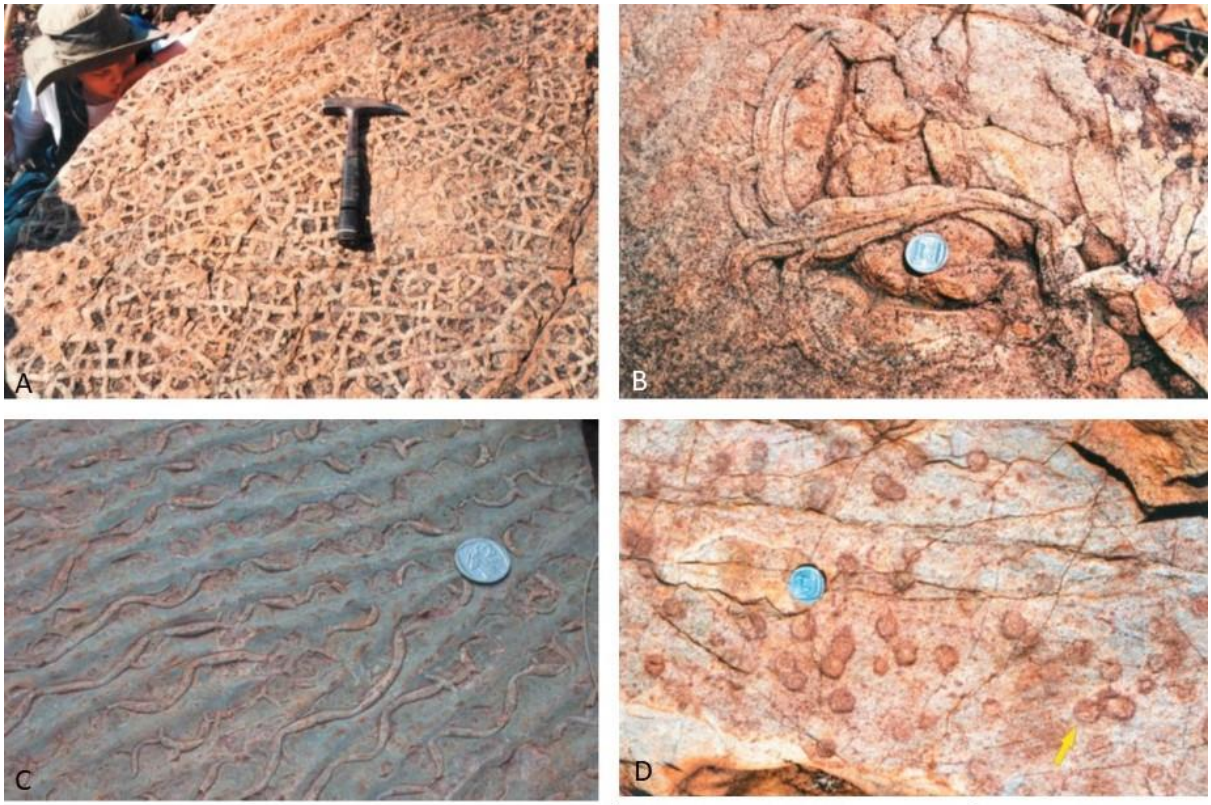
1. The following procedure is only required if fossils are seen on the surface and when drilling/excavations commence.
2. When excavations begin the rocks and must be given a cursory inspection by the environmental officer or designated person. Any fossiliferous material (trace fossils, tracks, stromatolites, microbialites, circles, etc) 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 trace fossils such as stromatolites or microbially features (trails, curls, rip-ups, mudcracks) trace fossils in the dolomites, limestones, shales and mudstones (for example see Figure 15-16). 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 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 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.

10. Appendix A – Examples of fossils from the Transvaal Supergroup

Figure 15: Photographs from the Malmani Subgroup of different types of stromatolites in dolomite.



Magaliesberg Fm trace fossils, near Pretoria (all from Bosch & Eriksson, 2008): A – cracks,. B – sinuous structure, C – *Manchuriphycus*, D – circular structures. R1 coin for scale.

Figure 16: Photographs of microbial features from the Magaliesberg Formation (in Bosch and Eriksson, 2008)

11. Appendix B – Details of specialist

Curriculum vitae (short) - Marion Bamford PhD June 2022

I) Personal details

Surname : **Bamford**
First names : **Marion Kathleen**

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.
NRF Rating: C-2 (1999-2004); B-3 (2005-2015); B-2 (2016-2020); B-1 (2021-2026)

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	13	0
Masters	12	2
PhD	13	4

Postdoctoral fellows	15	2

viii) Undergraduate teaching
Geology II – Palaeobotany GEOL2008 – average 65 students per year
Biology III – Palaeobotany APES3029 – average 45 students per year
Honours – Evolution of Terrestrial Ecosystems; African Plio-Pleistocene Palaeoecology; Micropalaeontology – average 12-20 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 –
Associate Editor Open Science UK: 2021 -
Review of manuscripts for ISI-listed journals: 30 local and international journals
Reviewing of funding applications for NRF, PAST, NWO, SIDA, National Geographic, Leakey Foundation

x) Palaeontological Impact Assessments

Selected from the past five years only – list not complete:

- 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
- Frankfort-Windfield Eskom Powerline 2020 for 1World
- Beaufort West PV Facility 2021 for ACO Associates
- Copper Sunset MR 2021 for Digby Wells
- Sannaspos PV facility 2021 for CTS Heritage
- Smithfield-Rouxville-Zastron PL 2021 for TheroServe

- Wolf-Skilpad-Grassridge Eskom line for Zutari
- Iziduli and Msengi WEFs, Eastern Cape for CTS Heritage
- Dealesville Springhaas SEFs for ASHA

xi) Research Output

Publications by M K Bamford up to June 2022 peer-reviewed journals or scholarly books: over 165 articles published; 5 submitted/in press; 12 book chapters.
Scopus h-index = 30; Google scholar h-index = 35; -i10-index = 92
Conferences: numerous presentations at local and international conferences.