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Memorandum

To	**Natanya Whitehorn, Deon Esterhuizen**	**From**	**Danica Mong, Steven Seymour**
Copy	**Gary Davis**	**Reference**	**1002570-0000-REP-GG-0001-Rev0**
Date	**2023-09-27**	**Pages (including this page)**	**12**
Subject	**Olifants Management Model Programme Bulk Raw Water Study Phase (OMMP-BRWSP): Geotechnical Desktop Study for Environmental Authorisation of the Proposed Mokopane Water Treatment Works**		

This memorandum provides a geotechnical desktop study for the proposed Mokopane Water Treatment works in the Limpopo Province. The intention of this geotechnical desktop study is to provide a site sensitivity verification assessment of the site as it pertains to the environmental authorisation process. The desktop study therefore focusses on the geotechnical aspects of the sites from an environmental perspective. The assessment was limited to a desktop study only and no site walk-over was conducted.

1 Available Information

The information available for the geotechnical desktop study included:

- An environmental screening report of the proposed Mokopane water treatment works "Screening report for an environmental authorisation as required by the 2014 EIA Regulations – proposed site environmental sensitivity", by Zinzi Portia Xakayi, dated 10/07/2023.
- Locality KMZ files, showing:
  - The position of the proposed preferred water treatment works site.
  - The position of the proposed alternative water treatment works site and its access road.
- Satellite imagery (QGIS Development Team, 2023)
- Published maps, including:
  - 1:250 000 geology map (Sheet 2428 Nylstroom, Council for Geoscience, 1978)
  - 1:50 000 geology map (Sheet 2429AA Mokopane, Council for Geoscience, 2010)
  - Weinert climatic N-value map from "The natural road construction materials of southern Africa", Weinert H. H. (1980)
  - Seismicity map from "Basis of structural design and actions for buildings and industrial structures, Part 4: Seismic actions and general requirements for buildings (SANS 10160-4:2011 Edition 1.1)", SABS (2011)
  - Council for Geoscience (2023) online maps.
- Report of a previous geotechnical investigation conducted at the current alternative site: "WSM Leshika Consulting (2016) Phase 1 Shallow Soil Engineering Geological Investigation for the proposed Mokopane Water Treatment Works No. 1 and Road Section, Mogalakwena Local Municipality, Limpopo Province, South Africa. Report revision V1.0, dated 25 August 2016".

- The report covered the proposed Mokopane Water Treatment Works site as of 2016, which is located at the position of the current alternative site.
- Scope included a geotechnical desktop study, 37 no. test pits, and laboratory testing.
- Photographs of the site walkover conducted in June and August 2016.

2 Site Location

The proposed Mokopane water treatment works site is situated in the Limpopo Province, South Africa, east of Mokopane CBD, between the N1 and R518 roads. The position of the preferred site and the alternative site with its access road is shown in Figure 1.

The preferred site is situated next to the road that leads to the Mogalakwena waste disposal facility and appears to have relatively flat topography. The alternative site is situated on a ridge at a higher elevation than the surrounding area. A new access road will be required to reach the alternative site, which has been proposed to extend from the existing road near the Mogalakwena waste disposal facility to the southwest of the alternative site. The access road will need to slope up towards the alternative site due to the elevation difference.

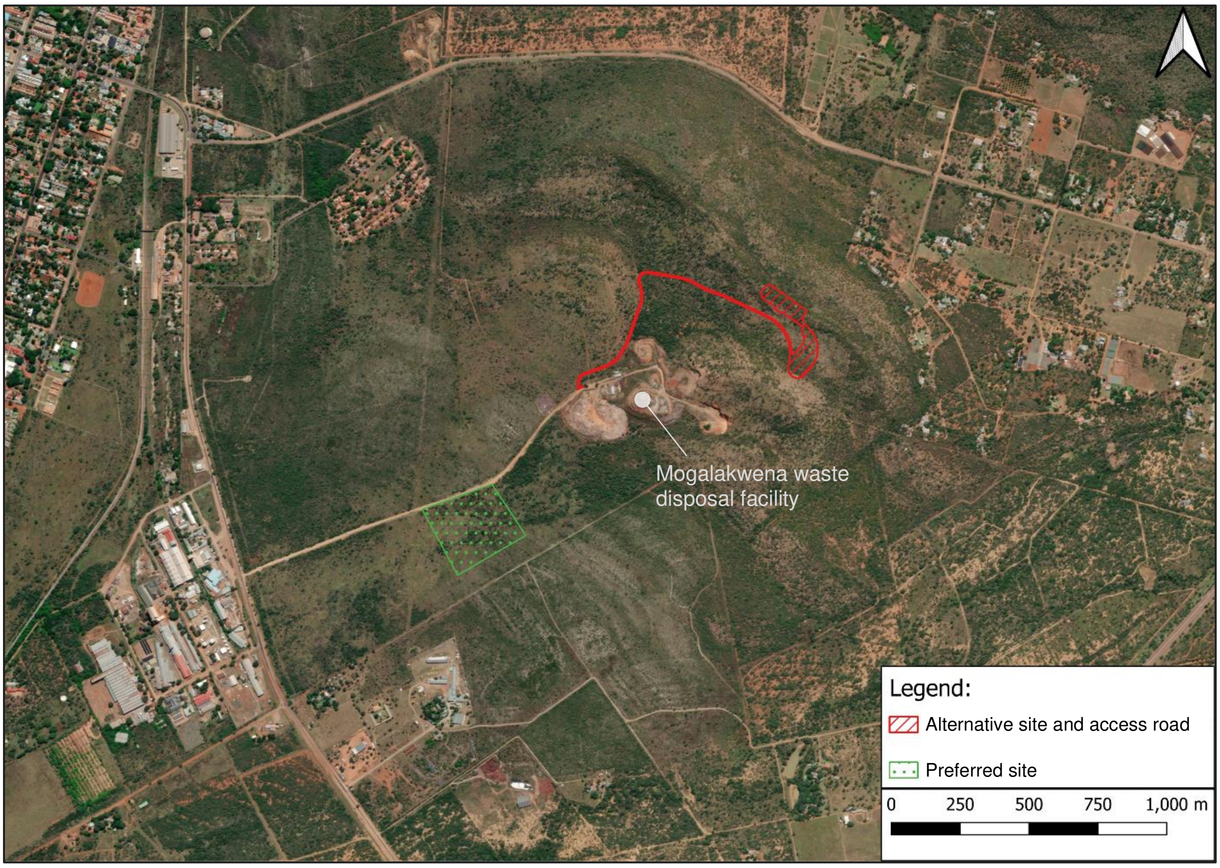

Figure 1 Location of the proposed preferred and alternative Mokopane water treatment works sites (QGIS Development Team, 2023).

3 Site Geology

The geological setting of the proposed preferred and alternative Mokopane water treatment works sites is shown in the extract of the 1:50 000 geological sheet 2429AA Mokopane in Figure 2. According to the 1:50 000 geological sheet, the preferred site is situated on Quaternary-aged soils (Q-r), in close vicinity to basaltic volcaniclastic rocks (Vmc) of the Silverton Formation. The alternative site is underlain by formations of the Vaalian age, all of which fall under the Transvaal Supergroup, Pretoria Group. The formations in the vicinity of the alternative site are listed below, noting that the footprint of the site is situated on Vdw, Vst and Vti1 according to the map:

- Q-r: Soil.
- Vmc: Basaltic volcaniclastics rocks.
- Vbn: Andalusite-biotite shist of the Silverton Formation.
- Vdp: Quartzite of the Daspoort Formation.
- Vst: Biotite schist of the Strubenkop Formation.
- Vdw: Greyish white quartzite with basal pebbly conglomerate of the Daalheuwel Formation.
- Vti1: Basal carbonaceous shale, andalusite-staurolite fels, pelites of the Timeball Hill Formation.

A prominent fault line is located approximately 1.0 to 1.5km west of the preferred and alternative sites. The fault strikes in the north-northeast to south-southwest direction. Towards the east, an inferred fault line strikes in the northeast to southwest direction. No prominent regional-scale fault lines are present within the sites themselves.

The sites are not underlain by potentially soluble rock such as dolomite. However, for reference, as shown in Figure 3, the Council for Geoscience (2023) indicates that there is probable dolomitic rock located approximately 5 km to 7 km northeast of the alternative site. It is likely that the probable dolomitic land refers to the Malmani dolomites of the Chuniespoort Group approximately 7 km northeast of the alternative site (Figure 2). Notwithstanding, the dolomite is a considerable distance away from the sites and is not considered a risk for the current sites.

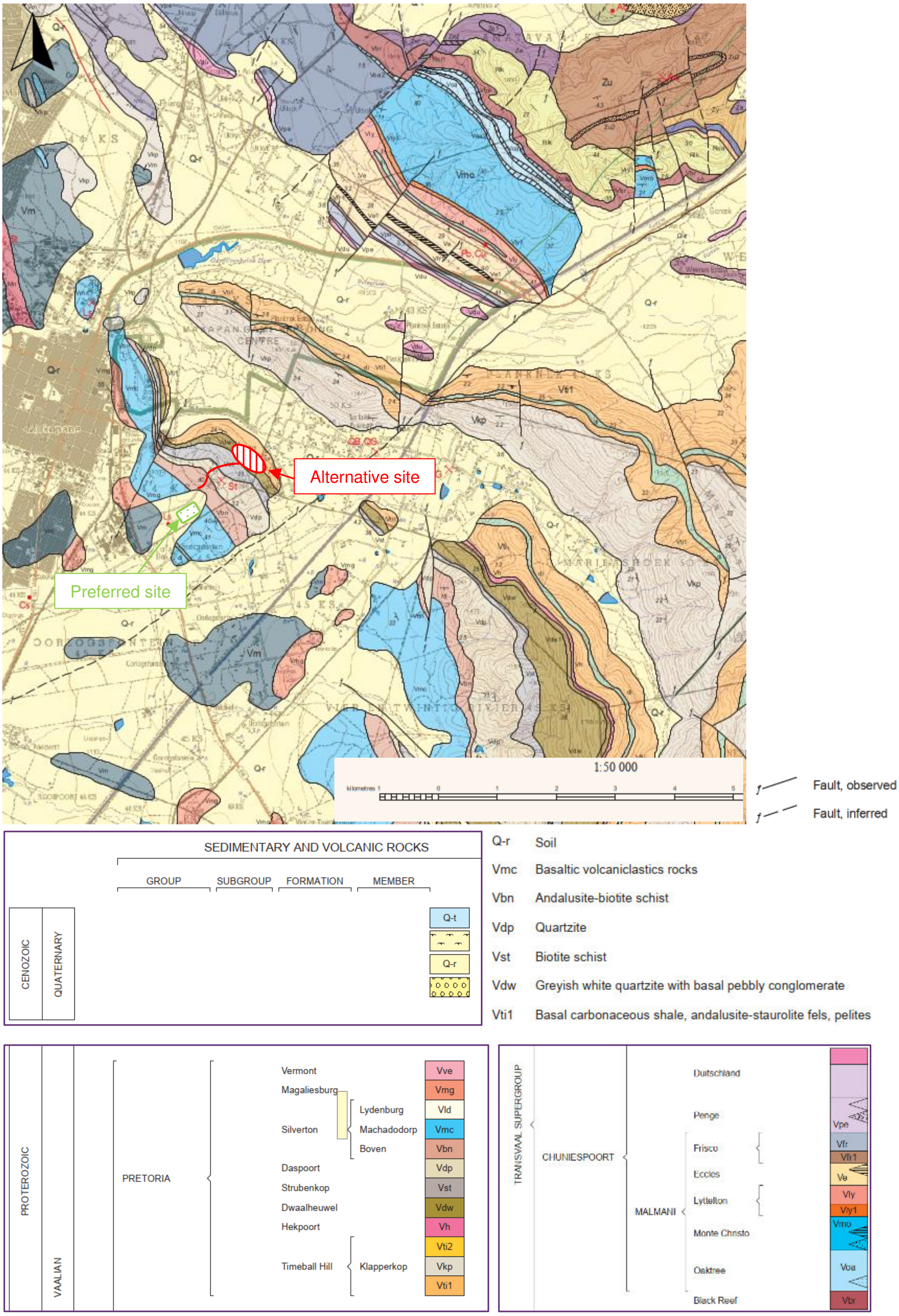

Figure 2 Regional geological setting of the site (from 1:50 000 Geological map; Sheet 2429AA Mokopane, Council for Geoscience, 2010)

ArcGIS Web Map

Figure 3 Inferred dolomitic risk map in the Limpopo Province South Africa (Council for Geoscience, 2023)

4 Climate

The Weinert N-value (Weinert, 1980) is an index used to estimate the effect of climate on the rock weathering process. In general, where the N-value is more than 5, disintegration (mechanical weathering) is the dominant form of weathering, and the residual soils are typically only thinly developed. Conversely, where the N-value is less than 5, there is a water surplus and decomposition (chemical weathering) is dominant, typically creating conditions that are favourable for the development of deeper residual soil profiles.

As indicated in Figure 4, the site is situated in an area with a Weinert N-value in the order of N=3.3 (Weinert, 1980). Decomposition (chemical weathering) is therefore the expected mode of weathering at the site, and deeper residual profiles may have resulted over time.

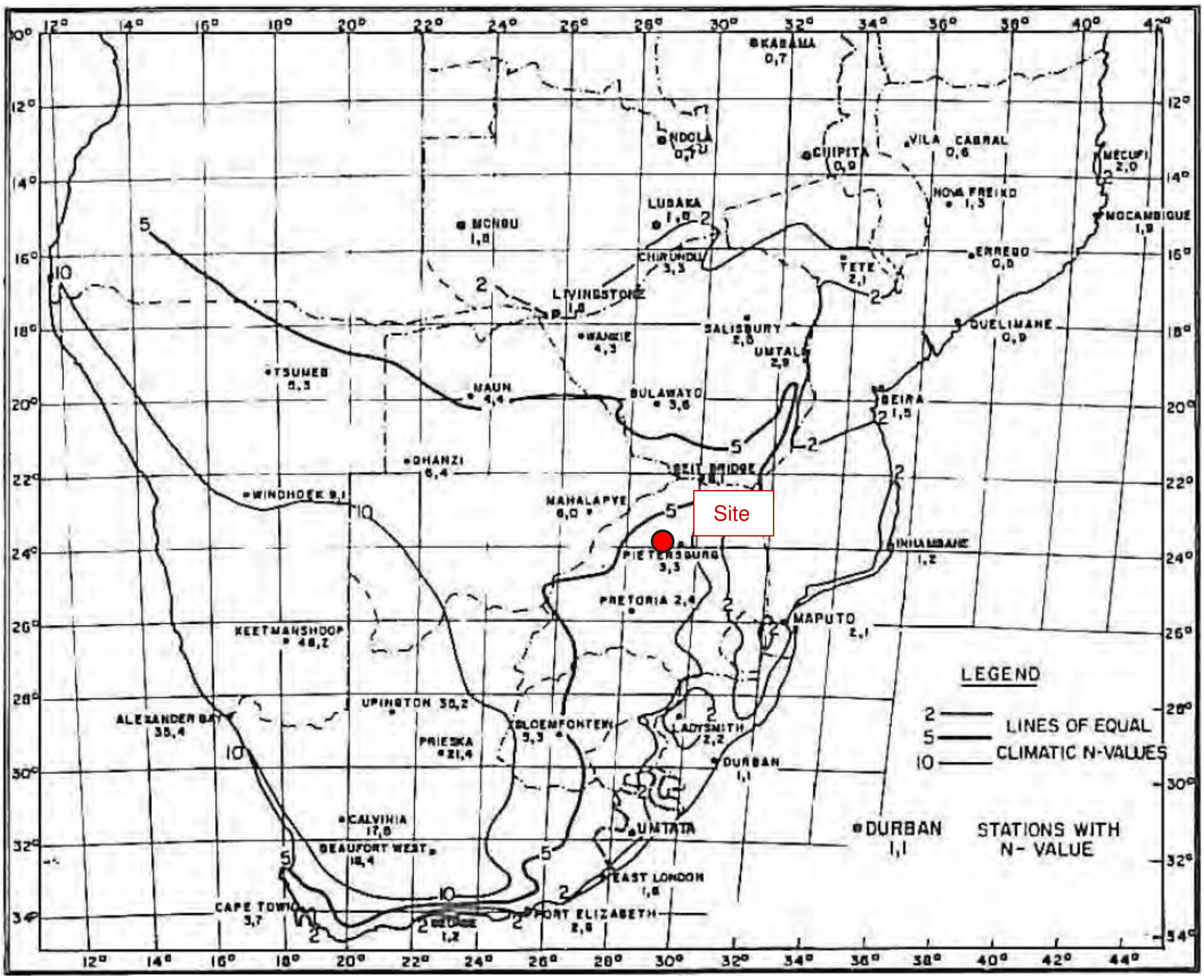

Figure 4 Contour map of climatic N-values for Southern Africa (Weinert, 1980)

5 Seismicity

The South African loading code, SANS 10160-4:2011 (SABS, 2011), suggests that the site is not located in a highly seismic hazard zone (Figure 5). However, as indicated in Figure 5, the site may nonetheless experience a peak ground acceleration in the order of 0.05g to 0.075g. The probability of exceedance of this peak ground acceleration is 10% in a 50-year period.

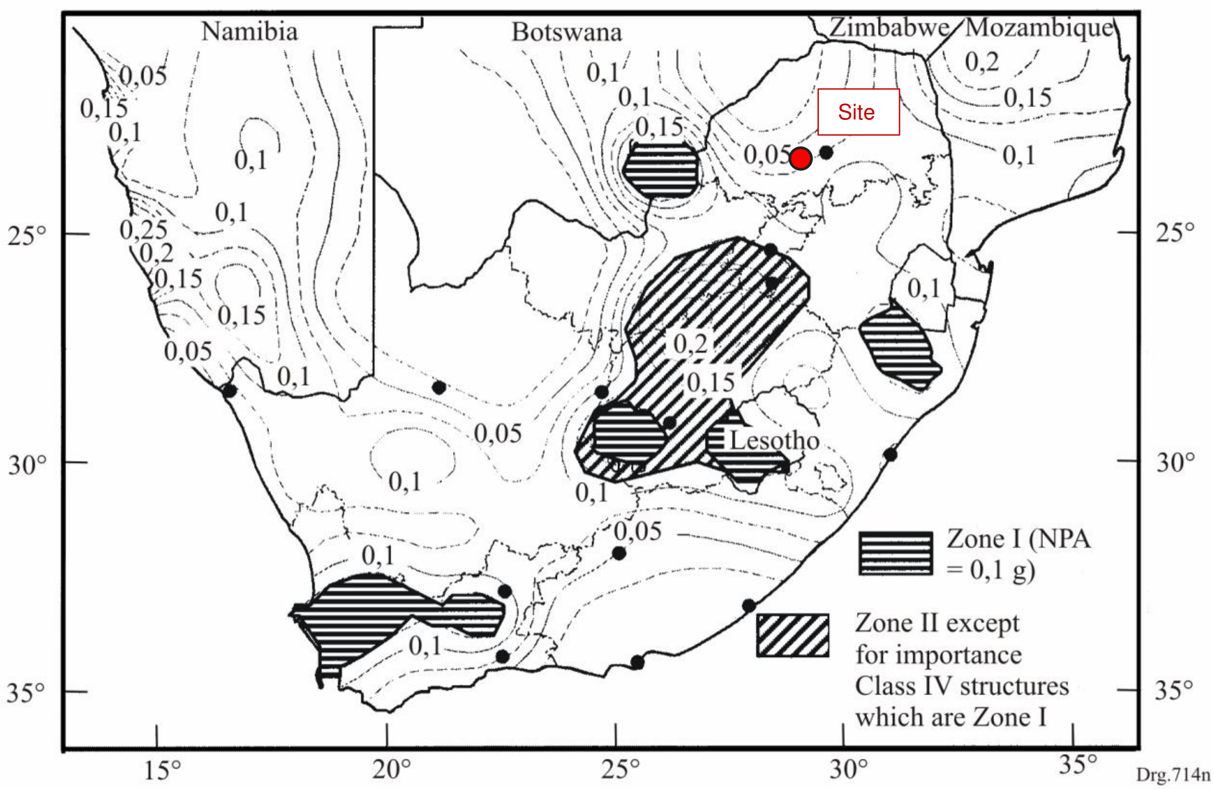

Figure 5 SANS 10160-4:2011 seismic hazard map of South Africa showing peak ground acceleration with 10% probability of being exceeded in a 50-year period (SABS, 2011)

6 Previous Geotechnical Investigation

Reference was made to the report of a previous geotechnical investigation conducted at the proposed site for the Mokopane water treatment works, as reported by WSM Leshika Consulting (2016). The previous geotechnical investigation was conducted at the position of the current alternative site, and no previous geotechnical investigation has been conducted at the location of the preferred site. The previous investigation covered a portion of the current alternative site, an access road route which differs from the currently proposed route, and nearby evaporation ponds. As shown in Figure 6, the investigation included eight (8 no.) test pits positioned across the indicated evaporation pond areas, seventeen (17 no.) along the indicated access road section, and twelve (12 no.) across the plant area (alternative site). Only the evaporation pond test pits were excavated by means of an excavator, whereas the access road and plant area test pits were hand-excavated with a shovel and pick.

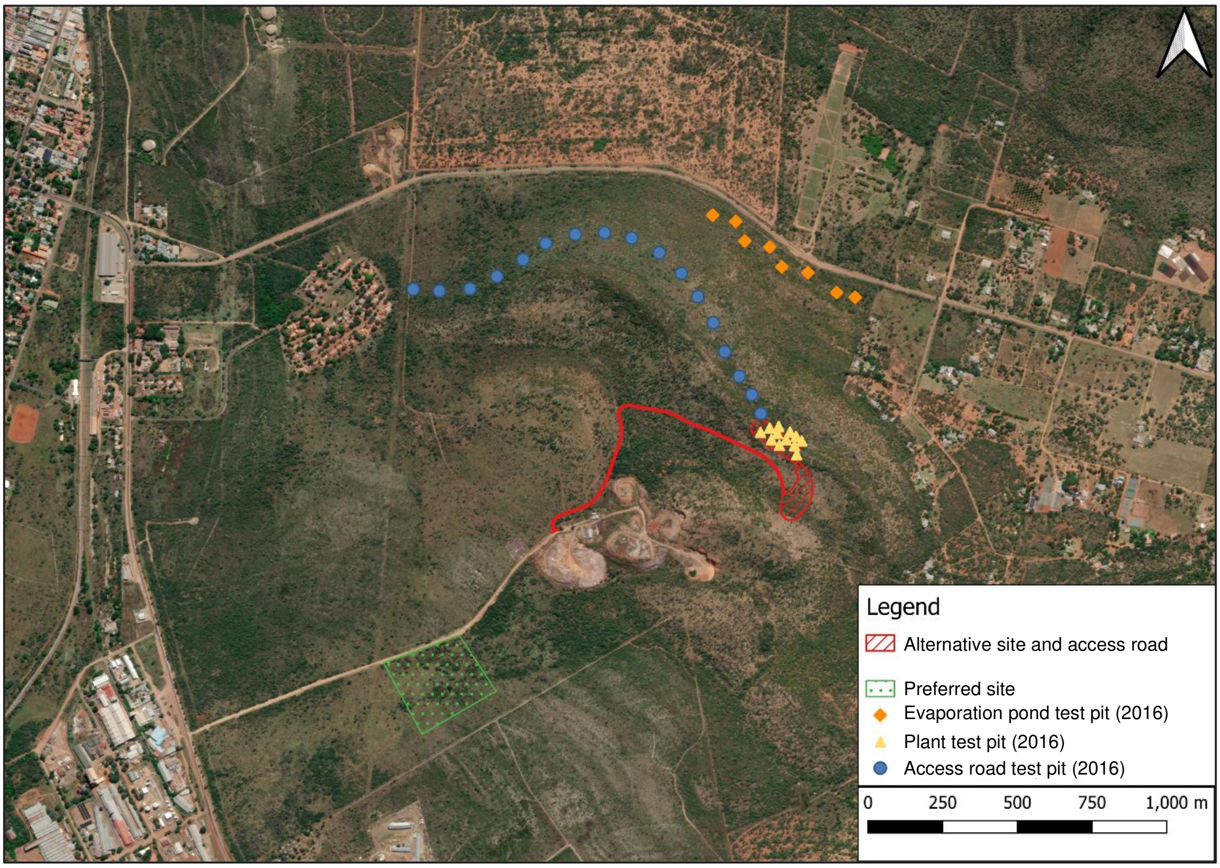

Figure 6 Test pit locations from previous geotechnical investigation (QGIS Development Team, 2023)

6.1 Soil profile

Seven (7 no.) of the twelve (12 no.) water plant test pits were located within the boundary of the current proposed alternative site for the water treatment plant, and the remaining five (5 no.) were within 20 m of the boundary to the northeast.

The ground profile from the twelve (12 no.) water plant test pits is summarised in Figure 7. The test pits were hand-excavated and limited to a maximum depth of 1.2 m. From surface, a small depth of clayey silty sands was encountered, from 0.1 m to 0.7 m (Figure 7). This material was described as topsoil, colluvium, reworked colluvium, or material of mixed origin, with overall consistency of medium dense to dense, and with an open soil structure (pinholed) (Figure 8). The open soil structure is indicative of potentially collapsible soil in its natural state, however the soil thickness at the site appears to be thin.

Below the upper soil, refusal was generally encountered on quartzitic-sandstone (Figure 7). The quartzitic-sandstone was typically described as coarse-grained, highly fractured, extremely close to closely jointed (Figure 9). The rock hardness at refusal depth of the quartzitic-sandstone was assigned an ISRM grade of R3 (medium strong rock).

Three (3 no.) test pits, near the south of the plant boundary (PTP 9, 11, and 12), were terminated on quartzite at shallow depths, of which one test pit (PTP 11 in Figure 10) refused on the surface (quartzite outcrop). It is inferred that the southern extent of the plant area is overlain by quartzite with a quartzite ridge, and the north-eastern portion by quartzitic sandstone. In general, the excavation conditions at termination depth were described as 'hard' according to the South African code for earthworks, SABS 1200 D-1988 (SABS, 1988).

Abundant, slightly weathered to unweathered boulders of 0.5 m and greater were located in the vicinity of the test pits in the plant area (Figure 11). Therefore, boulder excavation might be required.

At the western toe of the ridge, approximately 1 km from the proposed water plant, and 600 m from the proposed access road, moderately cemented calcrete concretions were visible within the slightly metamorphosed quartzitic-sandstone, and slightly calcreteous residual quartzitic-sandstone horizons.

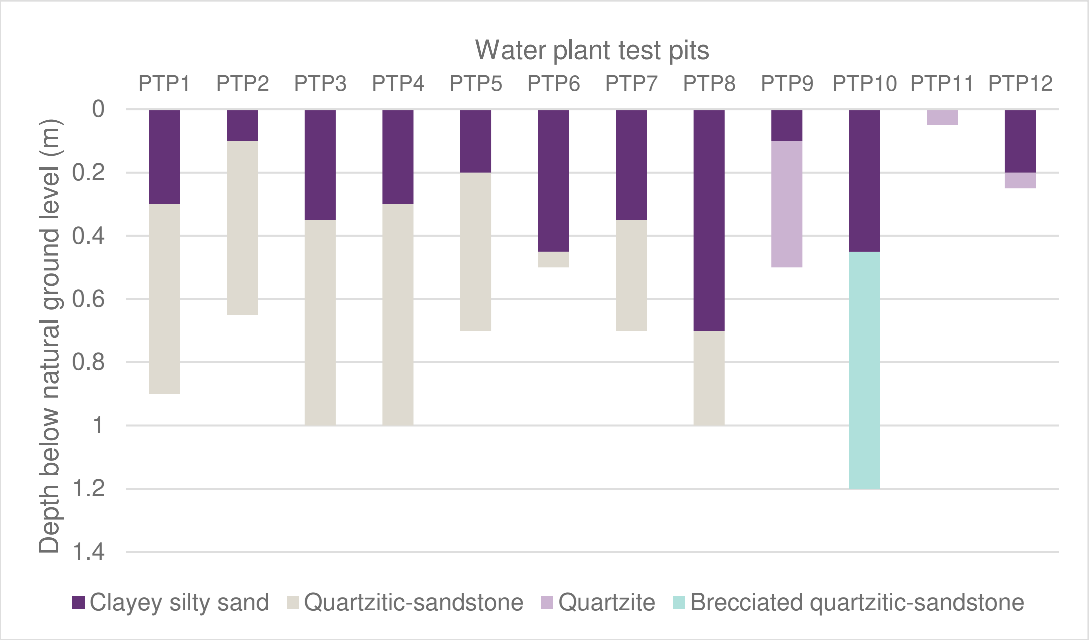

Figure 7 Test pit investigation of water plant area (data from WSM Leshika Consulting, 2016)

Figure 8 Upper open structured silty sand colluvium (PTP 4)

Figure 9 Highly fractured and jointed quartzitic sandstone (PTP 1)

Figure 10 Quartzite outcrop (PTP 11)

Figure 11 Typical vegetation and quartzite boulders (photograph taken from southern slope in direction south-west) (WSM Leshika Consulting, 2016)

6.2 Groundwater

In the WSM Leshika Consulting (2016) geotechnical investigation, no groundwater was encountered in any of the test pits (investigation conducted in April during the area's dry season). However, it must be noted that the test pits were relatively shallow, with a maximum depth of 1.20 m. Furthermore, the water plant test pits were excavated on a ridge with a higher elevation than the surrounding area, and therefore the presence of groundwater is considered unlikely at the higher elevations where the alternative site is situated. Notwithstanding, temporary seepage conditions may occur on the ridge during and after rainfall.

No groundwater information was available at the preferred site location. However, considering the flatter topography of the preferred site, there is a higher chance of groundwater being present at the preferred site than the alternative site.

6.3 Laboratory Results

Six (6 no.) soil samples were tested from the test pits in the plant area. All materials were non-plastic, with fine-grained fractions less than 10%. Furthermore, the materials were classified as GW-GP as per the Unified Soil Classification System (USCS). The California Bearing Ratio (CBR) of the materials ranged from 15% to 31% (average of 23%) at 93% Mod AASHTO, and the TRH14 classification varied between a G6 and G7, indicating that the material is suitable for reuse as selected fill.

7 Considerations

Geotechnical considerations relevant to the proposed preferred and alternative sites for the water treatment works are discussed below. Considering that more geotechnical information was available at the alternative site due to the existing geotechnical investigation, this site was discussed first followed by the preferred site.

7.1 Alternative water treatment works site

The key considerations for the water treatment works alternative site and access road are listed below:

- Excavatability to founding level: Eleven of the twelve hand excavated test pits at the water plant location were terminated due to refusal on either quartzite or quartzitic-sandstone with an ISRM rock description of medium strong to very strong (based on field description). Excavations at the site will therefore likely be difficult and require pneumatic breakers or blasting.
- Stability of cuts/fills: Stability of cuts and fills requires consideration for any platforms or excavations that may be required for the plant infrastructure. Excavation in the shallow rock conditions may have potential for kinematic modes of failure between the prominent joint sets.
- Upper soil erosion: Removal of the surrounding vegetation, as well as concentrated water flow during construction, may cause the upper soils to erode. The water plant is situated close to the crest of the ridge resulting in preferential water flow towards deep excavations/cuts.
- Material reuse: Based on the available laboratory test information, the upper materials at the site are suitable for reuse as selected engineered fill (G6 or G7).
- Collapse potential: The upper soil materials at the site were reported to have an open structure (pinholed), indicating the soils to be potentially collapsible in their natural state. Removal and replacement of the soils might therefore be required to mitigate collapse settlement of the plant infrastructure. Considering that the upper soil layers are thin, removal and replacement of the upper soil is considered feasible to avoid constructing on the potentially collapsible soil.
- Rock discontinuities: Where deep rock cuts are required, deeper investigation with core drilling into the subsurface is required to obtain information on the thickness of the formations, discontinuities, and contact positions and properties of the materials.
- Temporary/permanent access road to plant site: Given that the proposed access road requires an incline towards the site, cut and fills are likely required. Consequently, slope stability assessments will be required with possible lateral support interventions.

In summary, from a geotechnical perspective, no fatal flaws that would inhibit the proposed development were identified at the alternative site.

7.2 Preferred water treatment works site

The geology map indicated that the preferred site is underlain by Quaternary-aged soils (Section 3), and therefore the site may contain a deeper soil profile than what was encountered at the alternative site. No in-situ geotechnical investigation information was available at the preferred site to confirm this inference. Accordingly, key considerations such as the ground profile, material composition and properties, and water level are unknown at the preferred site, and thus a geotechnical investigation is required. Notwithstanding, it is considered unlikely, from a geotechnical perspective, that the preferred site would contain any significant fatal flaws that would inhibit the proposed development. However, compared to the alternative site, a deeper soil profile at the preferred site could present less favourable founding conditions for the proposed infrastructure, depending on the soil composition and properties. Furthermore, aspects similar to those described for the alternative site may also be relevant for the preferred site, including the presence of collapsible soils, stability of cuts/fills, and the potential for soil erosion. Due to the potential deeper soil profile at the preferred site, removal and replacement of collapsible soils (if present) may be impractical, and therefore another type of ground improvement such as impact roller compaction or rapid impact compaction may be required.

Considering that the preferred site appears to have flatter topography and does not require the construction of a new access road, there would potentially be reduced quantities of cuts and fills required. Moreover, if the preferred site was to contain a deeper soil profile compared to the shallow rock encountered at the alternative site, the excavation conditions would be more favourable.

8 Conclusions and Recommendations

A geotechnical desktop study was conducted for the proposed preferred and alternative sites of the Mokopane water treatment works. From the published 1:50 000 geology map of the region, the geology of the preferred site comprises Quaternary-aged soils, and the geology of the alternative site comprises greyish white quartzite, and possible biotite schist and basal carbonaceous shale. No potentially soluble rock like dolomite is present at either site.

Shallow test pitting from a previous geotechnical investigation at the alternative site encountered the presence of shallow rock, within approximately 0.5 m below ground level. This presents favourable conditions for founding of the infrastructure, but difficult excavation conditions that may require blasting. Additionally, a pinholed soil structure was identified in the upper soil cover, which may require removal and recompaction to avoid collapse settlement of the proposed infrastructure, however this is considered feasible because the soil layer is relatively thin. Furthermore, due to the steep topography, cuts and fills may be required at both the alternative site and its access road, which will require slope stability assessments and possible lateral support. Notwithstanding, from a geotechnical perspective, no fatal flaws that would inhibit the proposed development were identified at the alternative site.

No in-situ geotechnical investigation information was available at the preferred site, and hence the ground conditions are unknown. Considering that the geological map indicates the presence of Quaternary-aged soils, the preferred site may have a deeper soil profile than what was encountered at the alternative site. Notwithstanding, it is considered unlikely, from a geotechnical perspective, that the preferred site would contain any significant fatal flaws that would inhibit the proposed development. However, aspects similar to those described for the alternative site may also be relevant for the preferred site, such as the presence of collapsible soils, stability of cuts/fills, and the potential for soil erosion. Considering that the preferred site may have a deeper soil profile, the site may have less favourable founding conditions and it may not be practical to remove and replace collapsible soils (if present), and thus another type of ground improvement may be required. Potential advantages of the preferred site include its flatter topography, which would potentially reduce the quantities of cuts and fills, and easier excavation conditions if it contains a deeper soil profile.

Given the limited nature of the geotechnical information at the sites, additional geotechnical investigations would be required to reduce the geotechnical risk of the project as it moves into subsequent design phases, particularly at the preferred site where no intrusive information is currently available. To provide sufficient information for the geotechnical design of the foundations and slopes at the facility, it is recommended that further geotechnical investigation work be undertaken at the selected site, such as site walkovers with mapping of rock outcrops, excavating of test pits, drilling of rotary core boreholes, and laboratory testing. The quantity and extent of the geotechnical investigation will take into consideration the chosen site, the details of the infrastructure, and the stage of development, be it feasibility or concept design or detailed design.

9 References

Council for Geoscience, 2023. *Council for Geoscience Interactive Web Portal.* [Online] Available at: https://maps.geoscience.org.za/portal/apps/sites/#/council-for-geoscience-interactive-web-map-1-1 [Accessed 31 August 2023].

Desmet, P. G., Holness, S., Skowno, A. & Egan, V. T., 2013. *Limpopo Conservation Plan v2 Technical Report,* Polokwane: Limpopo Department of Economic Development, Environment and Tourism (LEDET).

QGIS Development Team, 2023. *QGIS Geographic Information System,* s.l.: Open Source Geospatial Foundation.

SABS, 1988. *Standardized Specification for Civil Engineering Construction Section (Earthworks).* Pretoria: South African Bureau of Standards (SABS).

SABS, 2011. *Basis of structural design and actions for buildings and industrial structures, Part 4: Seismic actions and general requirements for buildings (SANS 10160-4:2011 Edition 1.1).* Pretoria: South African Bureau of Standards (SABS).

Weinert, H. H., 1980. *The natural road construction materials of southern Africa.* Pretoria: National Institute for Transport and Road Research.

WSM Leshika Consulting, 2016. *Phase 1 Shallow Soil Engineering Geological Investigation for the Proposed Mokopane Water Treatment Works No.1 and Road Section, Mogalakwena Local Municipality, Limpopo Prov., South Africa,* (WSML Project no: WG16053): Dated 25/08/2016.