GEOHYDROLOGICAL INVESTIGATION REPORT FOR POTABLE GROUNDWATER EXPLORATION FOR A POLICE STATION IN SAMORA MACHEL, CAPE TOWN, WESTERN CAPE

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TABLE OF ABBREVIATIONS

Abbreviation	***Definition***
m amsl	Above Mean Seal Level
bgl	Below Ground Level
Cl	Chloride
DEM	Digital Elevation Model
DWS	Department of Water and Sanitation
E	East
EC	Electroconductivity
Luhlaza	Luhlaza Advisory and Consulting Pty Ltd
m	Metre (s)
mm	Millimetre
MPa	MegaPascal
mS/m	Millisiemens per meter
N	North
Na	Sodim
No.	Number
S	South
SANS	South African National Standards

1. TERMS OF APPOINTMENT

Luhlaza Advisory and Consulting (Pty) Ltd was requested to conduct a geohydrological investigation for the purpose of assessing quantity and quality of groundwater for potable use for Samora Machel Police Station in Philippi, Western Cape, South Africa.

The geohydrological investigation was carried out according to standard practice codes and guidelines as indicated in the South African National Standards (SANS) 10299:2003, titled "*Development, Maintenance and Management of Groundwater Resources*".

2. PROJECT BACKGROUND

Samora Machel Police Station is situated in Philippi Township under the jurisdiction of City of Cape Town Municipality, Western Cape Province (Figure 1).The site can be accessed through the M7 Jakes Gerwel Drive and Oliver Tambo Drive and the central coordinates are 34°01'2.74"S; 18°34'20.75"E.

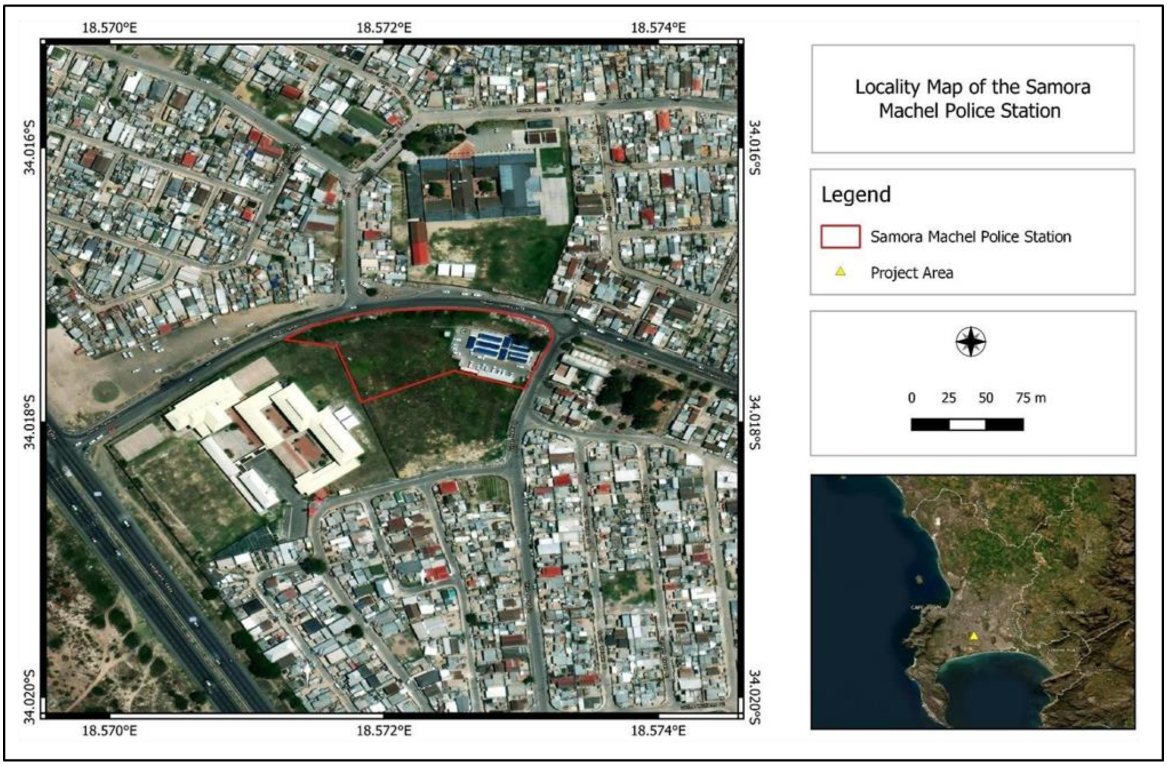

Figure 1: Locality map

This geohydrological investigation report outlines the 2nd phase investigation of the project and it entails a field reconnaissance and geophysical survey of the hydrological and geohydrological features. The main objective of this investigation is to identify technical and economically feasible locations for borehole drilling for groundwater exploration.

3. INFORMATION SOURCES

The following information sources were used to assist with the hydrogeological site investigation:

- LC 027-2023: Hydrogeological Desktop Study for the proposed police station in Samora Machel, Weltevreden Valley, Cape Town, Western Cape.
- National Groundwater Archive of the Department of Water and Sanitation (DWS).
- Council for Geoscience Geological Map of Cape Town 3318.
- Groundwater Occurrence Map of Cape Town 3318.
- A SRTM Digital Elevation Model (DEM) at 1-arc second of the Project Area sourced from the USGS Earth Explorer Project.
- South African National Standards (SANS) 10299:2003, titled "*Development, Maintenance and Management of Groundwater Resources*".

4. METHODOLOGY

The methods used to conduct this geohydrological study includes a review of a desktop study report, referenced LC 027-2023 compiled by Luhlaza, topographical and geological maps, geohydrological data from DWS, SANS 10299:2003 and available literature. Field investigation procedures includes a reconnaissance survey of the topography, geology and hydrology, and a magnetic geophysical survey.

5. DESCRIPTION OF THE STUDY AREA

5.1. METEOROLOGY

This region is regarded as "Csb" (Warm-summer Mediterranean Climate) in the Koppen-Geiger Climate Classification system with hot, dry summers and cooler, wet winters. The average minimum and maximum temperatures for the year, between the coldest month being August and the warmest month being February respectively range from 11.0°C – 25.0°C. Average precipitation for the year is 475 mm with most rainfall during the winter months.

5.2. GEOLOGY

The basement of the project area is underlain by the calcareous sands of the Witzand Formation (Figure 2). This formation is the youngest of the Sandveld Group, formed from aeolian activity and deflation processes from modern beach activity (Fouche, 2021). The sands are described as whitish, partly vegetated, fine to medium grained calcareous coast dunes (Theron et al., 1992; Browning and Dave, 2015). The area is not in proximity of any geological discontinuities such as fault zones, jointing, or fractures.

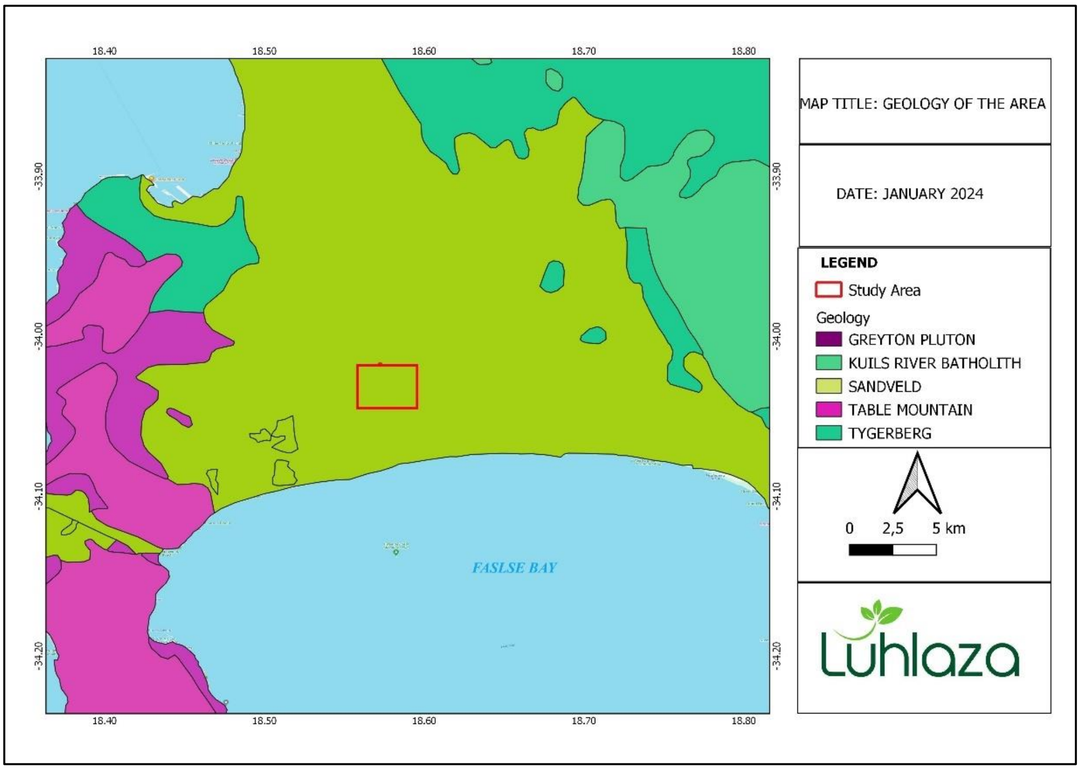

Figure 2: Geology of the Study Area

5.3. GEOHYDROLOGY

The project area forms part of the G22D quaternary catchment contained in the False Bay area. There are major rivers through this catchment are the Diep and Vygekraal rivers which drain directly into False Bay, Atlantic Ocean (Figure 3). The topography of the area is typical of a coastal plain, generally flat lying with low elevations. The elevation of the study area ranges from 31-34 m amsl (Figure *5*) which indicates a very shallow water table, and recharge predominantly by rainfall of the area.

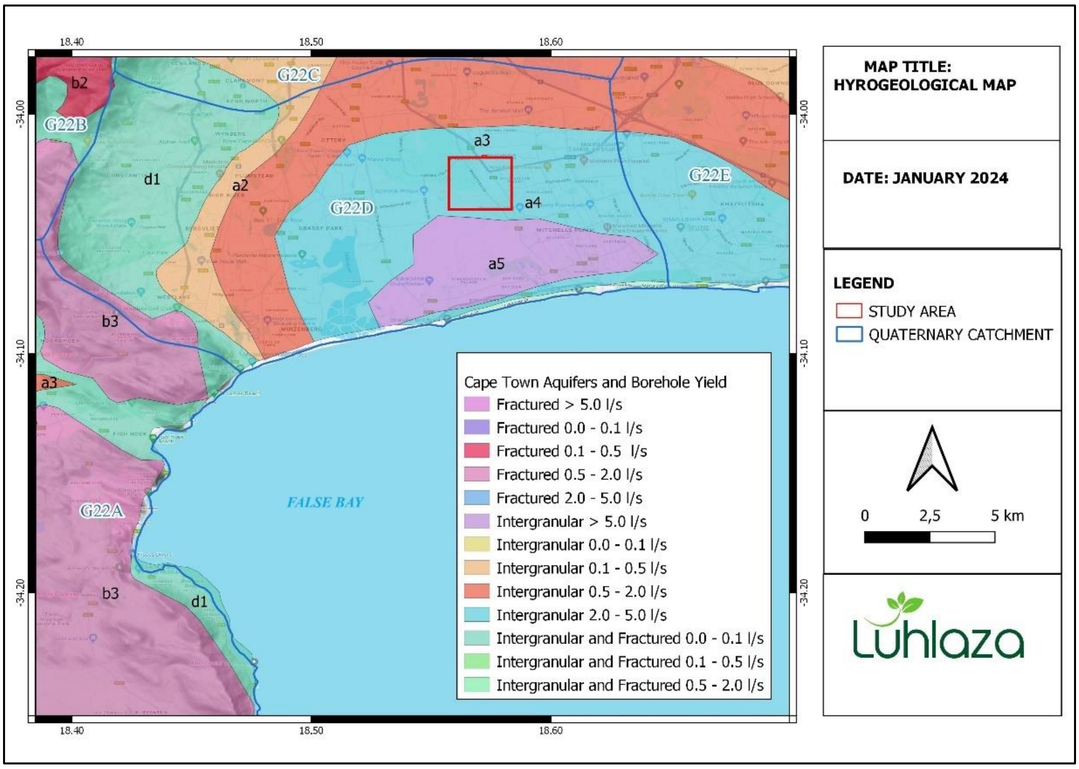

Figure 3: Hydrogeological Map.

The 1:250 000 hydrogeological sheet of Cape Town 3317 indicates that groundwater in area occurs within the Cape Flats Groundwater Resource Unit which is made of the Cape Flats aquifer (Figure 3). The Cape Flats aquifer is characterized by shallow, unconfined conditions with groundwater occurring in the intergranular interstices of the coarse-grained sand as well as clay, silt, sand, and gravel of the Witzsand formation. The aquifer typically has high yield of 2.0 – 5.0 l/s, where according to the hydrocensus, pump testing results of the boreholes, drilled between 20-30m bgl, in proximity to the project area reveal a yield of 6 l/s.

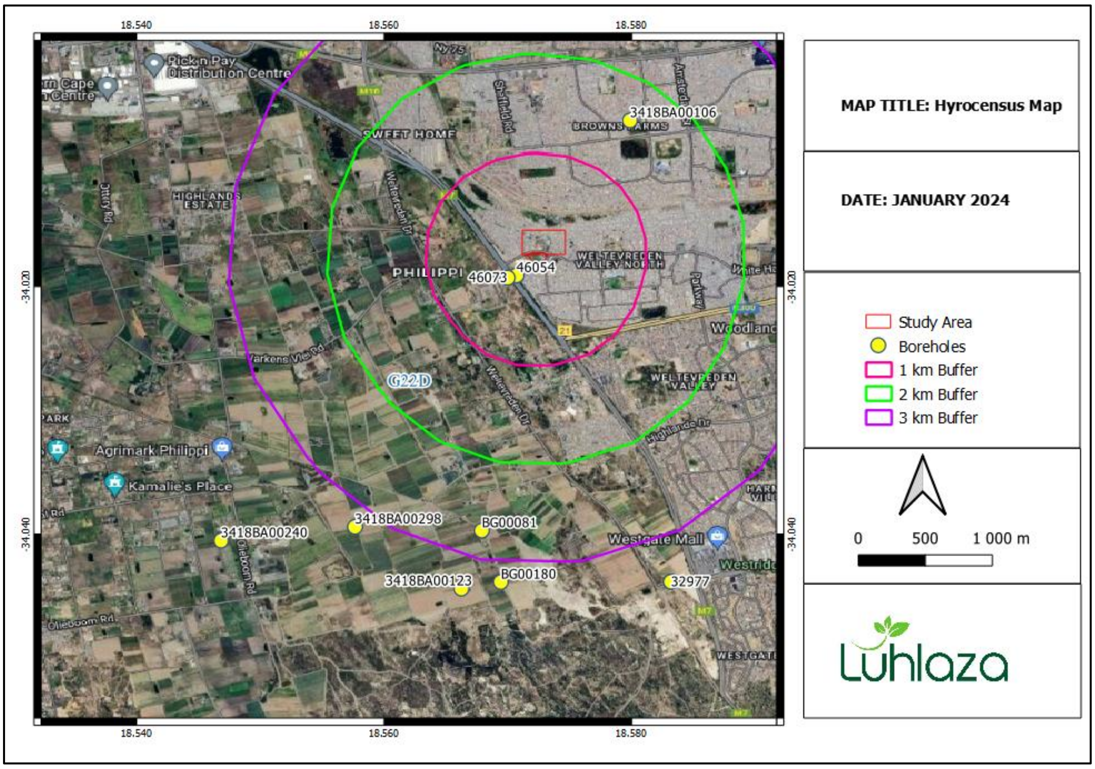

Figure 4: Hydrocensus Map.

The hydrocensus conducted on the study area reveals that there are two previously drilled boreholes within 2km of the project area. Table 1 presents information of the mentioned boreholes and Table 2 presents information of other boreholes present around the area.

Table 1: Boreholes within 1 km of the study area

Geosite:	Elevation (m m amsl)	Water Level (m bgl)	Discharge Rate	Electrical Conductivity (mS/m)	Depth	Water Strike (m bgl)	Lithology
46054	40	1.96	5.610 l/s	235.0	30.00	-	Unconsolidated Overburden
46073	20	5.75	6.000 l/s	-	30.00	11.00	White Sand

Table 2: Boreholes around the 2 km and 3 km buffer zones.

Data Owner	Geosite Identifier	Type	Longitude (E)	Latitude (S)	Water level (m bgl)
Dept. Water-Western Cape	3418BA00106	Borehole	34,06186°	18,58623°	3,51
Dept. Water-Western Cape	BG00801	Borehole	34,06158°	18,60123°	6,01
Dept. Water-Western Cape	32977	Borehole	34,05825°	18,6054°	2,93
Dept. Water-Western Cape	3318DC00274	Borehole	33,97273°	18,5987°	1,066

The terrain of the project area, from the acquired digital elevation model, can be described as flat lying and is typical of coastal plain which generally have a very low elevation. The elevation of the study area ranges between 31-34m m amsl (Figure 5). This implies that the water table is shallow and aquifer recharge is mainly through rainfall.

From the site investigation walkover, the project area is in a generally flat field despite being covered by heaps of sand and thick, dry grass. The area is also laden with plastic waste and rubble. The area is fenced off with a school to the west and is towards the east of Table Mountain. The are roads to access the site north and southwards from the area (Figure 6).

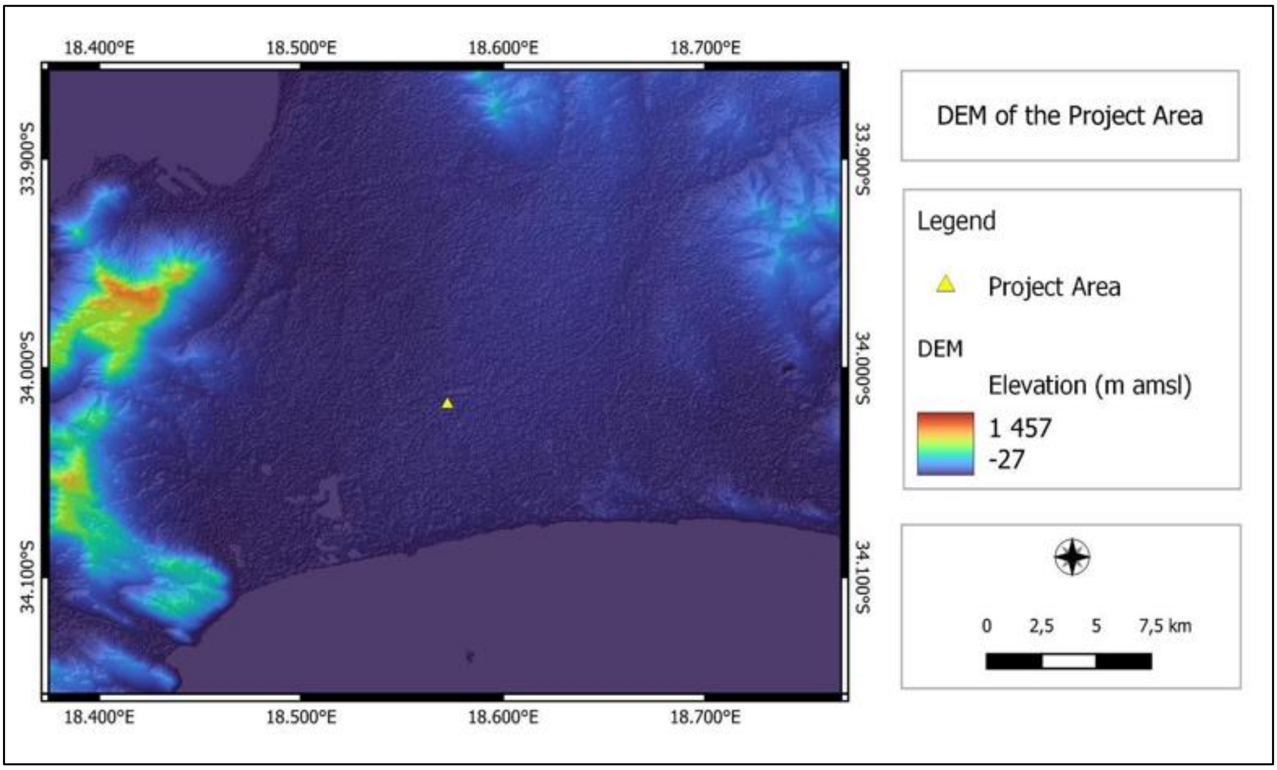

Figure 5: Digital Elevation Model (DEM) of the study area

Figure 6: Project area (east of Table Mountain) during site investigation with heaps of rubble and plastic waste.

5.4. HYDROGEOCHEMISTRY (Groundwater Quality)

During the wetter (winter) season, groundwater can occur at or close to the surface. Groundwater quality is easily influenced by the land use, saltwater intrusion and rainfall in the area due to the shallow unconfined water table conditions. Henzen (1973) conducted a study of the groundwater quality of the Cape Flats aquifer, which concluded with the abandonment of the water resource project due to poor water quality and drastic seasonal variance in the water table.
Saltwater or saline intrusion results from a rise of sea levels and groundwater overhaversting along the coast, and this results into seawater inflitrating into coastal aquifers. Since freshwater is less dense than saline water and freshwater tends to flow on top of underlying saline groundwater (Figure 7). When water is pumped from an aquifer that contains or near saline groundwater, the freshwater/saline boundary migrates in response to pumping which can progress to saline water infiltrating the borehole, hindiring fresh water supply (Figure 8).

As a result the groundwater in the area is likely to be saline and have high ionic concentration, and high electrical conductivity (EC) levels. This is an indication that the groundwater chemistry may not be to the required standards for potable use and various forms of treatment may be required to treat the water to the required standards. These methods of treatement required can include water softening, filtration, reverse osmosis and frequent quartely to bi annual laboratory testing.

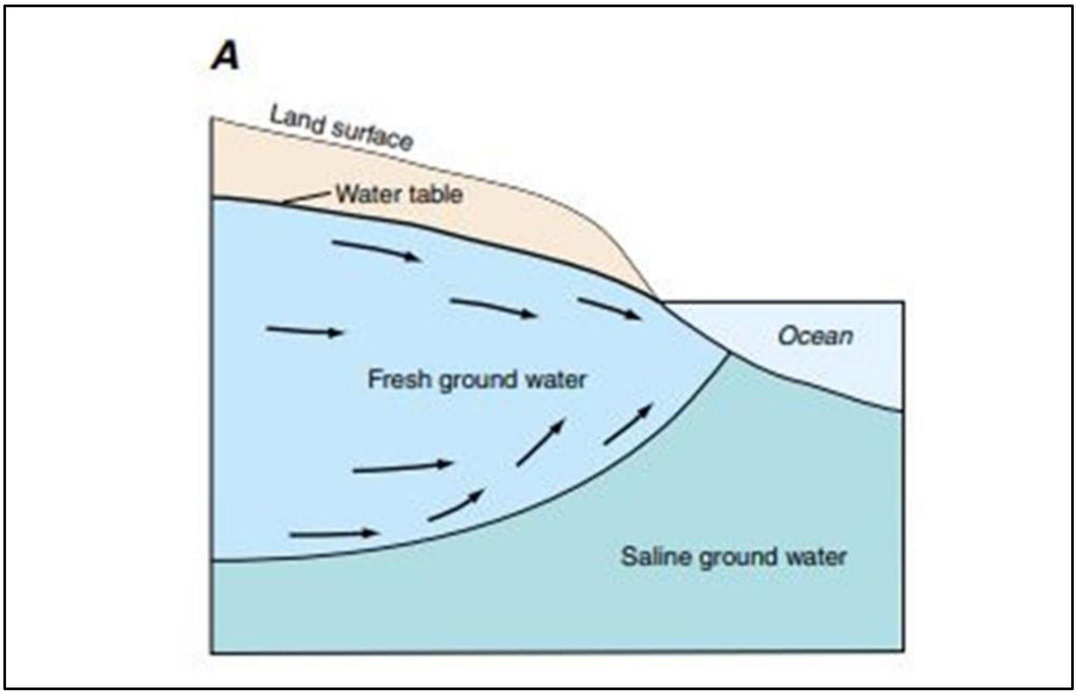

Figure 7: Groundwater floats on saline groundwater (Alley et al., 1999).

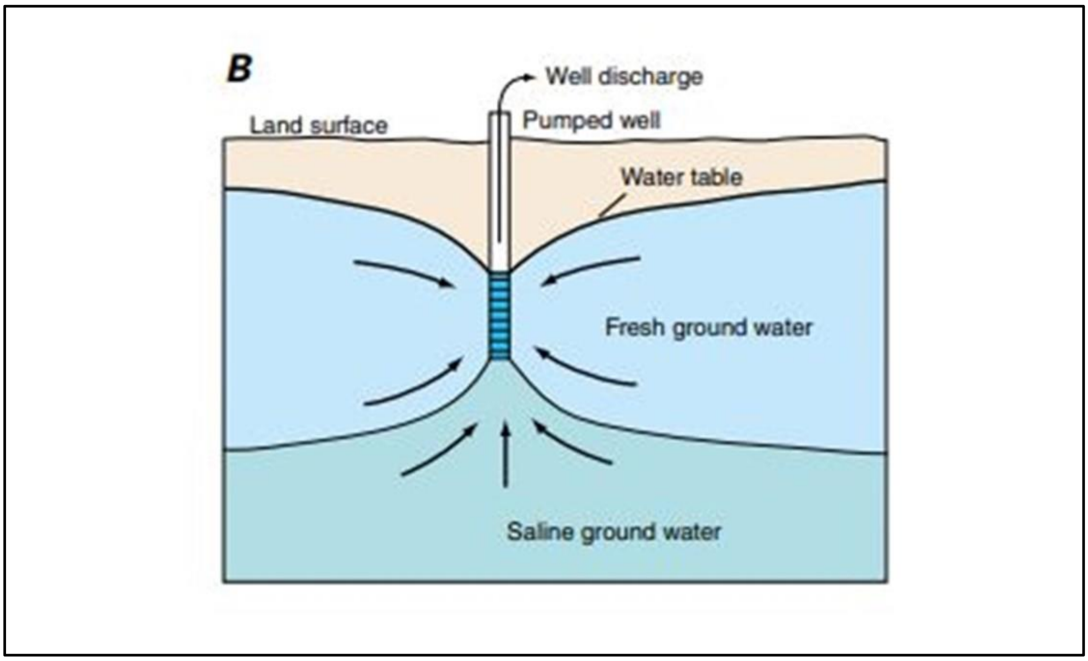

Figure 8: Over abstraction leads to saltwater intrusion of freshwater sources (Alley et al., 1999).

6. GEOHYDROLOGICAL INVESTIGATION FOR BOREHOLE SITING

6.1. GEOPHYSICAL SURVEY- MAGNETOMETER

Field investigation and site selection of the borehole's position in the project area was carried out on the 23rd of January 2024. The borehole siting was undertaken with the aid a magnetometer to understand the magnetic anomalies (deviations) that occur subsurface and its relationship to with potential groundwater conductive zones. The geophysical survey was conducted with the G816 Magnetometer Figure 9). During the survey, the data logger connected to the instrument recorded the results of each traverse as individual values of magnetic signatures based on two main considerations i.e., ground water flow and access for the drilling rig. A total of 3 traverses were taken for the siting of one borehole and a possible alternative borehole for the Samora Machel Police Station. Measurements were taken at 1 m intervals along 35 m long traverses each.

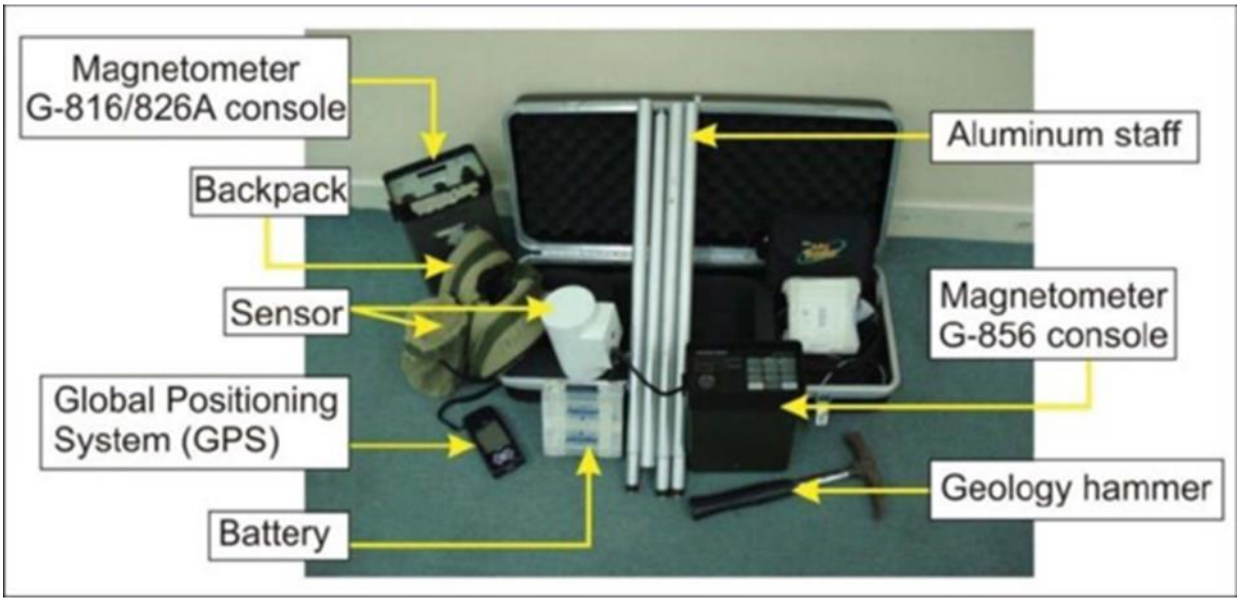

Figure 9: Magnetometer

6.2 RESULTS OF THE GEOPHYSICAL SURVEY AND CONCLUSIONS

The objective of conducting a magnetic survey is to detect anomalies in the magnetic field due to the variance in subsurface material characteristics. These anomalies are linked to the presence of geological structures such as faults, presence of magnetic minerals present in dykes or intrusions or man-made structures such as pipelines etc. that would either obstruct or increase the transmission of groundwater, and as such render a low productive or a highly productive well or borehole. From the traverse, zones of groundwater potential are highlighted. The traverse of each of the geophysical surveys are shown in Figure 10

Figure 10: Traverses taken during survey.

The magnetometer survey does not give an indication of the possible depth to the water table or groundwater as well as the depth to underground infrastructure. The presence of groundwater and/or geological boundary and underground infrastructure are inferred based on the magnetic intensity readings off the magnetometer data logger.

Traverse 1 displayed anomalous behavior at: at 2 m, 9 m, 15 m, 19 m, and 23 m (Figure 11). Thus, zones of groundwater potential are likely to be at the segment from 1- 3 m, 8-11 m and from 14-16 m along this traverse**. Traverse 2** displayed strong negative anomalies followed by strong positive anomalies, at 5 m, 10 m, 15 m, 17 m, 21 m, and 25 m (Figure 12). This traverse was taken perpendicular to the direction of the flow of water which discharges in a southwesterly direction into the ocean about 7 km away. Additionally, the results of the survey of traverse 2 proves it is not conducive to groundwater presence. **Traverse 3** displayed negative anomalies at 1 m, 3m, 9 m, and 15 m (Figure 13). Thus, the zones of groundwater potential are likely to be between 2-4m along this traverse. The readings of the magnetometer survey for each traverse are listed in the Appendix section.

Traverses 1 and 3 run in the East to West direction, parallel to the flow of groundwater, while Traverses 2 runs in the North to South direction, opposing groundwater flow.

Traverse 1 is most conducive to groundwater as compared to Traverse 2 and 3 because there are more consecutive strongly negative anomalies (Figure 11). Strongly negative anomalies between two strongly positive anomalies may be an indication of an obstruction, and thus is not suitable for drilling. Thus, the location of the borehole is identified along traverse 1 at 9m. Traverse 2 was taken along a direction that is almost perpendicular to the flow of groundwater, and it is a good indicator for the presence of groundwater but not the most suitable to drill a borehole. Traverse 3 also indicates a groundwater potential thus the alternative position for the borehole is identified at 4 m along the traverse Figure 10). Table 3 presents the coordinates for the potential borehole points shown in Figure 10.

Table 3: Location of the identified potential borehole sites.

Borehole	Latitude (°S)	Longitude (°E)
Borehole (BH)	34,0174	18,572111
Alternative Borehole (Alt. BH)	34,017989	18,572111

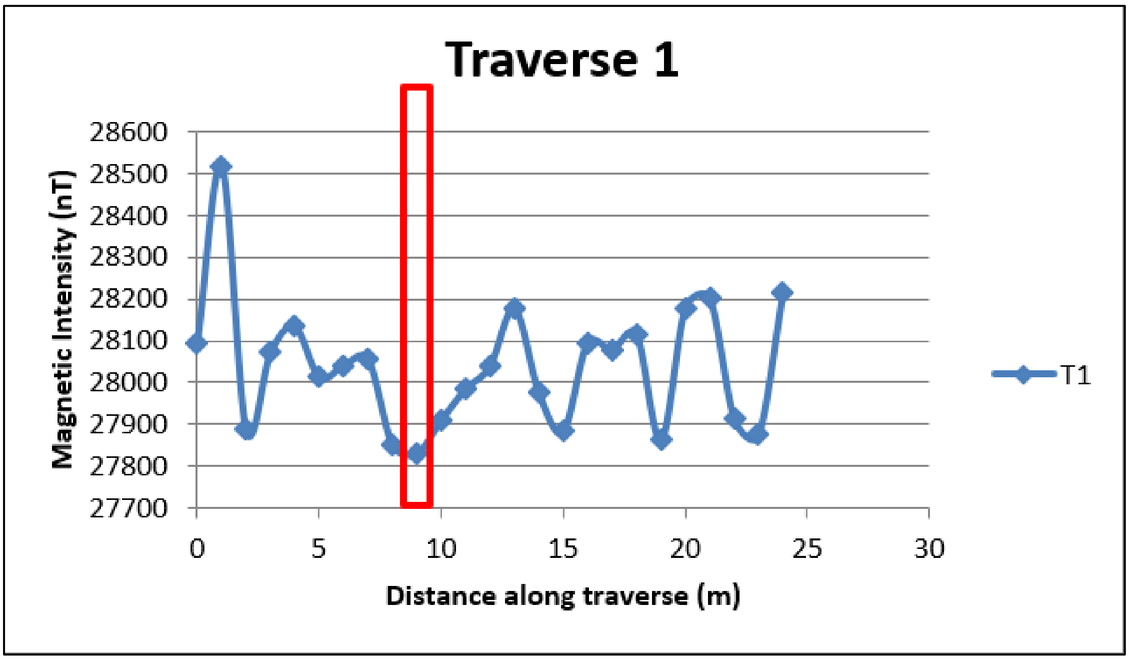

Figure 11: The results of the Geophysical survey with groundwater potential zone highlighted.

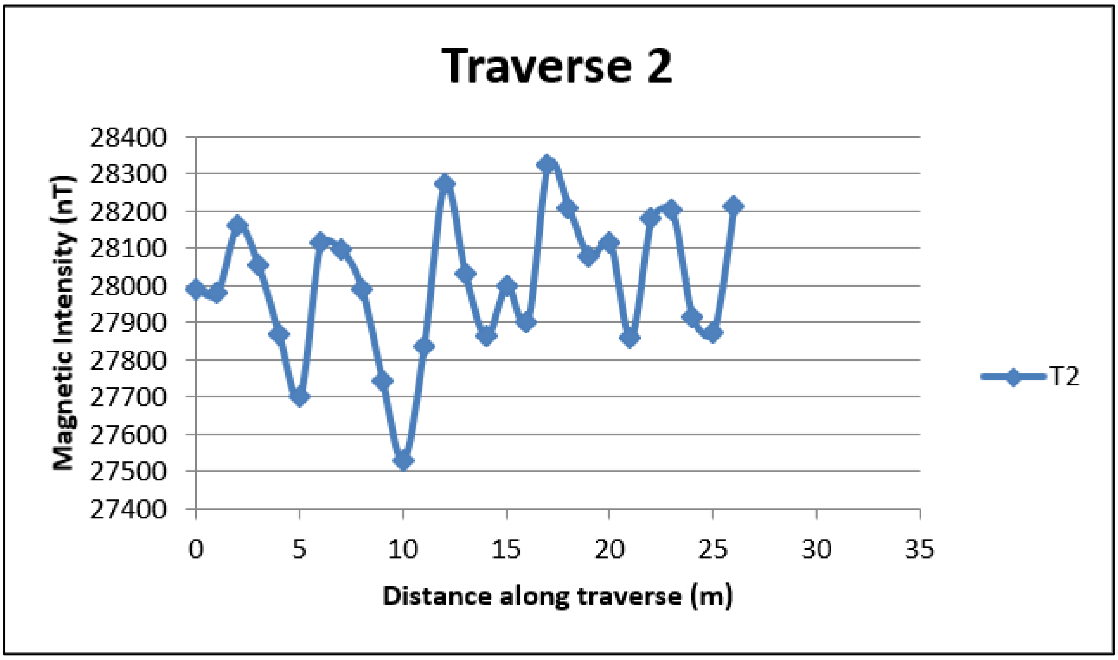

Figure 12: The results of the Geophysical survey along traverse 2 showing a general presence of groundwater.

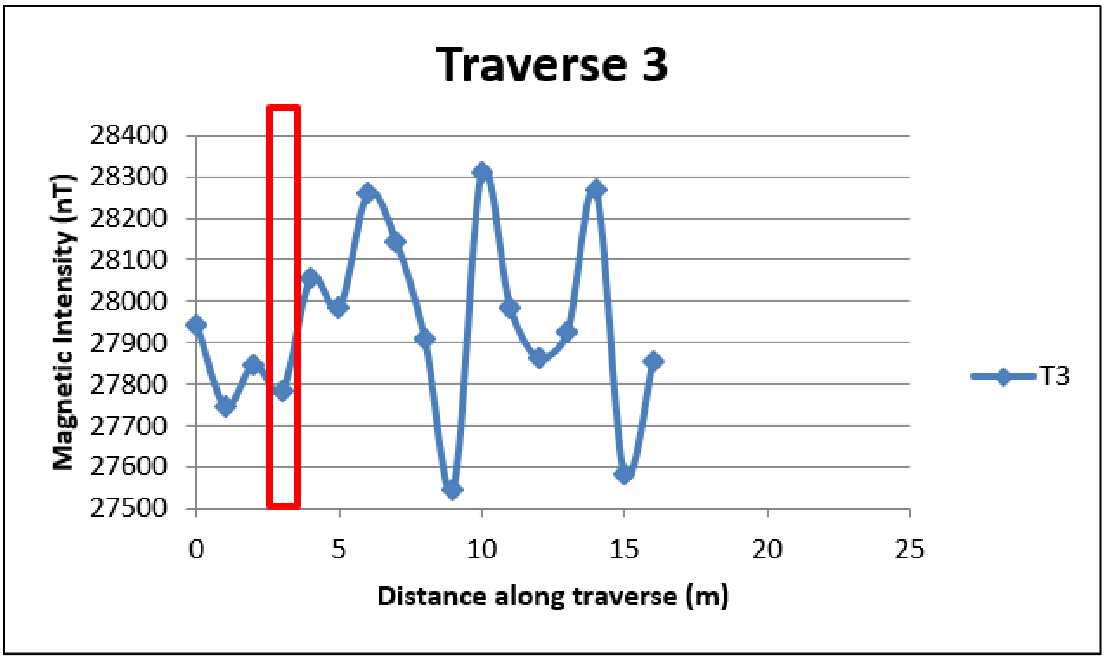

Figure 13:The results of the Geophysical survey with groundwater potential zone highlighted.

The ground and geohydrological conditions given in this report refer specifically based on the available data and information collected and analyzed from the desktop study and field Investigation carried out on site. It is therefore possible that conditions at variance with those given in this report could be encountered elsewhere on site. Luhlaza Advisory and Consulting (Pty) Ltd cannot be held responsible for any irregularities.

7. CONCLUSIONS and RECOMMENDATIONS

The conclusions of the desktop study noted that the Project Area is underlain by unconsolidated sand material with maximum borehole yields of 2-5 l/s which indicates a good presence of groundwater in shallow, unconfined conditions. The Site Walkover further displayed that the groundwater table is shallow due to the flat topography highlighted in Figure 5 and Figure 6.

Due to the shallow water table evident from the average water levels of 2-10 mbgl shown in Table 1, and the most proximal water strike level being 11 m (Table 2), and the elevation of the site being 35 m amsl the recommended depth for drilling would be 11-15 m. Percussion drilling while simultaneously inserting casing could prevent the sand from caving into the drilled hole as this is expected in unconsolidated basement.

The borehole would be able to fulfil its functions if not subjected to over-abstraction as that would lead to saltwater intrusion of the aquifer which would render the borehole inoperative. An alternative of rainwater harvesting during the rainy season and storage into water tanks.

The groundwater in the site is highly influenced by the ocean due to its proximity, and as a result would typically be concentrated with excess Na^+ and Cl^- ions. This type of water is commonly hard water with high EC values. As such, a water treatment plan such as water softening facilities near the borehole and using a reverse osmosis filtration system would need to be put in place with frequent laboratory testing throughout the year to ensure the prevention and mitigation of saltwater intrusion.

8. REFERENCES

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8. USGS (2023) SRTM Digital Elevation Model (DEM), Nasa EarthExplorer Project.

9. APPENDIX A

Table 4: Results of the Magnetometer survey.

Samora Machel Police Station			
Distance (m)	**T1**	**T2**	**T3**
0	28095	27991	27941
1	28517	27981	27747
2	27887	28162	27848
3	28072	28054	27785
4	28135	27868	28055
5	28013	27702	27984
6	28041	28115	28260
7	28057	28099	28143
8	27852	27992	27909
9	27831	27744	27547
10	27911	27531	28312
11	27985	27837	27985
12	28040	28274	27863
13	28177	28034	27924
14	27975	27863	28269
15	27884	28001	27583
16	28096	27901	27854
17	28078	28324	
18	28116	28211	
19	27862	28078	
20	28179	28116	
21	28203	27862	
22	27915,0	28179	
23	27875,0	28203	
24	28214,0	27915	
25		27875,0	
26		28214,0	