



**water & sanitation**

Department:  
Water and Sanitation  
**REPUBLIC OF SOUTH AFRICA**

**GROUNDWATER MONITORING OPTIMISATION WITHIN  
THE UPPER VAAL SUB-CATCHMENT AREA –**

**PART A: EVALUATION AND RECOMMENDATIONS ON THE  
PROPOSED NETWORK AT BOSKOP NATURE RESERVE AREA**

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## ABBREVIATIONS AND ACRONYMS

CA	Catchment Area
DWS	Department of Water and Sanitation
GIS	Geographical Information System
m and mm	metres and millimetre
mMSL	metres above Mean Sea Level
NGA	National Groundwater Archive
RSA	Republic of South Africa

# **PART A: EVALUATION AND RECOMMENDATIONS ON THE PROPOSED NETWORK AT BOSKOP NATURE RESERVE AREA**

## **1. Background**

The Department of Water and Sanitation (DWS) commissioned a study to *Review, Evaluation, and Optimisation of the South African Water Resources Monitoring Network* using AECOM SA group as a consultant or professional services provider (PSP). The AECOM SA group assessed the DWS monitoring network for surface and groundwater programmes in the nine Water Management Areas (WMAs). Upon completion of the study, they made recommendation based on their assessment for new monitoring sites of which the DWS must consider whether to implement them or not. However, before implementation commences these newly recommended sites per WMA needed to be critically evaluated in terms of feasibility and level of priority, based on the outcomes presented by the AECOM SA group.

### **1.1 Aim**

The aim of this report is to technically assess, evaluate and review the existing and proposed groundwater monitoring network in the Boskop Nature Reserve Area and ensure adequate spatial coverage, and select the feasible sites that are more representative to extend the current monitoring network.

### **1.2 Desk Top Evaluation of the Proposed New Monitoring Sites**

The proposed baseline and trendline network monitoring were plotted using both GooglePro and ArcGIS programs. A total of 12 new sites were proposed around the Boskop Nature Reserve Area. These geo-sites consist of 3 new baseline, 3 existing trendline and 6 new trendline monitoring sites (Figure 1). The new baseline associated with high yield aquifers and additional monitoring for surface-groundwater interaction for eyes/springs. The 3 existing trendline are current groundwater quantity monitoring sites, namely: C2N0002, C2N0104 and C2N0003 station. Each proposed site was evaluated for factors such as accessibility to site and drill, long-term accessibility for monitoring purposes, applicability for the type of monitoring and possible existing replacements.

## **2. Study Area and Data Analysis**

The Boskop Nature Reserve is situated about 20 kilometres north of Potchefstroom Town in the North West Province, Republic of South Africa (RSA). The Nature Reserve is bordered between the C23G and C23H sub-quadernary area. The proposed geo-

sites are scattered throughout 3 sub-quaternaries: C23G, C23H and C23K; within 7.5km radius apart. The Boskop Dam (C2R001) was constructed by DWS in 1959 and third of this dam located with the reserve. The dam is mostly fed by the Mooi River, which is one of the latest mid-tributaries of the Upper Vaal River. The Mooi River has reliable groundwater supply from karst aquifer of the Malmani Formation (e.g. Gerhardminnebron Eye) especially during dry seasons. The main purpose of the dam is for irrigation and domestic use. The Boskop Nature Reserve has a surface area of 3000 hectares of rolling grasslands vegetation that provide habitat to Zebra, Black Wildebeest, Eland, Springbok, Giraffe and Blesbok.

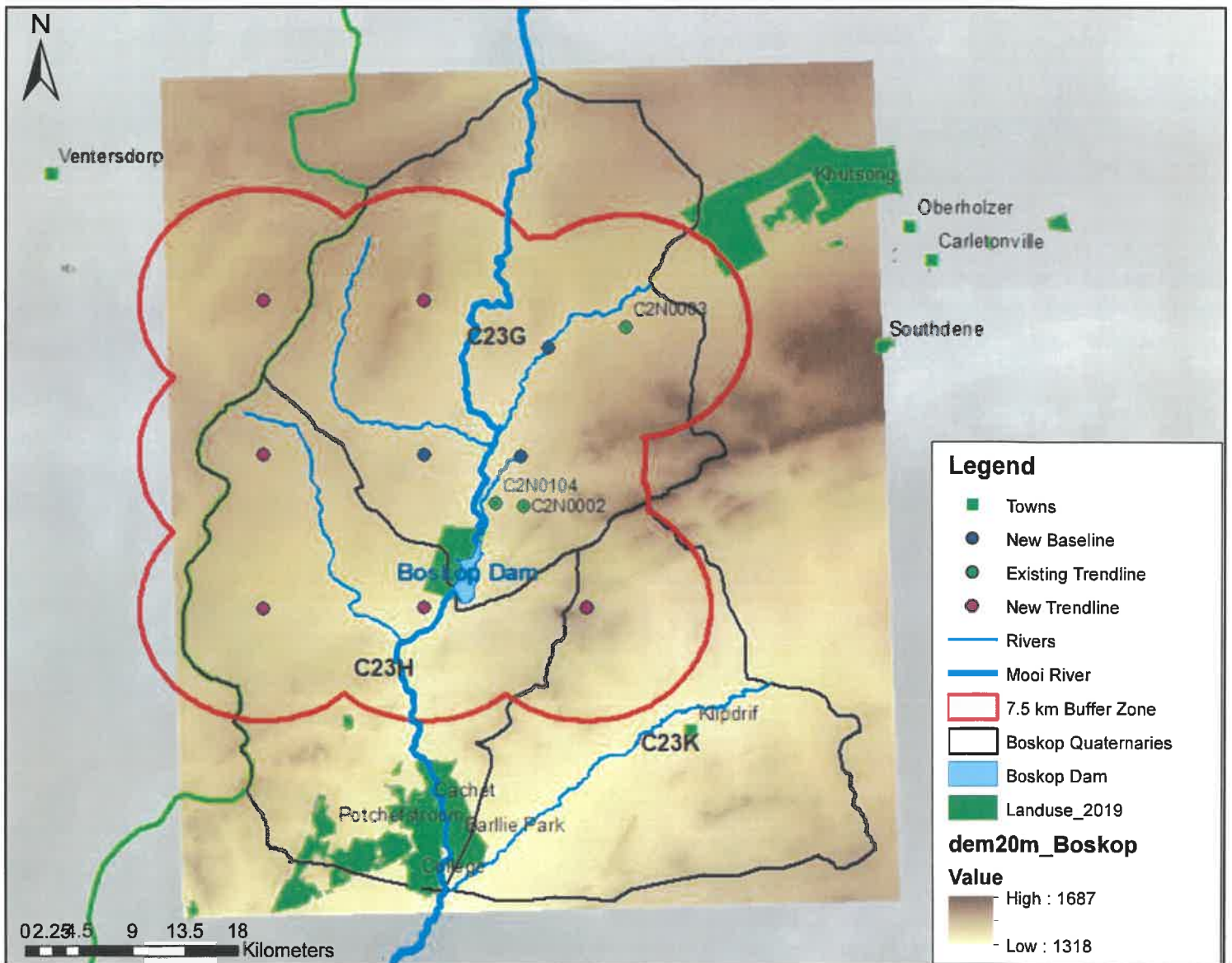


Figure 1: GIS map location showing the proposed and existing geo-sites around Boskop Nature Reserve Area

## 2.1 Climate

Precipitation, namely in the form of rainfall, provides the raw input of water to a catchment but its availability for supporting river flows, replenishing aquifer storage and supporting water supplies depends on catchments conditions such as soil type, geology, climate and land use that affect catchment runoff properties (Brassington, 1998). The climate in the C23F sub-catchment area is sub-tropical dry savanna, with the mean annual evaporation at ~ 900 mm and far exceeding the rainfall of ~600 mm (Jury 2016). The average temperature in this area range between 15 - 21°C in summer and drop to 12°C in the winter (DWAF2, 2002). The C2E009 DWS meteorological station (situated in Boskop Dam) recorded the highest rainfall event of 145.73 mm on the 25 -26 January 1981. The second highest rainfall recorded was 141.33 m on the 02 - 03 January 2011 (Figure 2). The lowest rainfall records were observed during the drought event of 2016/17. The rainfall records also show a very correlation with the nearby C2E015 station at Klipdrift Dam.

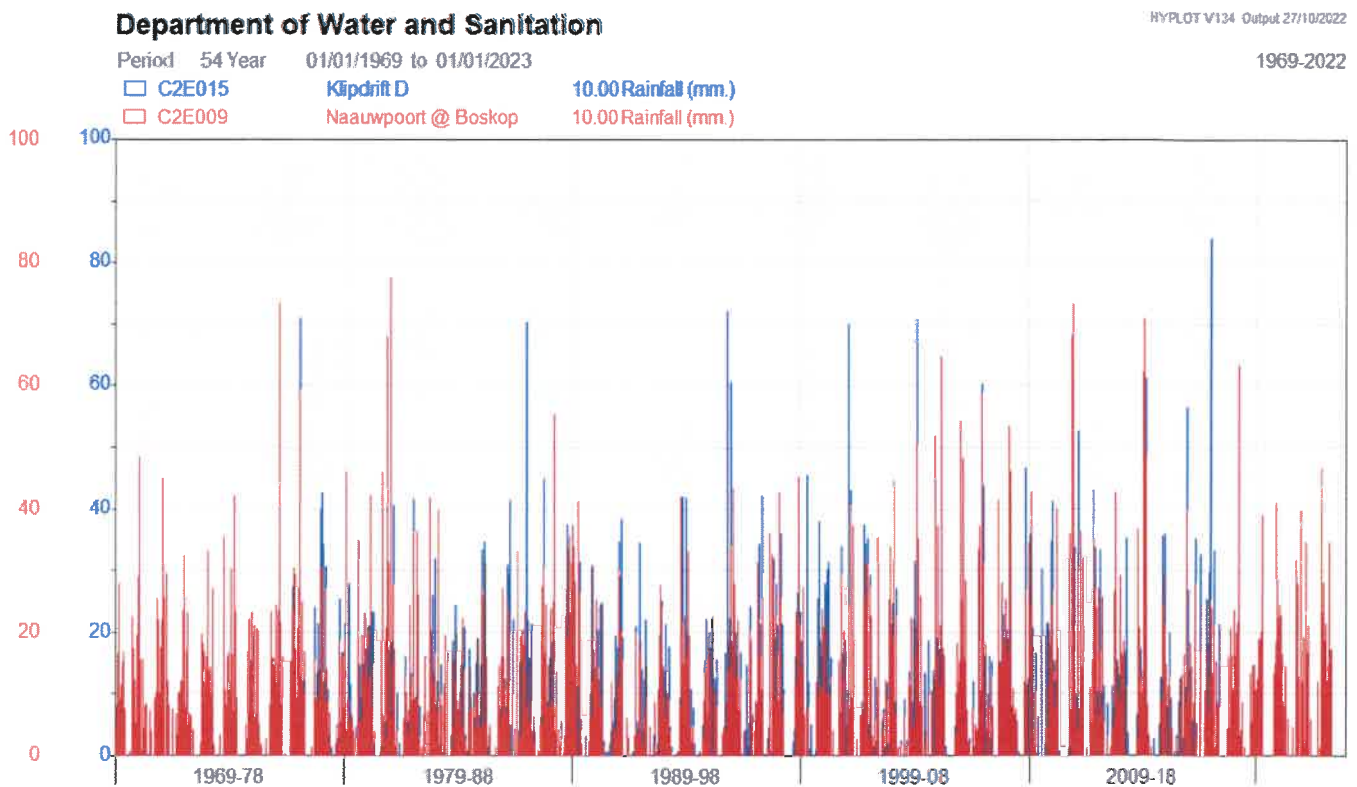


Figure 2: Continuous rainfall data from at C2E009 and C2E015 meteorological stations

## 2.2 Geology and Geohydrology

The groundwater compartments are underlain by the Malmani Formation and Timeball Hill Formation which belongs to the Pretoria Subgroup of the Transvaal sequence. The

Pretoria Subgroup formations are separated or intersected by the Pretoria Syenite dyke/sills (diabase) (Naidoo, 2014). The Timeball Hill Formation is composed of a coarsening upward carbonaceous shale, siltstone (fine grained sandstone) and hematite oolite-bearing quartzite, overlain by conglomerate, quartzite and shale of the Boshhoek Formation (Coetzee, 2009). Part of the site is underlain by a diabase (basaltic lava) sill of Hekpoort Formation that was intruded into the shale sequence (Aurecon, 2015).

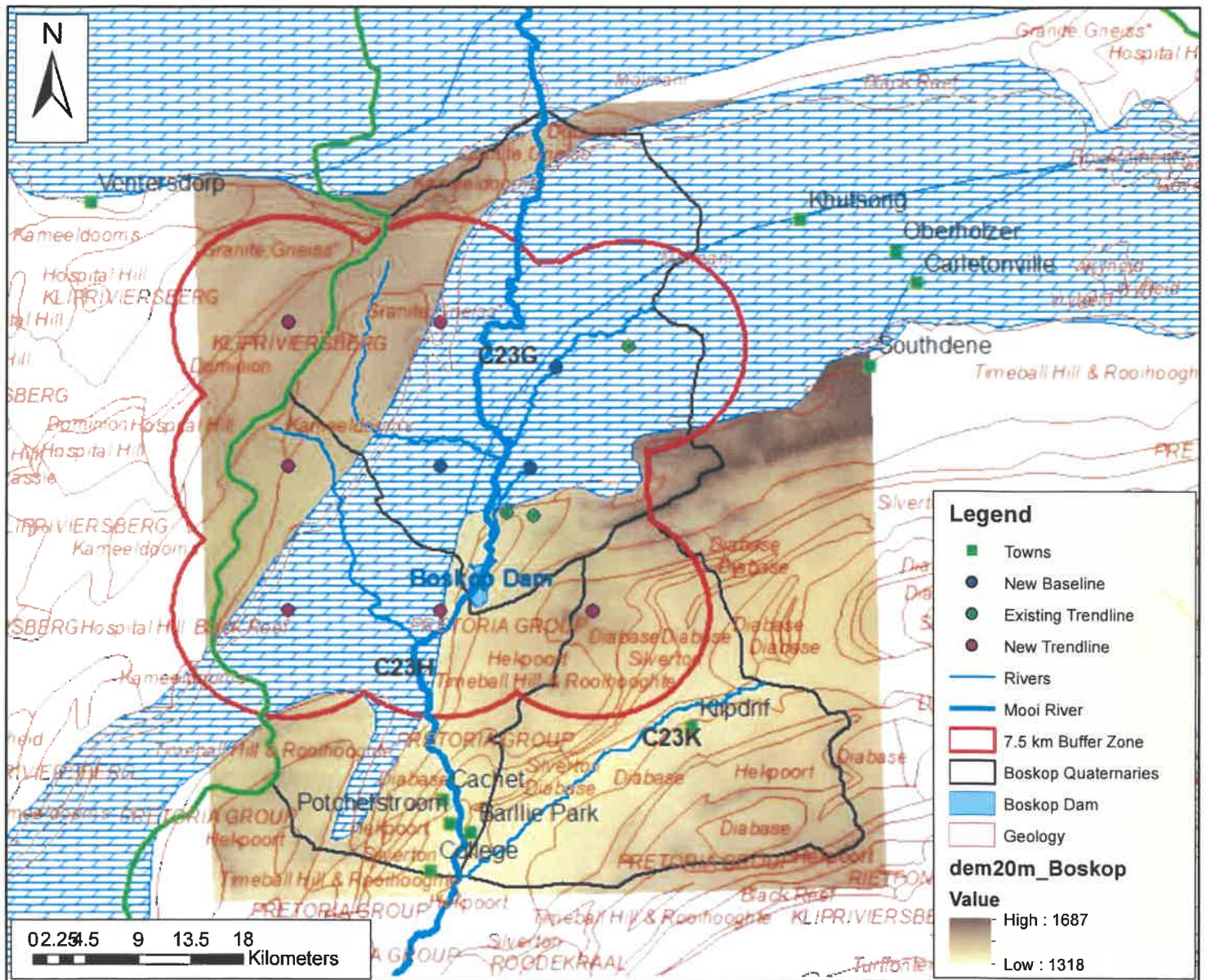


Figure 3: The geological formations and structures at C23F Sub-catchment area (sourced: a 1:250 000 geological map)

The dolomites have been tectonically deformed, faulted and are intruded by volcanic dykes and other structures (Johnson *et al.*, 2006). They are thought to have been deposited in shallow marine environments as a chemical precipitate and in association

with algal mats and structures called stromatolites (McCarthy and Rubidge, 2005). In outcrop, dolomite is a fairly hard, greyish to brown rock which may weather to a surface “elephant skin” texture. They are divided into different formations based partly on the chert content. The North West dolomites are made up of the Eccles, Lyttelton, Monte Christo and Oaktree Formations, which together comprise the Malmani Subgroup of the Chuniespoort Group. The Eccles and Monte Christo Formations are chert-rich, whilst the Lyttelton Formation is chert free. The chert-rich Eccles and Monte Christo Formations are more susceptible to weathering and as a result have higher coefficients of storativity and transmissivity, and are better aquifers (Holland *et al.*, 2009). The Monte Christo Formation can be divided into three sub-formations or members (*Table 1*). The entire sequence dips to the north underneath the Pretoria Group.

*Table 1: Formations of the Malmani Subgroup (DWAF, 2006)*

Symbol	Formation	Description
Vf	Frisco	Stromatolitic dolomite, chert-poor dolomite, shale
Ve	Eccles	Interbanded dolomite and chert
VI	Lyttelton	Chert-poor dolomite
Vmo <sub>3</sub>	Monte Christo	Chert-rich dolomite
Vmo <sub>2</sub>	Monte Christo	Interbanded chert and dolomite
Vmo <sub>1</sub>	Monte Christo	Oolitic chert and dolomite
Vo	Oaktree	Chert-poor dolomite

## 2.3 Topography and Land use

The geomorphology of a region reflects the historical processes forming the land and water features within the catchment. Many geomorphic features can be described by the surface elevation and drainage network. The topography influences how water is precipitated, evaporated, stored and routed through the landscape. A topography driven flow system is one in which groundwater flows from higher elevation (recharge area) to lower elevation (discharge area). The soils in the upslope are more likely to be eroded and their topsoil as compared to fertile downslope where deposition occurs. The 20-meter elevation contours and spot heights data were obtained from the National Geo-spatial Information (NGI) section in the Department of Rural Development and Land Reform. Figure 1 shows the derived digital elevation model (DEM), where the elevation ranges vary from 1687 m above sea level (MSL) at the western and north eastern boundaries to 1318 m at the southern boundaries. The soils are sandy silt-loam and the groundwater recharge rate in this area is estimated to be

43.1 mm/month (Middleton and Bailey, 2009). The recharge is enhanced by the grassveld vegetation in C23F sub-catchment area. The land use is dominated by seasonal agricultural crop farming, which is likely to influence soil erosion during dry/windy season.

## **2.4 Available Groundwater Data**

### **2.4.1 Boreholes or Geo-sites**

The Malmani Formation in this area (C23G) is well represented by the C2N0003 borehole station on the eastern side (*Photo 1*). The Timeball Hill Formation is also monitored by C2N0002 and C2N0104 borehole stations (*Photo 2 & 3*). The construction of the boreholes is durable and reliable since it lasted for more than four decades (see photo 1, 2, 3 & 2). There are currently no instrumentations installed inside the monitoring station. However, in the past some of the boreholes were installed with the autographic chart recorders which are no longer functioning, but data is stored safely in the archives. Since the dolomite is unstable the boreholes were cased all the way down with a steel pipe casing. It should be not that Farmers took advantage of some of DWS borehole by installing windmills (some submersible pump) but it is still possible to carry out quantity monitoring. As a result, the boreholes are not sealed tops and thus making it very difficult from prevent bees/termites from building shelter inside the wells. The sanitary seal of concrete slaps is still good condition to supports the sides of the holes and protecting water from contamination. The new proposed baselines and trendlines groundwater monitoring sites will be a good representative of the geological formation network once implemented.



*Photo 1: View of C2N0003 existing site.*



*Photo 2: View of C2N0002 existing site.*



*Photo 3: View of C2N0104 existing site.*

## 2.4.2 Groundwater Level Data

The groundwater level measurements are collected monthly at the three existing geo-sites. The **C2N0002** station has been monitored since 1957, water level was ranging between -1 to -9m until June 1968. This borehole once experienced the gap from 1968 to 2006, after the gap period water levels started to decrease from -18 to -29m. The **C2N0003** has been monitored since 1961 and the autographic chart recorder was installed to early 1970. The groundwater table fluctuates between -15 to -28m. The monitoring at this borehole also experiences massive gap from 1967 to 2006 and the automatic recording was reduced to monthly monitoring after the gap. The water levels started to decrease -23 to -29m. The reduction could be due to agricultural abstraction as these areas entirely using groundwater for production. The **C2N0104** station has undisturbed monitoring records from 1963 with no gap, water level is ranging from -13 to -18m. The variation in data can also be attributed to groundwater abstraction from the windmill.

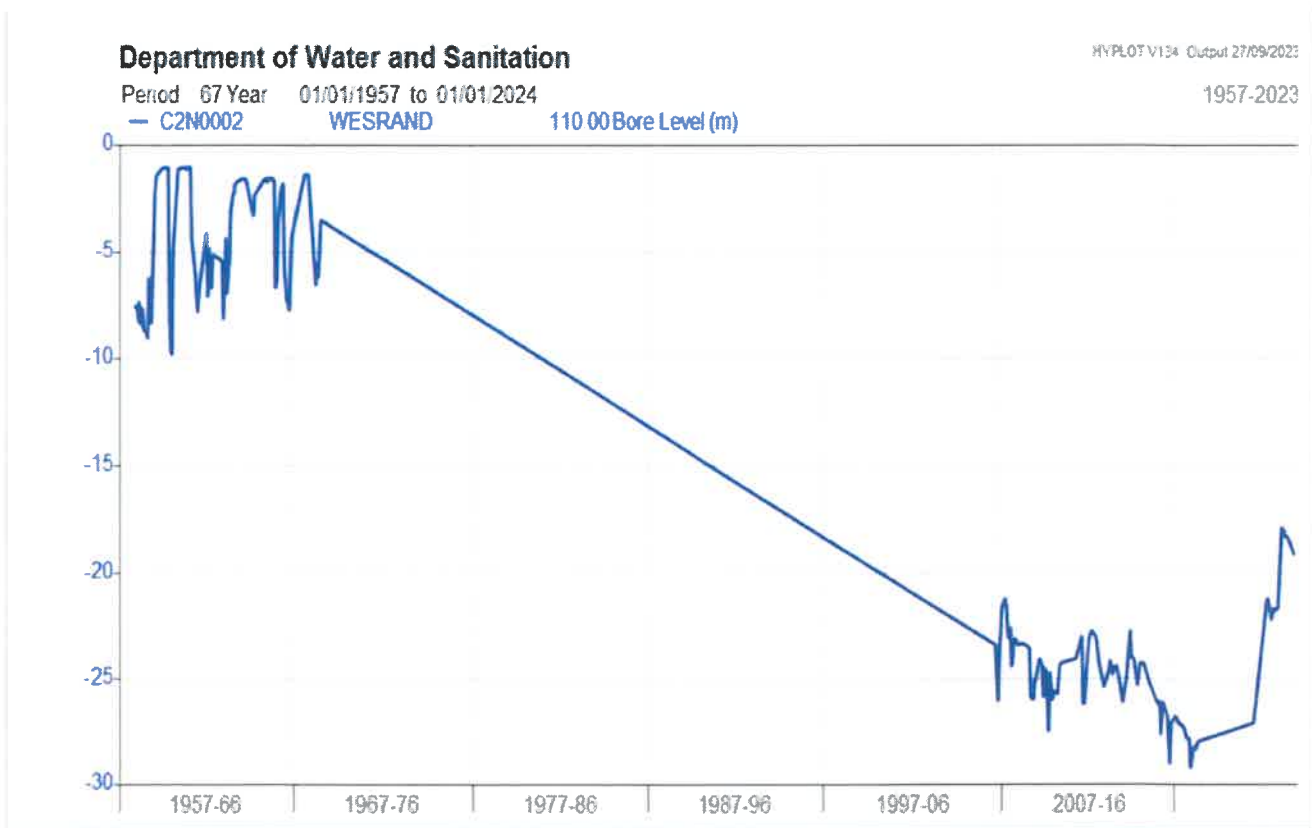


Figure 4: Showing continuous groundwater level series of the C2N0002 station

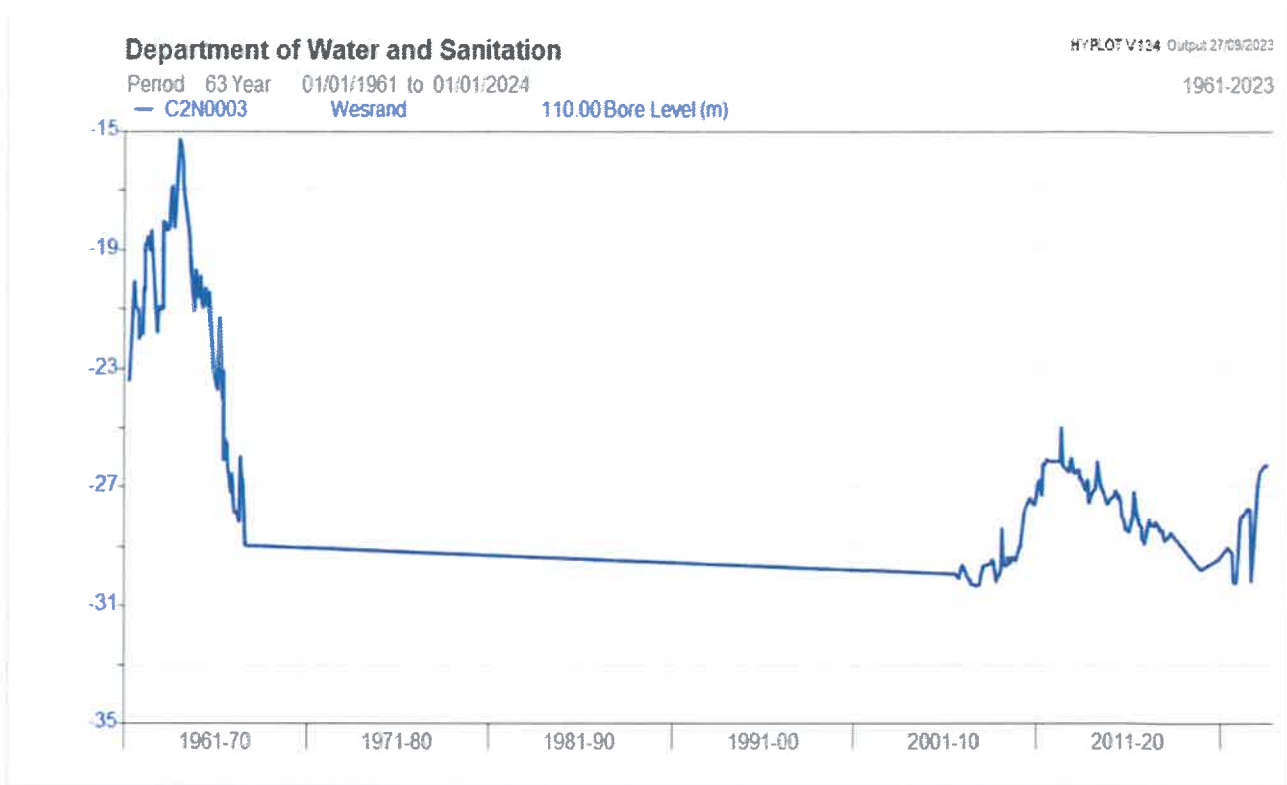


Figure 5: Showing continuous groundwater level series of the C2N0003 station

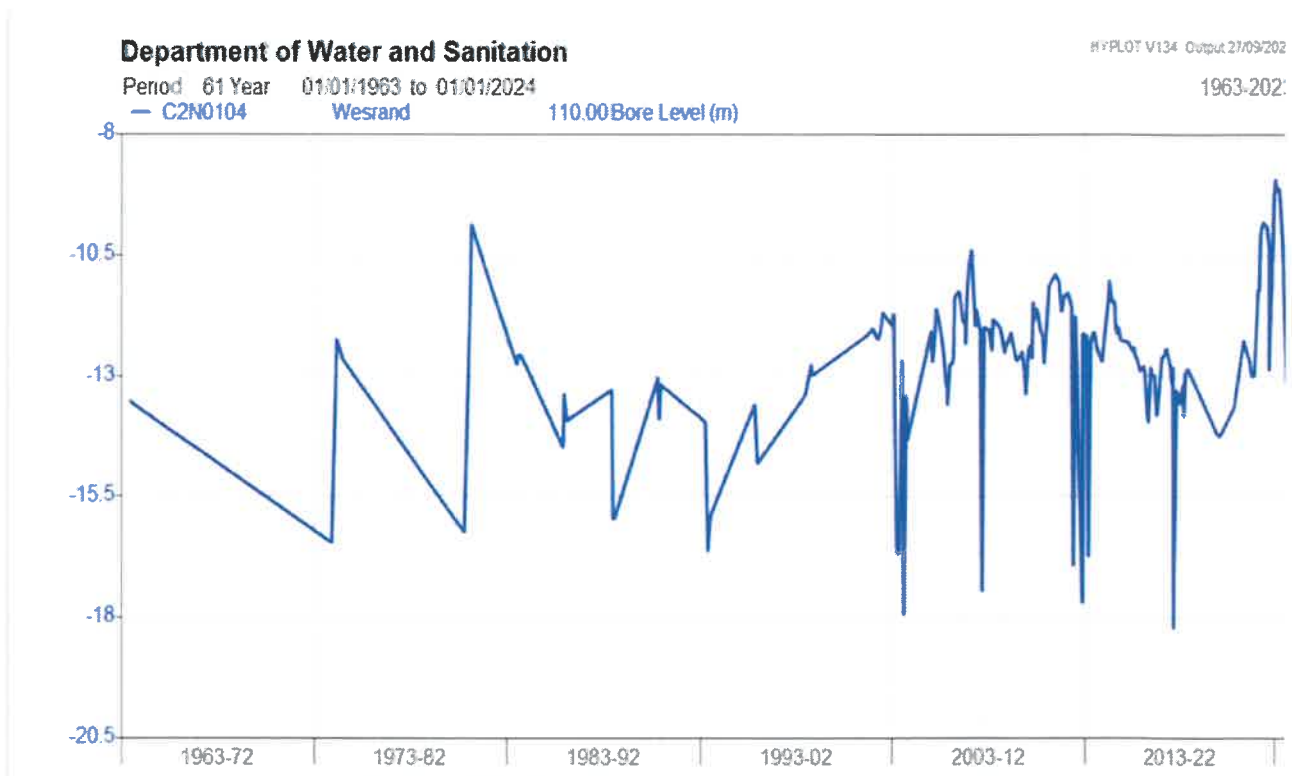


Figure 6: Showing continuous groundwater level series of the C2N0104 station

### 3. Ground Findings

A total of 10 new baseline/trendline proposed geo-sites were visited on 20 - 21 July 2023 within the Boskop Nature Reserve Area. These consist of 4 new baseline, 3 existing DWS borehole and 3 new trendline monitoring sites. The proposed sites are identified by numbers (e.g. 252, 253, etc.), see *Appendix A*. The sites were placed within a 7.5 km radius from each other. Each proposed site was evaluated for factors such as accessibility to site and drill, long-term accessibility for monitoring purposes, applicability for the type of monitoring and possible existing replacements. It should be noted that three proposed monitoring points, namely: 252, 253 & 254, were unable to be inspected mainly due to lack of time.

#### 3.1 Site Inspection on 20 July 2023

- The first point visited was C2N0002 borehole station, which is an existing DWS monitoring point, located at -26.510108 S and 27.152371 E. This site is located inside a farm and during the field visit a submersible pump was installed inside the well and therefore we were unable to monitor the groundwater level.
- The second point inspected was C2N0104 borehole station, which is also an existing monitoring point, located at -26.400919 S and 27.215302 E. The borehole is also located in a private farm and the owner is aware of the monitoring taking place in his premises. The water level was recorded as 10.88m at 14:09 pm.
- The last point visited on this day was C2N0003, which is also an existing DWS monitoring point, located at 26.507419 S and 27.136772 E. The borehole is located inside the private farm. The entrance to the borehole must be arranged with the owner. The permission was granted after two hours of waiting and upon his arrival he mentioned that going forward he is going to utilise the borehole for water production. This is because the farmer thinks the borehole belongs to him and not the department. The groundwater level was recorded as 26.29m at 16:10 pm.
- The three existing DWS boreholes are in good condition within the private property, where some boreholes need prior access arrangement with the owners. The C2N0002 and C2N0104 borehole station have submersible pumps installed. All the boreholes need painted identifying poles so they can be easily identified even if the owner of the farm are not accompanying the DWS officials for monitoring.

*Table 2: Groundwater level data collected during site visit at Boskop Area*

Geo-sites	Reading (m)	Date	Time	Remarks
C2N0002	-	20/07/2023	13:45	Pump installed and collar not measured
C2N0003	26.29	20/07/2023	16:10	Collar not measured

C2N0104	10.88	20/07/2023	14:09	Pump installed, but was not pumping and collar not measured
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### 3.2 Site Inspection on 21 July 2023

- The first point visited was **263**, which is a proposed for trendline monitoring and it is located at -26.3863 S and 26.995434 E. This site appeared to be not suitable for trendline monitoring since it is located inside the locked private property (*Photo 4*). However, the monitoring point can be established outside the property not far from the gate next to the road for easy access at -26.394140 S and 27.007241 E, at an elevation of 1511 mMSL. There is no NGA borehole near this proposed site.
- The second point visited was **264**, which is a proposed for trendline monitoring and it is positioned at -26.386219 S and 27.093124 E. The point is located inside a farm and there was no problem with access road. There is suitable open area within the farm at -26.382271 S and 27.100929 E at an elevation of 1481m where a monitoring point can be established (*Photo 5*).
- The next point visited was **262**, which is proposed for baseline monitoring and it is placed at 26.4144 S and 27.16775 E. This point is not suitable for establishing a groundwater monitoring because it is positioned inside the private property (*Photo 6*). The alternative position to establish the monitoring point is recommended at 26.435702 S and 27.149212 E. at an elevation of 1413 mMSL. There is NGA boreholes located nearby but is currently in use for livestock production (*photo 7*).
- The next point visited was **259**, which is proposed for baseline monitoring and is located in a private property. This site is not suitable for baseline monitoring due to accessibility (*photo 8*). There is no new recommended point for this proposed site as it is less than a kilometre distance from the 262 proposed site.
- The next point visited was **260**, which is a proposed baseline monitoring and is located inside private property with locked gates (*photo 9*). This site is it not suitable for baseline monitoring mainly due to accessibility. However, new a monitoring point can be established outside the facility across the road at -26.464908 S and 27.115036 E, at an elevation level of 1411 mMSL, but the distance of how far from the road can be determined during the geophysics with the consultation with Sanral/Municipality for their standards not to be compromised. There is no NGA borehole located close to the proposed site.
- The next point visited was **261**, which is a proposed for trendline monitoring and it is located inside the private property with locked gates, at -26.478923 S and 26.995517 E. The site appeared to be not suitable position for trendline monitoring due to accessibility (*photo 10*). There is also an NGA borehole observed closer to the proposed site, but it is currently in use for water supply in the farm (*photo 11*)



*Photo 4: View of 263 proposed site.*



*Photo 5: View of 264 proposed site.*



*Photo 6: View of 262 proposed site*



*Photo 7: View of NGA near 262 proposed site*



*Photo 8: View of 259 proposed site*



*Photo 9: View of 260 proposed site*



Photo 10: View of 261 proposed site



Photo 11: View of NGA site near 261

#### **4. Conclusion**

Proposed monitoring sites identified by DWS (2016) report at Boskop Nature Reserve area, are mostly located inside the farms that are privately owned. The NGA boreholes which are located close to the proposed areas are mostly used for farm production.

## 5. Recommendations

Drilling is recommended outside the properties as most of the proposed points are located inside private properties. NGA boreholes which are located close to the proposed sites are in production use. The following are recommended:

- Proposed point number **263** is not suitable for trendline monitoring mainly because it is located inside the private farm. However, the monitoring point can be established outside the property not far from the gate next to the road for easy access at -26.394140 S and 27.007241 E, at an elevation of 1511 mMSL.
- Proposed point number **264** is located inside a farm and there was no problem with access road and there is suitable open area within the farm at -26.382271 S and 27.100929 E at an elevation of 1481m where a monitoring point can be established
- Proposed point number **262** is not suitable for trendline monitoring because it is located inside the private property (*Photo 6*). The alternate position to establish the monitoring point is recommended at 26.435702 S and 27.149212 E. at an elevation of 1413 mMSL.
- Proposed point number **260** is not suitable for baseline monitoring because it is located inside the private property. However, new a monitoring point can be established outside the facility across the road at -26.464908 S and 27.115036 E, at an elevation level of 1411 mMSL.
- Proposed point number **261** is not a suitable trendline monitoring because it is located inside the private property with locked gates (*photo 10*). New monitoring point can be established outside the property for easy access at -26. 26.482506 S and 26.994266 E, at an elevation level of 1479 mMSL.
- Proposed point number **272** is located inside the farm therefore it is not suitable for trendline monitoring but drilling is recommended outside the farm at - 26.221145 S and 27.453664 E, at an 1572m elevation level 1572 mMSL.

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# Appendix A

