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A synopsis of groundwater level status assessment for the hydrogeological regions of South Africa

Groundwater level assessments

REPORT STATUS

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1. Introduction

The Department of Water and Sanitation is mandated to protect develop and conserve water resources of the country. This is acknowledged by the National Water Act (Act 36 of 1998). The act further states that monitoring of the water resources is required and further outlines the number of required monitoring programmes to be established are outlined. Groundwater resources form part of these monitoring programmes to be established. Strides have been made over the years with monitoring of groundwater resources for the country, with datasets (albeit having monitoring gaps) dating back more than 40years. Several information products which are the conversion of these datasets into information have been produced, aiding the public, the scholars and groundwater consultants with understanding of basic groundwater information (quality and quantity) at national scale.

As with any data gathering programme, there will always be areas for development needed when it comes to analysis and interpretation of the datasets gathered to expand the audience benefiting from the information. This starts with internal stakeholders (whom are the data gatherers so that they get to understand the latest information about groundwater resources and where active effort on management is required. This report aims to interpret groundwater trends over identified periods to ascertain whether any active management efforts or interventions are required.

South Africa is subdivided into sixty-four (64) hydrogeological regions, which define the groundwater units based on unique hydrogeological characteristics. These have been utilized to interpret the groundwater datasets. They crosscut the catchment and provincial boundaries, as geology or groundwater knows no catchment of provincial boundaries. These hydrogeological units, however, give a better understanding of the groundwater performance for those regions.

1.1 Report Objectives

The object of this report is to summarize the detailed results of the groundwater level status assessment as described in the following reports:

- Groundwater levels status assessment for the Hydrogeological Regions in the Eastern Cape and KwaZulu- Natal Provinces- volume 1
- Groundwater levels status assessment for the Hydrogeological Regions in the Western Cape, Northern Cape and Free State Provinces- volume 2
- Groundwater levels status assessment for the Hydrogeological Regions in the Gauteng, Northwest, Mpumalanga and Limpopo Provinces- volume 3

To identify the areas that require attention where impacts to groundwater quantity prevail and possible give recommendations for interventions.

2. Methodology

The existing datasets from the groundwater database (the National Groundwater Archive) were extracted with the purpose of analyzing water level trends of the monitoring boreholes from the various hydrogeological regions alluded to earlier. The processing of datasets was primarily done on MS Excel. The initial plan was to utilize data dating back to 2015. However, this was not possible with other hydrogeological regions. Some of the shortcomings included a delayed comprehensive monitoring programme which commenced recently. In some instances, the gaps were too big to close them using both the forward and backward data patching method that MS Excel offers. A summary of step by step into ensuring completeness and accuracy of datasets involved:

- Assessing the data gaps and how best they could be closed.
- Gap closure/ data patching utilizing the forecasting method to obtain consistent trends. This was limited to small gaps using linear regression to project future data points along a line that best fits the historical data.
- Data smoothing, utilizing the exponential method to define clearly the trends. This forecasting technique for time-series data assigns exponentially decreasing weights to past observations, placing more importance on recent data than older datasets. The utilized statistical formula is as follows:

  $s(t) = \alpha x(t) + (1-\alpha)st\text{-}1$

  Where:

  $s(t)$ is the smoothed value (or forecast) for the current period.

  α is the smoothing factor.

  $x(t)$ is the actual observed value for the current period.

  st-1 is the smoothed value (or forecast) from the previous period.

Subsequently, hydrographs could be generated. The water level elevations were chosen as these have a better-defined reference point i.e. the mean sea level. These hydrographs were coupled with zoom-in analysis of level fluctuations, setting the initial water level where dataset starts (as the reference point) to determine the gains or losses, indicated as a declining or a rising trend, over the assessment period.

Because the emphasis was on hydrogeological regions, the individual borehole trends were aggregated and an average water level trend for the hydrogeological region was determined using the formula:

$$Average\ GWL = \sum (GWL\ of\ individual\ wells) / Number\ of\ wells$$

This allowed for determination of the groundwater level trends with reference to the selected background point, determining whether there is a general water level decline or a rise and how steep or gradual it is.

3. The results

3.1 The Eastern Cape and KwaZulu-Natal hydrogeological Regions

With the methodology set out, the first areas tackled included the hydrogeological regions covering the Eastern Cape and KwaZulu Natal Provinces. These are geographically indicated in **Error! Reference source not found.**, with provincial boundaries.

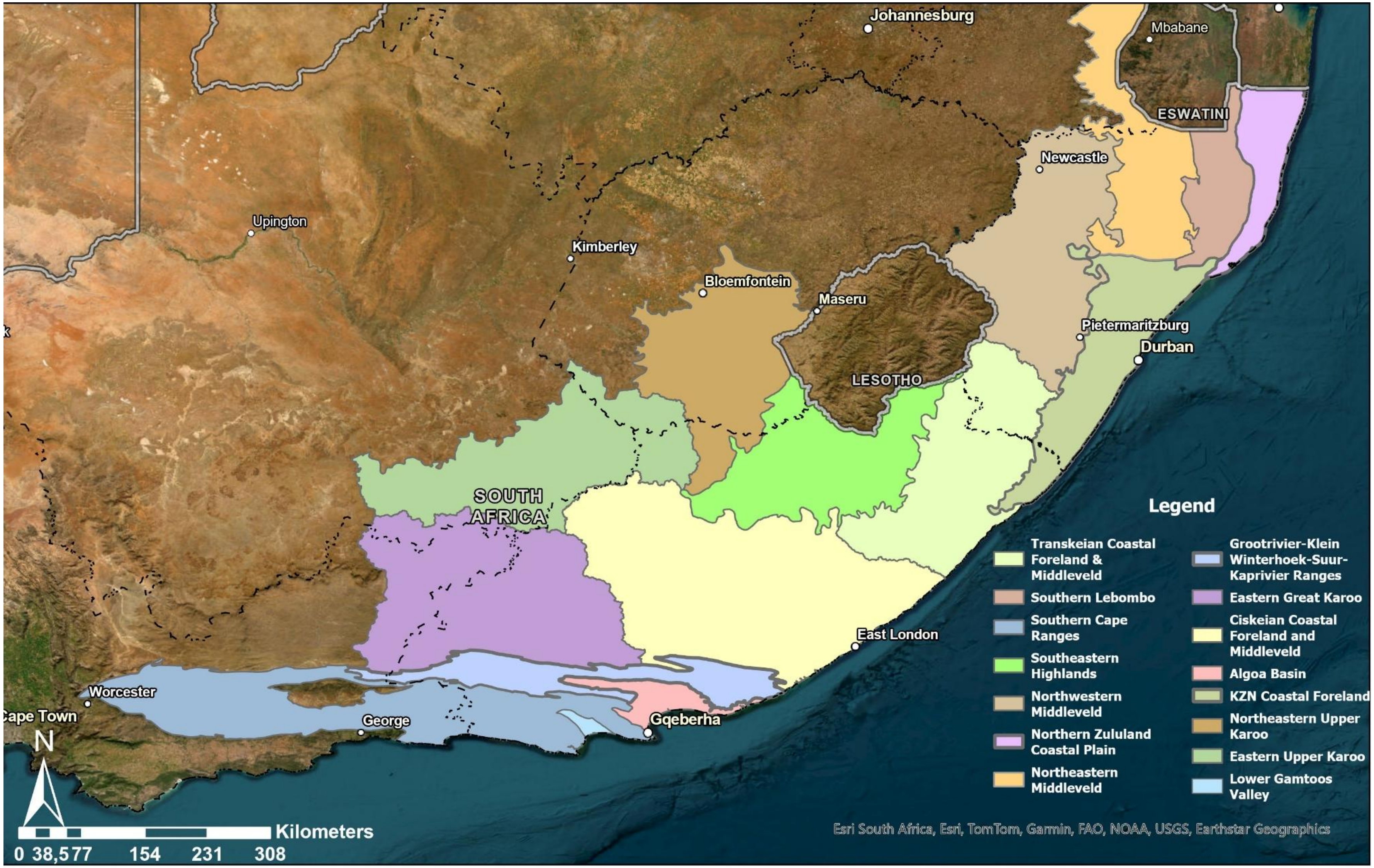

Figure 1: Hydrogeological regions covering the Eastern Cape and KwaZulu Natal Provinces.

The mean groundwater level drawdown trends for each of the regions were graphed to indicate the overall picture for the 2 provinces. Figure 2 indicates the performance of groundwater for the hydrogeological regions in the KwaZulu-Natal and the Eastern Cape over a 10-year observation period. What is evident from the graph is that the groundwater resources for the two provinces experienced a decline in water availability between November 2016 and April 2022 in response to environmental stressors/ low rainfall the two provinces experienced. The impacts varied from region to region as Figure 2 shows that water level decline was prominent in some regions while others experienced a slight decline. The Grootrivier-Klein Winterhoek-Suur-Kaprivier Ranges, the Ciskeian Coastal Foreland and Middleveld, the Algoa Bay, the Eastern Great Karoo, the Southern Cape Ranges and to a lesser degree the Transkeian Coastal Foreland and Middleveld were largely impacted over the period but have since recovered. The water level assessment for Algoa Bay and the Grootrivier-Klein Winterhoek-Suur-Kaprivier Ranges hydrogeological regions indicated more than just environmental stressors on their groundwater levels. The water level drawdown for these regions barely replenished even when good rains were prevalent in the area. A groundwater investigation in these two regions is required to understand the impacts better.

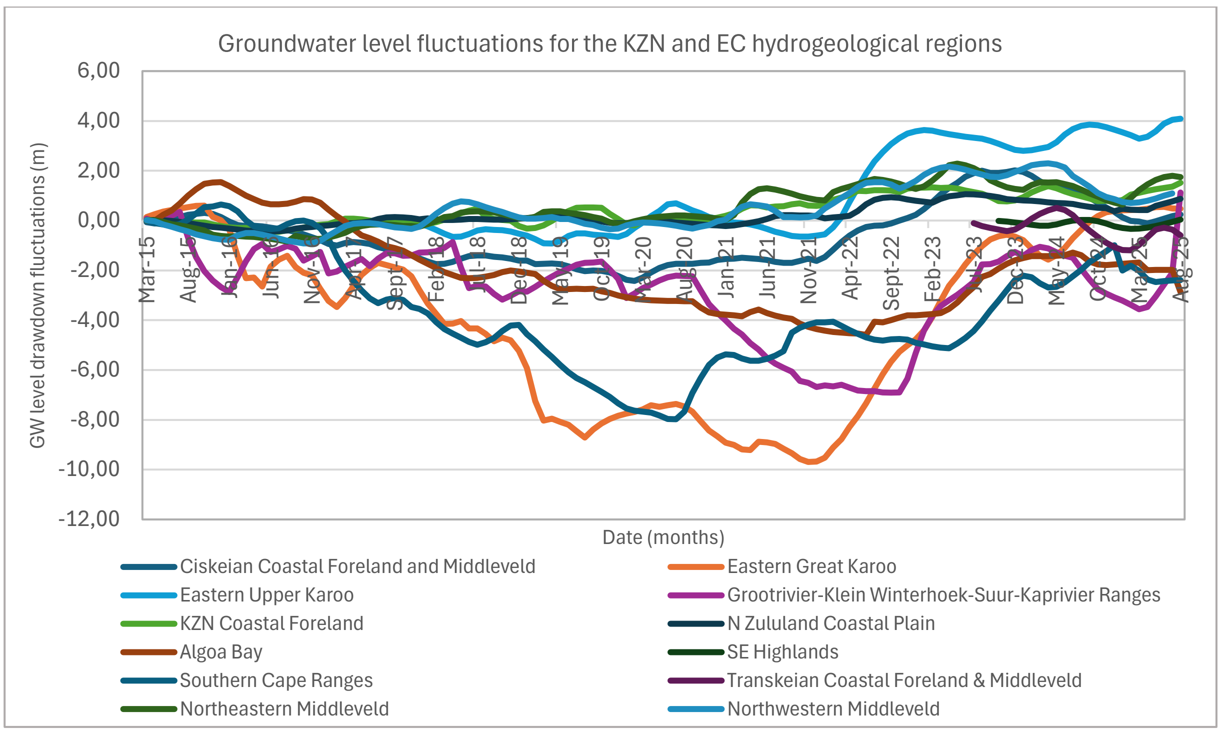

Figure 2: Groundwater level status for the hydrogeological regions in Eastern Cape and KwaZulu-Natal Provinces

The second batch of analysis was for the Western cape, The Northern Cape and Free State Provinces as shown in Figure 3. The results outline the outcomes of the water level drawdown assessments conducted for the hydrogeological regions in the provinces of the Western Cape, the Northern Cape and the Free State. Thirty-eight hydrogeological regions make up the three provinces mentioned above. The extent and coverage of these hydrogeological regions is shown in Figure 3**.**

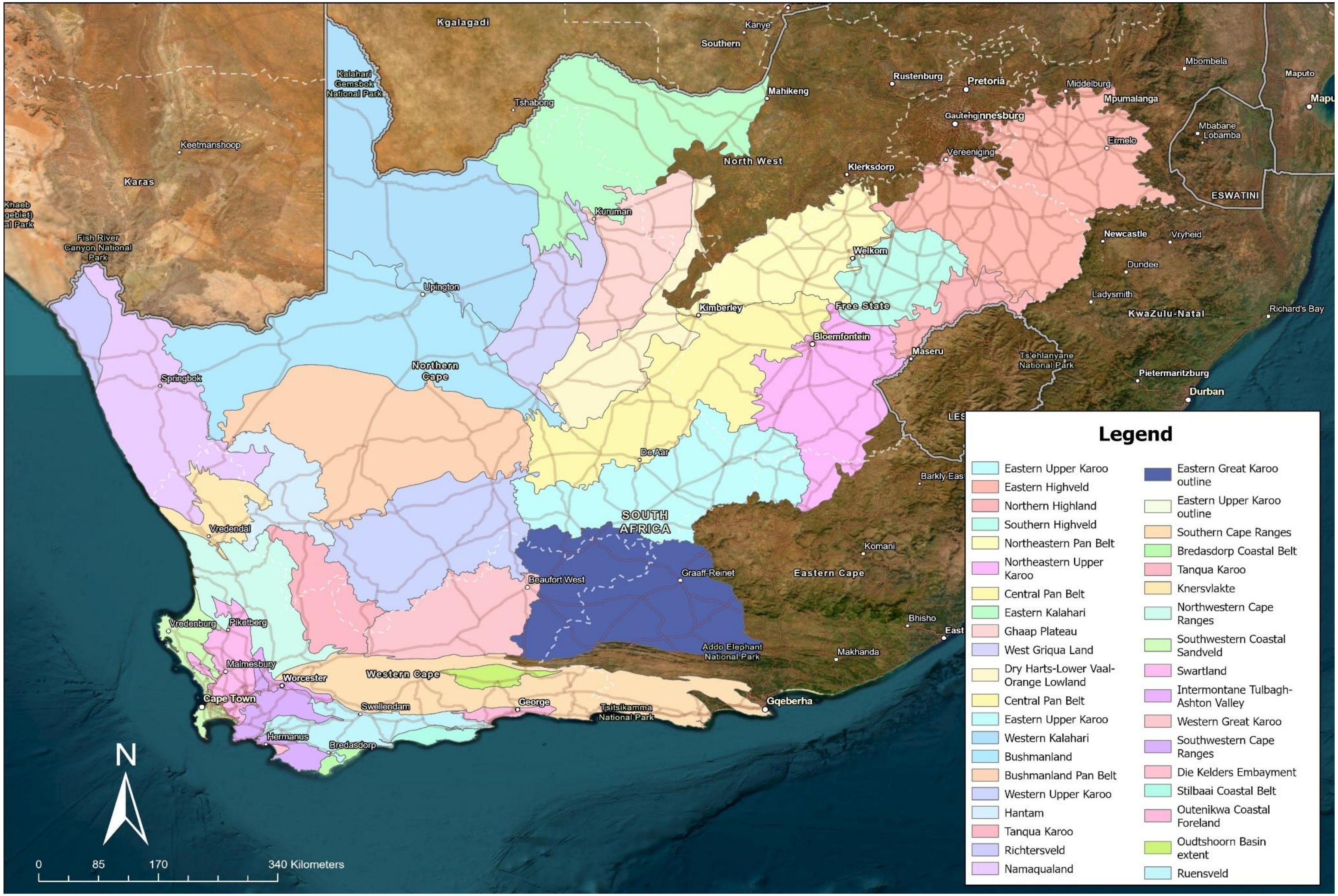

Figure 3: Hydrogeological region for the Western Cape, Northern Cape and Free State Provinces

3.2 The Western Cape, Northern Cape and the Free State hydrogeological Regions

The mean groundwater level drawdown trends for the Western Cape regions are presented in Figure 4. Water level declines were recorded over the observation period, marking a period of low rainfall. Few regions such as Oudtshoorn Basin and the Southern Cape Ranges were not as impacted as others. These two maintained positive trends for the most part of the observation period while other regions reported downward trends of up to 8m decline. It was until late 2021 that groundwater levels for all these regions had a fluctuating upward trend in response to rainfall recharge. This is the prevailing trend to date. The water level rebound (drawdown) in the Knersvlakte has been slow compared to other regions, but the latest information shows that it is gradually improving, catching up with other regions**.** Although the latest rains for the regions have shown a reduction in intensity, the groundwater levels still reflect an upward trend indicating a delayed response to rainfall recharge. The latest information for the Southern Cape reflects a downward trend, calling for close monitoring for a region whose water level drawdown trends never fully recovered.

For the Northern Cape and Free State Provinces (Figure 5) the hydrogeological regions that were most affected by historic groundwater level declines are Hantam and the Bushmanland Pan Belt (both in the Northern Cape). Other regions maintained horizontal, slightly upward trends until late 2021 where a prominent rise was observed (including the groundwater levels for the two regions Hantam and the Bushmanland Pan Belt, which were impacted severely previously), lasting until early 2024. Thereafter, a gradual decline lasted until March 2025. The latest water levels are marked by upward trends for most regions save for Bushmanland and Bushmanland Pan Belt. A closer observation is needed for these two regions.

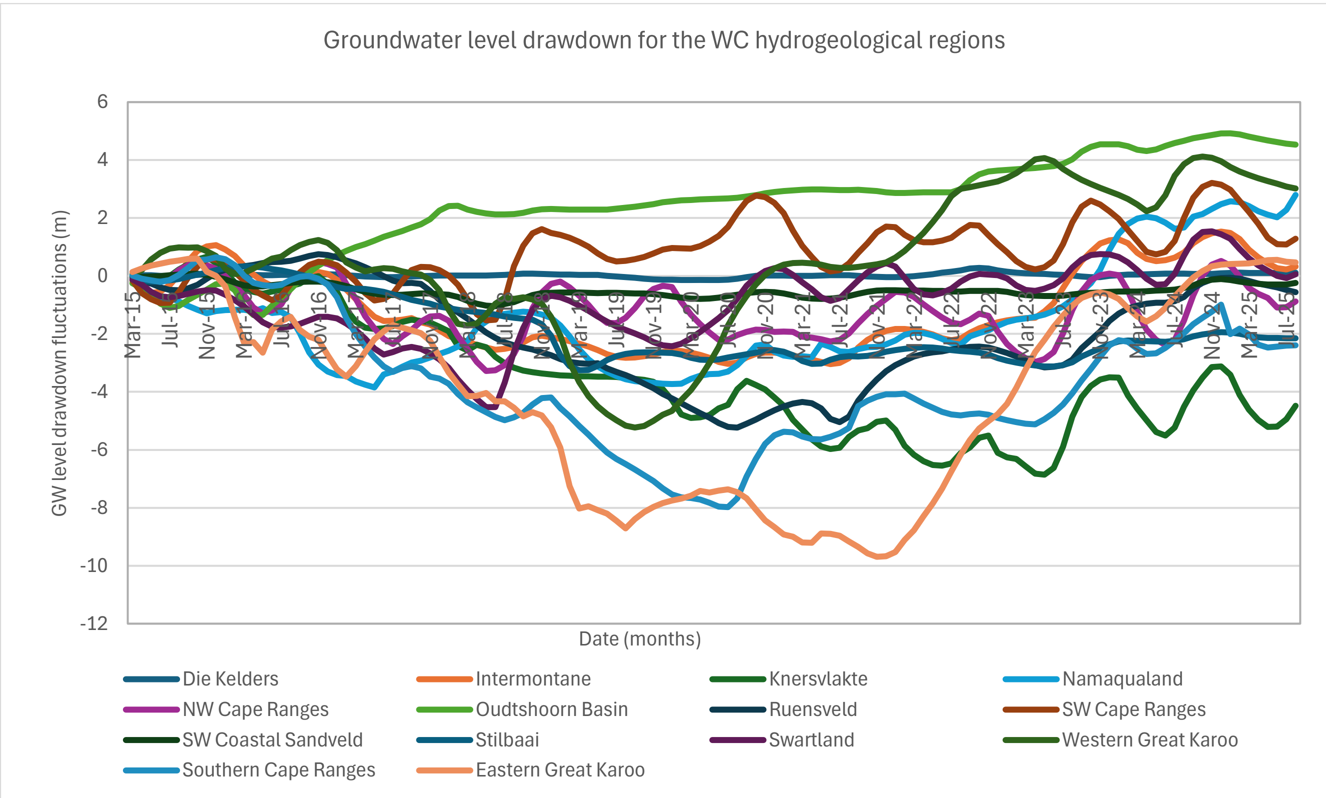

Figure 4: Groundwater levels for the hydrogeological regions in the Western Cape

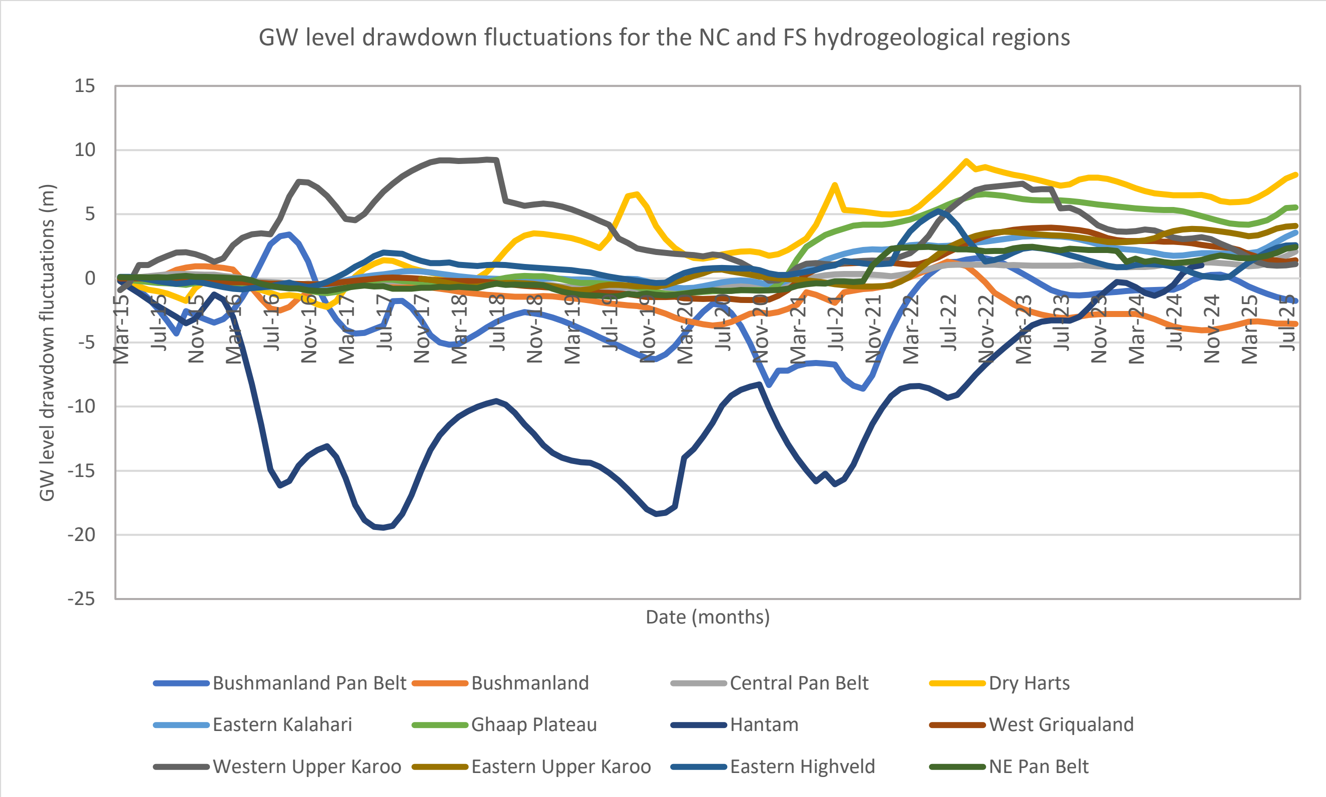

Figure 5: Groundwater level drawdown for the hydrogeological regions in the Northern Cape and Free State Provinces

3.3 The Gauteng, Northwest, Limpopo and Mpumalanga hydrogeological Regions

The last batch of hydrogeological regions tackled included the Gauteng, Northwest, Mpumalanga and Limpopo as shown in Figure 6.

The graphs for these provinces were split so that they could be legible. The Gauteng and Northwest Provinces hydrogeological regions are shown in Figure 7. Generally, the groundwater level drawdown trends for these hydrogeological regions have maintained positive trends with rising water levels with time. The latest is indicating the healthy status of groundwater with climbing groundwater levels after a slight decline in 2024- possibly responding to rainfall recharge.

The Limpopo and Mpumalanga hydrogeological regions generally maintained horizontal trends with latest data indicating rising water levels (Figure 8). An exception holds for the Springbok Flats hydrogeological region where, for the longest period, its water levels declined by about 12m. Nevertheless, the latest status for this region indicates rising water levels, albeit still below the initial water levels. The latest trends for Soutpansberg hydrogeological region showed a downward leaning since 2023 while the Pietersburg Plateau has consistently maintained downward trends since the beginning of the reporting period till to date. An investigation into groundwater use/ and aquifer replenishment is recommended for these two regions.

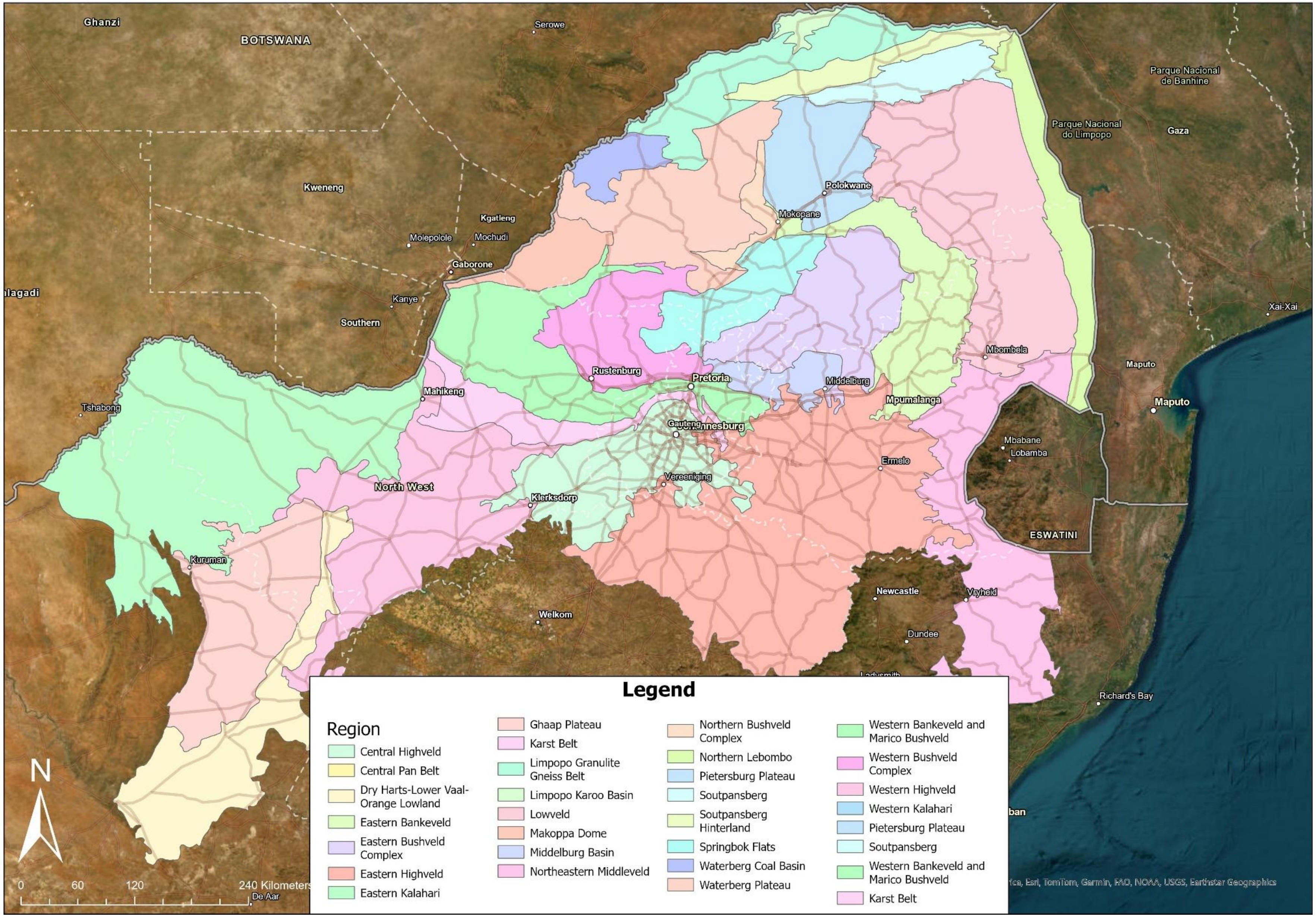

Figure 6: Hydrogeological region for the Gauteng, Northwest, Mpumalanga and the Limpopo Provinces

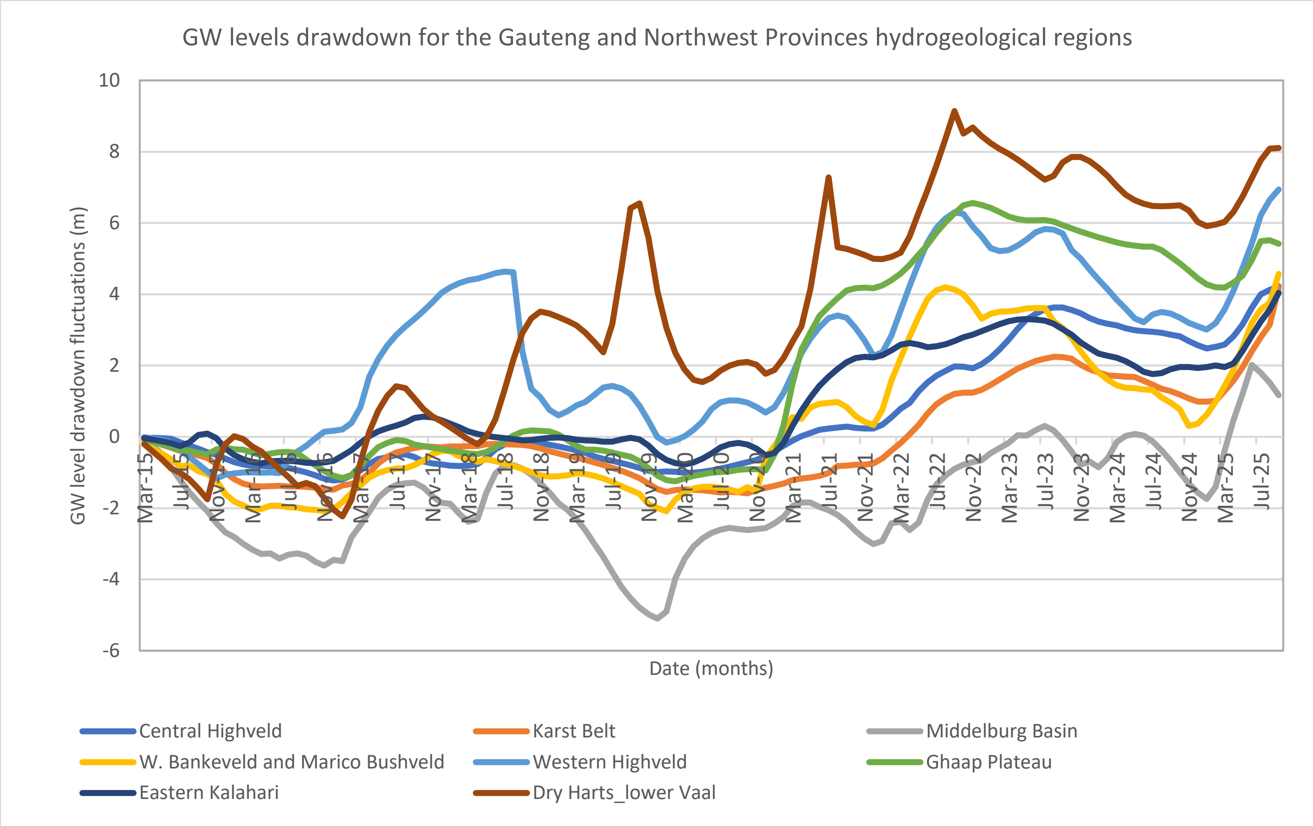

Figure 7: Groundwater level fluctuations for the hydrogeological regions in the Gauteng, and Northwest Provinces

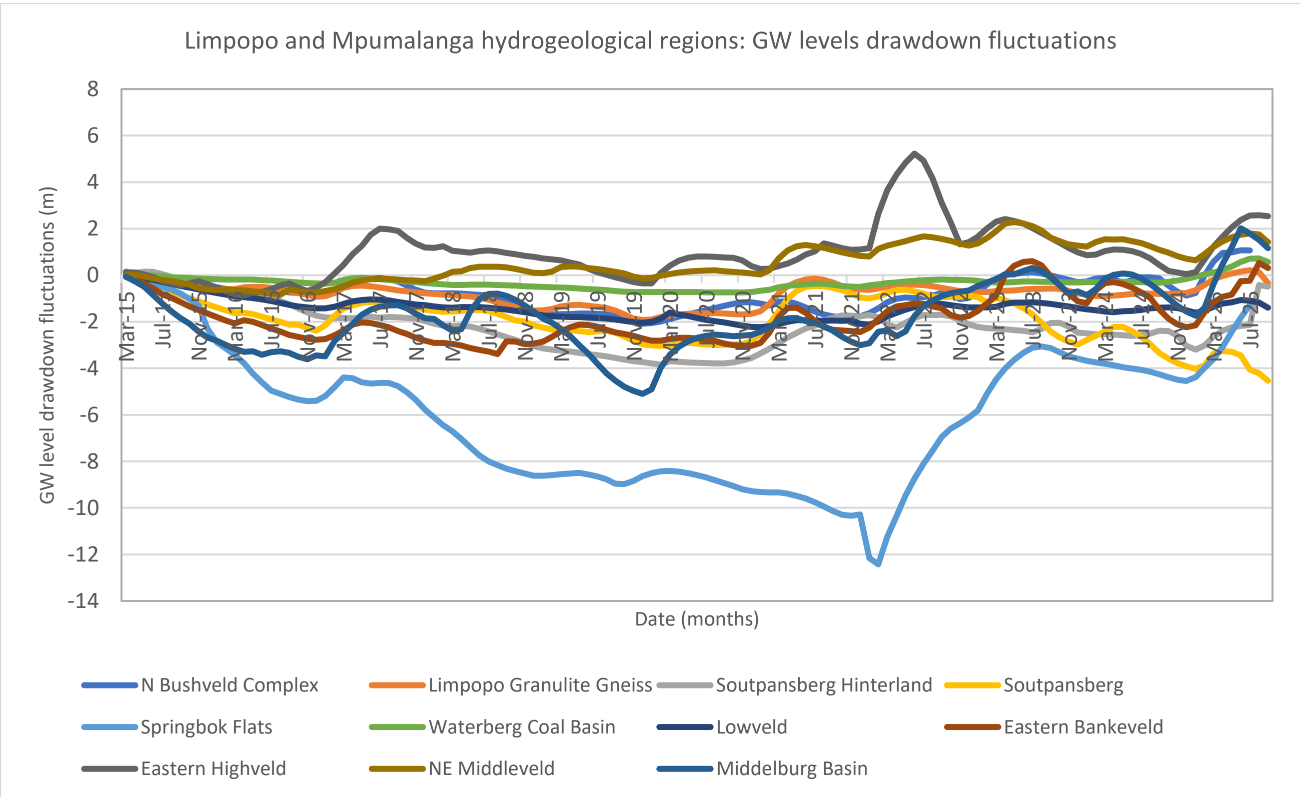

Figure 8: Groundwater level fluctuations for the hydrogeological regions in the Limpopo and Mpumalanga Provinces

4. Conclusions

Generally, the groundwater status for all the assessed regions indicated, largely, horizontal to rising trends. The rising trends have been prevalent since 2023. Exceptions exist though where declining trends were noted These included the regions in the Northern Cape i.e. the Bushmanland and the Bushmanland Pan Belt; the Soutpansberg and Pietersburg Plateau in Limpopo Province. Close monitoring is required for these regions. In the Eastern Cape, the Grootrivier-Klein Winterhoek-Suur-Kaprivier Ranges and the Algoa Bay also indicated a downward trend, surprising at the time when all other surrounding regions are responding positively to rainfall recharge. Anthropogenic impacts are suspected to be at play for these regions and further investigation is recommended.

Historically, the Western Cape hydrogeological regions have been dominated by fluctuating rising trends to the latest. A below average rainfall had a significant impact on groundwater levels for the hydrogeological regions in the Western Cape, the Eastern Cape and KwaZulu-Natal between 2017 to late 2022. These have since recovered to healthy levels.

On a national scale, the groundwater levels seem to be in a viable state with no major concerns, save for the few regions mentioned above (which are not alarming, but would require close investigation).