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Groundwater level trend analysis for the Namaqualand Vegter Region.

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1. Introduction

1.1 Background

The Namaqualand Vegter region is one of many Vegter regions within South Africa (Figure 1). This region stretches over the boundaries of the Northern Cape and Western Cape provinces covering an area of approximately $32655\ km^2$. Within this region several boreholes were used to gather information regarding the area's groundwater level status. From this information a comparison of the groundwater levels between the 2022/23 hydrological year and the 2023/24 hydrological year was made. The knowledge of the depth to groundwater level in a specific hydrological unit (Namaqualand) tells us how water can be exploited and how much of it can be brought to the surface.

The depth to water table is a dynamic, not static process impacted by both anthropogenic and natural processes. The two main factors influencing groundwater levels are groundwater recharge and discharge (abstraction). The dynamic movement of groundwater is governed by the following principle; if recharge surpasses discharge, the volume of water in storage will increase and water levels will rise; if discharge surpasses recharge, the volume of water in storage will decrease and water levels will fall.

Borehole information is significant in analysing these changes in groundwater levels. The groundwater level in boreholes provide insight into aquifer properties like storage, recharge, and discharge since these factors affect the timing and intensity of responses to hydrologic stresses such as precipitation or pumping (abstraction). To assess the changes in groundwater levels for the Namaqualand region different methodologies were utilised. These methods were given similar data inputs but used different formulas to generate representative outcomes, for short term (2022/23 – 2023/24 hydrological years) and for long term (5 years). The captured data was used to create graphs, and tables to understand the groundwater status and determine what the main influences are affecting the groundwater levels.

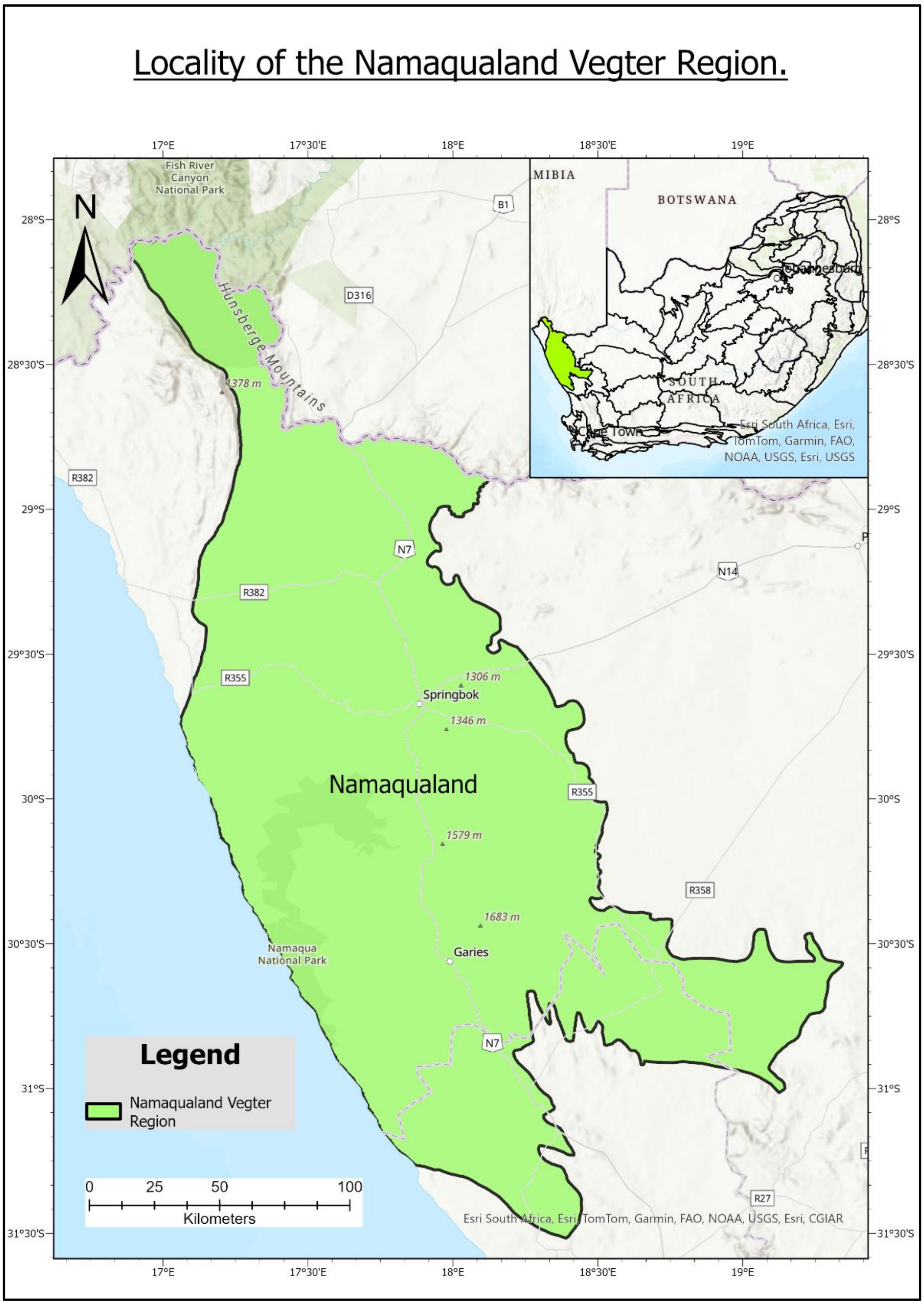

Figure 1 – Namaqualand Vegter region.

1.2 Climatic region

Climate and weather have a large impact on our country's water resources. Higher temperatures lead to increased evaporation and lower water availability, while extreme events like droughts and floods worsen water shortages. Rainfall patters have a direct impact on the recharge of the aquifer systems. Rain can directly influence whether a water table can increase or decrease. Shallow water tables are usually more susceptible to climate changes since the annual fluctuation happens in response to wet season recharge and dry season depletion.

The Namaqualand region is considered a water scarce area with very little rain. The region falls within the winter rainfall season where most rain occurs between April – August, receiving an annual rainfall of 150mm. Figure 2 shows the monthly rainfall figures of the Northern Cape province over different hydrological years. Comparing the rainfall data between the 2022/23 and 2023/24 hydrological years the 2023/24 hydrological year had less rain than that of the 2022/23 year. Another observation from this graph is the 2021/22 line that is far above the normal rainfall (green) section.

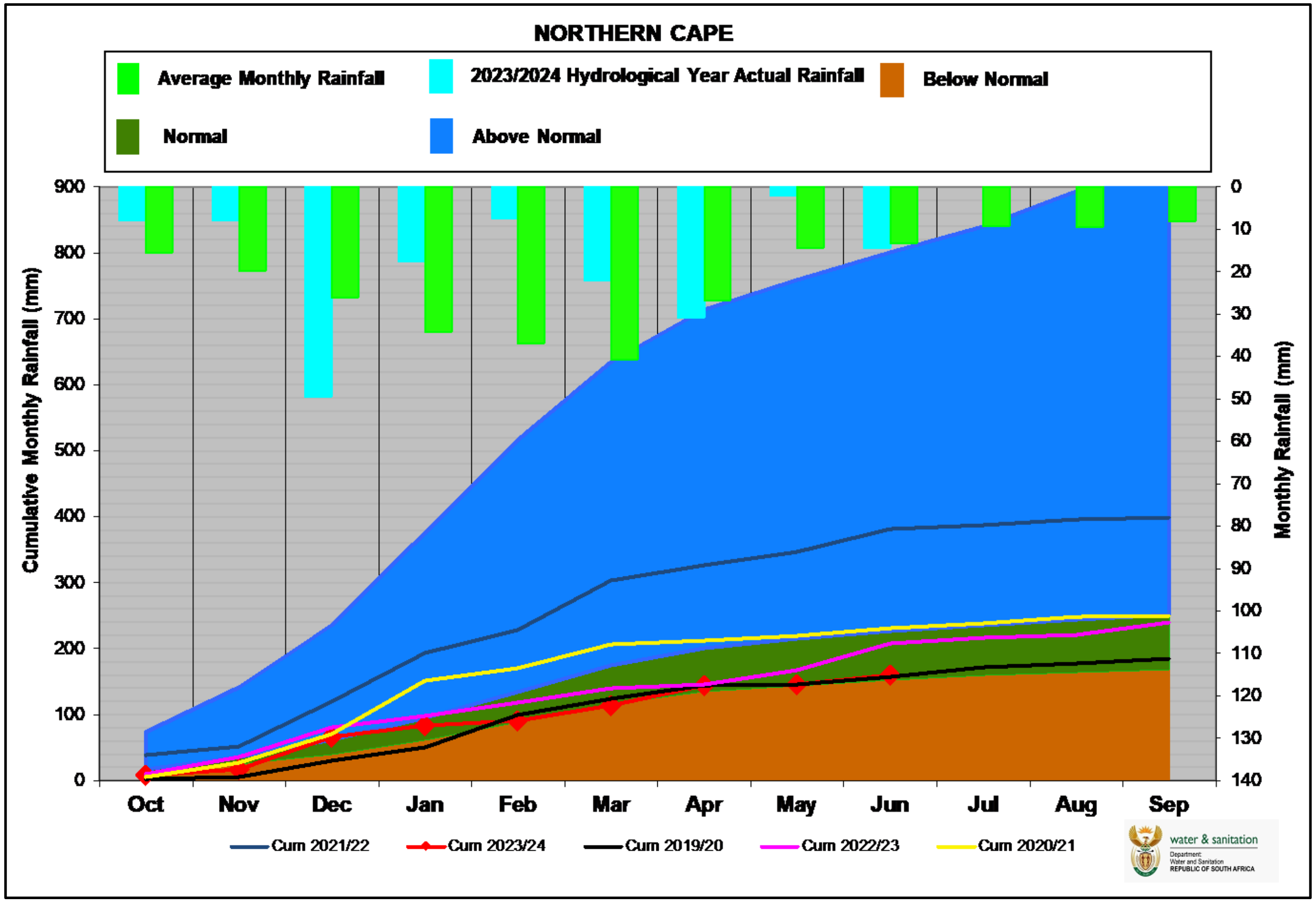

Figure 2 - Monthly rainfall data for the Northern Cape over different hydrological years

1.3 Geological setting

The Namaqualand Vegter region has a vast geology stretching from the older Paleoproterozoic period to the surficial quaternary deposits. Figure 3 below shows the geological setting of all the different lithologies within the Namaqualand Vegter region. From this map below the western and central part of the Namaqualand region is dominated by two lithologies whereas the southern and northern parts are comprised of a variety of lithologies.

A large number of granitic suites are found within the Namaqualand region forming ±67% of the Namaqualand region. All the granitic suites belong to the Namaqua-Natal Province (Mesoproterozoic). The two most dominant suites are the Little Namaqualand Suite and the Garies Suite (Table 1). The quaternary sedimentary deposits also comprise of a large part (11%) of the study area. Other sedimentary deposits do occur within this region in the form of shales and limestones (Schwarzrand), and quartzites (Kuibis).

Table 1 - The % coverage of the different lithologies in the Namaqualand region.

Lithologies	% area coverage
GARIES	11.58%
LITTLE NAMAQUALAND	40.74%
QUATERNARY	10.97%
SPEKTAKEL	9.05%
GLADKOP	5.06%
VIOOLSDRIF	5.90%
HOOGOOR	3.72%
OKIEP	2.00%
SCHWARZRAND	3.19%
Other	7.79%

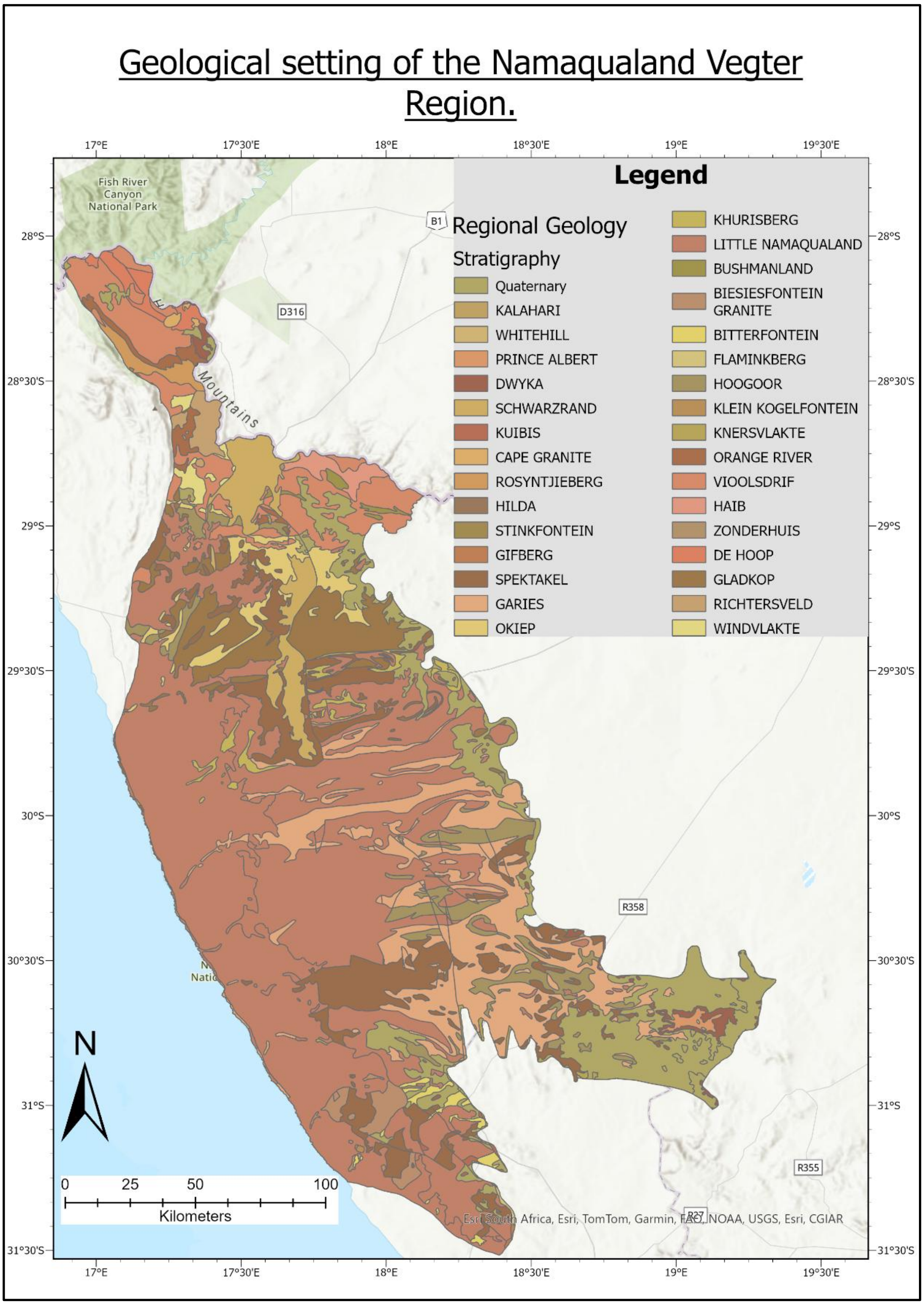

Figure 3 - Geology of the Namaqualand Vegter region.

1.4 Hydrogeology

1.4.1 Aquifer yield

Aquifer yield is a concept or objective embracing the sustainable volume of water that can be abstracted from an aquifer over the long term. Within the Namaqualand region three aquifer types (fractured, intergranular, and intergranular and fractured) were identified with a yield range provided to each type. Figure 4 shows the distribution of these aquifer types together with their corresponding yield values. The intergranular and fractured aquifer is most prominent within this region with yields ranging from 0.0 – 0.1 l/s (coastal areas), 0.1 – 0.5 l/s (inland areas), and 0.5 – 2.0 l/s (central part of the map). The fractured aquifers and intergranular aquifers occupy a limited areal extent in the Namaqualand region.

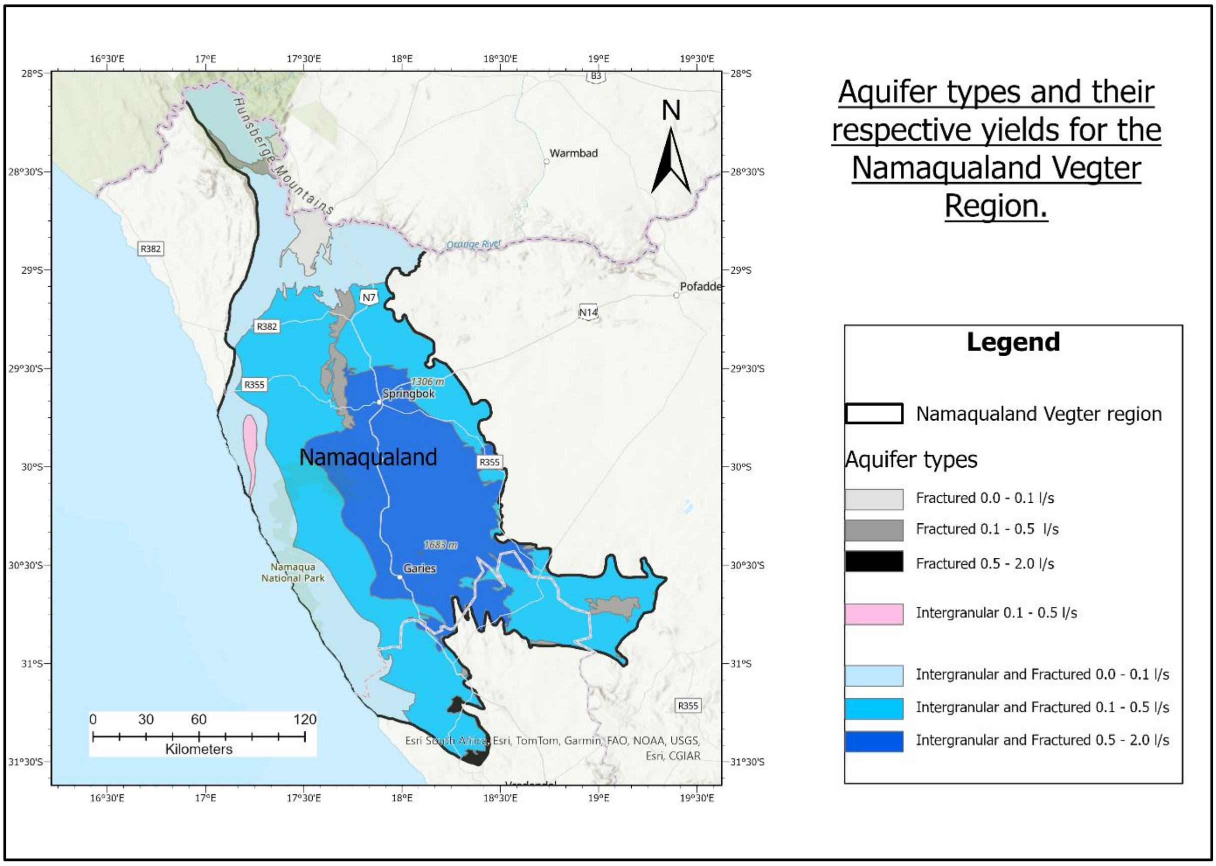

Figure 4 – Aquifer Types and Yields for Namaqualand.

1.4.2 Aquifer quality

The water quality maps for the Namaqualand Vegter region were analysed looking at the following parameters:

- Electrical conductivity (mS/m)
- Fluoride (mg/l)
- Chloride (mg/l)
- Sodium (mg/l)

The above-mentioned parameters showed cases of very high measurements. Some values measured within the ‘unacceptable’ category. High EC, Na, Cl, Mg levels were identified near Bitterfontein which is a sign of severe groundwater salinization. High fluoride levels were identified near the tows Kamieskroon and Garies. All the aquifer quality maps can be found in Appendix A. The Piper diagram also supports the presence of high saline to brackish groundwater since the overall facies is sodium-chloride or sodium-chloride–sulphate.

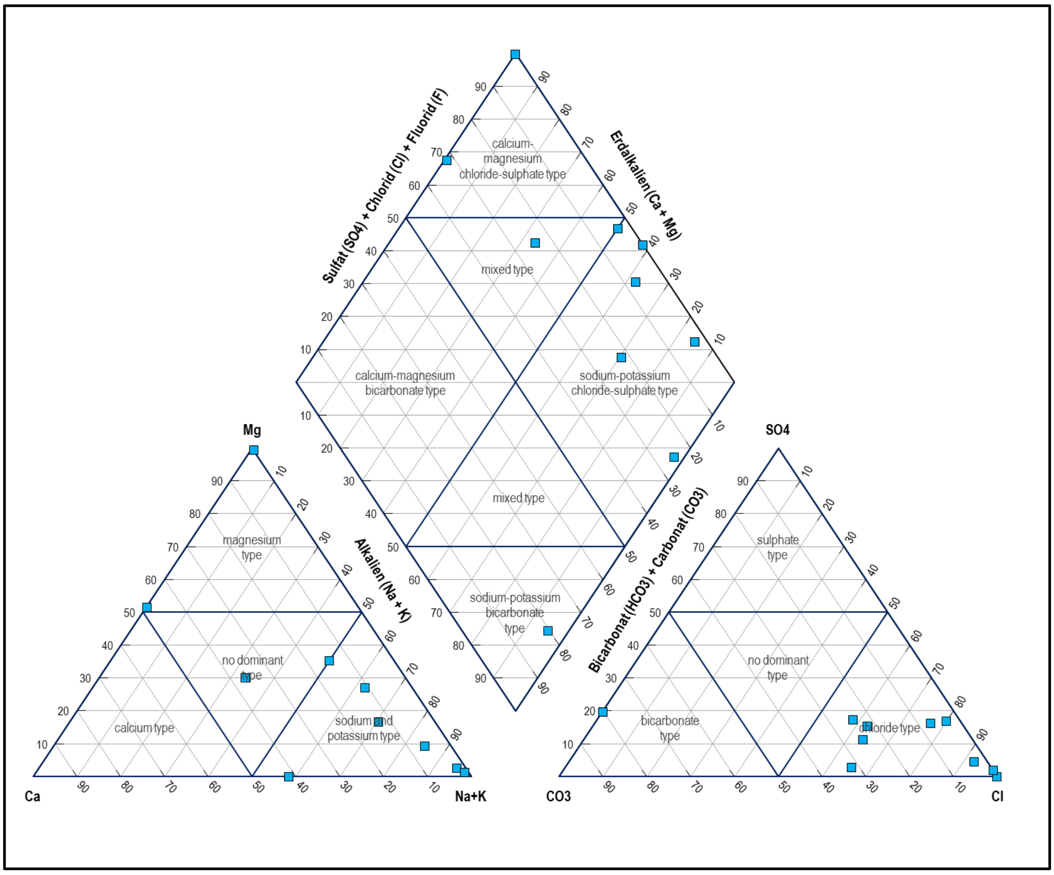

Figure 5 - Piper diagram summarising the overall water quality in the Namaqualand Vegter region.

[The number of boreholes used for the aquifer quality analyses were not enough to be considered as a representative amount for the whole Namaqualand Vegter region.]

1.4.3 Aquifer class

There are three main aquifer classes that are used to describe the aquifer properties. Classifying aquifers into major, minor, and poor classes describes whether these aquifers are high yielding, moderate yielding, or low yielding respectively, and takes the water quality in consideration. Table 2 shows the % area of the Namaqualand region that is represented by each aquifer class. Figure 6 shows that the Namaqualand region is mainly underlain by poor aquifer systems (78%). The minor aquifer class covers approximately 22% of the Namaqualand region whereas major aquifer systems do not feature in this area.

Table 2 - Aquifer classes in the Namaqualand Vegter region.

Aquifer Class	% Area
Minor	22
Poor	78

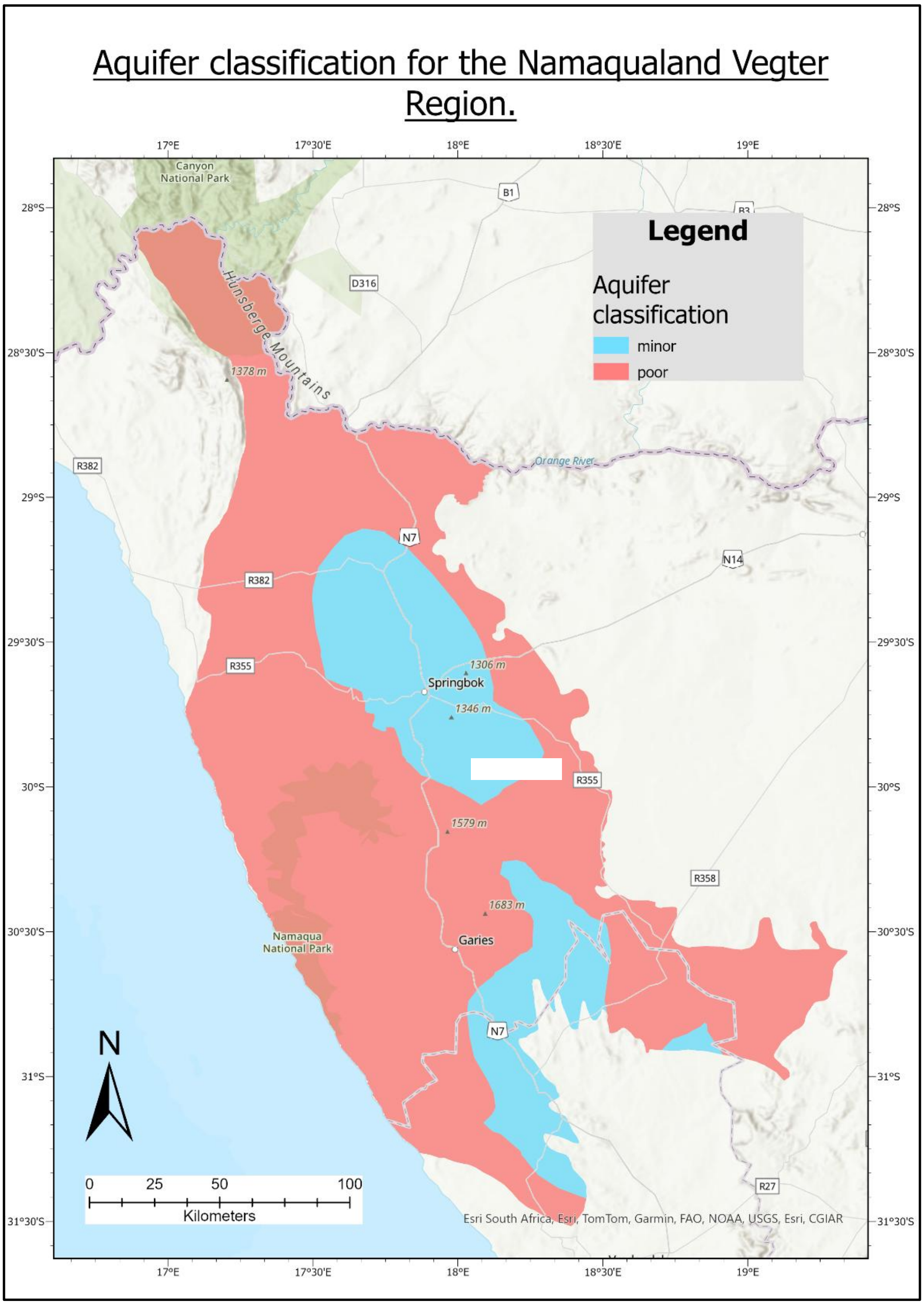

Figure 6 - Aquifer classes for the Namaqualand Vegter region.

1.4.4 Aquifer vulnerability

Aquifer vulnerability refers to the exposure that a specific aquifer has towards surface-based contaminants. The effect that surface-based contaminants have on groundwater system is determined from a rating and weighting system. This system assigns each aquifer a vulnerability rating; very low (1), low (2), low/medium (3), medium (4), high (6), and very high (9). These ratings are determined from a weighting system developed by Aller et al, 1987. The weighting system follows the DRASTIC methodology where the following factors are considered:

D = depth to groundwater (5)

R = recharge (4)

A = aquifer media (3)

S = soil type (3)

T = topography (1)

I = impact of the vadose zone (5)

C = conductivity (hydraulic) (3)

In this DRASTIC method the vulnerability of an aquifer system can be assessed by the numerical DRASTIC index. The weighting of each factor (values indicated in brackets) is used to determine the total numerical value. A high numerical value results in a higher vulnerability towards contaminants.

According to the aquifer vulnerability map for the Namaqualand Vegter region (Figure 7) the aquifer vulnerability classes are: low and very low. From these classes the 'very low' vulnerability class represents the largest area of the Namaqualand Vegter region (73% of the area). The 'low' vulnerability class covers an area of approximately 27%. No aquifer systems with a 'high' vulnerability were encountered, indicating that the aquifers in this Vegter region had no high vulnerability towards surface-based contaminants. This highlights the importance of having an effective monitoring system in place to pick up when contaminants do become a threat, making the underlying aquifer systems more vulnerable. There is a good correlation between the aquifer classes and aquifer vulnerability, where the minor aquifers are more vulnerable compared to the poor aquifers in this region.

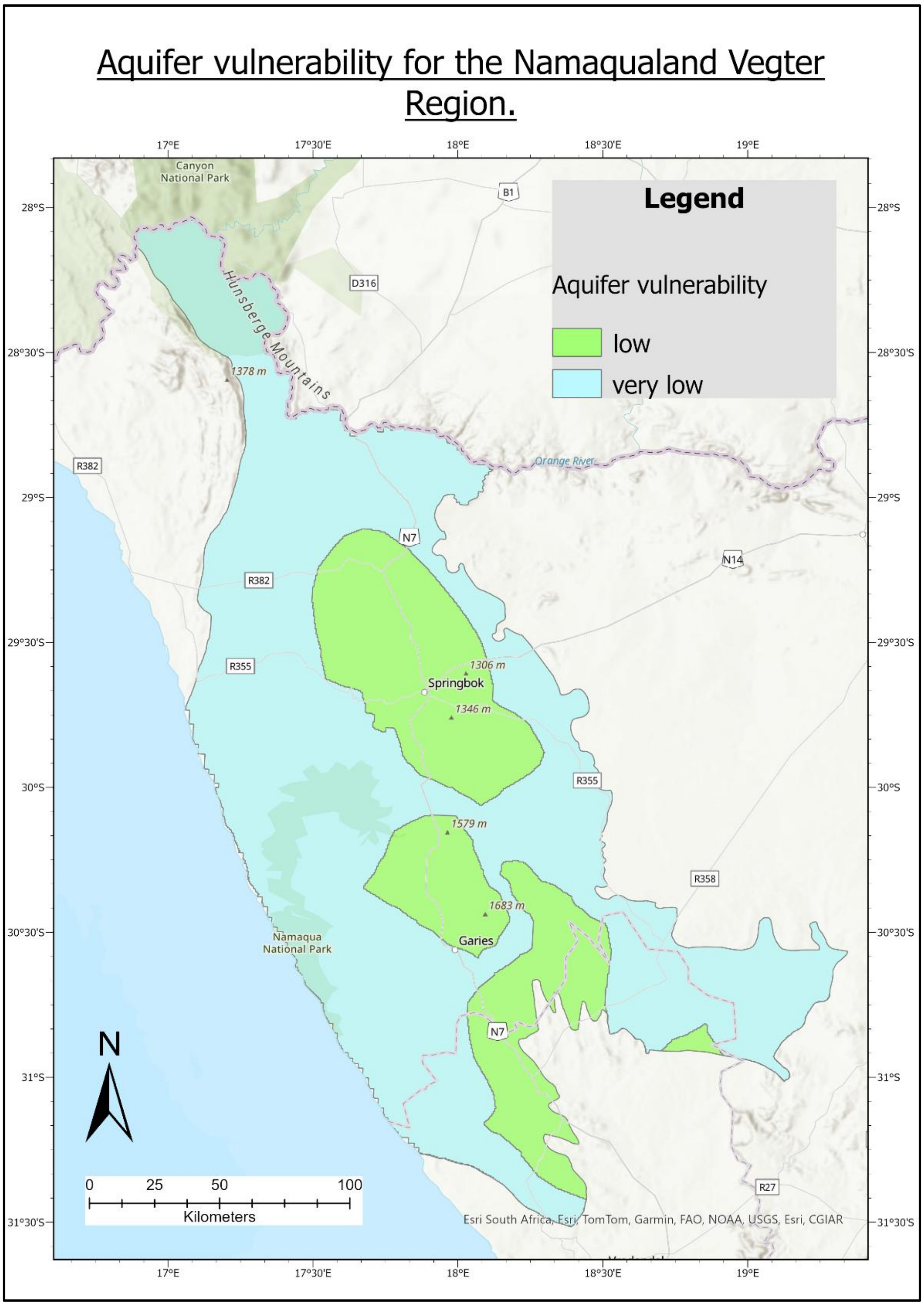

Figure 7 - Aquifer vulnerability within the Namaqualand Vegter region.

1.5 Groundwater use

According to the water use data for the Namaqualand Vegter region the sector with the highest registered water use volume is the agriculture sector (84%). The water supply service has the second most water use volume (11.36%) followed by the mining sector (3.80%). The scarcity of surface water in this region explains why groundwater is regarded as a popular source of water for these sectors, especially the agricultural sector. Old copper mines as well as active mines are scattered throughout the central parts of the Namaqualand region. Valuable copper deposits were found in the early 1900s which led to a copper mining boom. This explains the 3.8% of the water being allocated to the mining sector.

According to Figure 8 the mining – and water supply service sector are scattered across the central part of the Namaqualand region. The agricultural sector is more spread out over the entire region with high concentrations plotted along the Orange River in northern part of the region.

Table 3 - Total registered/allowable abstraction volumes within Central Highveld.

Groundwater use	Total abstraction volume (cubic meters)	%
Agriculture	10285934	84.85%
Mining	460122	3.80%
Water supply service	1376967	11.36%
Total	12123023	

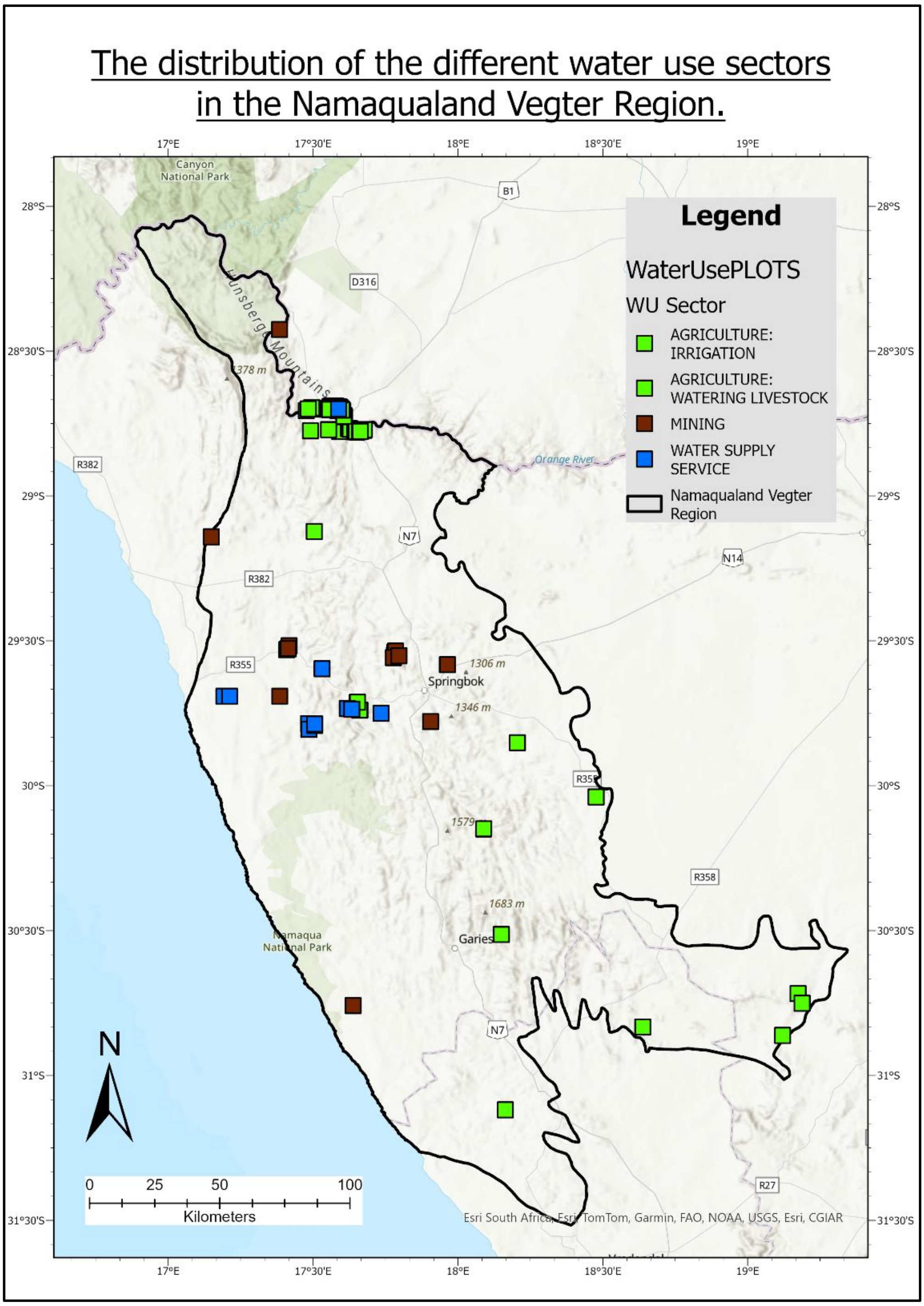

Figure 8 - The distribution of the different Water Use sectors within the Namaqualand Vegter region.

2. Methodology

2.1 ΔGW

This method calculated the difference in the average groundwater level (ΔGW) of each borehole from the current hydrological year (AVG_C) and the previous hydrological year (AVG_P). This calculation can be seen in equation 1:

$$\Delta GW = AVG_C - AVG_P \qquad (1)$$

The change in groundwater levels obtained from using this formula were categorised into five classes, shown in Table 4. These classes describes whether there was a major, moderate, or stable change in the groundwater level. A major change referred to a decrease or increase of more than 5 meters from the previous groundwater level. A moderate change referred to a decrease/increase between 0.2 – 5 meters. A decrease/increase of the groundwater level was considered stable where the change was less than 0.2 meter.

Table 4 – Categorization of the different changes in Groundwater Levels.

Change in GWL (ΔGW)	Class
ΔGW > 5	Major Increase
0.2 < ΔGW < 5	Moderate Increase
-0.2 < ΔGW < 0.2	Stable
-5 < ΔGW < -0.2	Moderate Decline
ΔGW < -5	Major Decline

2.2 Monitoring Objectives

The monitoring system within the Namaqualand Vegter region lacks a design set specifically for the needs of each borehole. Hence, according to the standards set out by Mokoena and Lalumbe (2024), each borehole needs a specific monitoring objective. The objective is allocated through a methodology involving groundwater use, surface activity, and groundwater levels/fluctuations (hydrographs). Data is collected from these different fields to determine whether a borehole meets the criteria of a **baseline** or **trendline** station. Baseline stations should represent natural, unaltered conditions without any nearby groundwater activity. Thus, if boreholes are in developed areas with high groundwater use, they should be classified as trendline stations. A breakdown of the methodology can be seen in Figure 9 below.

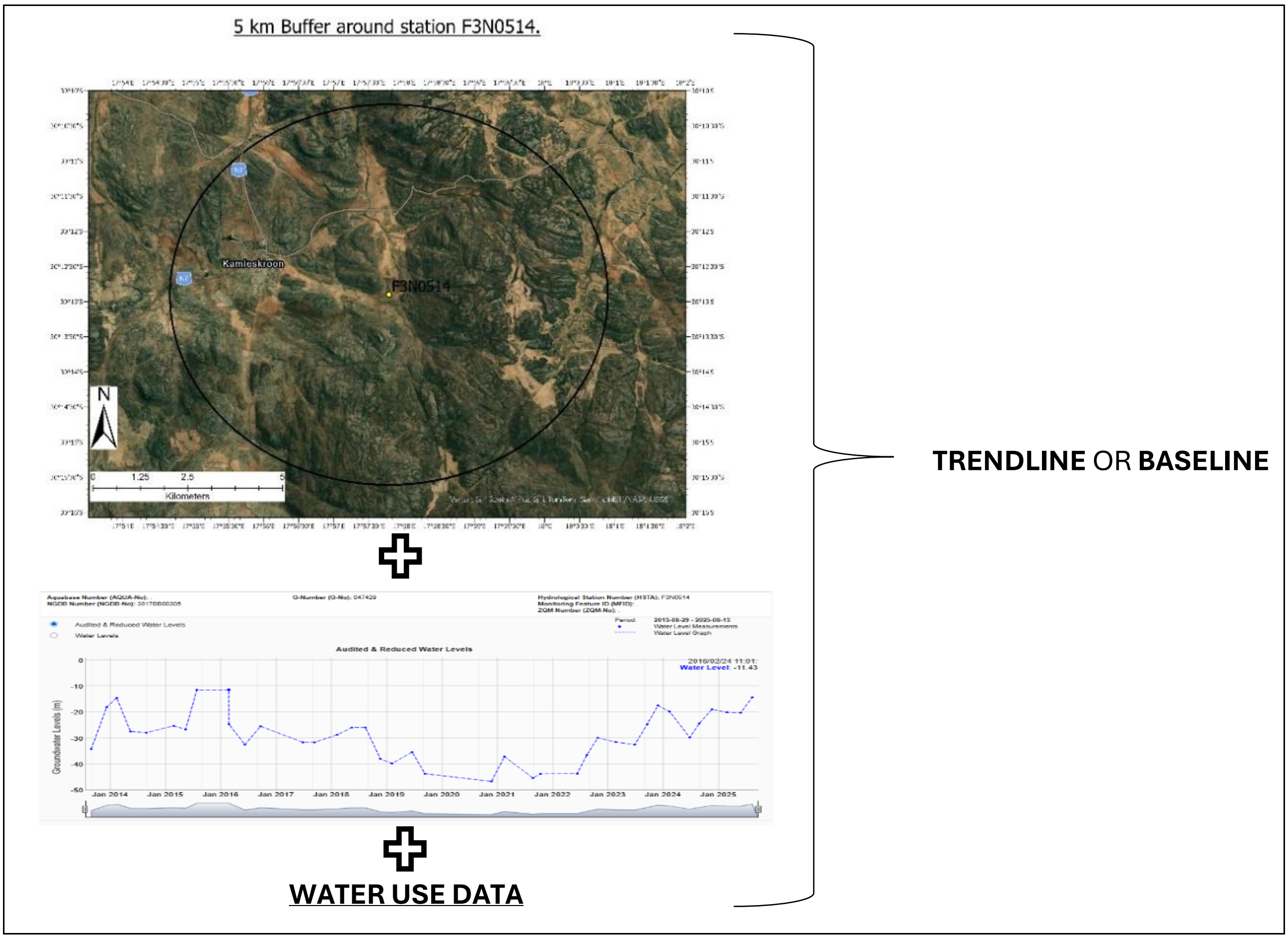

Figure 9 - Groundwater monitoring objective methodology.

3. Results and Discussions

3.1 Borehole distribution

The results were obtained from analysing a total of 17 boreholes that provided groundwater level data within the Namaqualand Vegter Region (Figure 10). The borehole distribution map shows that the boreholes have a good distribution over the study area, reaching most areas in this Vegter region. Table 5 shows the borehole distribution per aquifer type where the intergranular and fractured aquifer system is well represented. This is because this aquifer system covers 94% of the study area.

Gaps were identified in the coastal areas where no boreholes are located on the western coastline. Zero (0) boreholes were also identified within the intergranular aquifer. Thus, the results obtained from the data does not represent the groundwater conditions within these areas.

Table 5 - Borehole and aquifer types distribution over the study area.

Aquifer type	Number of boreholes	Area coverage of aquifer type
Fractured aquifer	3	5.53%
Intergranular aquifer	0	0.56%
Intergranular and Fractured aquifer	14	93.91%
Total	17	

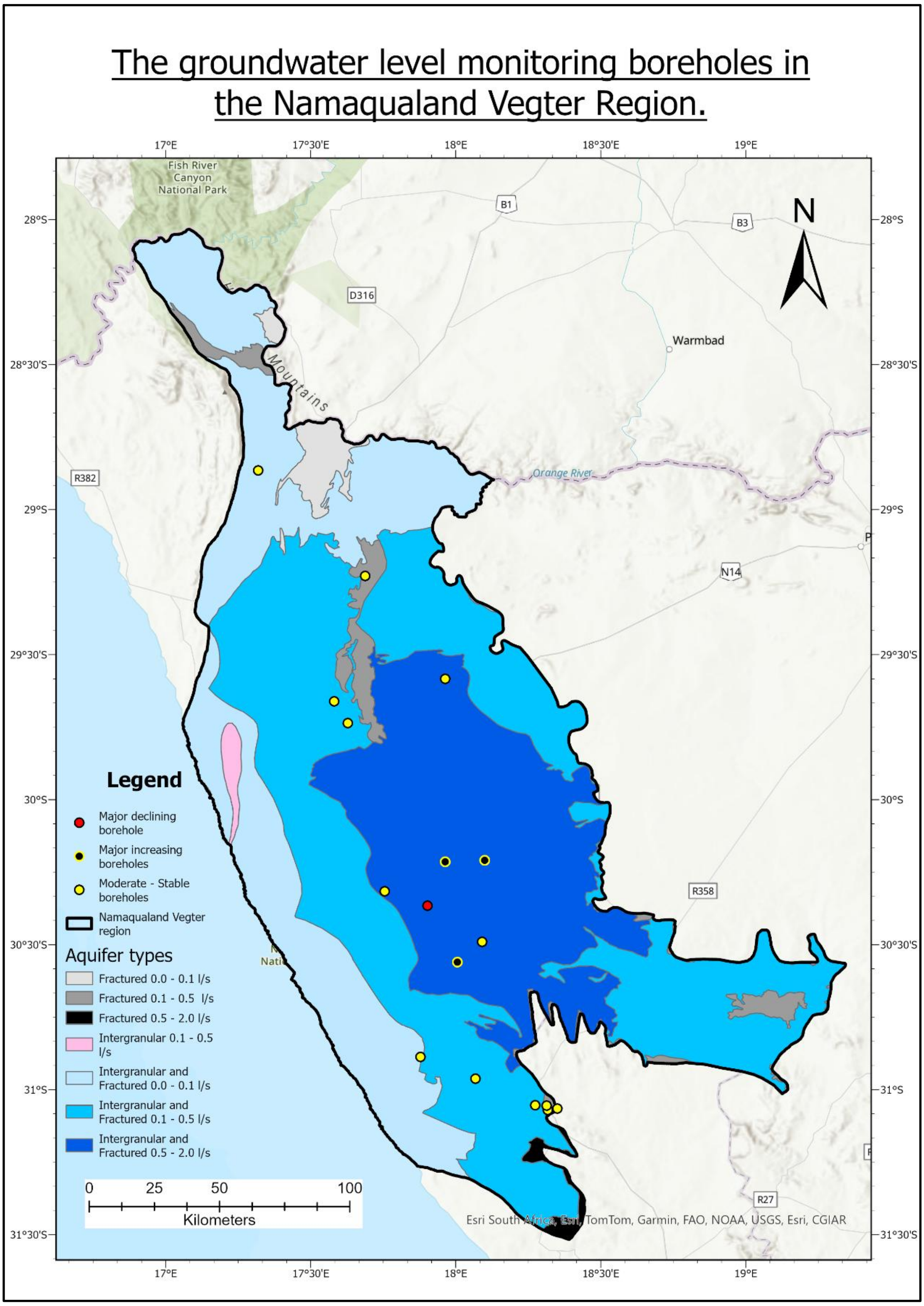

Figure 10 - Borehole distribution.

3.2 Groundwater level

Figures 11 and 12 show the groundwater levels for two consecutive hydrological years (October 2022 – September 2023; October 2023 – September 2024). The two histograms show a very small difference in the groundwater levels between the two timelines. For both hydrological years the majority of boreholes indicate a groundwater level between 10 – 30 meters below ground level (mbgl); 47.06% of boreholes in the 2022/23 hydrological year, and 58.82% of boreholes in the 2023/24 hydrological year. No boreholes in this Vegter region recorder water levels of < 2 mbgl and no water levels were recorder deeper than 100 meters below ground.

The graphs show that less to no changes occurred within the deep groundwater systems (60 – 100 mbgl) since both percentages stayed constant at 5.88%. The shallow groundwater systems however did show minor changes. The number of boreholes with water levels between 10 – 30 mbgl increased from 8 to 10 boreholes. This indicates that there was a rise in the water table moving from the 2022/23 hydrological year to the 2023/24 hydrological year. These changes highlights that shallow aquifer systems are more directly affected by seasonal events whereas deep aquifer systems take longer to show these impacts and are more isolated from seasonal events. It should be noted that the water levels between 2 – 10 mbgl stayed constant (5 boreholes) between the two consecutive hydrological years.

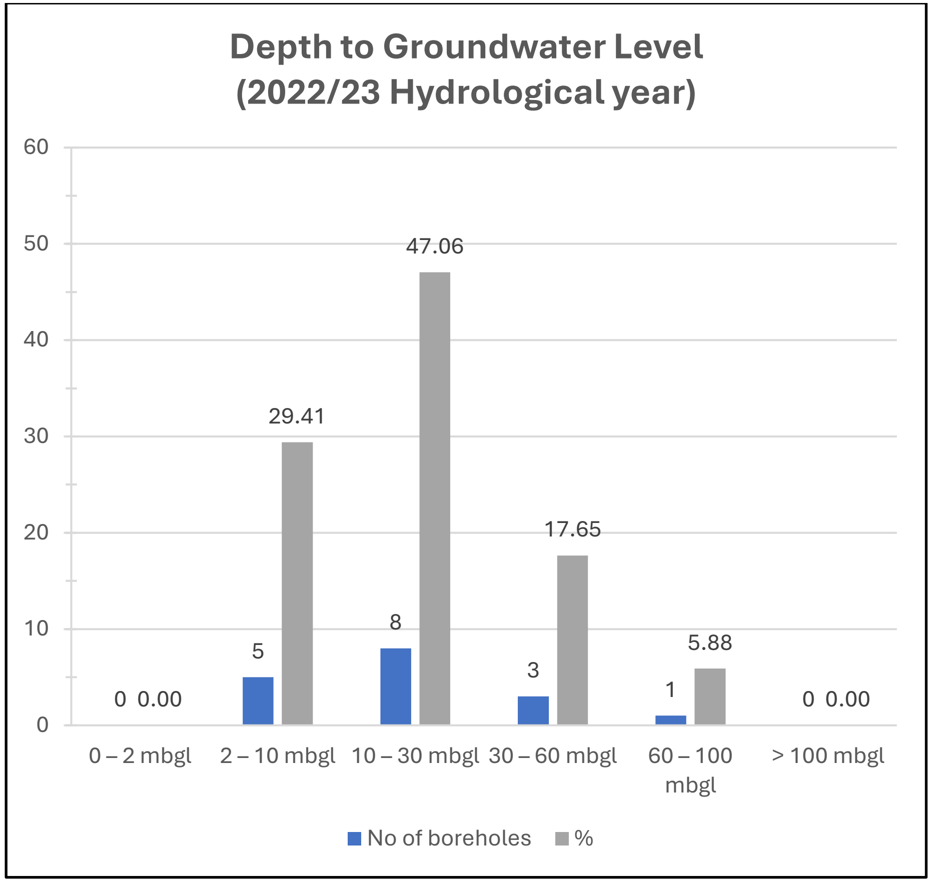

Figure 11 - Groundwater Levels for the 2022/23 hydrological year – Namaqualand.

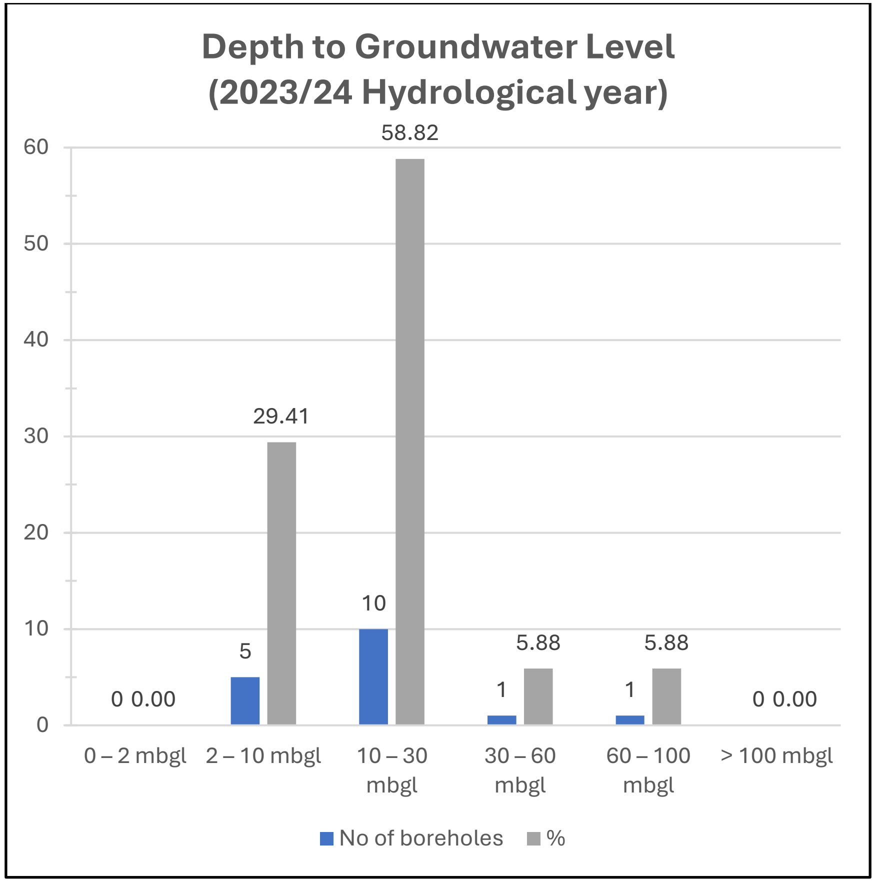

Figure 12 - Groundwater Levels for the 2023/24 hydrological year – Namaqualand.

3.3 Groundwater Level Fluctuation

Figure 13 below shows the number of boreholes within each fluctuation class for the Namaqualand Vegter region. Majority of the boreholes (47.06%) indicated a stable groundwater level fluctuation. Only 5.88% showed moderate declining fluctuations (-5 < ΔGW < -0.2), whereas 23.53% of the boreholes showed a moderate increasing fluctuation in the groundwater level (0.2 < ΔGW < 5). The two extreme fluctuation classes showed the following results. Three boreholes (17.65%) had groundwater levels that increased by more than five (5) meters; and one borehole (5.88%) had a decrease of more than five (5) meters:

- F3N0509 = 15.018 meters ***(INCREASE)***
- F3N0514 = 7.497 meters ***(INCREASE)***
- F5N0512 = 10.944 meters ***(INCREASE)***
- F4N0005 = - 12.054 meters ***(DECREASE)***

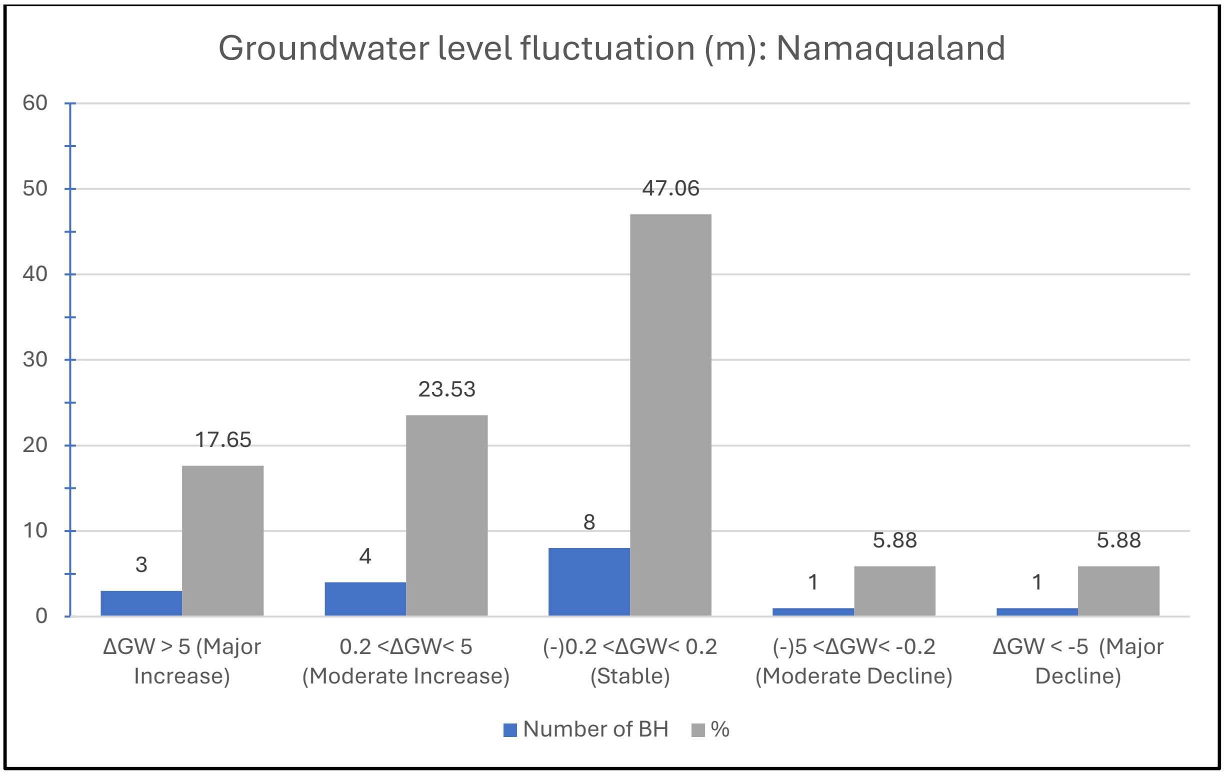

Figure 13 - Groundwater Level Fluctuations.

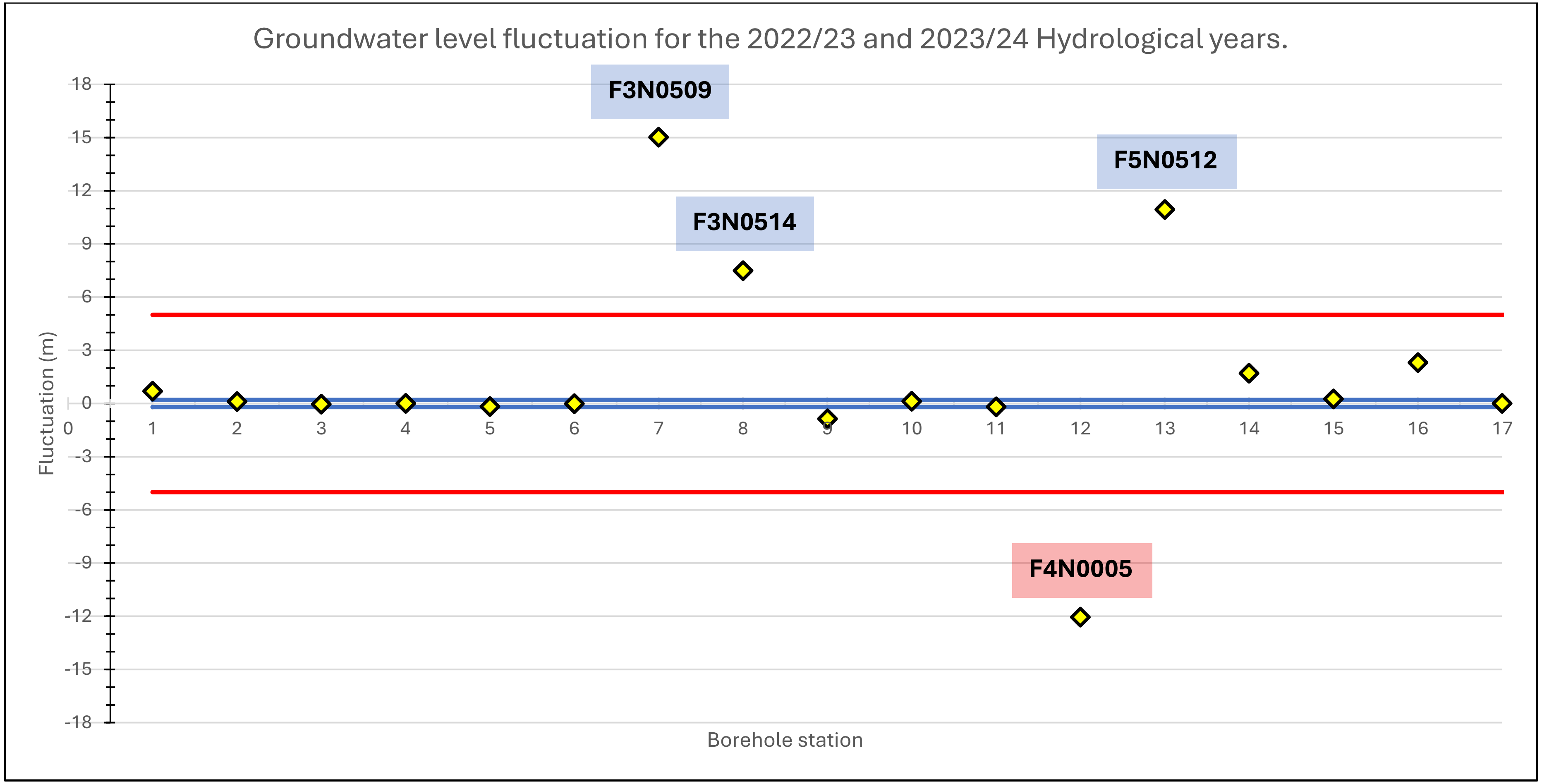

Figure 14 - Groundwater level fluctuations for the 2022/23 and 2023/24 hydrological years.

3.4 Climatic analysis

As mentioned previously, climate can have a direct influence on the groundwater conditions of a region. It is therefore important to analyse the climatic differences between the 2022/23 and 2023/24 hydrological years, as these variations may help explain major groundwater level fluctuations.

Figures 15 and 16 below show the rainfall percentage maps for South Africa for the 2022/23 and 2023/24 hydrological years, respectively. A rainfall percentage map represents the rainfall that occurred during a specific period (in this case, one hydrological year) as a percentage of the long-term average for that same period. Areas with high percentages (>100%) indicate above-normal rainfall, whereas areas with low percentages (<100%) indicate below-normal rainfall and possible drought conditions.

The rainfall percentage maps show a clear difference in rainfall patterns between the 2022/23 and 2023/24 hydrological years. Overall, more rainfall was recorded across the country during the 2022/23 hydrological year, particularly within the Namaqualand Vegter region. It was found that the 2022/23 hydrological year had an average rainfall of 16.4 mm in the Namaqualand region, compared to the 10.1 mm average rainfall for the 2023/24 hydrological year. This is supported by higher rainfall percentages (dark blue) in the central part of the Namaqualand region during 2022/23 compared to the lighter blue colours observed during 2023/24. This indicates that the central part of the Namaqualand region received substantially more rainfall in 2022/23 than in 2023/24.

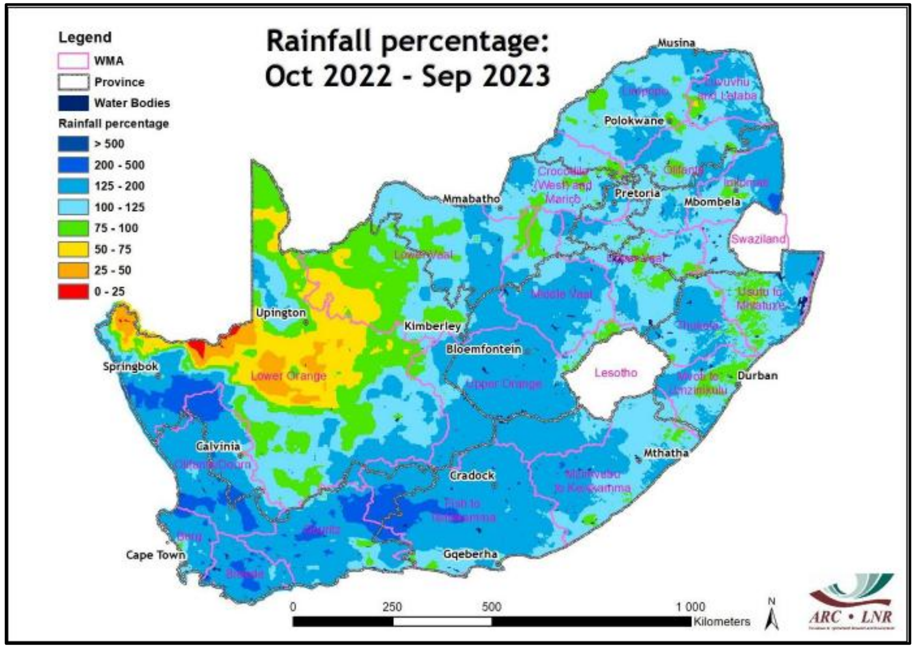

Figure 15 - The rainfall % for South Africa during the 2022/23 hydrological year.

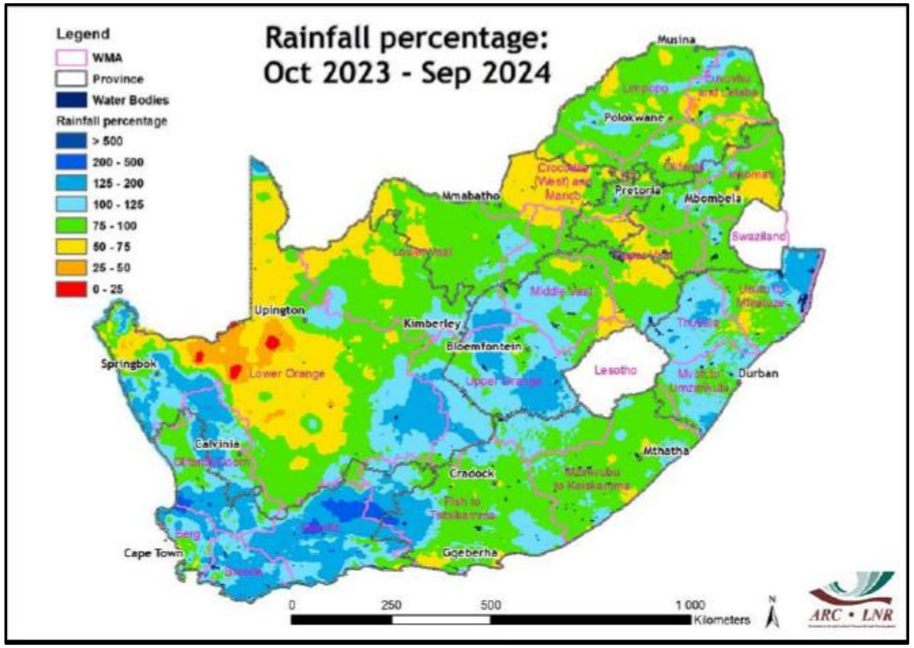

Figure 16 - The rainfall % for South Africa during the 2023/24 hydrological year.

3.5 Individual Borehole Trends

Figure 10 shows the localities of these major increasing and major declining boreholes. Analysis found that the four boreholes have similar geohydrological conditions. All four (4) boreholes are located within the intergranular and fractured aquifer system (0.5 – 2.0 l/s) in the central part of the Namaqualand. Similar geology (granitic/gneiss bedrock) and similar borehole depths (at least 120 meter deep) were observed at all four boreholes. These similarities made it easier to determine the causes of the individual fluctuation trends of each borehole.

The individual borehole trends in the figures below, represents a 5-year groundwater level trend. The four boreholes showing major groundwater fluctuations were selected for further deeper analysis to determine the origin of these major fluctuations.

3.5.1 F3N0509

The F3N0509 borehole is located in a mountainous area outside of the town Klein Nourivier. This borehole showed an increasing groundwater level trend of 0.0156 (m = gradient) over the 5 years. Majority of the groundwater increase occurred between the 2022/23 and 2023/24 hydrological years. A sharp increase can be seen (Figure 17) starting in August 2023 which falls at the end of the rainfall season of Namaqualand. From the climatic analysis it was found that above normal rain had been recorded from October 2022 – September 2023. Hence, this increase in groundwater levels could be due to seasonal rainfall recharge.

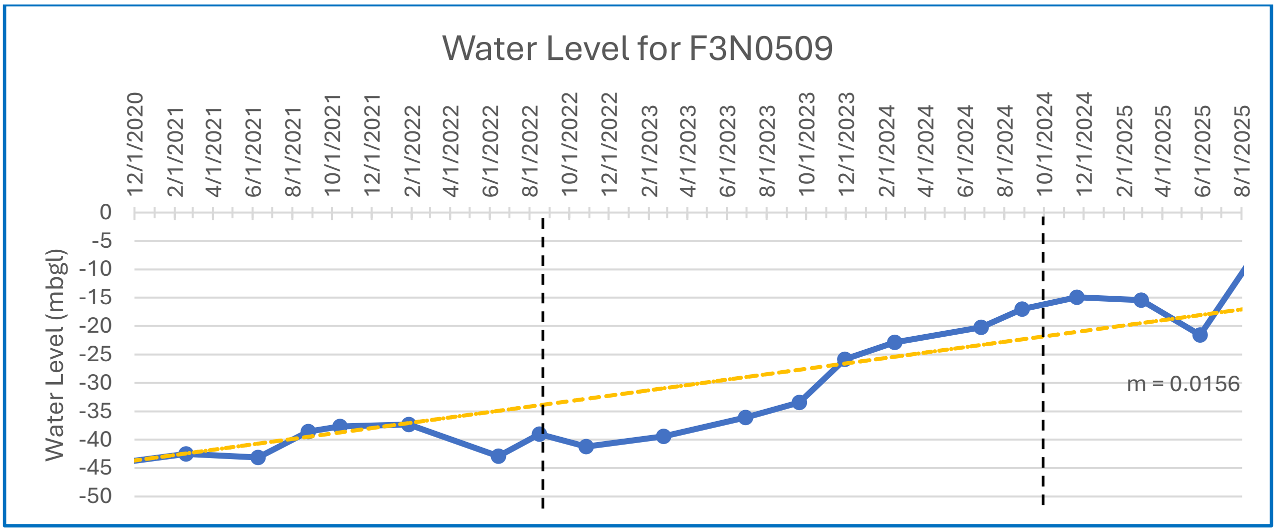

Figure 17 – 5-Year timeline of the groundwater levels for BH F3N0509.

3.5.2 F3N0514

Figure 18 (below) shows the 5-year trend of borehole F3N0514, located in a valley in proximity to agricultural farmland. The 5-year trend line has an increasing groundwater level trend of 0.013 over the 5 years. Three positive spikes can be seen with each one starting in June 2022, June 2023, and June 2024, respectively. The similar timing of these spikes in groundwater levels can possibly be linked to rainfall recharge since June falls within the rainfall season. The highest peak in Figure 18 was observed after the rainfall season in 2023, which had recorder above normal rainfall levels. This motivates the fact that the positive groundwater level fluctuations are linked to rainfall recharge.

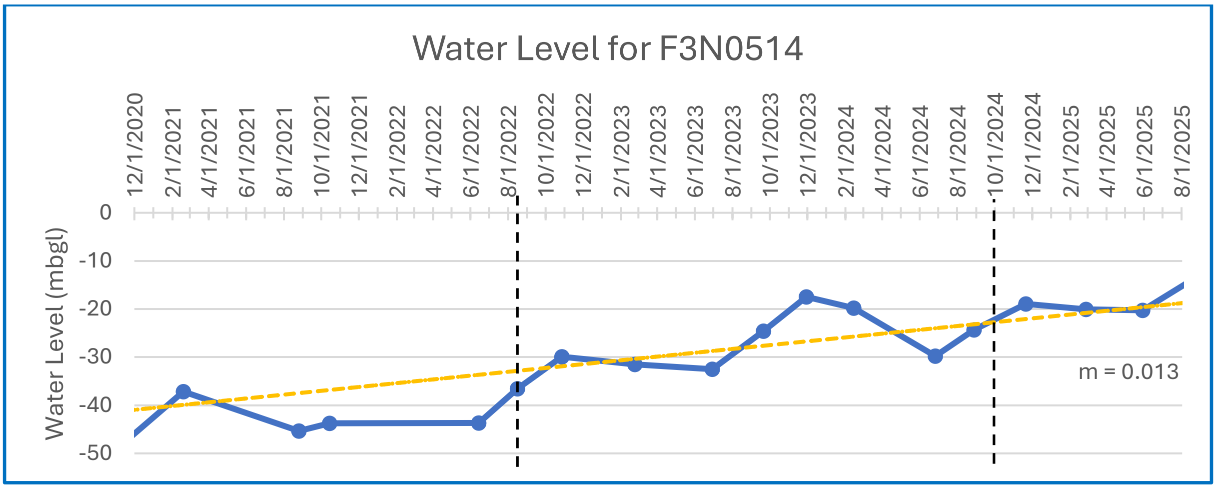

Figure 18 – 5-Year timeline of the groundwater levels for BH F3N0514.

3.5.3 F5N0512

Figure 19 (below) shows the 5-year trend for borehole F5N0512, located ±1.5 km east of the town Garies. The 5-year trend line has an increasing groundwater level trend of 0.0048 over the 5 years, which is the weakest trend compared to the other two (groundwater level increasing) boreholes. Many positive spikes in groundwater levels can be observed throughout the 5 years, but these spikes are immediately followed by sudden drops in groundwater levels. The timing of the spikes (being within the raining season) is significant since it can be linked to rainfall recharge. The sudden groundwater level decrease could be the water table returning to its natural (balanced) level or the cause could be that of groundwater discharge by the surrounding community.

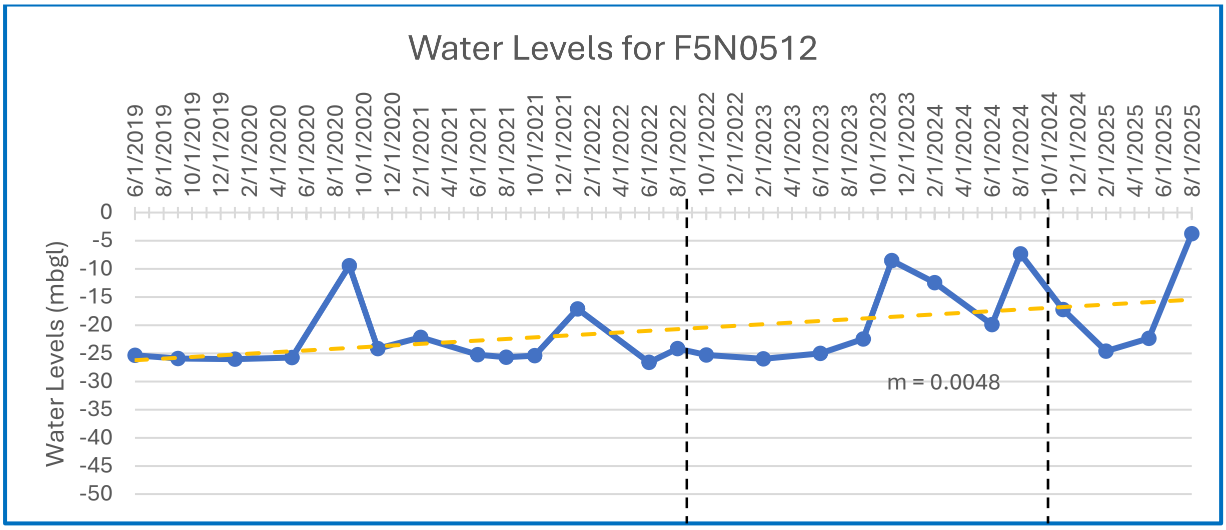

Figure 19 – 5-Year timeline of the groundwater levels for BH F5N0512.

3.5.4 F4N0005

Figure 20 (below) shows the 5-year groundwater level trend for borehole F4N0005, located next to the Brand River, outside of Kharkams The gradient of the trendline for the 5-year period is negative with a value of -0.0016. Even though the 5-year trend is very close to stable some major fluctuations did raise concerns. After the water table being at a constant level for almost 3 years, there was a major drop in groundwater level that started in August 2023 (even though high rainfall was recorder before this time). The groundwater level then stated to recover from this sudden drop in February 2024. This means that there was a period of 5 months where the groundwater level was deceasing with a rate of 7.7 meters per month.

A possible cause for these fluctuations may be anthropogenic in nature (i.e., influenced by human activity). For nearly three years, the water level showed no major fluctuations, suggesting two possible scenarios. Firstly, the rainfall or climatic conditions during this period may not have significantly affected the groundwater table and are therefore unlikely to explain later changes. Secondly, the initially stable water table could be the result of human inactivity — meaning no abstraction occurred from the borehole. Thus, when climatic influences are excluded, the sudden drop in the water table can most likely be attributed to the onset of human abstraction.

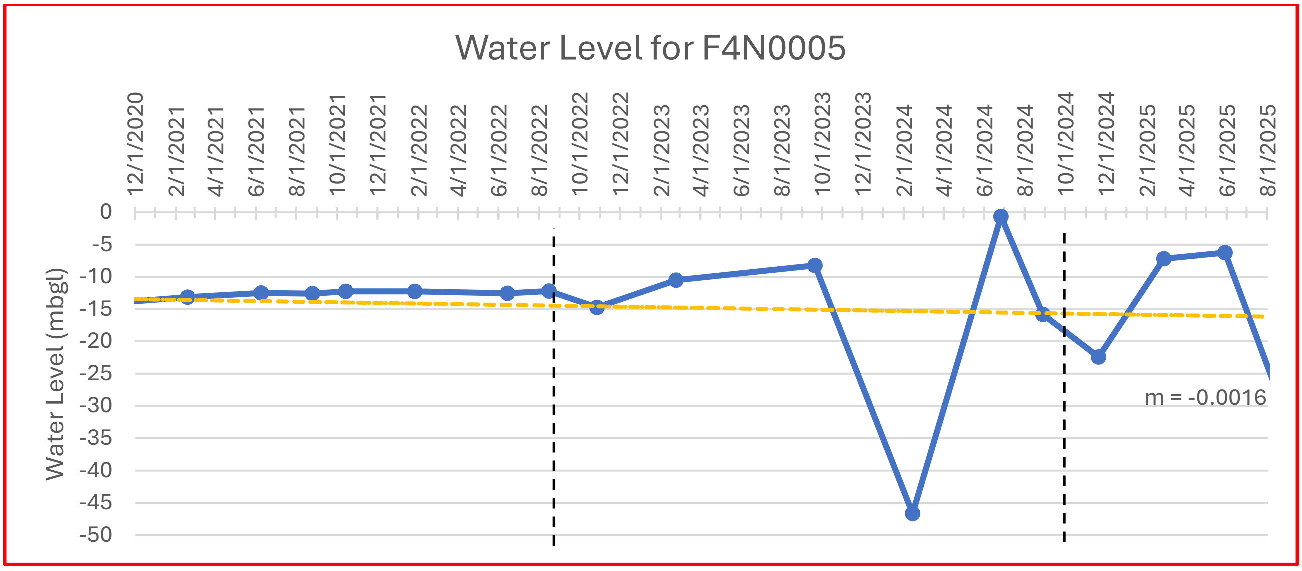

Figure 20 – 5-Year timeline of the groundwater levels for BH F4N0005.

3.6 Groundwater Abstraction VS Groundwater Level Fluctuation

Figure 21 below illustrates the interpolated map of registered groundwater abstraction volumes within the Namaqualand Vegter region. Boreholes exhibiting significant increases in groundwater levels are predominantly located within areas of low abstraction volumes, whereas the borehole displaying a major decline in groundwater levels occurs within a zone of moderate abstraction. Boreholes with moderate to stable groundwater levels are distributed across various abstraction zones. Some stable boreholes are in the zones characterized by very high abstraction volumes.

Overall, there appears to be no clear correlation between registered abstraction volumes and groundwater level fluctuations. Although boreholes with substantial groundwater level increases are situated in low abstraction zones, stable groundwater level boreholes are also present within areas of high abstraction. Consequently, no consistent relationship can be established between high abstraction volumes and major groundwater level declines, or vice versa.

From Figure 8, it is evident that there are large gaps within the Namaqualand region where no registered groundwater use is recorded. It is possible that groundwater abstraction is occurring within these areas but has not been officially registered, resulting in its absence on the interpolation map. This lack of registration reduces the accuracy of the interpolation map shown in Figure 20 and may lead to a misleading interpretation of the relationship between groundwater level fluctuations and groundwater abstraction volumes.

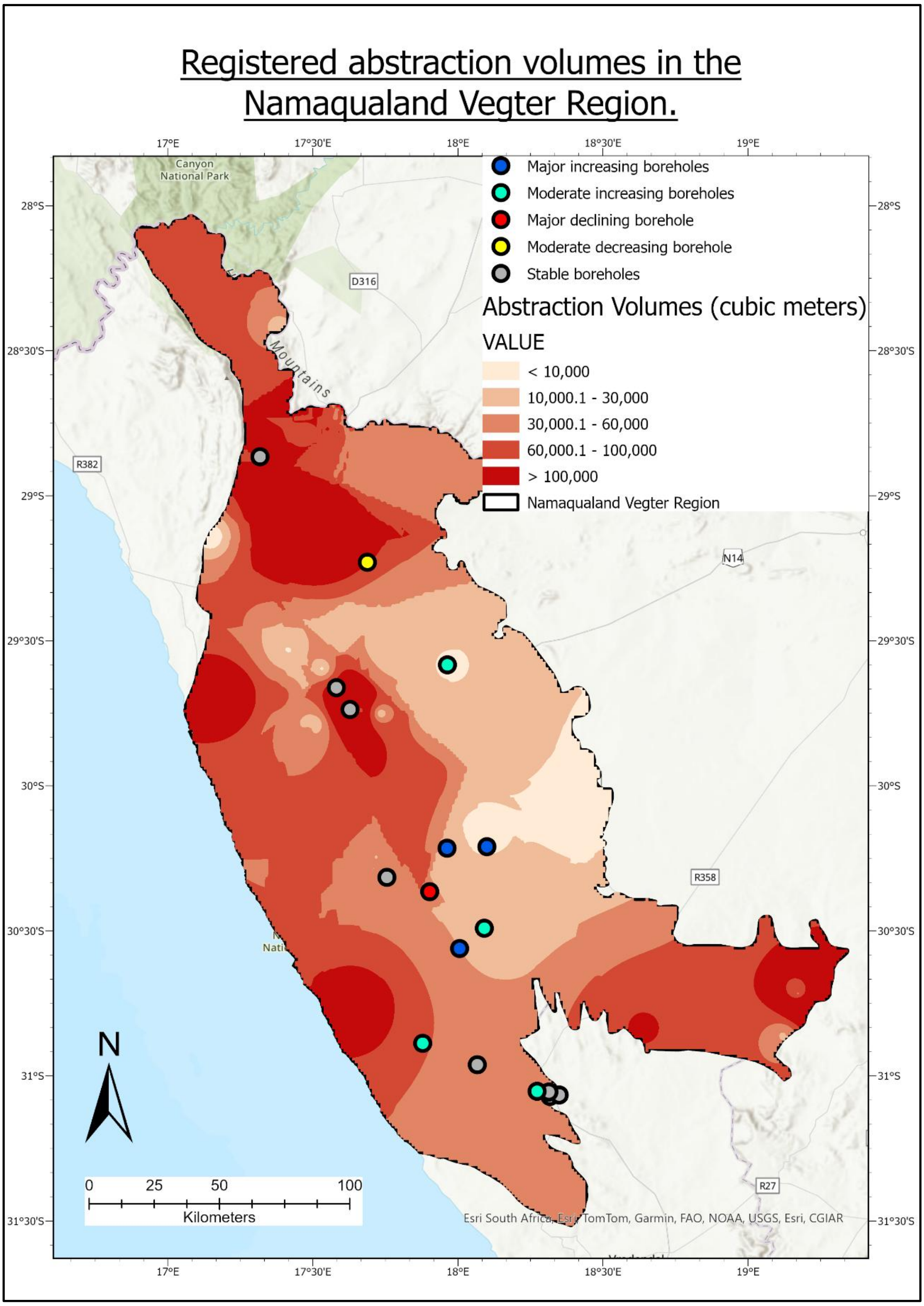

Figure 21 - The registered abstraction volumes for the Namaqualand Vegter region.

4. Monitoring objectives

17 Boreholes were analyses within the Namaqualand region to determine each borehole's monitoring objective. From the table below each borehole is either classified as a 'baseline' or 'trendline' station. The lack of registered water use data made the monitoring objective allocations more challenging, highlighting the fact that these allocated objectives are not "set in stone" and should be adapted as one obtains more information with regards to the study area. Evidence of these monitoring objective allocations can be found in the appendix.

Table 6 - Groundwater monitoring objectives.

STATION	LATITUDE	LONGITUDE	PURPOSE OF MONITORING SITE	INITIAL MONITORING OBJECTIVE	GWU WITHIN 5 km RADIUS	GROUND WATER USE SECTOR	GROUNDWATER MONITORING ONBJECTIVE
D8N0016	-28.86554	17.31836	Background monitoring	Baseline	No registered activity. Stable groundwater levels.	N/A	Baseline
F3N0515	-29.22886	17.68774	Background monitoring	Baseline	No registered activity. 4.7 km away from Steinkopf town. Stable groundwater level fluctuations.	N/A	Baseline
F3N0516	-29.66165	17.58142	Background monitoring. Monitoring impact of river (Next to Buffels River)	Baseline	No registered activity. 150m from abandoned copper mine. Surrounding settlements. Stable groundwater level fluctuations.	N/A	Baseline
F3N0507	-29.73639	17.62807	Monitoring impact of pumping. Monitoring impact of river (Next to Buffels River)	Trend	I. 500m away from GWU activity (186000 m^3) I. 900m away from GWU activity (636800 m^3)	I. Water Supply Service	Trendline

					II. 3.6km away from GWU activity (100000 m^3) II. 3.2km away from GWU activity (80000 m^3)	II. Agriculture	
D8N0014	-29.58335	17.96343	Background monitoring. One might need quality monitoring due to mining activities.	Baseline	III. 100m away from GWU activity (700 m^3) Stable groundwater level fluctuations.	III. Mining	Trendline
F3N0514	-30.21501	17.96305	Monitoring impact of pumping.	Trend	No registered activity. 2.5km away from Kamieskroon town. Next to Haas River. Surrounded by agriculture. Major groundwater level fluctuations.	N/A	Trendline
F3N0509	-30.20972	18.10001	Monitoring impact of pumping.	Trend/MAR	No registered activity. 3.5km away from Klein Nourivier town. Major groundwater level fluctuations.	N/A	Trendline
F4N0004	-30.31583	17.75555	Background monitoring.	Baseline	No registered activity. 3.2km away from Spoegrivier town. Surrounding agricultural activities.	N/A	Baseline
F4N0005	-30.36547	17.90277	Monitoring impact of pumping.	Trend	No registered activity. 1 km away from Kharkams town.	N/A	Trendline

			Monitoring impact of river (Next to Brand River)		Surrounding agricultural activities.		
F5N0512	-30.56055	18.00611	Monitoring impact of pumping	Trend	No registered activity. 1.5 km east of Garies town. Major groundwater level fluctuations.	N/A	Trendline
F5N0513	-30.49027	18.09138	Background Monitoring	Baseline	No registered activity. 3.4 km away from Magata Mine. Major groundwater level fluctuations.	N/A	Trendline
F6N0012	-30.88731	17.87848	Background Monitoring	Baseline	No registered activity. Surrounding agricultural activities. Moderate groundwater level fluctuations	N/A	Baseline
F6N0013	-30.96207	18.06754	None	None	No registered activity. 2 km away from Rietpoort town.	N/A	Baseline
F6N0002	-31.05363	18.2735			No registered activity. Immediately downstream of a water treatment plant. 1.8 km away from Bitterfontein town. Surrounding agricultural activities.	N/A	Baseline

					Stable groundwater level fluctuations.		
E3N0148	-31.05495	18.31372			No registered activity. Surrounding agricultural activities. Stable groundwater level fluctuations	N/A	Baseline
E3N0008	-31.07062	18.31734			No registered activity. Surrounding agricultural activities. Stable groundwater level fluctuations	N/A	Baseline
E3N0132	-31.06553	18.34993			No registered activity. Stable groundwater level fluctuations	N/A	Baseline

5. Conclusion and Recommendations

An investigation was done on the groundwater level fluctuations within the Namaqualand Vegter region through comparing the average groundwater levels of the 2022/23 – and 2023/24 hydrological years. Groundwater level data was obtained from the existing groundwater level monitoring system. This monitoring system comprised of 17 boreholes distributed throughout the Namaqualand region, but it is recommended that more boreholes with groundwater level data should be included to achieve an increased representative view of the entire study area. The expansion of the groundwater level monitoring system can be achieved from identifying existing boreholes within the study area (see Appendix A, Figure 24) to “close” the gaps.

The results show that 35% of the monitored boreholes recorded declining groundwater levels, while 65% showed increases. From the 17 boreholes that were analysed, only 3 had major groundwater level increases (> 5 m) and 1 had a major decrease in the groundwater level (< -5 m). The locations of the increasing boreholes correspond with areas that received above-normal rainfall in 2023, indicating delayed recharge as the likely driver of these rises.

One borehole displayed a sharp 12 m decline after a period of historically stable levels; this anomaly requires further investigation to confirm whether local abstraction or other factors are responsible. It is recommended that a hydrocensus be completed in this area by the local municipality. Thereafter, the licenses for groundwater ought to be reviewed to determine whether these abstractions are sustainable. Dataloggers can also be installed to improve the effectiveness of the groundwater level monitoring system.

No clear relationship was found between available abstraction volumes and groundwater-level fluctuations due to limited groundwater use data. It is recommended that more recent abstraction data should be acquired to make this connection.

The monitoring objective of each boreholes showed that 10 boreholes are classified as baseline and 7 as trendline. As mentioned previously, more groundwater use data is required to allocate an accurate monitoring objective for each borehole. These monitoring objectives should also be reviewed and updated as more information becomes available.

5. References

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Appendix A

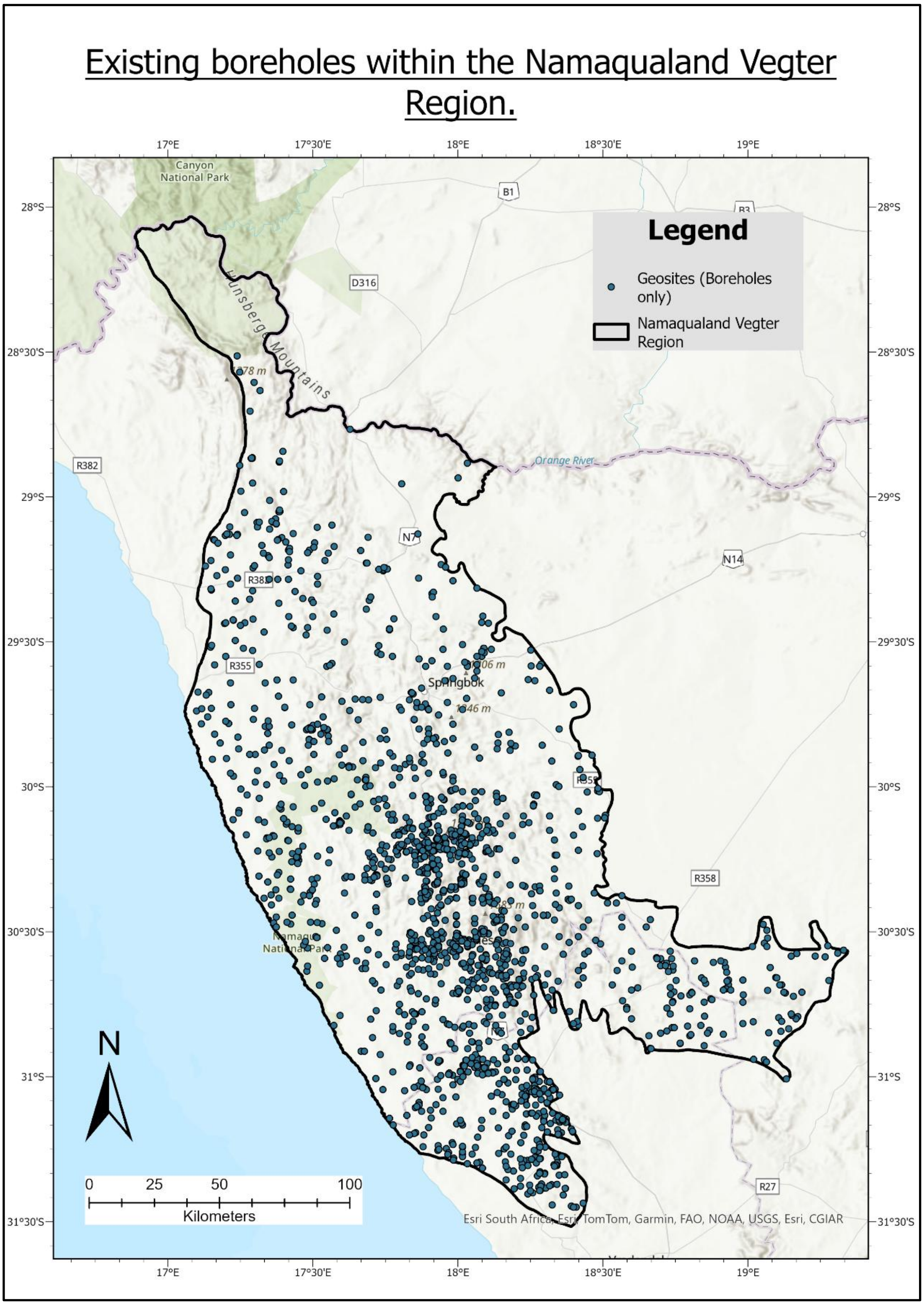


Figure 22 - Existing boreholes within the Namaqualand Vegter region.

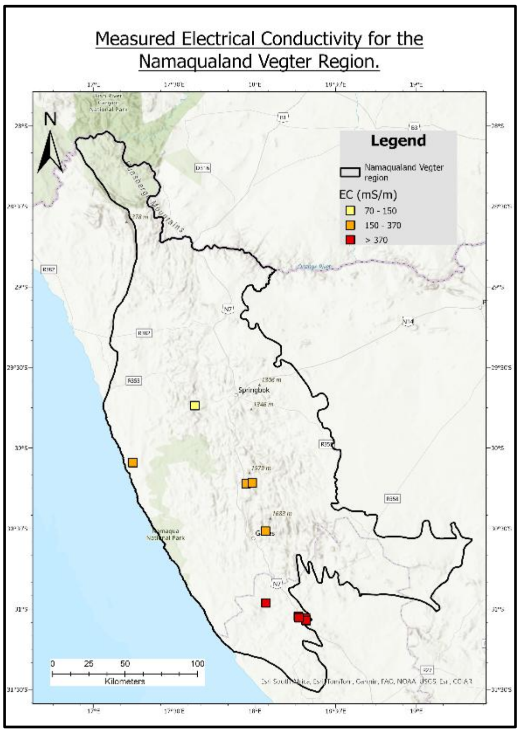


Figure 23 - EC levels for the Namaqualand Vegter region.

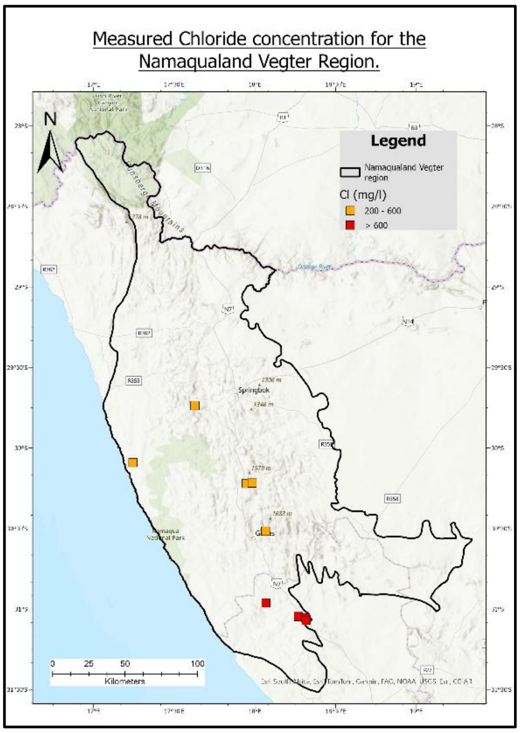


Figure 24 - Chloride levels for the Namaqualand Vegter region.

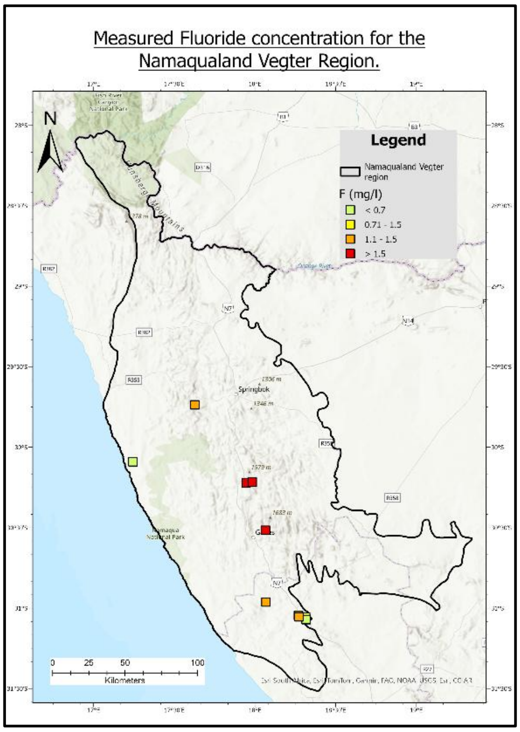


Figure 25 - Fluoride levels for the Namaqualand Vegter region.

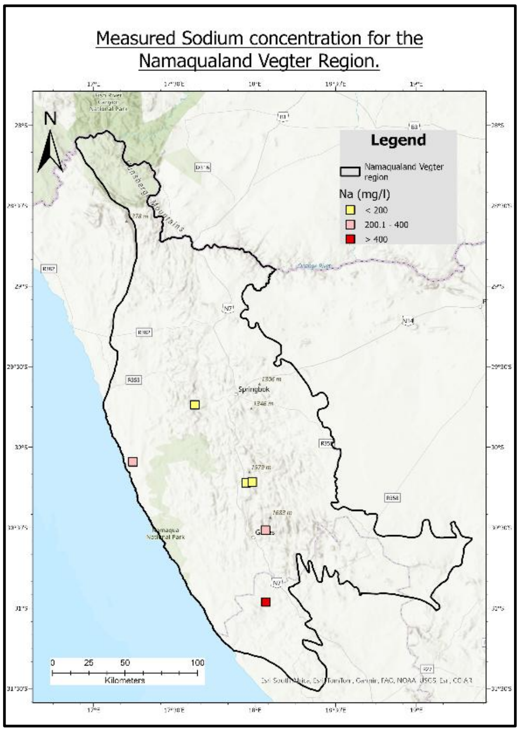
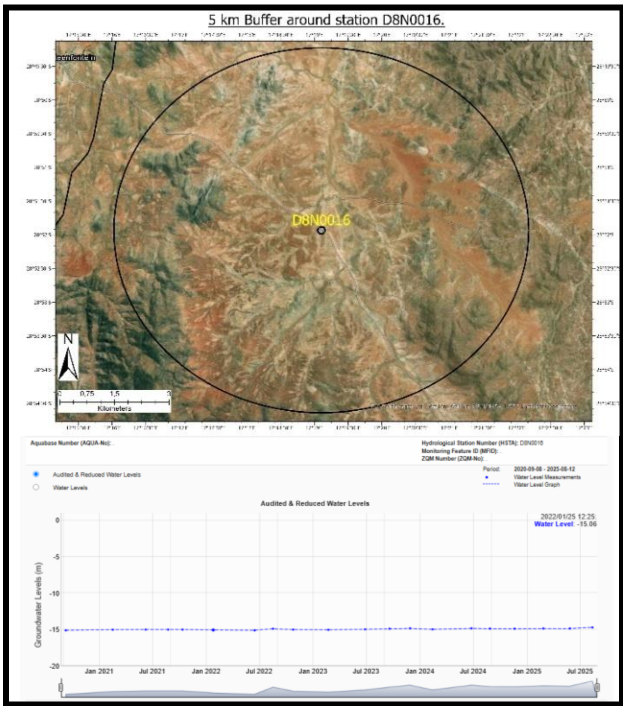


Figure 26 - Sodium levels for the Namaqualand Vegter region.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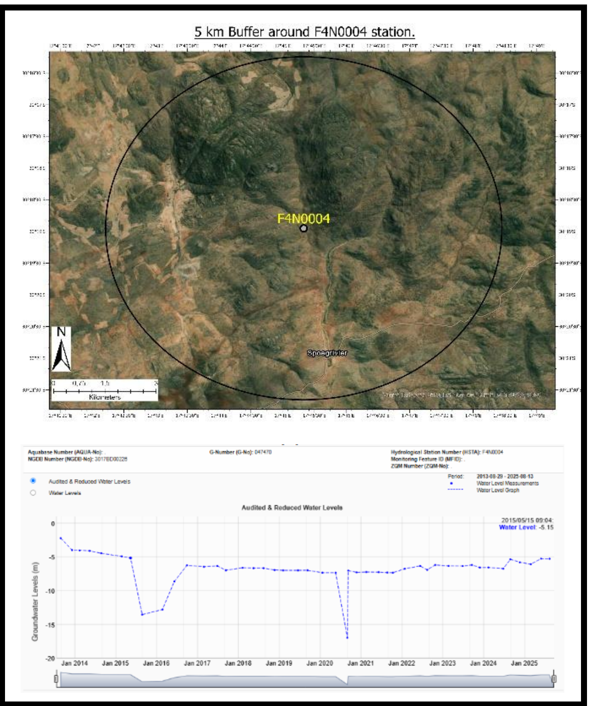
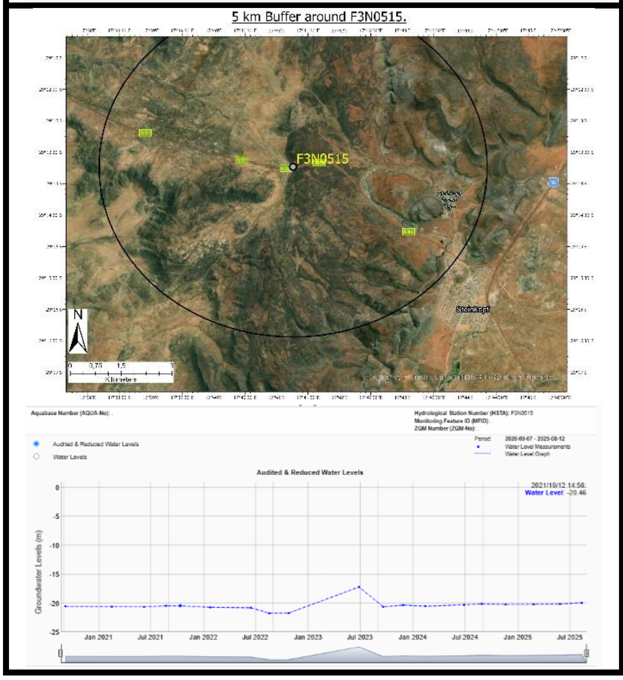
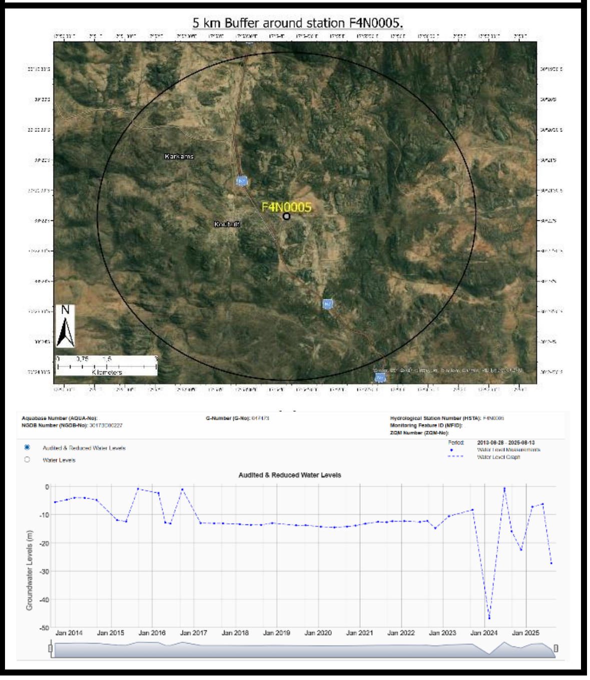
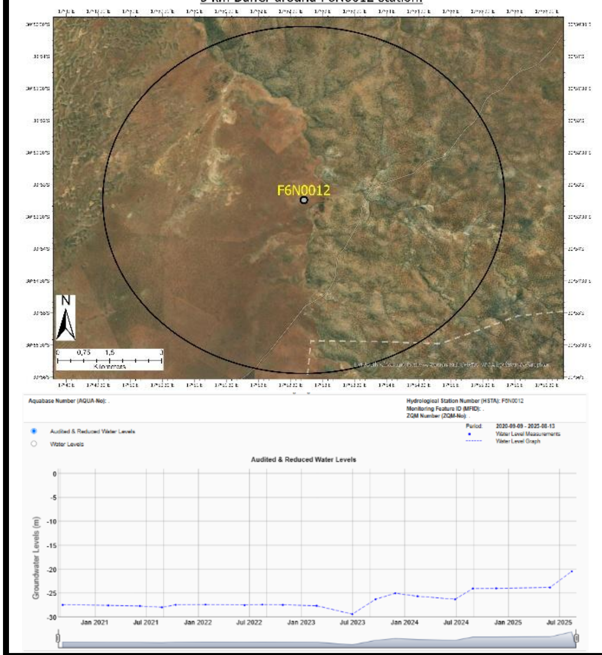
D8N0016
Kilometers
Audited & Reduced Water Levels
Water Levels
2022/01/25 12:25
Water Level: -15.06
Groundwater Levels (m)
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024
Jan 2025
Jul 2025


5 km Buffer around F4N0004 station.
F4N0004
Kilometers
Audited & Reduced Water Levels
Water Levels
2015/05/15 09:04
Water Level: -5.15
Groundwater Levels (m)
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018
Jan 2019
Jan 2020
Jan 2021
Jan 2022
Jan 2023
Jan 2024
Jan 2025

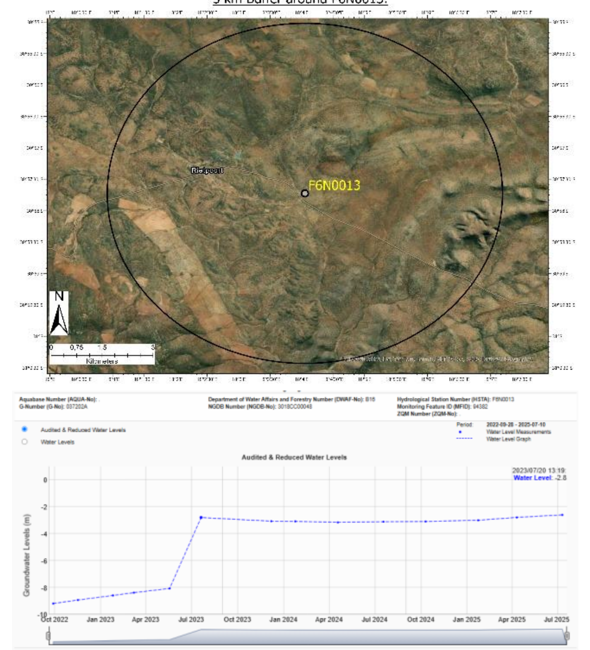

5 km Buffer around F3N0515.
F3N0515
Kilometers
Audited & Reduced Water Levels
Water Levels
2021/10/12 14:56
Water Level: -20.46
Groundwater Levels (m)
Jan 2021
Jul 2021
Jan 2022
Jul 2022
Jan 2023
Jul 2023
Jan 2024
Jul 2024
Jan 2025
Jul 2025


5 km Buffer around station F4N0005.
F4N0005
Kilometers
Audited & Reduced Water Levels
Water Levels
Groundwater Levels (m)
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018
Jan 2019
Jan 2020
Jan 2021
Jan 2022
Jan 2023
Jan 2024
Jan 2025

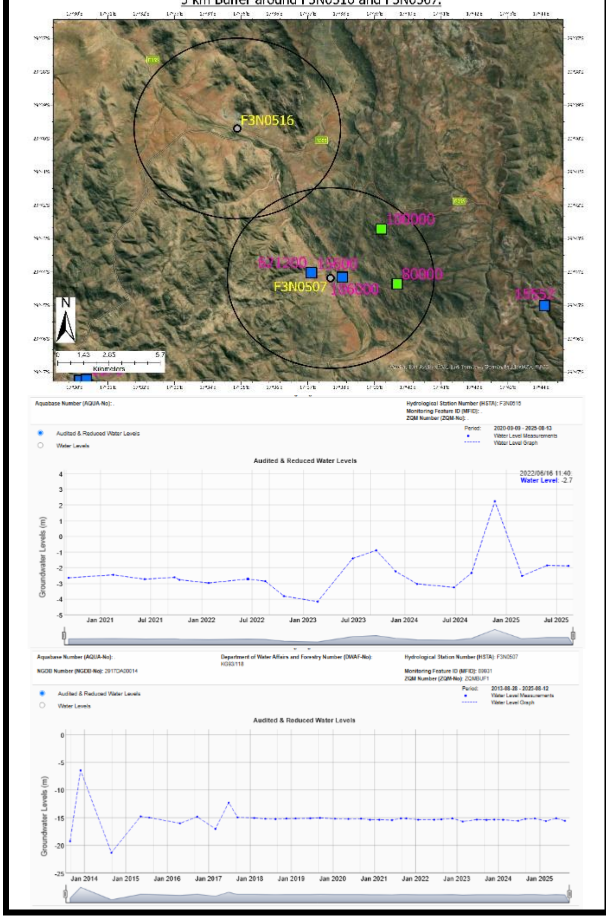
5 km Buffer around F6N0012 station.



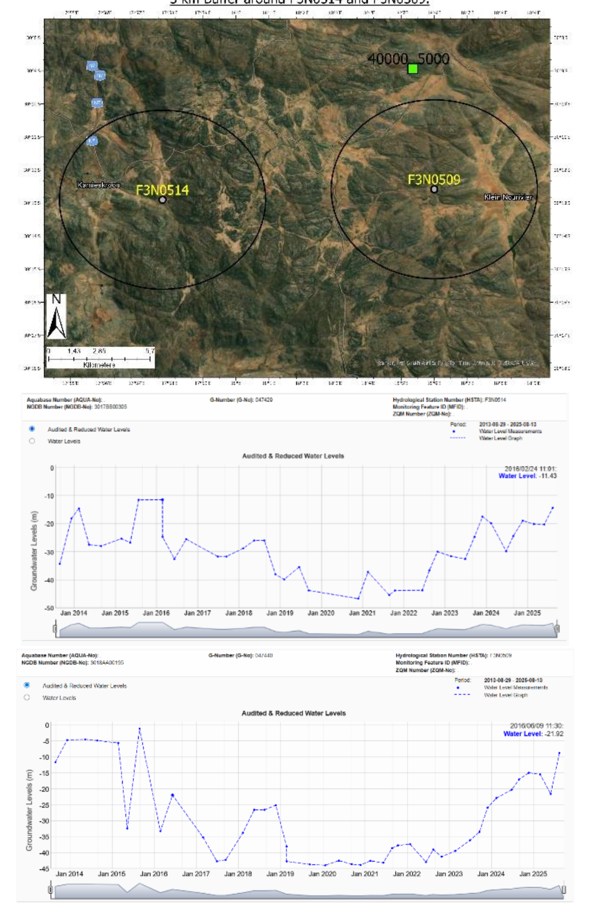
5 km Buffer around F6N0013.



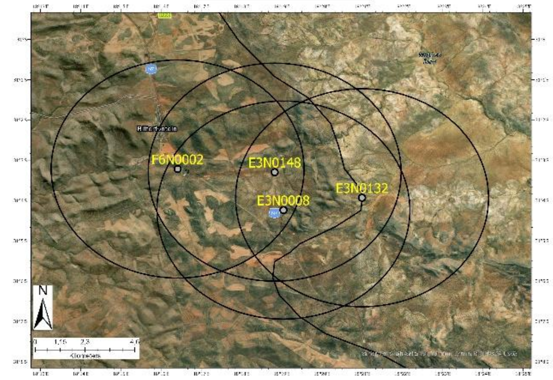
5 km Buffer around F3N0516 and F3N0507.

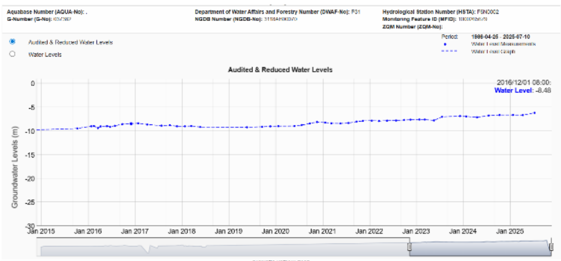


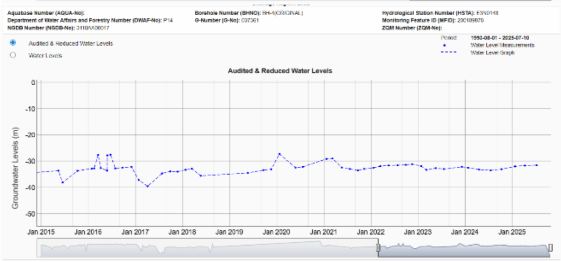
5 km Buffer around F3N0514 and F3N0509.

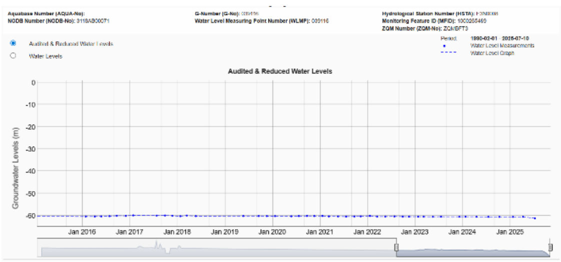


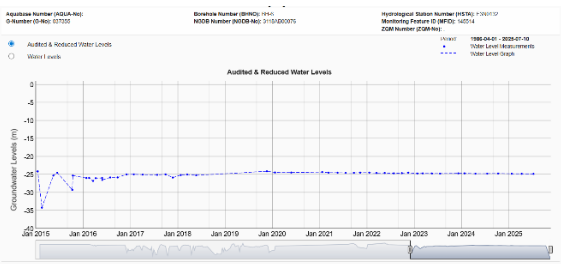
5 km Buffer around 4 stations.



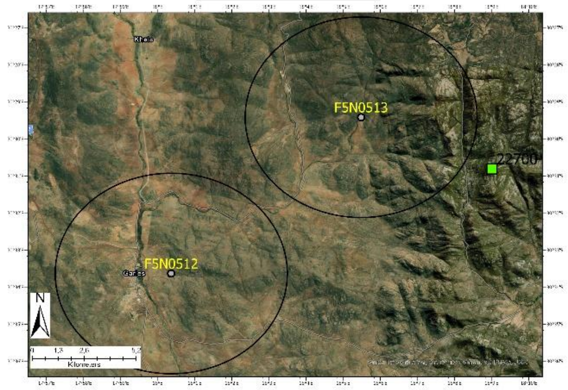


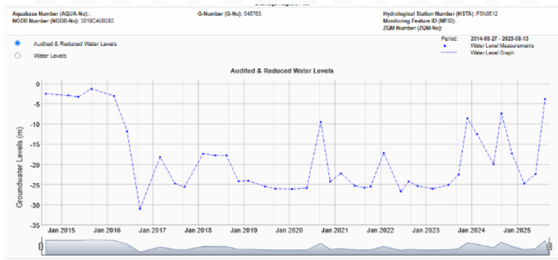


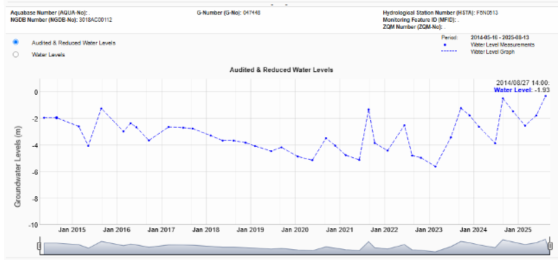




5 km Buffer around 2 stations.







5 km Buffer around D8N0014.