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Assessment of groundwater level and quality trends in the Algoa Basin

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Authors:	*Tholoana Mabula*
Signature:	
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Approval	Dr Lindelani Lalumbe *Scientist Manager: Geohydrological Information Services*
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1. Background

1.1 Background

Groundwater is widely used for irrigation and rural water supply. Global water demand is largely influenced by population growth, urbanization, food, and energy security policies, and macroeconomic processes such as trade globalization and changing consumption patterns. Twenty percent of the earth's freshwater supply is groundwater, and an estimated 25% of the global population relies on groundwater as a water source (Lathamani et al., 2015). In comparison to surface water, groundwater has many advantages. It is less affected by seasonal and perennial fluctuations, better protected from direct pollution and evaporation, usually of higher quality (Vandala, 2023).

South Africa is a relatively water-stressed country, receiving an annual average rainfall of 500 mm, hence a semi-arid country (Knuppe, 2011). The Eastern Cape Province is South Africa's poorest province, where the standard of living is low and where many people live without access to fresh potable water. The advancement of groundwater research to mitigate some of the socio-economic challenges faced in the Eastern Cape and other provinces across the country is essential (Vandala, 2023). The Algoa Basin, a potential hydrocarbon basin, is hydrogeological region is in the eastern Cape province of South Africa as seen in Figure 1. This basin includes the coastal area of Port Elizabeth (Gqeberha) which is part of the Nelson Mandela Bay Municipality which includes Despatch and Kariega (Uitenhage). Since 2015, the area has been experiencing hydrological drought due to a dry period of below average rainfall which resulted in the fall of water levels for both surface water and groundwater reservoirs (Department of Water and Sanitation, 2022). The hydrological year is defined as the yearlong cycle of the development of hydrologic processes. In the Department of Water and Sanitation the hydrological year is considered from October to September. This report provides information on the groundwater monitoring activities, particularly water levels, that took place in the 2022/23 to 2023/24 hydrological years. The water quality for the past 10 years was also assessed. The groundwater monitoring objectives were also re-assessed.

The Eastern Cape Regional Office is responsible for data collection and uploading the data onto the Hydstra system where it can be extracted and used for analysis.

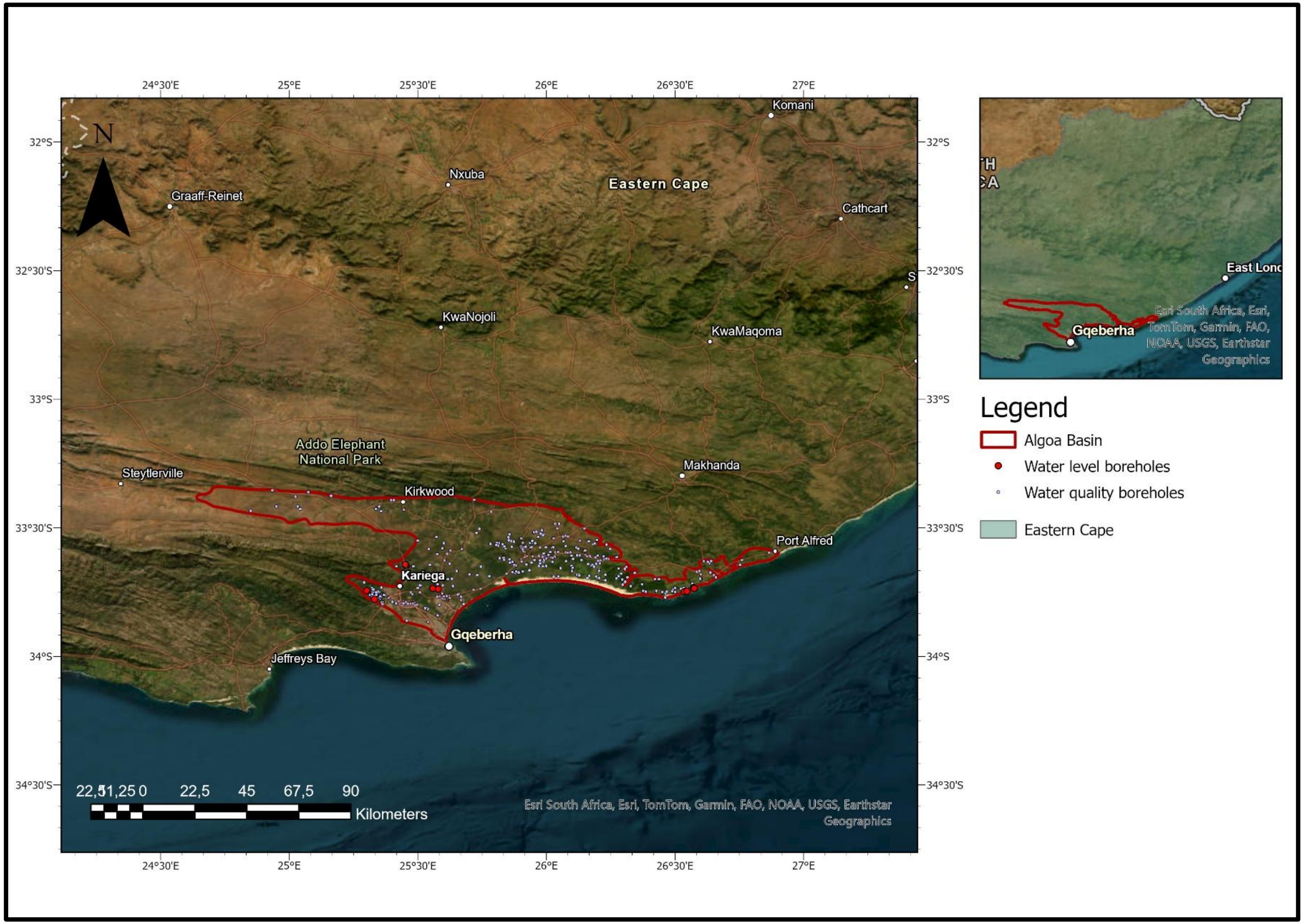

Figure 1: Locality map of the Algoa Basin hydrogeological region

1.2 Climatic setting

The Algoa Basin hydrogeological region includes the Nelson Mandela Bay region (Despatch and parts of Gqeberha) which is located in a transition zone between the warm Agulhas current of the east coast and the cold Benguela current of the west coast. The east coast receives summer rainfall, and the west coast receives winter rainfall. The Algoa Basin region receives rainfall both during summer and winter seasons as a result of the two varying ocean currents. Overall, the highest precipitation is experienced during the June – October months (seen in figure 2). The area receives an annual average rainfall of about 613 mm per annum and has an evapotranspiration rate of 1800 mm per annum. During the past 25 years, the Gqeberha area climate has shown notable warming, indicating climate change. Climate change affects not only surface water resources but also groundwater reservoirs. The amount of rainfall affects the groundwater recharge, which affects the baseflow to rivers and wetlands (Schael et al., 2015). Although aquifers differ in properties, the relationship between the amount of rainfall and groundwater recharge is the same, especially in shallow aquifers (Vandala, 2023).

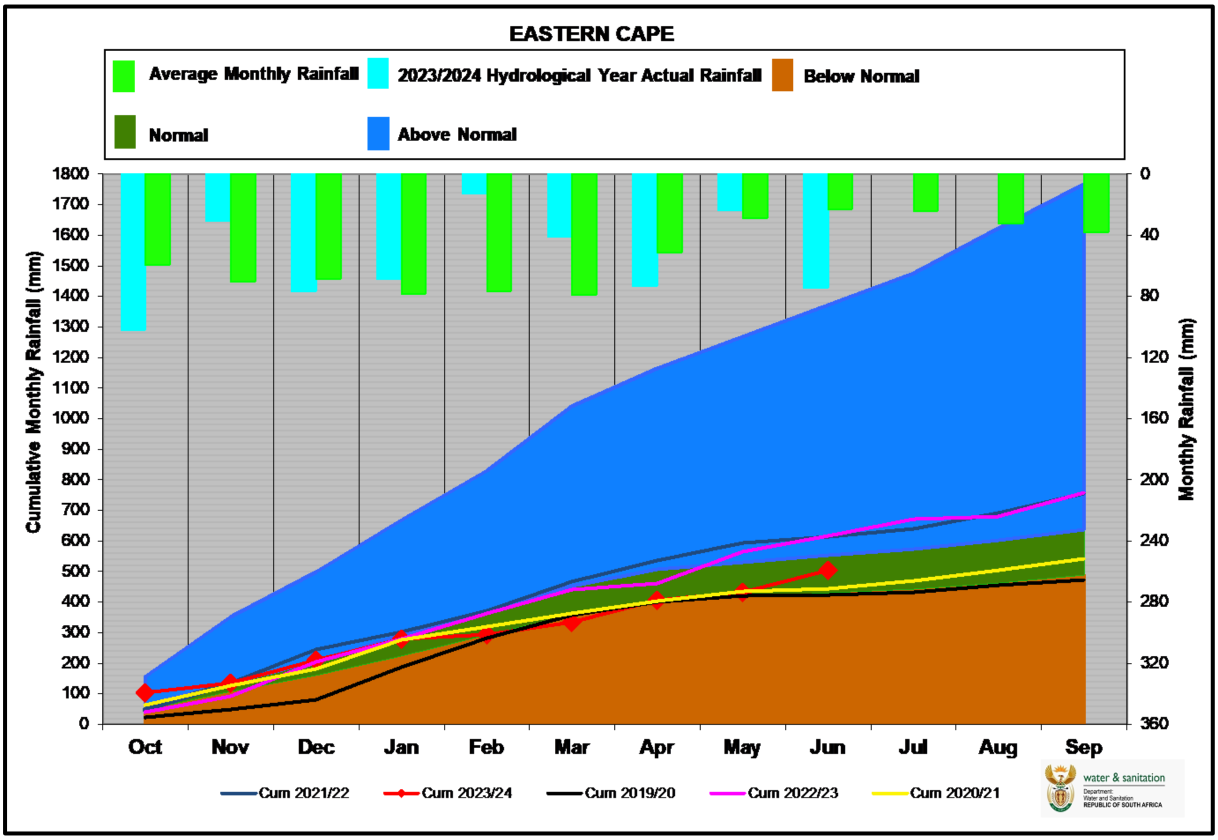

Figure 2: Eastern Cape rainfall for 2023/24

1.3 Geology

The geology in the Algoa Basin consists of quarternary sediments, the Alexandria, Bokkeveld, Ceres, Dwyka, Ecca, Enon, Kirkwood, Lake Mentz, Nanaga, Nardouw, Peninsula, Sundays River, Suurberg, Traka and Weltevrede formations, subgroups and groups.

The Algoa Group, 41 million years old (Ma), unconformably overlies the Cape Supergroup and the Uitenhage Group. It consists of the Alexandria and Nanaga formations. The Alexandria formation consists mainly of conglomerates, limestones and clays, and the Nanaga of arenites and sands.

The Uitenhage Group, 183 million years old (Ma), consists of the Enon, Sundays River and Kirkwood formations and is overlain by the Algoa Group. The Enon formation consists of arenites and conglomerates, the Sundays River consists of arenites, mudstones and shales, and the Kirkwood consists of mudstones, arenites and conglomerates.

The Cape Supergroup consists of the Bokkeveld group (419-382 Ma), Ceres subgroup, Lake Mentz subgroup, Traka subgroup and the Weltevrede subgroup. The Cape Supergroup rocks were deposited in a purely marine setting, within a 1,300 kilometres wide passive margin basin known as the Cape Basin. The rocks were deposited over a 170-million-year period ranging from approximately 485 Ma (Tremadocian) to the Early Carboniferous (about 330 Ma; late Mississippian). The Ceres, consisting of shales and arenites, and Traka subgroups, consisting of shales, siltstones and arenites, form part of the Bokkeveld Group. Lake Mentz subgroup belongs to the Witteberg group of the Cape Supergroup and consists of diamictites, arenites and shales. The Nardouw subgroup and Peninsula formation belong to the Table Mountain Group of the Cape Supergroup.

The Karoo Supergroup (300-180 Ma) consists of the Dwyka and Ecca groups. The Dwyka group consists of tillites, mudstones and shales, and the Ecca group consists of shales and arenites. The Algoa Basin hydrogeological region has minimal Karoo Supergroup coverage.

The quaternary coverage consists of sands and calcrete and is the youngest of the stratigraphy.

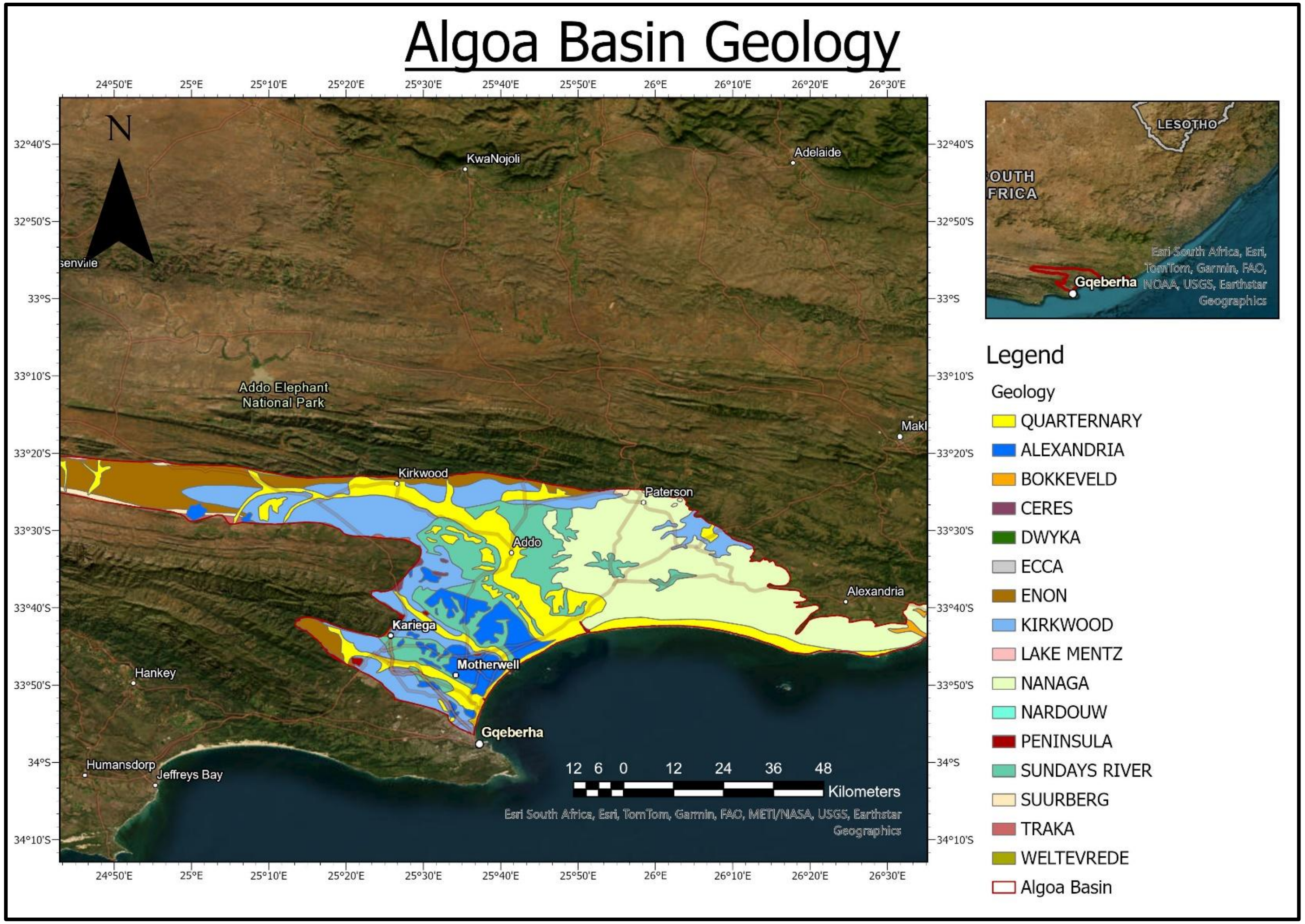

Figure 3: Map displaying Algoa Basin Geology

1.4 Hydrogeology: Aquifer Type, Yield, Vulnerability

In this chapter the hydrogeology of the various geological groups and formations are briefly described in terms of its geographical location, occurrence, general use, and quality.

1.4.1 Aquifer type and yield

The aquifer units are grouped together based on the interpreted groundwater occurrence. The Algoa Basin consists of namely, the Fractured aquifer type and the Intergranular and Fractured aquifer type (see Figure 4). The Fractured aquifer has yield ranges from 0 to >5 l/s, with the yield class of 0.1-0.5 l/s dominating for fractured aquifers. This is a low to moderately yielding aquifer. The Intergranular and Fractured aquifer has yields ranging from 0.1 to 2.0 l/s, with the dominant yield class for the Intergranular and Fractured aquifer being 0.5-2.0 l/s. This is a moderate to high yielding aquifer.

The aquifer class dominating in the region is 'minor' aquifers which covers about 72% of the Algoa Basin. 'Poor' aquifers cover about 24% of the Algoa Basin, as seen in Figure 5.

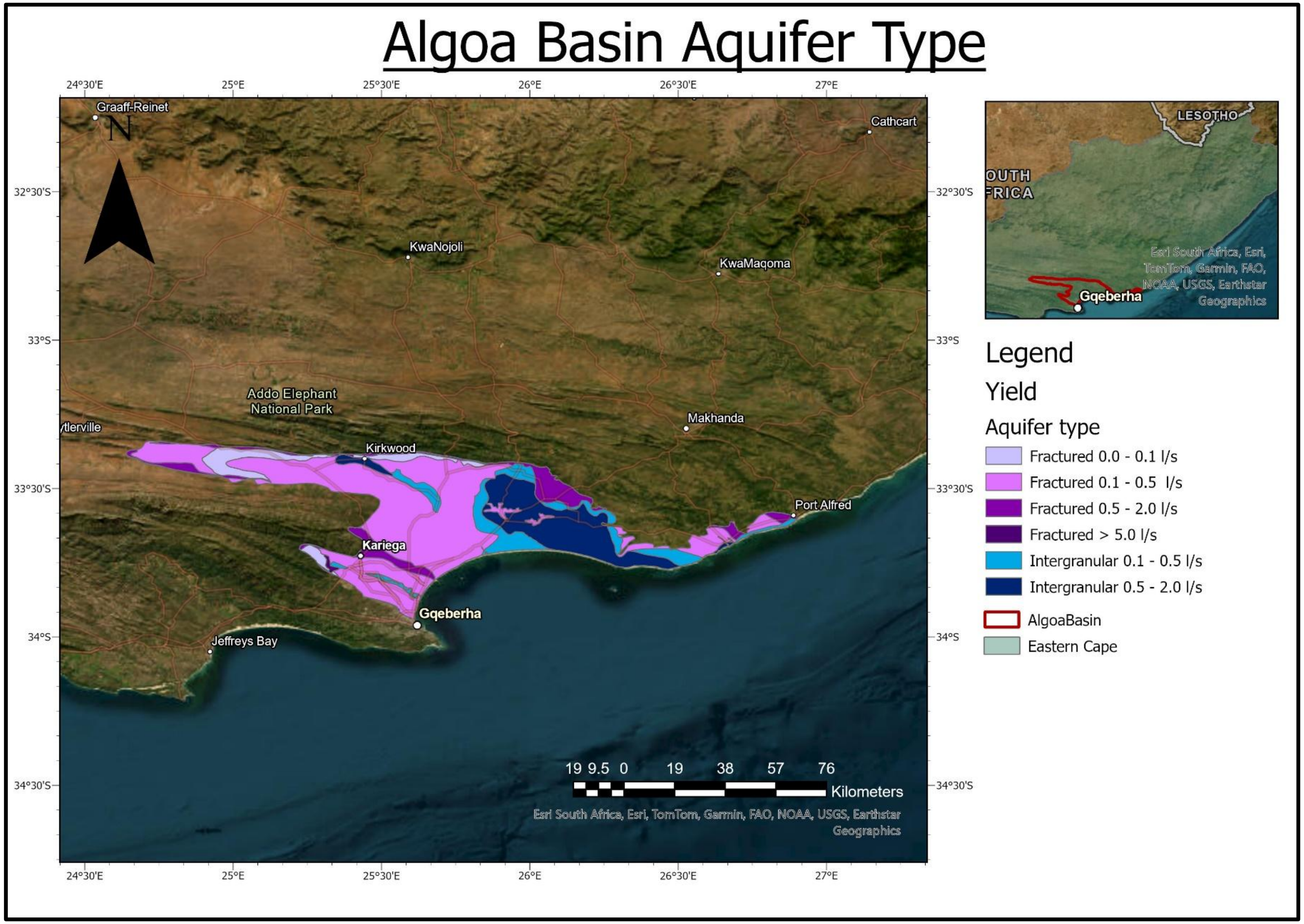

Figure 4: Aquifer type and associated yields for Algoa Basin

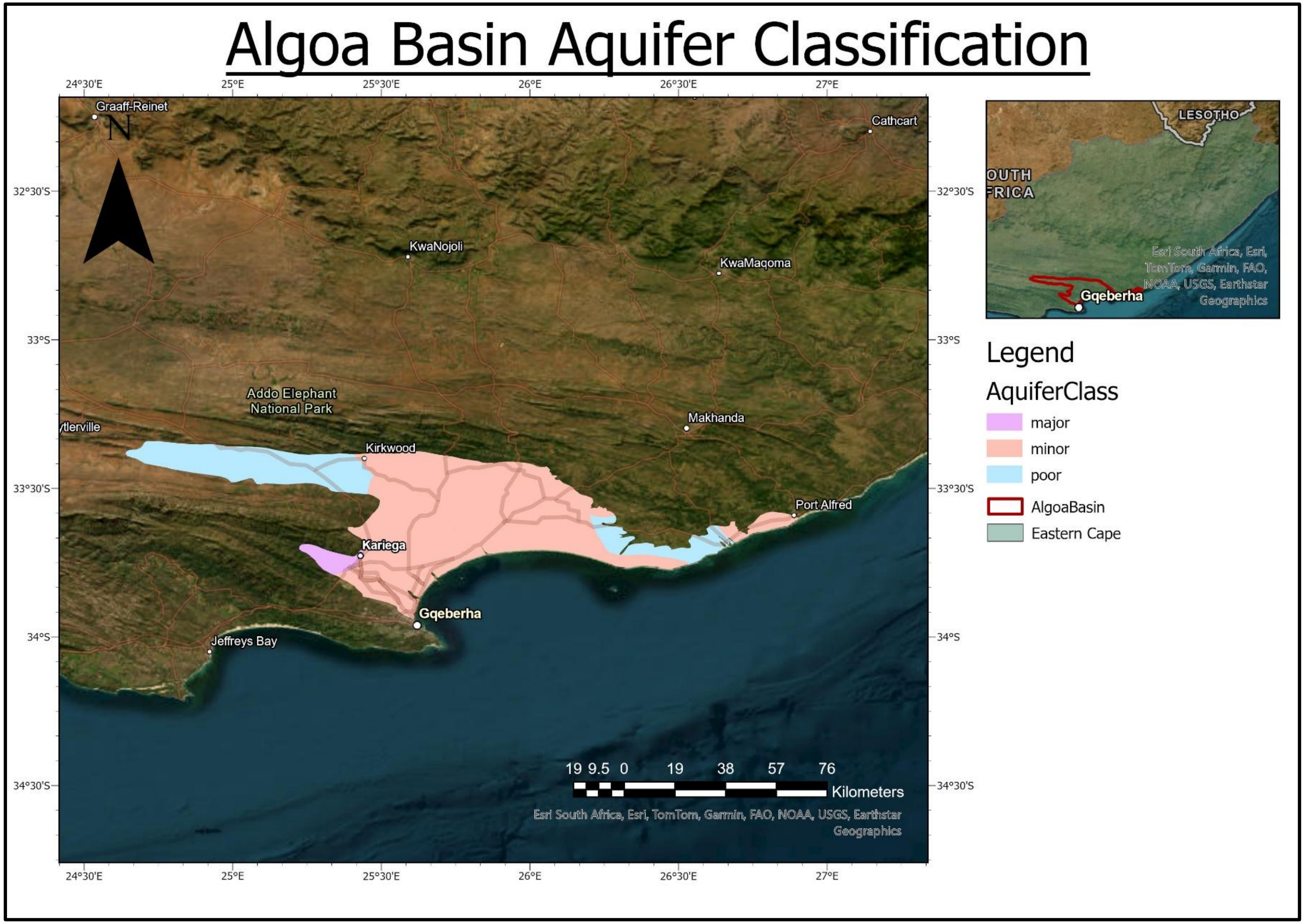

Figure 5: Map displaying aquifer classification of the Algoa Basin

1.4.2 Vulnerability

About 48% of the aquifers in the Algoa Basin fall within an area of moderate vulnerability. The spatial coverage of least vulnerable aquifers to contamination/pollution is 52% of the Basin (figure 7).

1.5 Groundwater use

The main supply of water in the Algoa basin region is surface water (dams and weirs), however groundwater is utilised in conjunction with it from various sectors. Before March 2023, only one groundwater or wellfield scheme was used in the bulk water supply across the Nelson Mandela Bay Municipality (NMBM), the Uitenhage Springs, with abstraction rates of 5.44 Ml/day (NMBM, 2020). Since then, the St. George's Park wellfield, with four boreholes, has been added to the bulk water supply system yielding 2.1 Ml/day (NMBM, 2020). According to the NMBM (2020), there are eight more future groundwater projects, and seven are within Gqeberha. Across the city, there are many small-scale boreholes where users are drilling for their homes or small businesses. This is because, during times of droughts, groundwater is often seen as a short-term solution (Morris et al., 2003; Vandala, 2023). The agricultural sector utilises most of the groundwater, namely for watering livestock and irrigation.

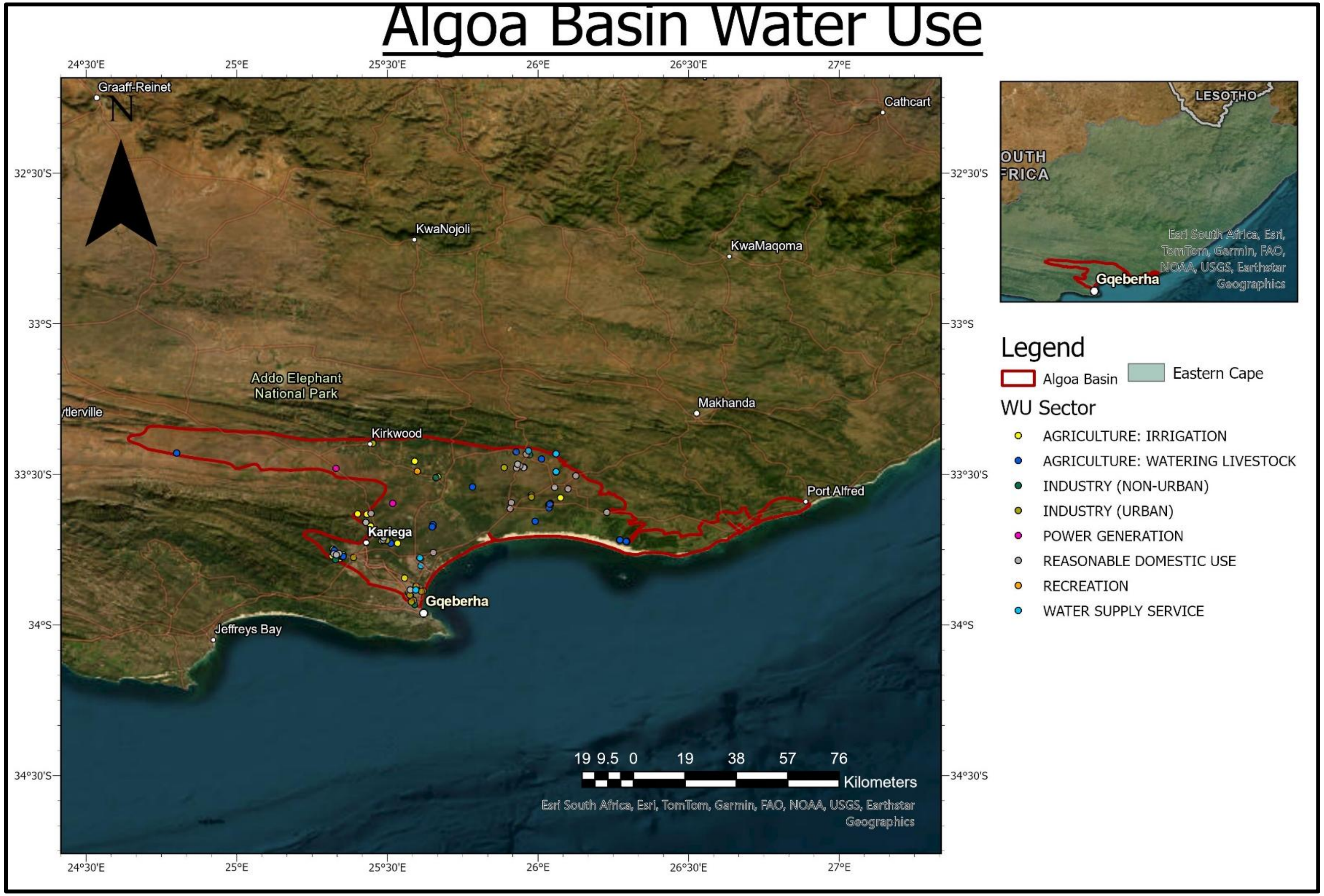

Figure 6: Groundwater use for Algoa Basin

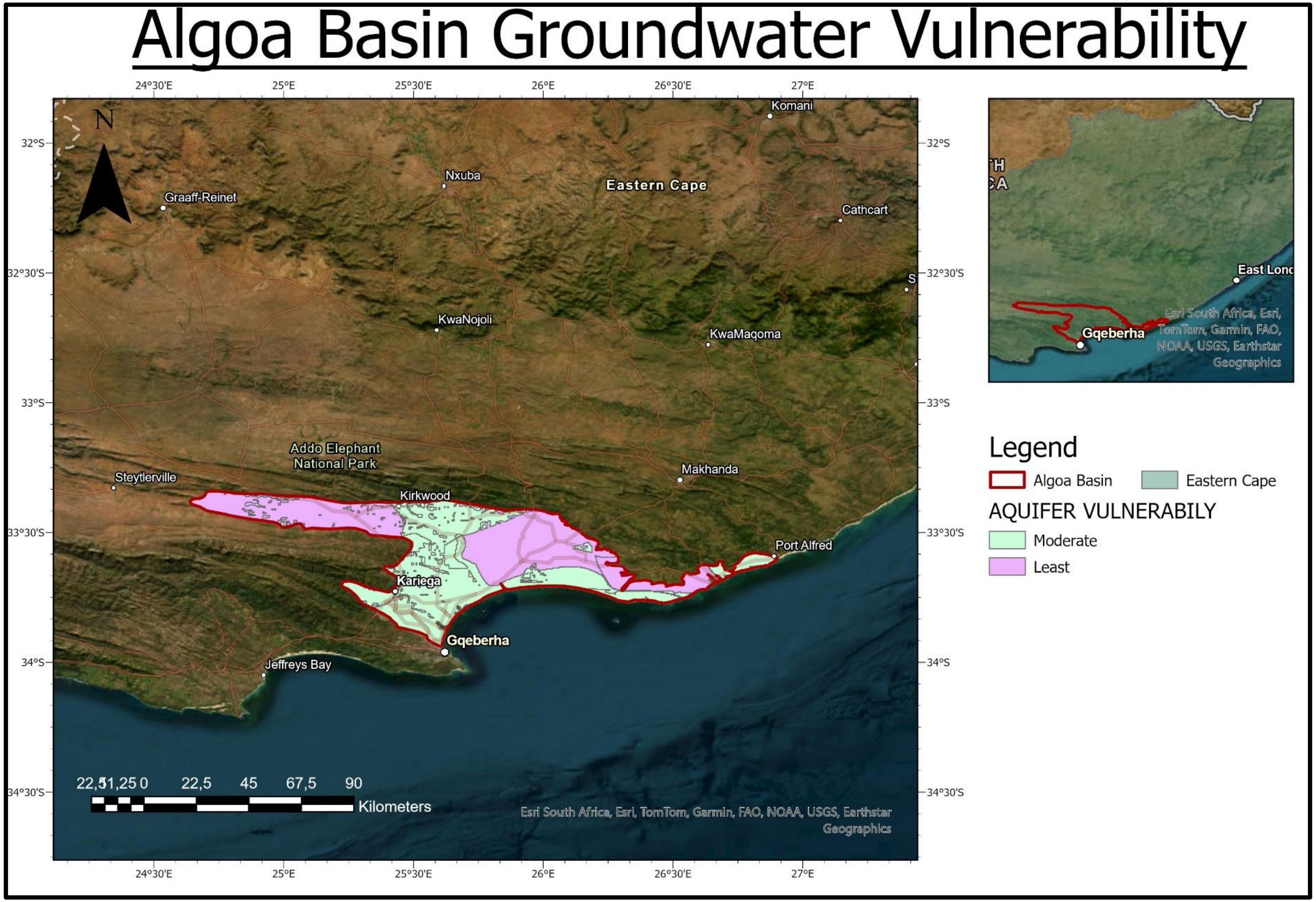

Figure 7: Map displaying Pietersburg Plateau groundwater vulnerability

2. Methodology

2.1 Depth to groundwater

The depth to groundwater level is influenced by various factors mainly the recharge and discharge of the groundwater. The groundwater level data was used to create graphs and tables to understand the groundwater status of the country for the 2022/23-2023/24 hydrological year.

The distance from the ground surface to the top of the saturated zone of the aquifer, i.e., the depth to water table, has a major impact on how water can be exploited and how much of it can be brought to the surface. Depth to water table is a dynamic value that fluctuates dependent on the season. Wet seasons generally result in recharge and dry seasons result in depletion. Depletion is a natural process caused by evapotranspiration at the ground surface and lateral flow toward rivers and lakes as their water levels drop. Just as anthropogenic factors affect recharge, the rate of depletion is also a combination of natural and manmade factors. Therefore, it is very important to recognise and be able to separate these factors these factors for better management and protection of the groundwater resource.

2.2 Groundwater Level Fluctuation

Water levels in aquifers reflect a dynamic balance between groundwater recharge, storage, and discharge. 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. Recharge and discharge are not distributed uniformly in space and time, therefore, groundwater levels are continuously rising or falling to adjust to the resulting imbalances. Water levels in wells reflect these changes and provide the principal means of tracking changes in aquifer storage over time. Water level measurements also provide insight into the physical properties that control aquifer recharge, storage, and discharge since these factors affect the timing and intensity of responses to hydrologic stresses such as precipitation or pumping.

The annual changes in groundwater level can be calculated as the difference between the average groundwater level of each borehole from the current hydrological year and the previous hydrological year. A positive difference (Δ) indicates a rise in groundwater level and negative indicate the opposite. Changes in groundwater levels (ΔGW) were determined by comparing average groundwater level (each borehole) of current (AVGC) hydrological year with average groundwater level of the previous (AVGP) hydrological year based on equation 1.

$$\Delta GW = AVGc - AVGp \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

3. Results and discussion

3.1 Depth to groundwater level

The groundwater level data for 10 boreholes monitored during the 2022/23 to 2023/24 hydrological years indicated that one of the boreholes had shallow groundwater levels of less than 2 mbgl (meters below ground level) as tabulated in table 2. Depth to groundwater level of between 2-10 mbgl changed from 3 boreholes in 2023 to 4 boreholes in 2024. Depth to groundwater levels ranging between 10-30 mbgl changed from 4 boreholes in 2023 to 2 boreholes in 2024, the 30-60 mbgl range increased from 2 boreholes in 2023 to 3 boreholes in 2024. None of the boreholes had water levels deeper than 45 mbgl (see figure 13).

Table 1: Depth to groundwater level for Algoa Basin

2023

Depth to water level	No. of boreholes	%
0-2	1	10
2 to 10	3	30
10 to 30	4	40
30-60	2	20
60-100	0	0
>100	0	0
Total	10	100

2024

Depth to water level	No. of boreholes	%
0-2	1	10
2 to 10	4	40
10 to 30	2	20
30-60	3	30
60-100	0	0
>100	0	0
Total	10	100

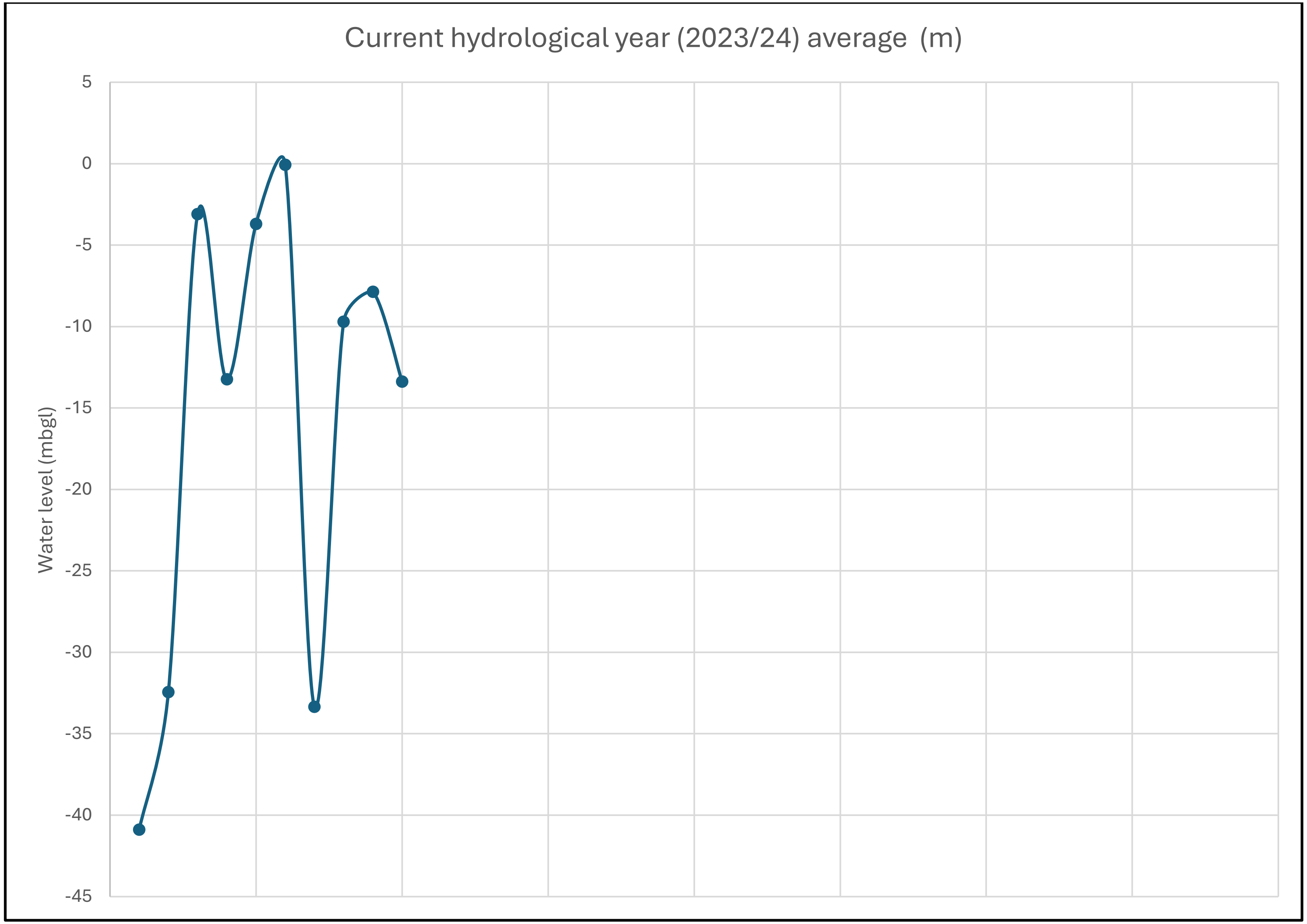

Figure 8: Depth to groundwater level for Algoa Basin

3.2 Groundwater level fluctuations

The change in groundwater level in this report is classified into three classes, major, moderate and stable. If the groundwater level increases or decreases five (5) meters from the previous level it was then, it is considered as major change and if it lies between (0.2 – 5 m) it is considered moderate, and anything below (0.2 m) is considered stable as seen in Figure 12 and Figure 9. Overall, groundwater level generally remained stable (50%) as compared to 3 boreholes (30%) that recorded an increase (moderate) in groundwater levels during the current hydrological year as presented in Table 2.

When it comes to groundwater level fluctuations per classification, only one borehole (M1N0036) displayed a major decline in groundwater level (-5.493 mbgl). The decline in the borehole at M1N0036 (-33.777611, 25.331361) may be as a result of the irrigation/watering livestock (agricultural) activity. One borehole (10%) recoded a moderate decline (-0.2 to -5 m) during the 2022/23 - 2023/24. Stable groundwater fluctuation refers to boreholes with minimal change in groundwater level (<0.2 m) and 5 (50%) of the boreholes recorded a stable change in groundwater levels. When it comes to positive groundwater level fluctuation, 3 (30%) of the boreholes recorded a moderate increase groundwater level of between 0.2 and 5 m.

Table 2: Groundwater fluctuation for Algoa Basin

GW Level Fluctuation	No. of boreholes	%
>5 Major increase	0	0
>0.2- <5 Moderate increase	3	30
>-0.2-<0.2 Stable	5	50
>-5-<-0.2 Moderate decline	1	10
<-5 Major decline	1	10

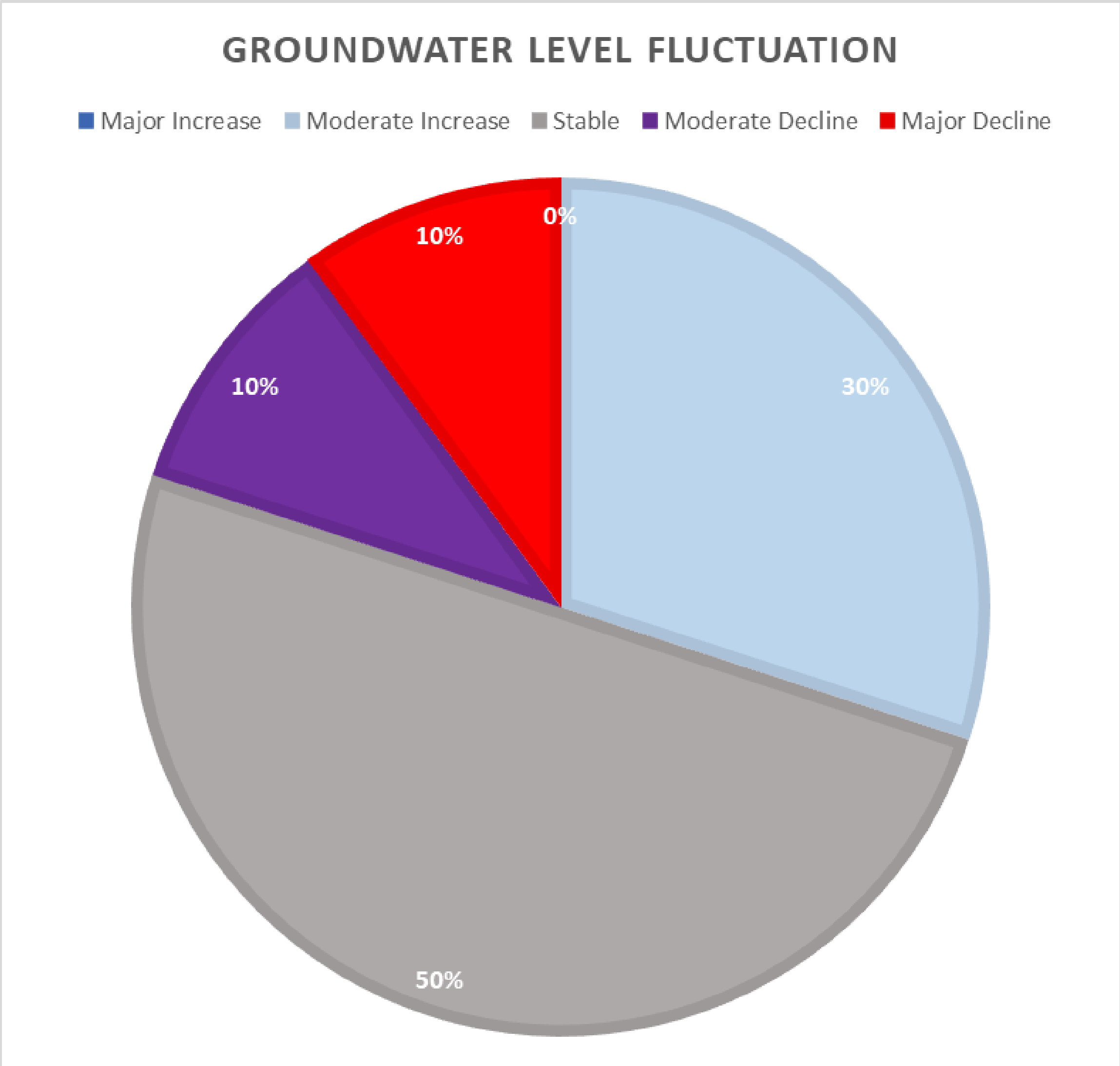

Figure 9: Pie chart displaying groundwater level fluctuation classifications for Algoa Basin

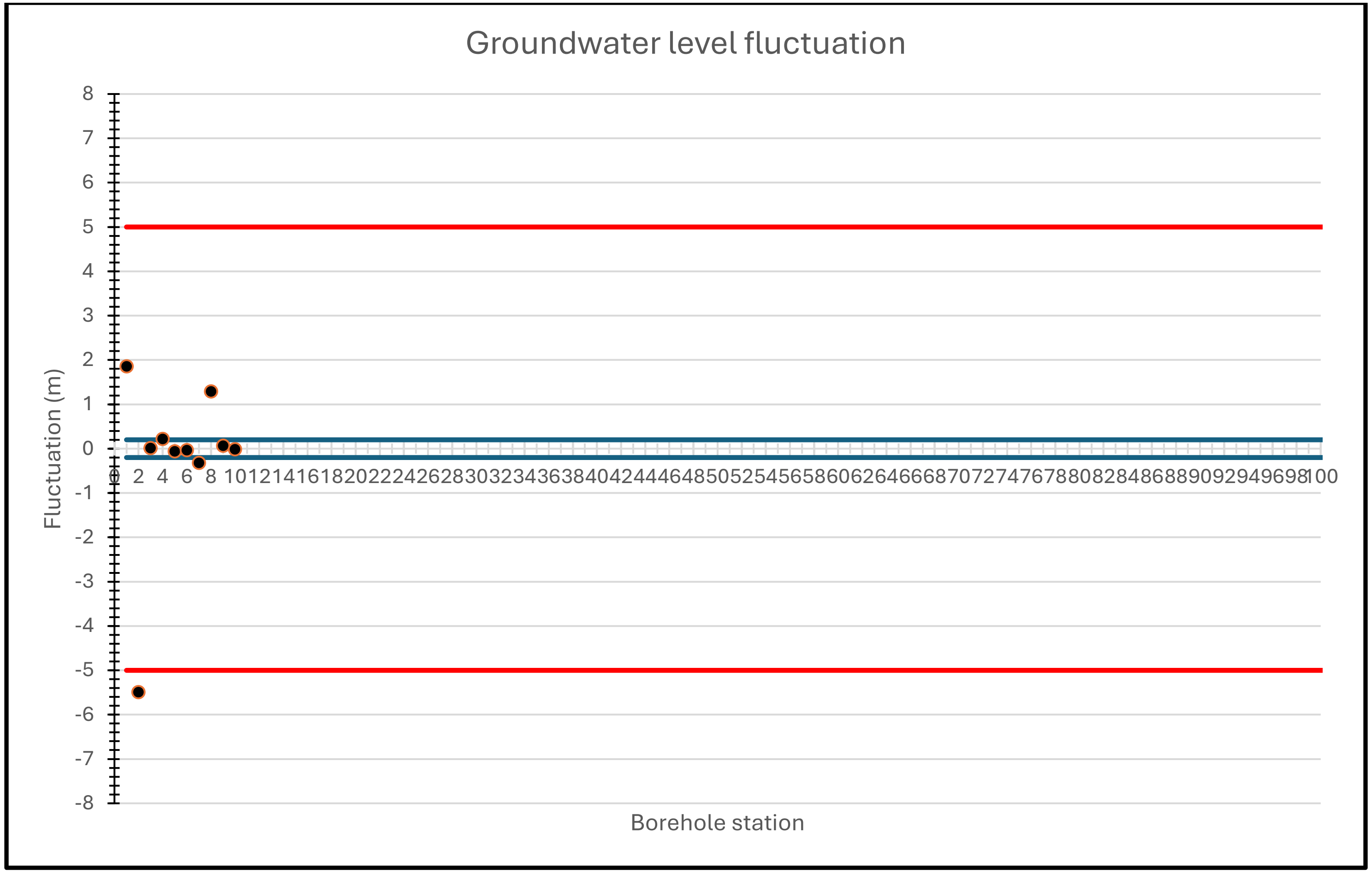

Figure 10: Groundwater level fluctuation graph

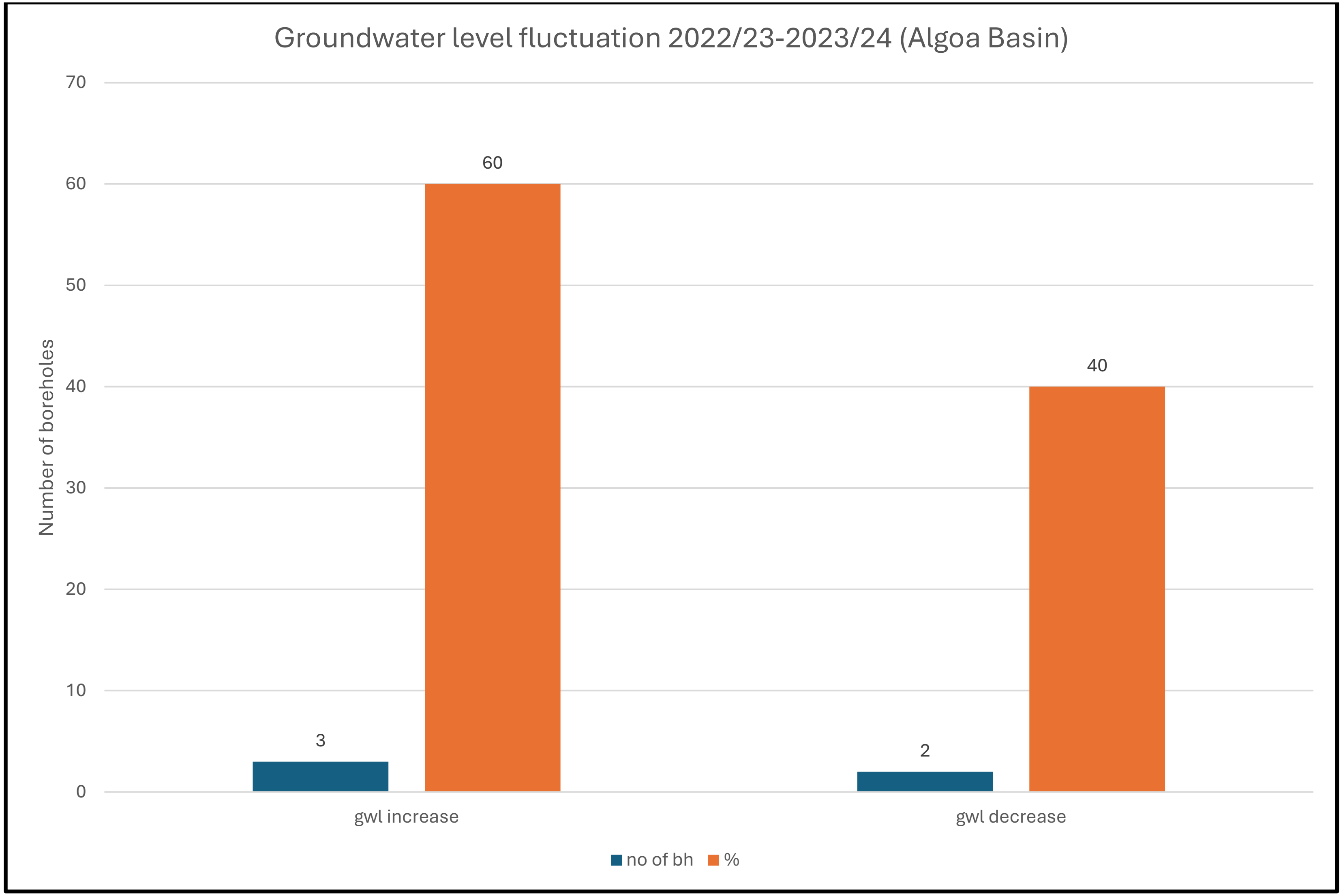

Figure 11: Number of boreholes that have increased and decreased in the Algoa Basin

3.3 Groundwater status and groundwater use

The dominant land use/water use activities in the Algoa Basin are agriculture, both irrigation and watering livestock, domestic use and power supply (see Figure 12). Where a major decline in groundwater level is recorded, the dominant water users are irrigation, watering livestock and domestic use (Figure 12 and Figure 13). These land use activities may explain why there seems to be a problematic borehole as a result of over abstraction. The abstraction values in the region surrounding the borehole displaying a major decline range from 15 170 m^3 to 29 250 m^3 (see Figure 13). There are no boreholes which display major increases in their water levels which may be as a result of the abstraction rates exceeding the recharge rates in the area thus having a minimal impact on the overall water levels. Five boreholes display stable water levels and three boreholes display a moderate increase in groundwater levels. The abstraction volumes where 'stable' water levels are noted are higher than those where 'declines' are recorded. These areas may potentially be the recharge zones whereby the abstraction volumes have a minimal effect of the water levels.

Figure 12: Groundwater status vs groundwater use for Algoa Basin

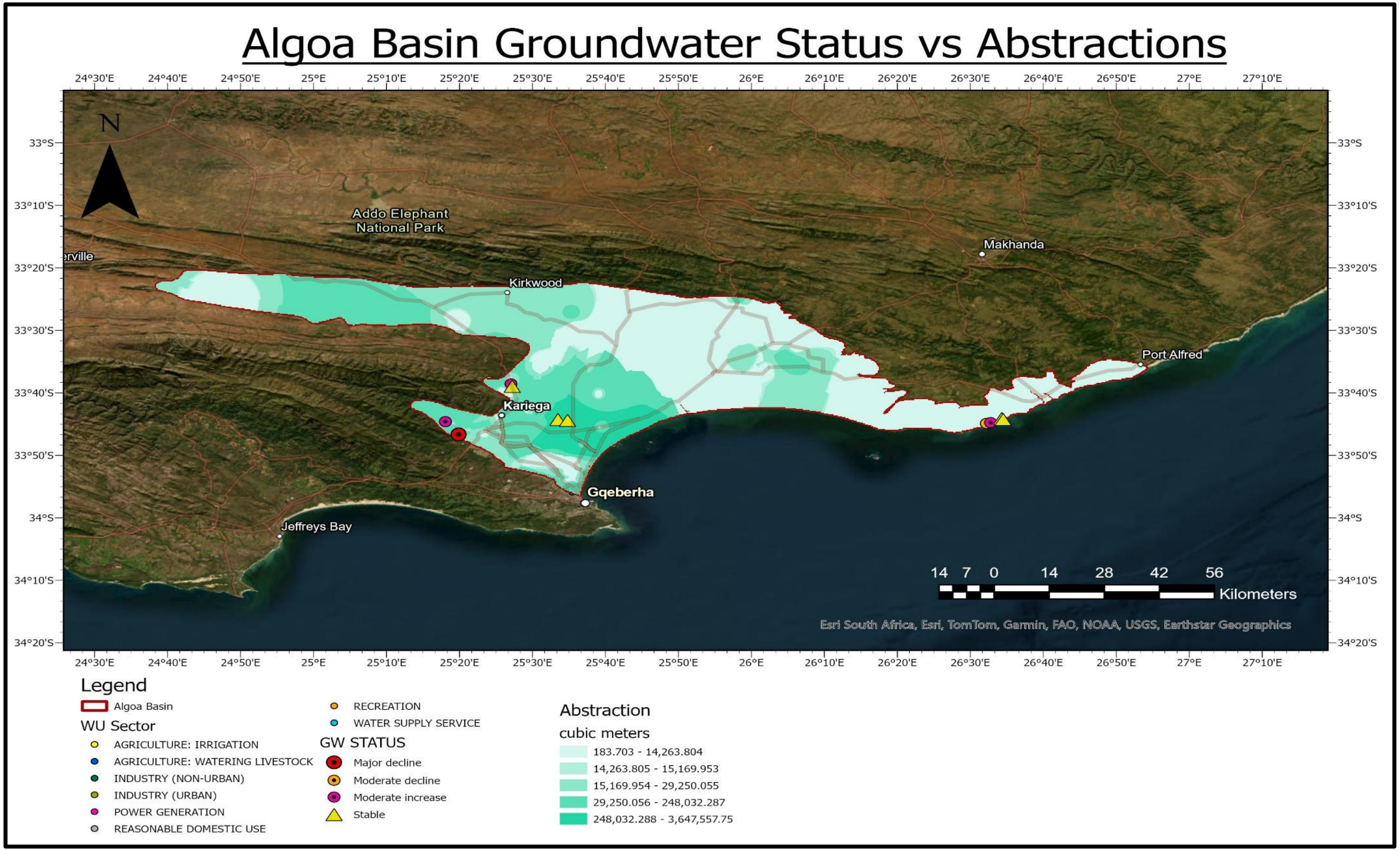

Figure 13: Groundwater abstraction vs fluctuation of water levels

3.4 Monitoring objectives

Groundwater monitoring networks provide the main source of information about water levels and water quality within aquifers. A groundwater monitoring network is defined as a system designed to generate groundwater level and quality records that are accessible and evaluable. These records provide fundamental information to understand the water quantity and quality in space and time. Groundwater monitoring networks generate data that can be utilized for different purposes relating to groundwater resources. This includes understanding the effect of climate change on groundwater resources, early warning systems for assessing the impacts of pollution and over-exploitation and supporting research-related studies needed for groundwater management and development programs (Fuku *et al.*, 2025).

The criteria for a borehole to be considered a baseline station are as follows:

- Should be located in pristine areas with no to low environmental impacts
- There should be no groundwater abstraction within a 5-km radius
- No observed effect of pumping on the borehole groundwater level
- Should feature long-term stable groundwater levels

The criteria for a borehole to be considered a trend station are as follows:

- Located in developed areas with high groundwater use
- Observable abstraction impacts on the groundwater level
- Hydrographs should indicate a fluctuating trend

The water level monitoring boreholes in the Algoa Basin were reviewed for the monitoring objectives (table 4).

The water level monitoring boreholes in the Algoa basin are clustered next to each other in pairs and are within close proximity to other registered water users/water use sectors. This in turn disqualifies them as being classified as baseline monitoring stations (see figures 14-17). The four boreholes (P2N0002, P2N0003, P2N0004, P2N0005), which are clustered next to each other with no registered water users within the 5km radius, display insignificantly fluctuating groundwater levels (<5m) therefore allowing them to be classified as potential baseline stations (see figure 18-22).

Table 3: Monitoring objectives review

Borehole ID	Latitude	Longitude	Purpose	Water use sector	Groundwater monitoring objective	Reasoning
M1N0034	-33.743611	25.30125	Water level monitoring borehole	Agriculture Domestic water use (abstracting **1038996** m^3/a)	Trend	• Borehole M1N0036 within 5km radius • Agricultural (irrigation and watering livestock) and domestic use boreholes within 5 km radius of the borehole
M1N0036	-33.777611	25.331361	Water level monitoring borehole	Agriculture Domestic water use (abstracting **1038996** m^3/a)	Trend	• Borehole M1N0034 within 5km radius • Agricultural (irrigation and watering livestock) and domestic use boreholes within 5 km radius of the borehole
M3N0003	-33.643056	25.450944	Water level monitoring borehole	Agriculture Domestic water use (abstracting **235310** m^3/a)	Trend	• Borehole M3N0003 within 5km radius • Agricultural (irrigation) and domestic use boreholes within 5 km radius of the borehole

M3N0002	-33.647167	25.453639	Water level monitoring borehole	Agriculture Domestic water use (abstracting **235310** $\boldsymbol{m^3/a}$)	Trend	• Borehole M3N0003 within 5km radius • Agricultural (irrigation) and domestic use boreholes within 5 km radius of the borehole
M3N0006	-33.735556	25.558139	Water level monitoring borehole	Agriculture (abstracting **719 233** $\boldsymbol{m^3/a}$)	Trend	• Borehole M3N0007 within 5km radius • Agricultural (irrigation and watering livestock) boreholes within 5 km radius of the borehole
M3N0007	-33.737861	25.58	Water level monitoring borehole	Agriculture (abstracting **719 233** $\boldsymbol{m^3/a}$)	Trend	• Borehole M3N0006 within 5km radius • Agricultural (irrigation and watering livestock) boreholes within 5 km radius of the borehole
P2N0002	-33.74848	26.53659	Water level monitoring borehole	No registered water users/sector use boreholes (WARMS) in area (coastal)	**Baseline**	• Boreholes P2N0003, P2N0004, P2N0005 fall within 5km radius of borehole but minimal/insignificant fluctuation (<5m) is seen in the hydrograph (see figure 19)

P2N0003	-33.7463	26.5463	Water level monitoring borehole	No registered water users/sector use boreholes (WARMS) in area (coastal)	**Baseline**	• Boreholes P2N0002, P2N0004, P2N005 fall within 5km radius of borehole but minimal/insignificant fluctuation (<5m) is seen in the hydrograph (see figure 20)
P2N0004	-33.733	26.57142	Water level monitoring borehole	No water users/sector use boreholes (WARMS) in area (coastal)	**Baseline**	• Boreholes P2N0003, P2N0002, P2N005 fall within 5km radius of borehole but minimal/insignificant fluctuation (<5m) is seen in the hydrograph (see figure 21)
P2N0005	-33.73525	26.57485	Water level monitoring borehole	No water users/sector use boreholes (WARMS) in area (coastal)	**Baseline**	• Boreholes P2N0003, P2N0004, P2N0002 fall within 5km radius of borehole but minimal/insignificant fluctuation (<5m) is seen in the hydrograph (see figure 22)

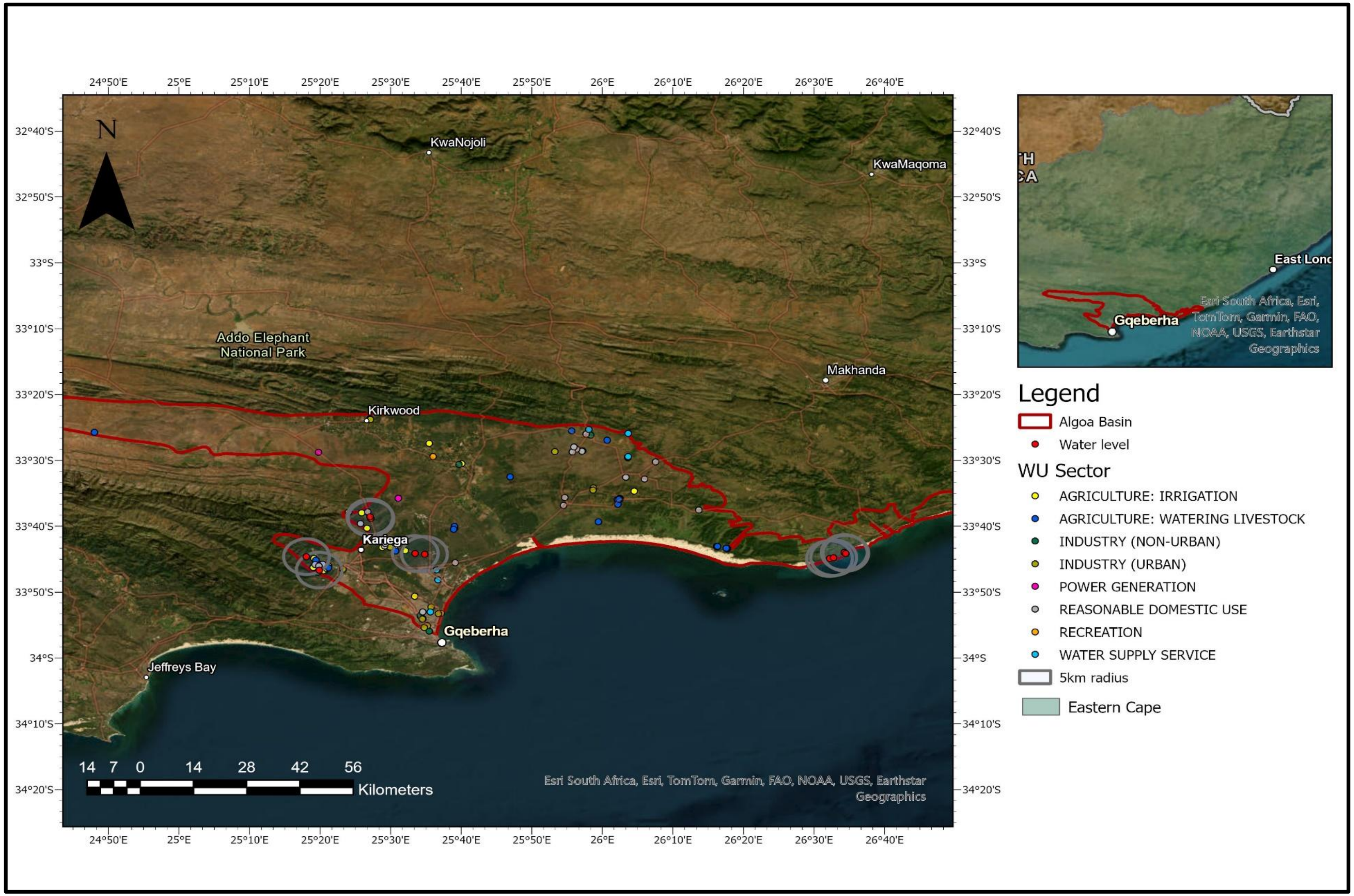

Figure 14: Water level monitoring boreholes with 5km radius delineation

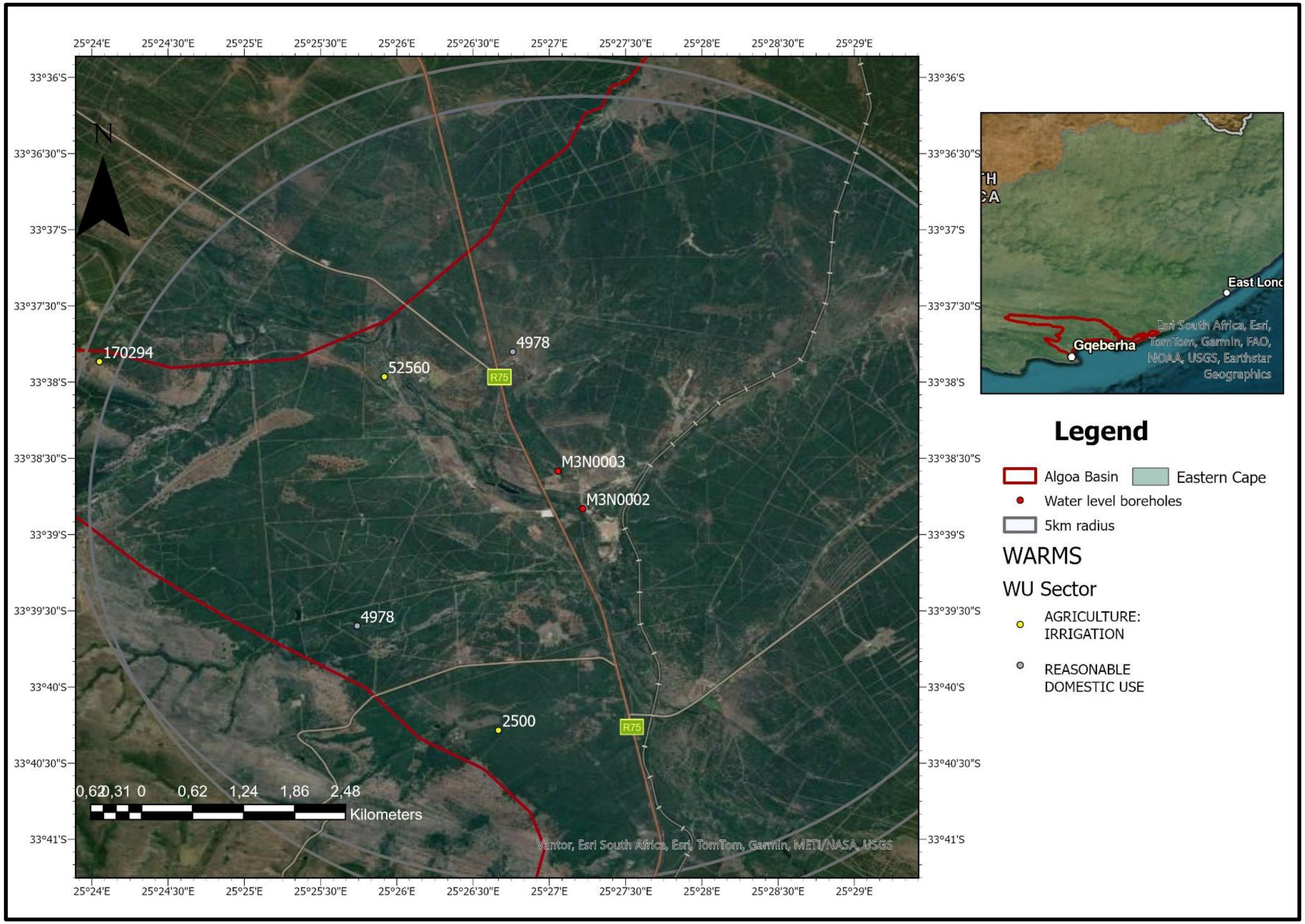

Figure 15: Boreholes M3N0003 and M3N0002 with 5km radius along with registered water users

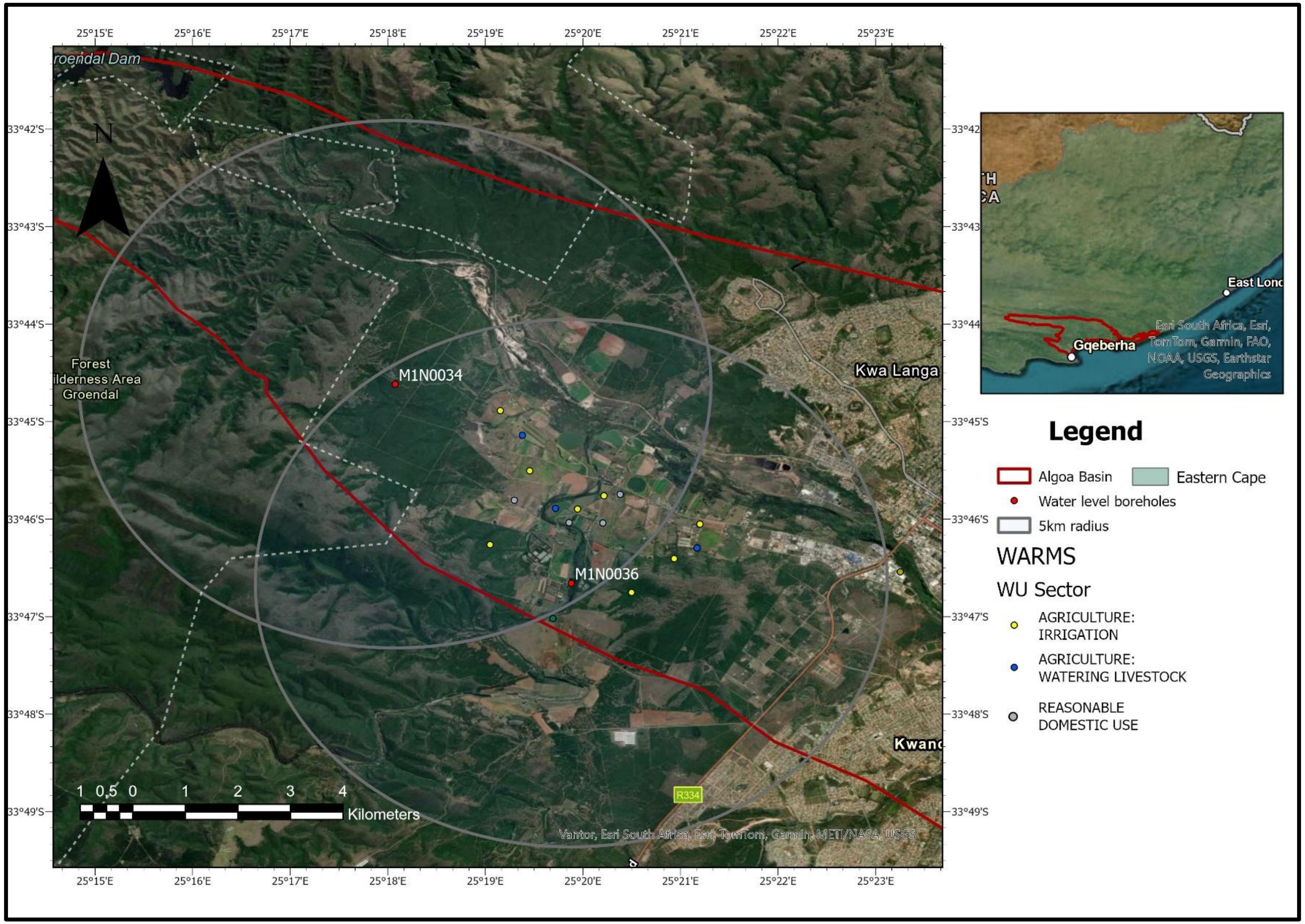

Figure 16: Boreholes M1N0034 and M1N0036 with 5km radius along with registered water users

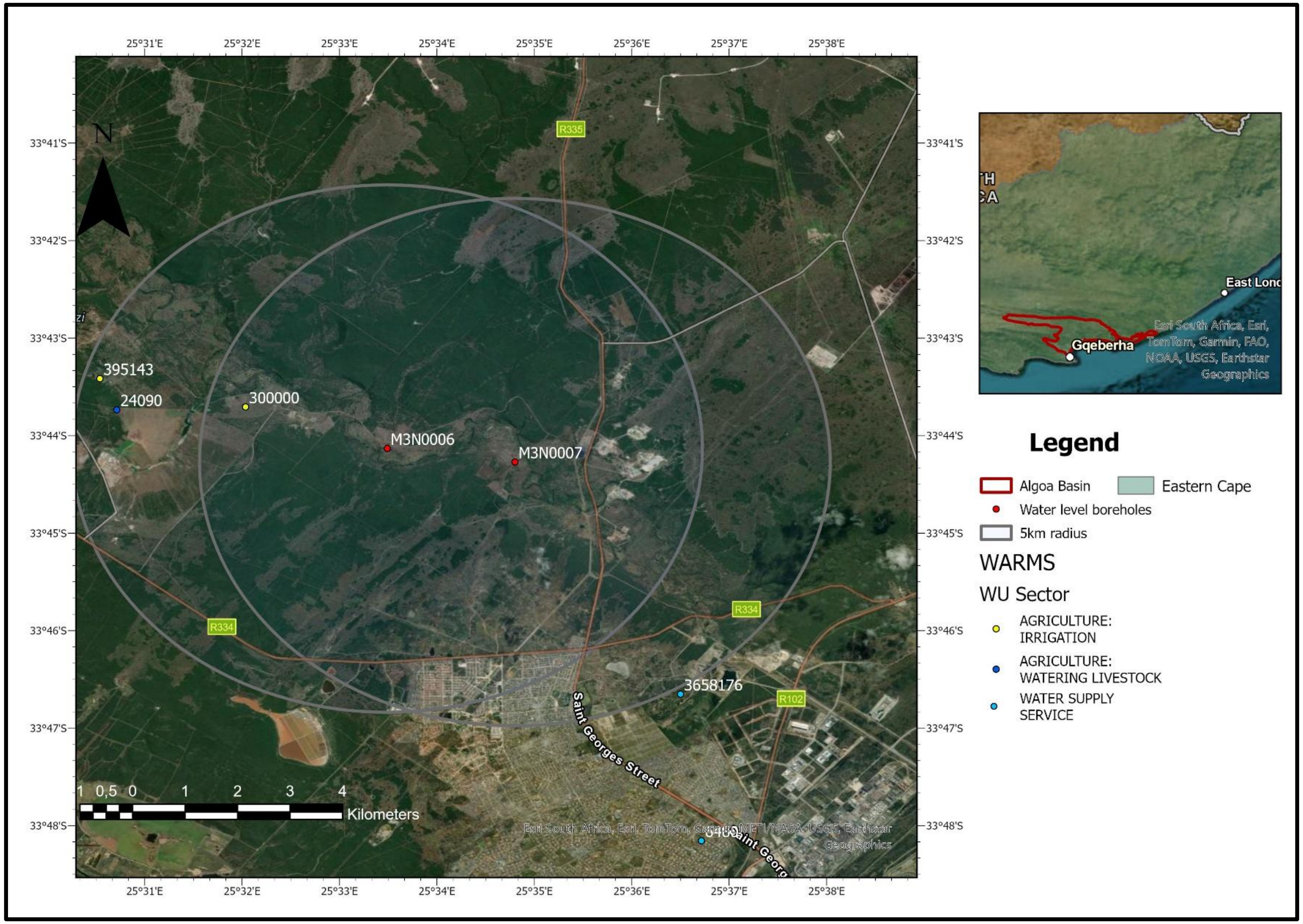

Figure 17: Boreholes M3N0006 and M3N0007 with 5km radius along with registered water users

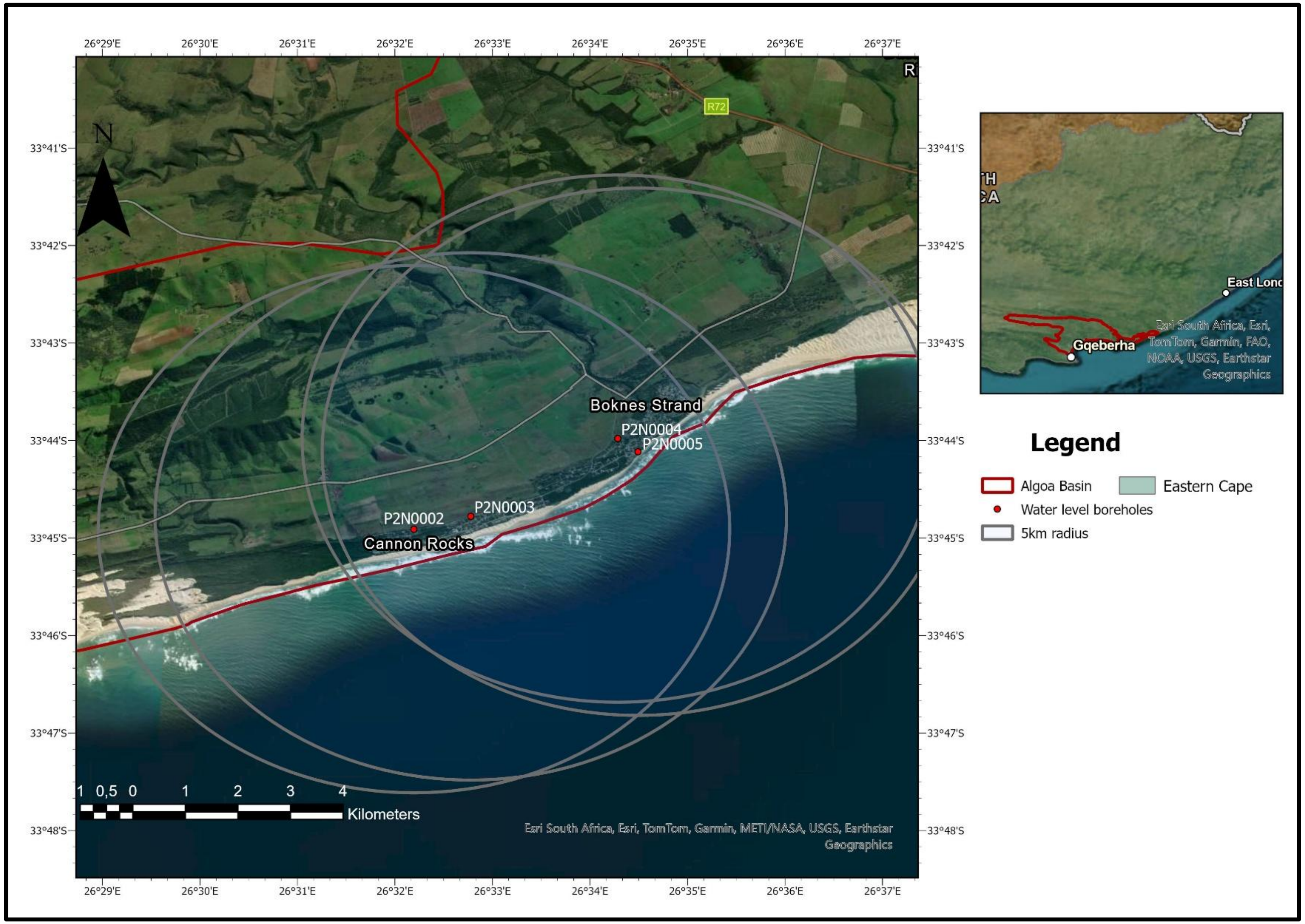

Figure 18: Boreholes P2N0002, P2N0003, P2N0004 and P2N0005 with 5km radius

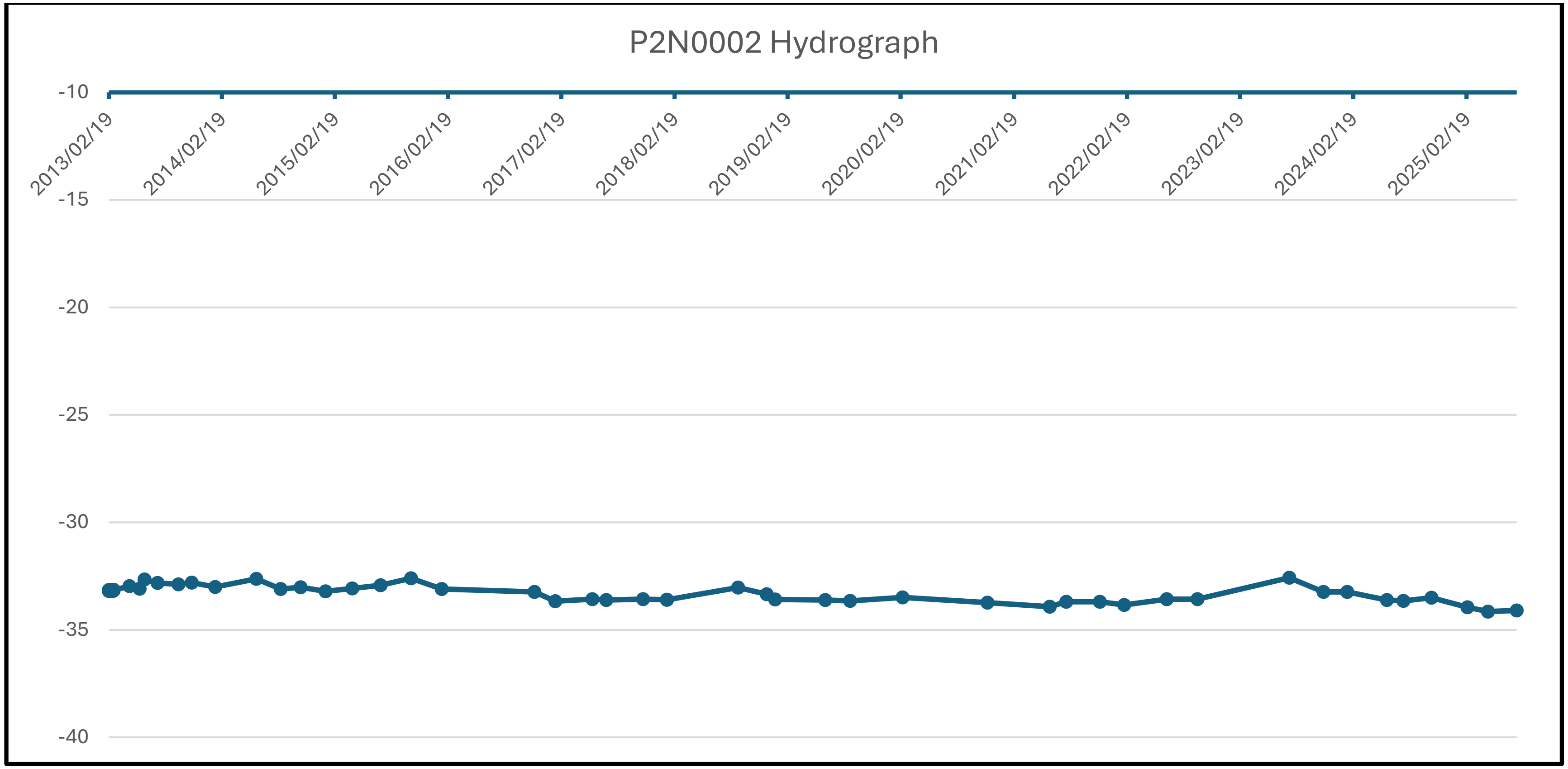

Figure 19: Water level trend in borehole P2N0002

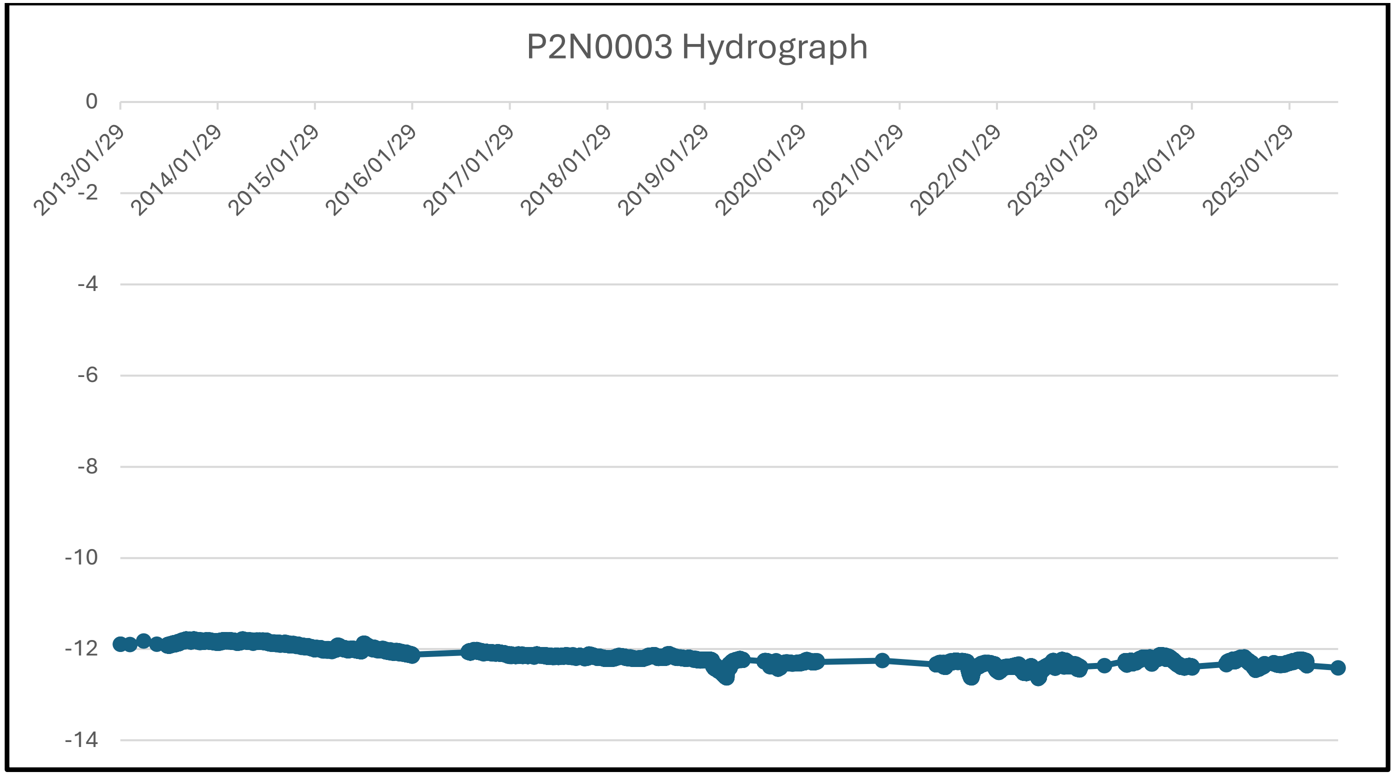

Figure 20: Water level trend in borehole P2N0003

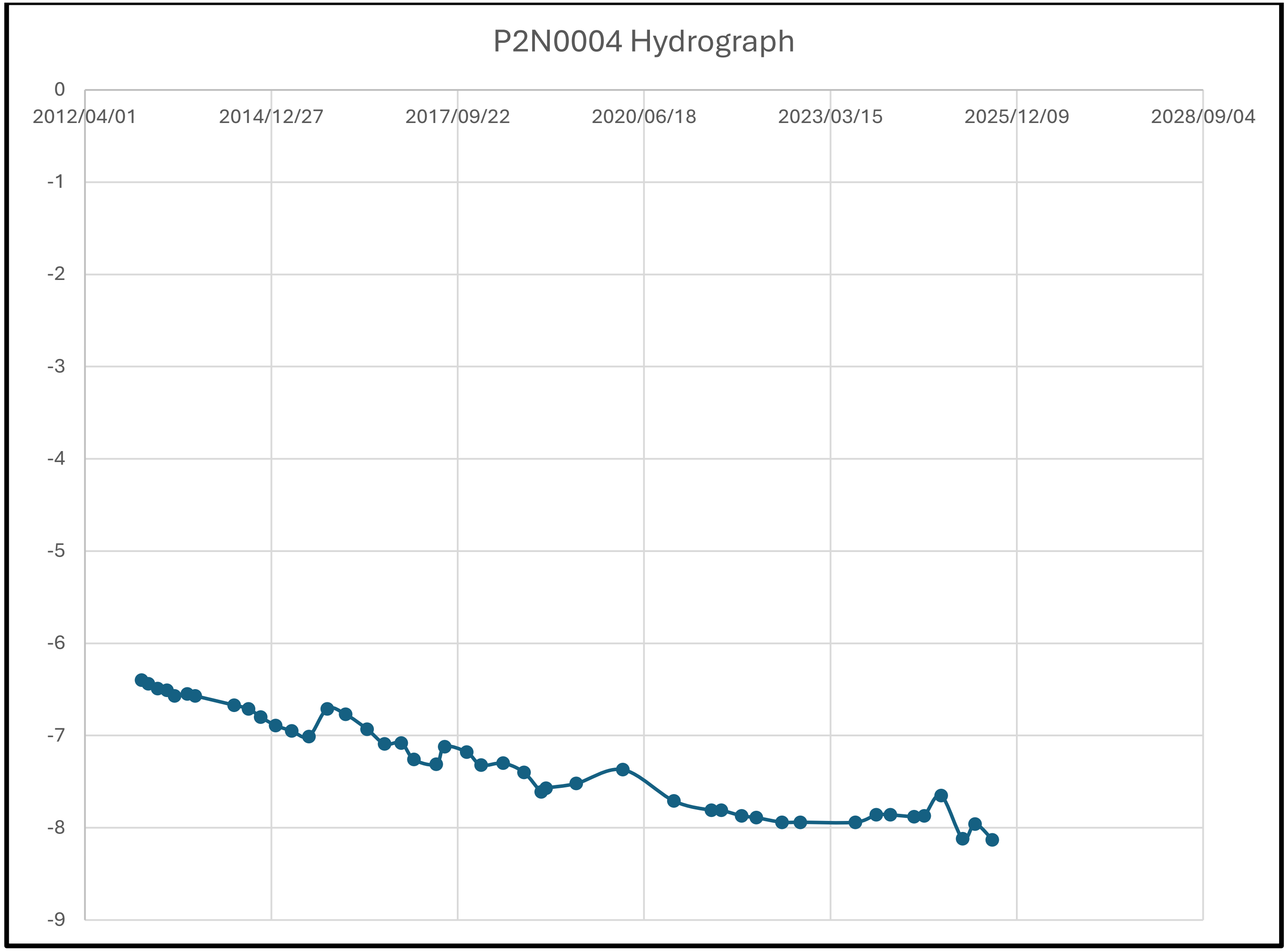

Figure 21: Water level trend in borehole P2N0004

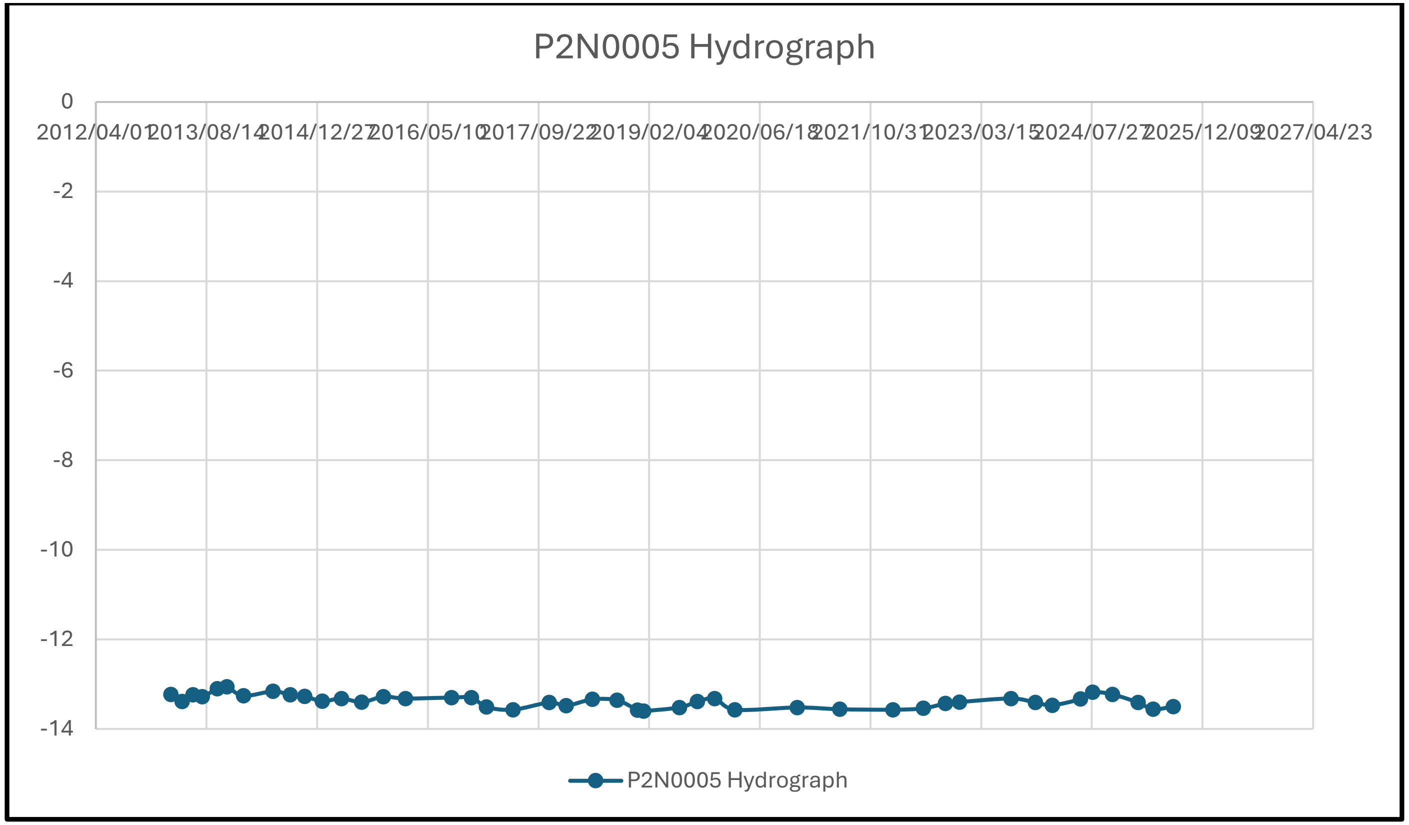

Figure 22: Water level trend in borehole P2N0005

3.5 Groundwater Quality

Approximately 447 groundwater quality boreholes are present in the Algoa Basin region over the past 10 years (2014-2024). 236 boreholes display water quality within acceptable ranges for electrical conductivity (EC). 158 boreholes have acceptable chloride concentrations, and 179 boreholes are within acceptable sodium ranges.

Table 4: Acceptable limits for EC, Cl and Na

Constituent	Acceptable limit	No. of BH
EC	<370 mS/m	236
Cl	<600 mg/l	158
Na	<400 mg/l	179

3.5.1 Sodium (Na) concentrations

The sodium concentrations in majority of the recorded boreholes are relatively elevated and are within unacceptable limits for domestic water use in accordance with the South African domestic water use standards (South African Water Quality Standards, Domestic Use). The elevated concentrations are linked to seawater ingress of the ocean along the area’s coast.

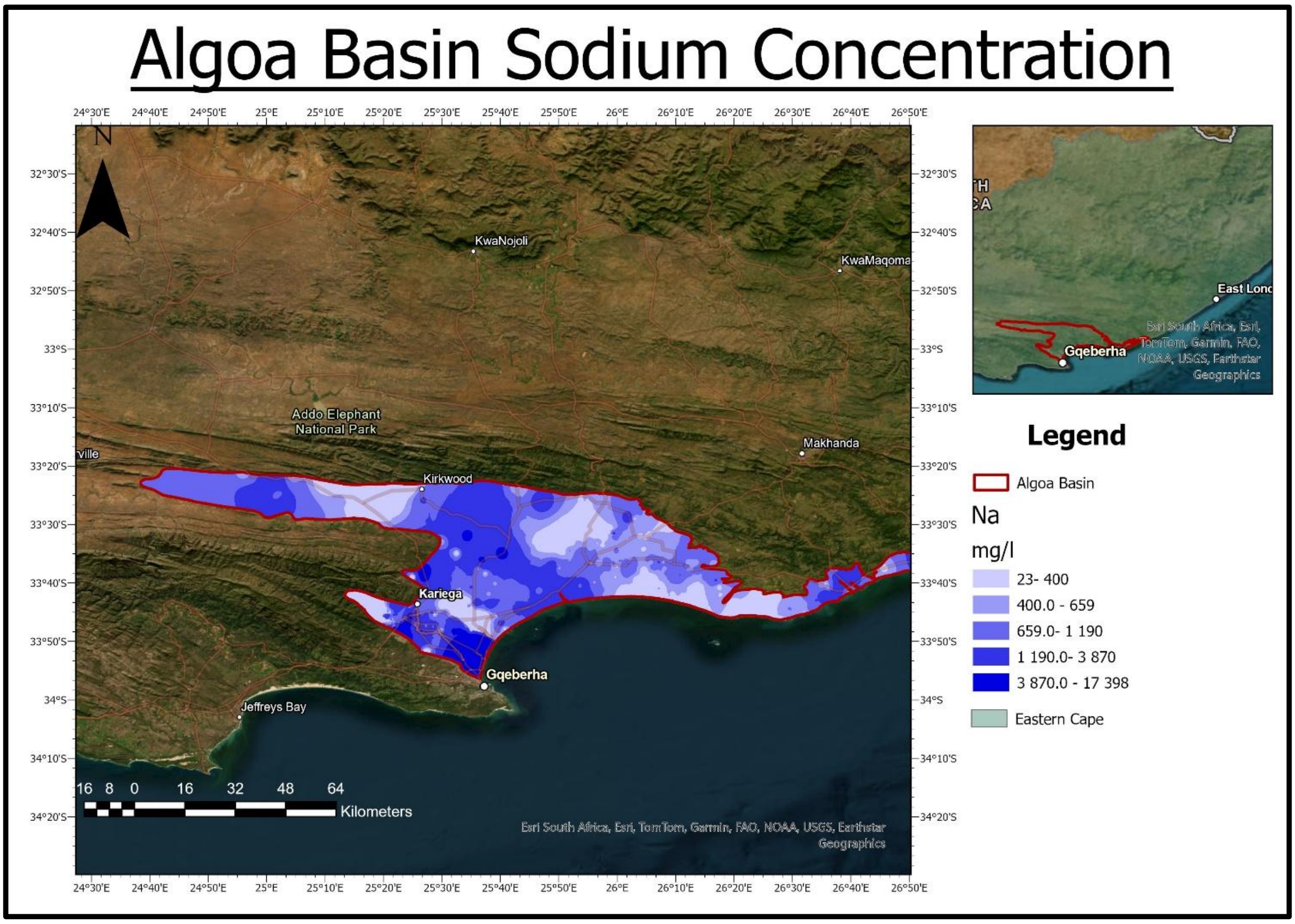

Figure 23: Sodium concentrations for the groundwater

3.5.2 Chloride concentrations (Cl)

Chloride (Cl^-) concentration in groundwater varies widely depending on geology, proximity to the coast, human activities, and climate. Only 158 of the 447 boreholes are within acceptable limits for domestic use according to the South African Water Quality Standards. The elevated signatures of >600 mg/l may be attributed to saline intrusions/seawater ingress due to the borehole’s proximity to the coast.

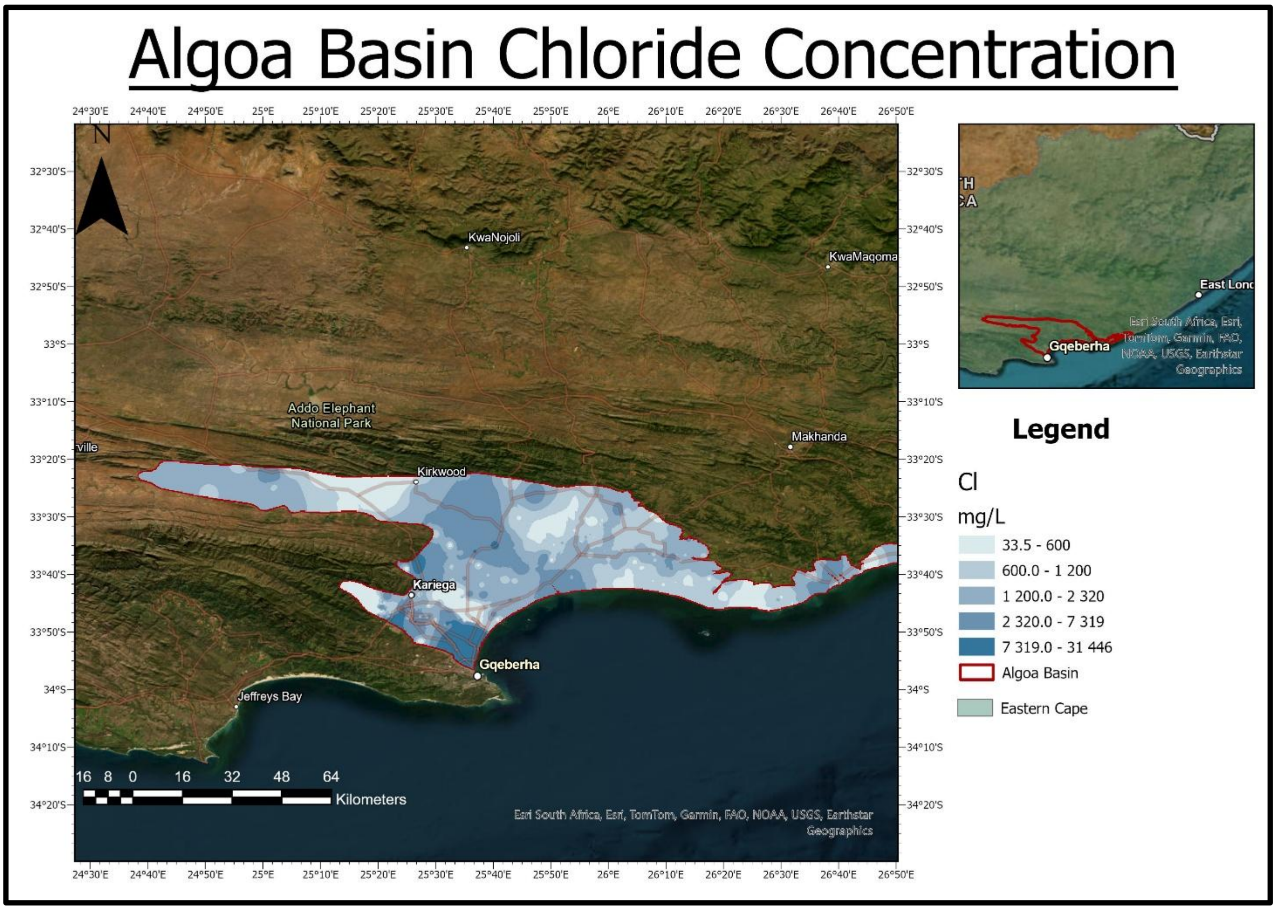

Figure 24: Chloride concentrations in groundwater

3.5.3 Electrical conductivity

Electrical conductivity (EC) is a measure of the ability of water to conduct an electrical current. This ability is a result of the presence of ions in water such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium ions, all of which carry an electrical charge. Most organic compounds dissolved in water do not dissociate into ions, consequently they do not affect the EC. The total dissolved solids (TDS), which is directly proportional to EC, is a measure of the amount of various inorganic salts dissolved in water. The 236 boreholes in the Algoa Basin are within acceptable limits (370 mS/m) for domestic water use according to the South African Water Quality Standards for domestic purposes (South African Water Quality Standards, Domestic Use).

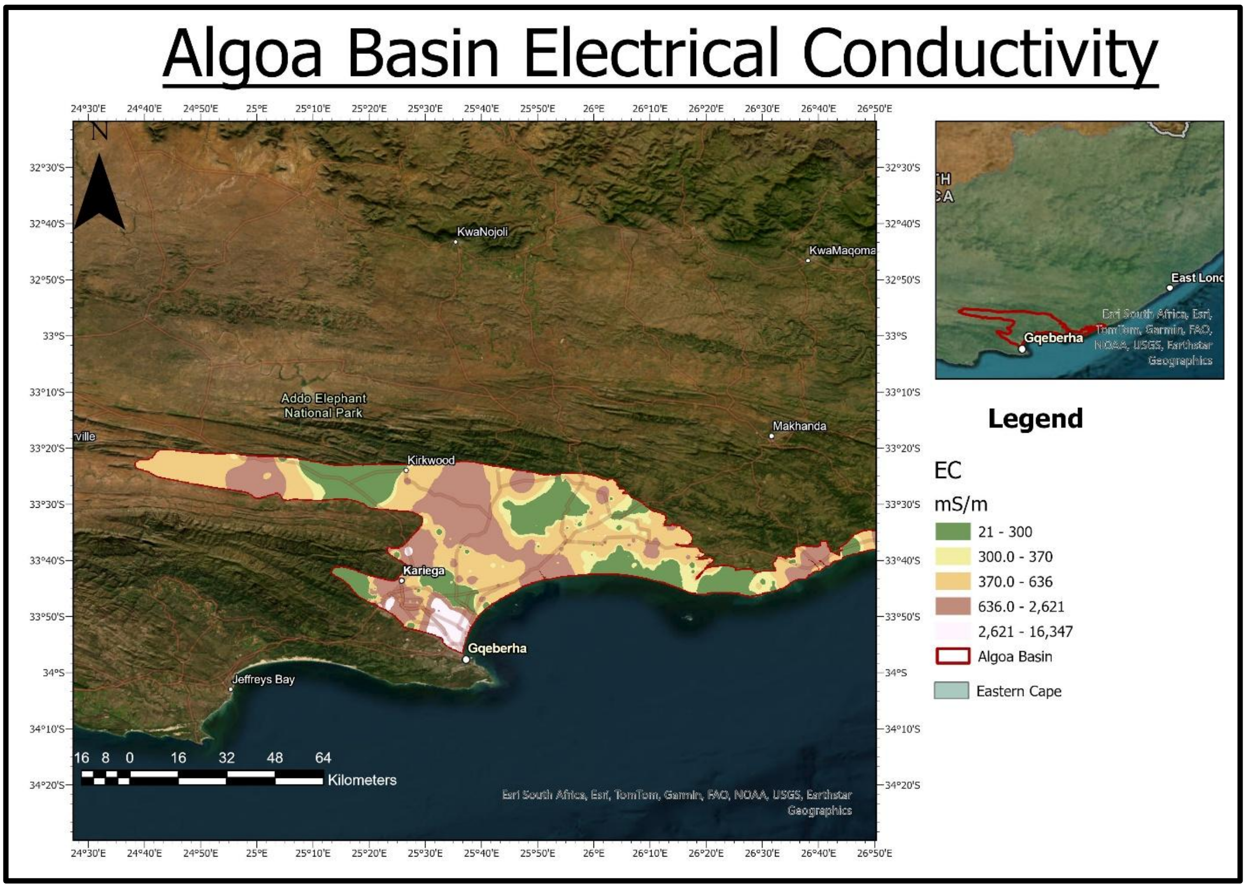

Figure 25: Electrical conductivity for the groundwater

3.5.4 Total nitrate concentration (NO_3)

Based on the available 10-year data, the majority of Algoa Basin's boreholes have groundwater quality within acceptable nitrate limits (10 mg/L) with only a small area exceeding the limit. The elevated concentrations may be attributed to anthropogenic activity however further investigation is required for accurate conclusions to be made.

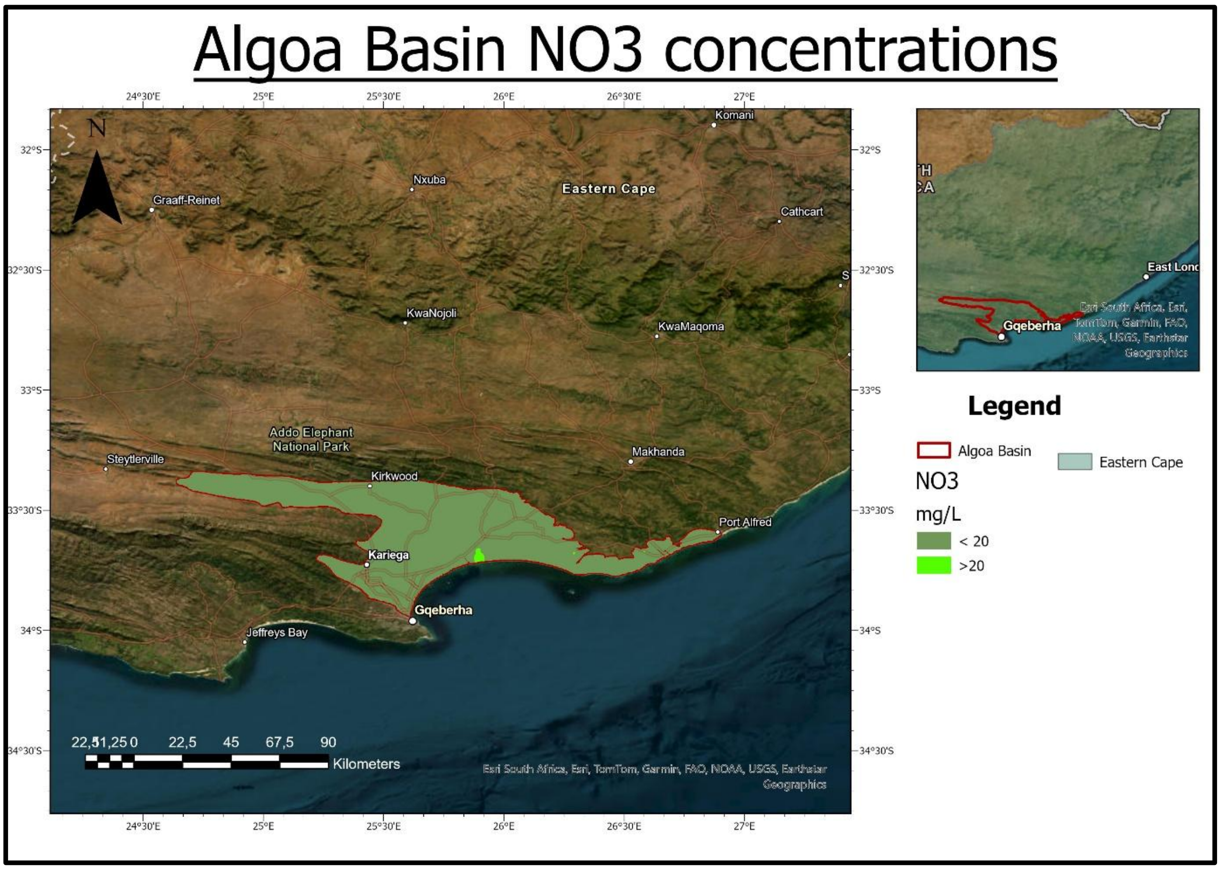

Figure 26: Algoa Basin's total nitrate concentrations

3.5.5 Sulphate concentrations (SO_4)

The groundwater in the Algoa Basin has a quality which consists of both good and excessive sulphate concentrations. A reasonable amount of spatial coverage on the east of the Basin falls within the 2-158 mg/L range which is compliant with the SANS 241 drinking water standards. The west, north and southern sections of the Basin display elevated sulphate concentrations which exceed the acceptable limit, 600 mg/L. The elevated concentrations may be attributed to the agricultural activity taking place in the region (irrigation and watering livestock) or leaching of sulphate-rich shales however further investigation/hydro census is required for an accurate conclusion to be made.

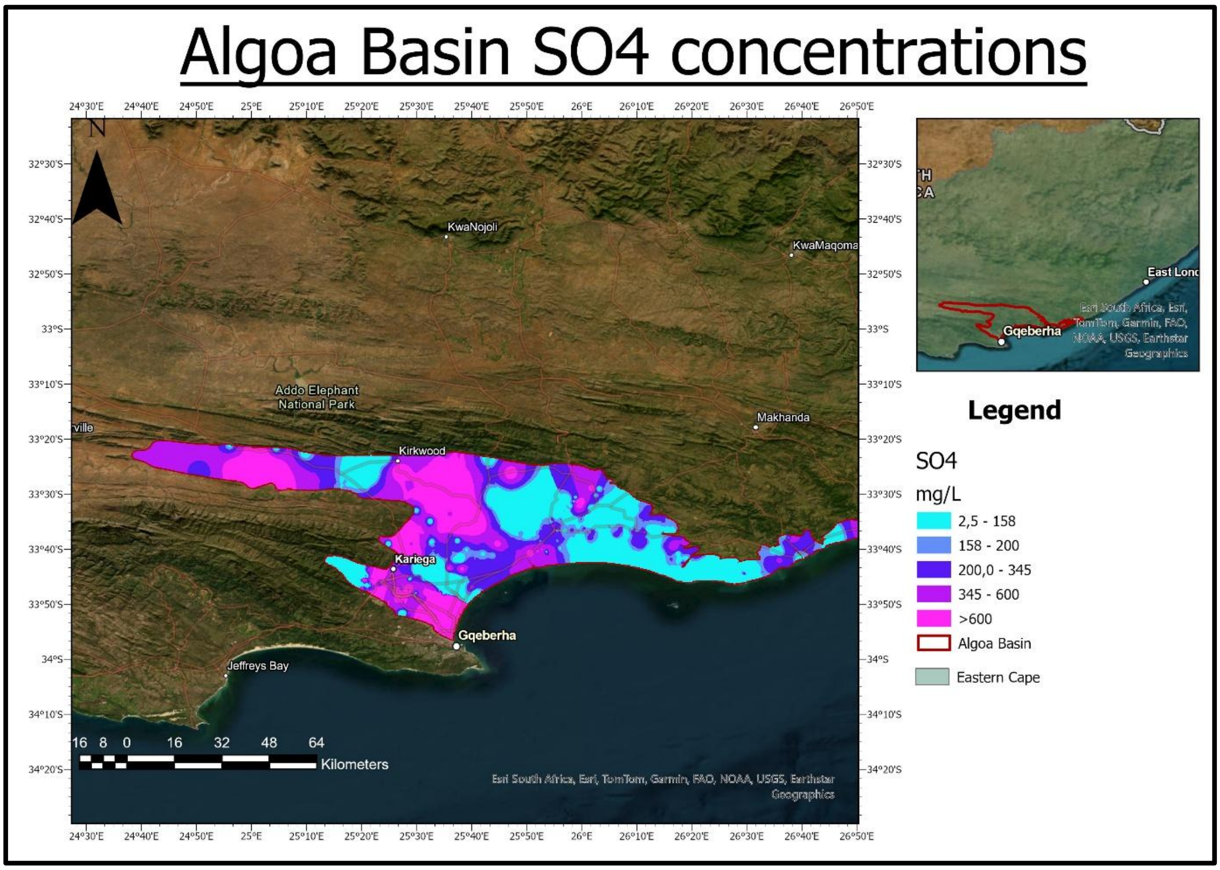

Figure 27: Algoa Basin's sulphate concentrations

3.5.6 Phosphate concentration (PO_4)

The drinking water standards according to the World Health Organization (WHO) state that the acceptable limit for phosphate concentration in drinking water is 1 mg/L. The vast majority of the Algoa Basin is within the acceptable range for phosphate in drinking water. A smaller section of the Basin exceeds the acceptable limit from Kariega to the northern part of Port Elizabeth which may be associated with the agricultural (irrigation) activities taking place in the region whereby fertiliser is introduced into the groundwater system. That area also consists of industrial activities, both urban and non-urban, which may contribute to the phosphate excess in groundwater. Further investigation on the source of the phosphate is required for appropriate recommendations to be made for decision making.

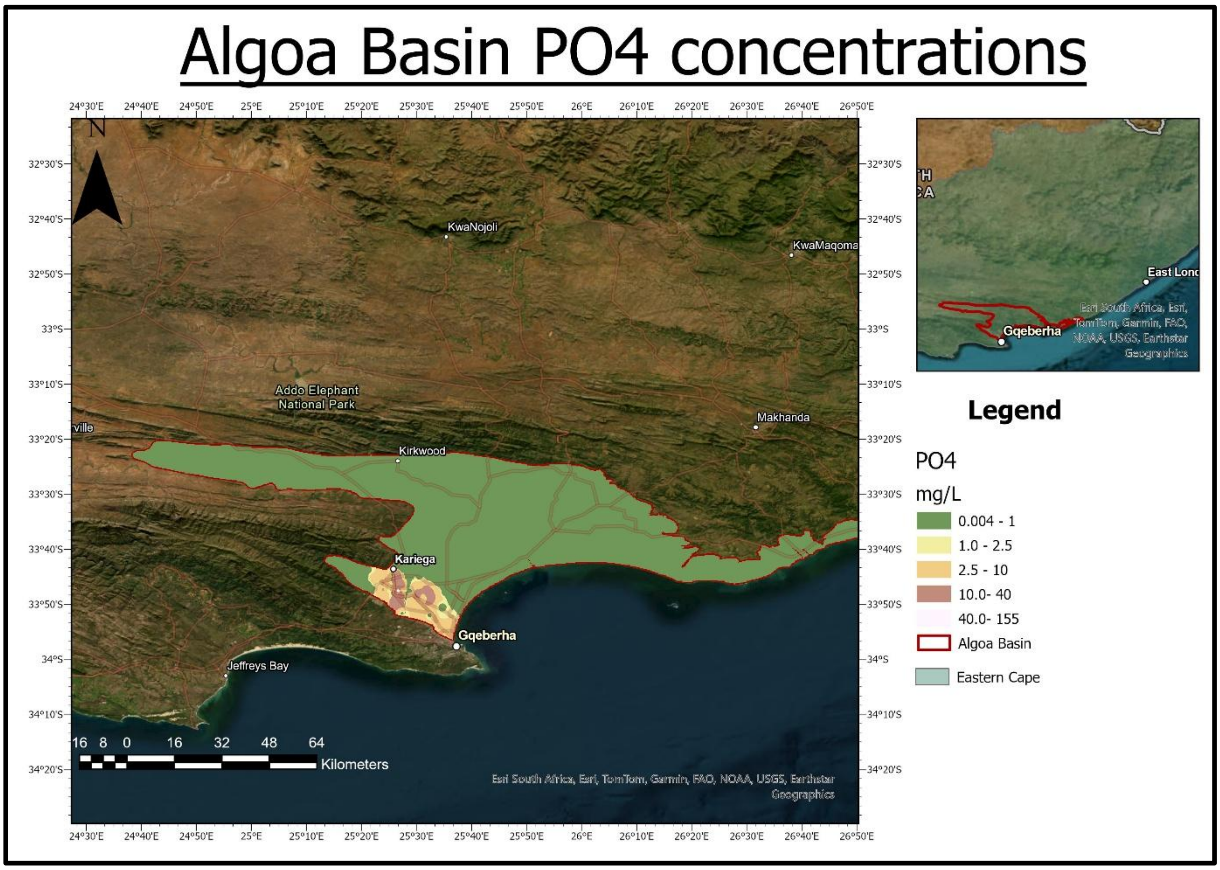

Figure 28: Phosphate concentration in Algoa Basin

3.5.7 Hydrogeochemistry

In the cation triangle, most of the boreholes plot in the sodium (Na +) and potassium (K+) corner due to their high concentrations in those cations. Only a few of the boreholes plot in the 'no dominant type' and calcium type 'regions. The majority of boreholes in Algoa Basin plot in the anion triangle cluster in the chloride (Cl-) area which is as a result of elevated concentrations. Only a few boreholes plot within the 'bicarbonate' type and 'no dominant type' regions of the anion triangle. The diamond displays the boreholes plotting mainly in the sodium chloride (NaCl) hydrochemical facies type water. Some of the boreholes fall within a 'mixed type' facies as well as in the 'sodium bicarbonate type' facies. The mixed type has both a calcium chloride (CaCl2) influence as well as magnesium bicarbonate (MgHCO3) and sodium bicarbonate (NaHCO3) influence Two of the boreholes lie within the 'magnesium bicarbonate type' facies. Only one borehole lies within the 'calcium-chloride type'. The boreholes which lie within the sodium chloride (NaCl) type water may be due to proximity to the coast and as a result of seawater ingress/saltwater intrusion from the ocean.

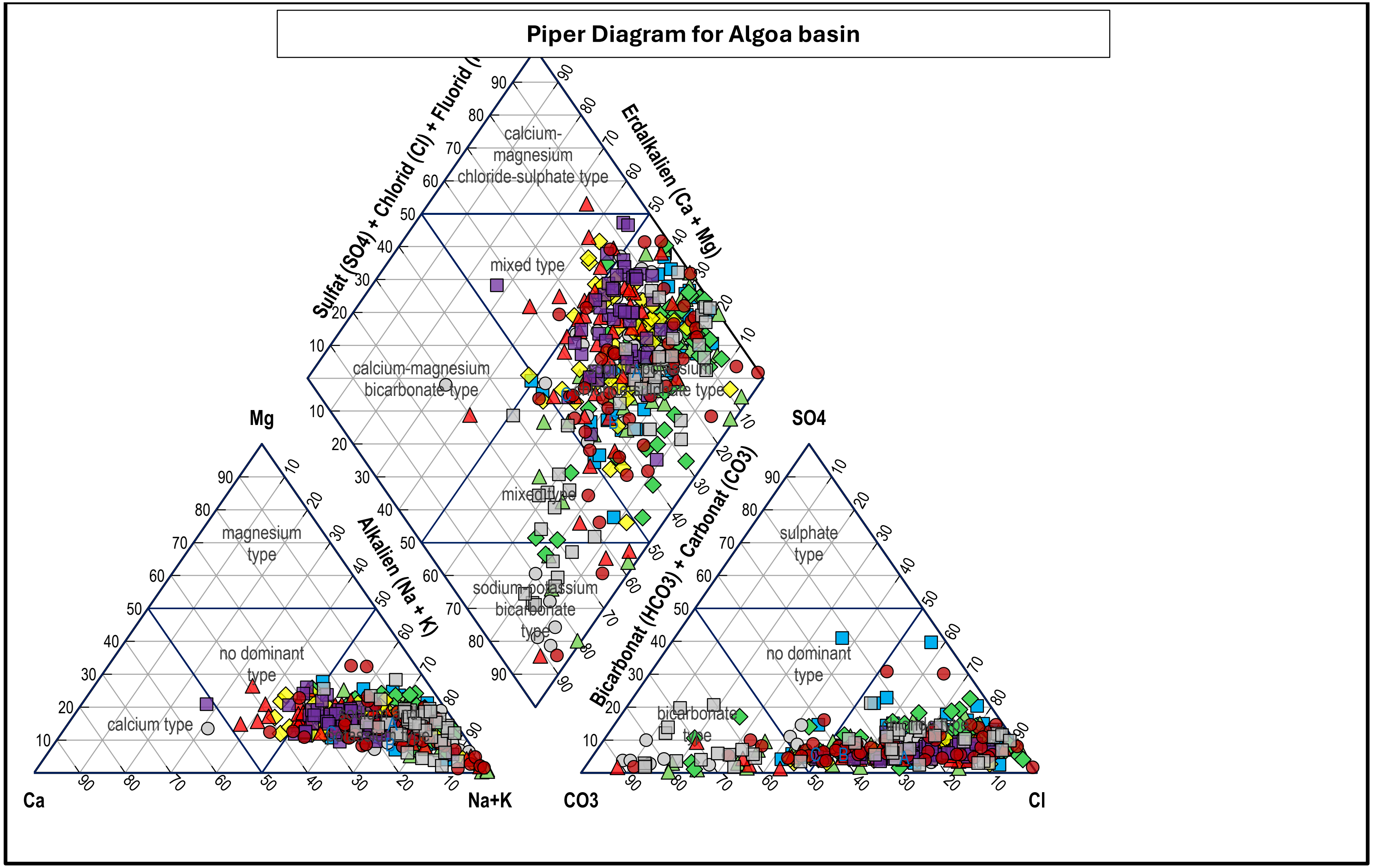

Figure 29:Piper diagram displaying water type for Algoa Basin

4. Conclusions

The groundwater quality in the Algoa Basin displays about 50% of the boreholes within acceptable electrical conductivity ranges, 35% of the boreholes lie within acceptable chloride ranges and 40% within acceptable sodium ranges set by the South African Water Quality Standards for domestic use. Electrical conductivity, sodium and chloride values are elevated indicating seawater intrusion/saline influence from the ocean. Elevated concentrations of phosphate are present surrounding the Kariega area There is reasonable amount of agriculture in the area which may contribute dissolved salts to the area's groundwater reserves and confirming the water's unsuitability for human consumption. The piper diagram also displays that the dominant water type is sodium chloride (NaCl) type further displaying the saline influence. Sulphate concentration in certain parts of the Algoa Basin

Half (50%) of the groundwater level monitoring boreholes display stable trends. Over the 2022/23 to 2023/24 hydrological years, the boreholes recorded stable water levels, with only two displaying declining patterns. The short-term analysis displays stables trends whereas long-term analysis displays a decline in water levels as a result of the Eastern Cape struggling to recover from the 2015 drought. The two boreholes displaying the declining trends (major and moderate) require further monitoring and recommendation/amendment of water use license terms and conditions. This is due to the trends being linked to high abstraction volumes for various uses, specifically the irrigation agricultural sector.

The findings highlight the importance of ongoing monitoring and sustainable groundwater management. While water quality remains high, continued depletion of groundwater resources—likely influenced by both natural variability and anthropogenic factors such as irrigation—could pose risks to long-term water availability in the region.

5. Recommendations

- The study area only consisted of 10 water level monitoring boreholes therefore the extensive expansion of the groundwater level monitoring network is required to reduce gaps in data, for more representative data and conclusions of the area.
- Further investigation on borehole depth and distance to coast are required to determine extent of seawater ingress.
- Further investigation/hydro census/field observations on what is causing 2 boreholes to decline in groundwater level (M1N0036 and P2N0002) and amendment of terms of water use licenses.

- Investigate correlation between groundwater fluctuations and groundwater use or allocation in the Algoa Basin.
- Hydro census and investigation/frequent monitoring of groundwater quality, particularly for the sodium and chloride concentrations, to verify the cause of elevated concentrations the Algoa Basin for further recommendations such as potential remediation.
- Hydro census and investigation/frequent monitoring of groundwater quality, particularly the elevated phosphate concentrations in Kariega and Port Elizabeth.

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