# 4

# STATE OF RIVERS

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## 4.1 Streamflow

The Department of Water and Sanitation (DWS) is mandated by the National Water Act (No. 36 of 1998) Chapter 14, Section 137, to establish and monitor streamflow in the South African rivers. The Department monitors 628 river flow gauging stations across South Africa. Several streamflow monitoring stations are equipped with data loggers that measure the amount of water passing through a point over time in cubic meters per second ($m^3/s$). The NWRS2 indicated that streamflow monitoring aims to address our national concerns and is also in response to our obligations within international river basins (DWS, 2013).

Approximately 60% of the streamflow in South African rivers is shared through transboundary water systems. Therefore, South Africa must implement Integrated Water Resource Management (IWRM) in a manner that conforms to international water protocols and treaties while being compliant with the legislation governing water resource management in South Africa (DWS, 2013). The international agreements have guidelines and limits on the quantities of water that South Africa may use out of the rivers and the amount of water the country must release to the neighbouring countries.

South African rivers demonstrate variations in flow regimes or flow sequences, continuously deviating from the historical flows. The flow regime changes are both natural and anthropogenically driven by high variability in rainfall, population increase, land and water use changes playing significant roles. Some catchments demonstrate increased streamflow while declining trends are also observed in other catchments. The decline in streamflow affects water availability and supply, resulting in competing water requirements between different water use sectors such as agriculture, industrial, and urban water supply.

## 4.2 Streamflow Anomaly at Strategic Points

The Department has several surface water monitoring points of strategic importance (outlet of catchments, international obligations importance, SDGs reporting). These strategic stations contain long-term data which were used to assess the deviation of streamflow during the current reporting period from the median of the normal period (1980-2010). A streamflow anomaly map displayed in Figure 4.1 shows the deviation of streamflow in the 2021/22 hydrological year from the median (median period of 1981-2010).

The map shows that of the 21 strategic stations displayed, four stations experienced below normal streamflow's, while eight stations were just above normal during the reporting period. One station in the Pongola-Mtavuma WMA V5H002 (Tugela River at

Mandeni) was flagged out as it was much below normal. The historical observed streamflow data revealed that this station was also moderately low in November 2021, and it tends to peak in January to March of each year, with the highest 5-year peak flow of 457 $m^3/s$ observed in January 2017. Moreover, a detailed streamflow anomaly for V5H002 displayed in Figure 4.2 demonstrated that the flow in the station is continuously declining and has been below normal since the 2014/15 hydrological year.

Similarly, two stations in the Orange WMA, D8H014 (Blouputs River) and D7H005 (Orange River at Upington), were extremely above normal during the reporting period, and the observed flow data shows that in November 2021, the flow in these stations was also moderately high. The stream flow in D7H005 was further examined using a streamflow anomaly plot displayed in Figure 4.2, which detailed a variety of flow patterns over time. The plot demonstrated that a similar pattern (above normal flows) had been maintained in the station for the past two hydrological years.

A station of strategic importance, L7H006 (Gamtoos River), located in the Mzimvubu-Tsitsikamma WMA, was below normal, as shown in Figure 4.1, during the reporting period. The station was also examined using a streamflow anomaly plot (Figure 4.2) which demonstrated a continuously declining trend since the 2015/16 hydrological year. The station deviated from the median with **21,9 MCM** and **5,18 MCM** in the hydrological years 2020/21 and 2021/22, respectively. The station's lowest flow observed during the 2021/22 hydrological year was 0.13 $m^3/s$ in May 2022, while the highest observed 5-year peak flow was 3.0 $m^3/s$ (February 2019).

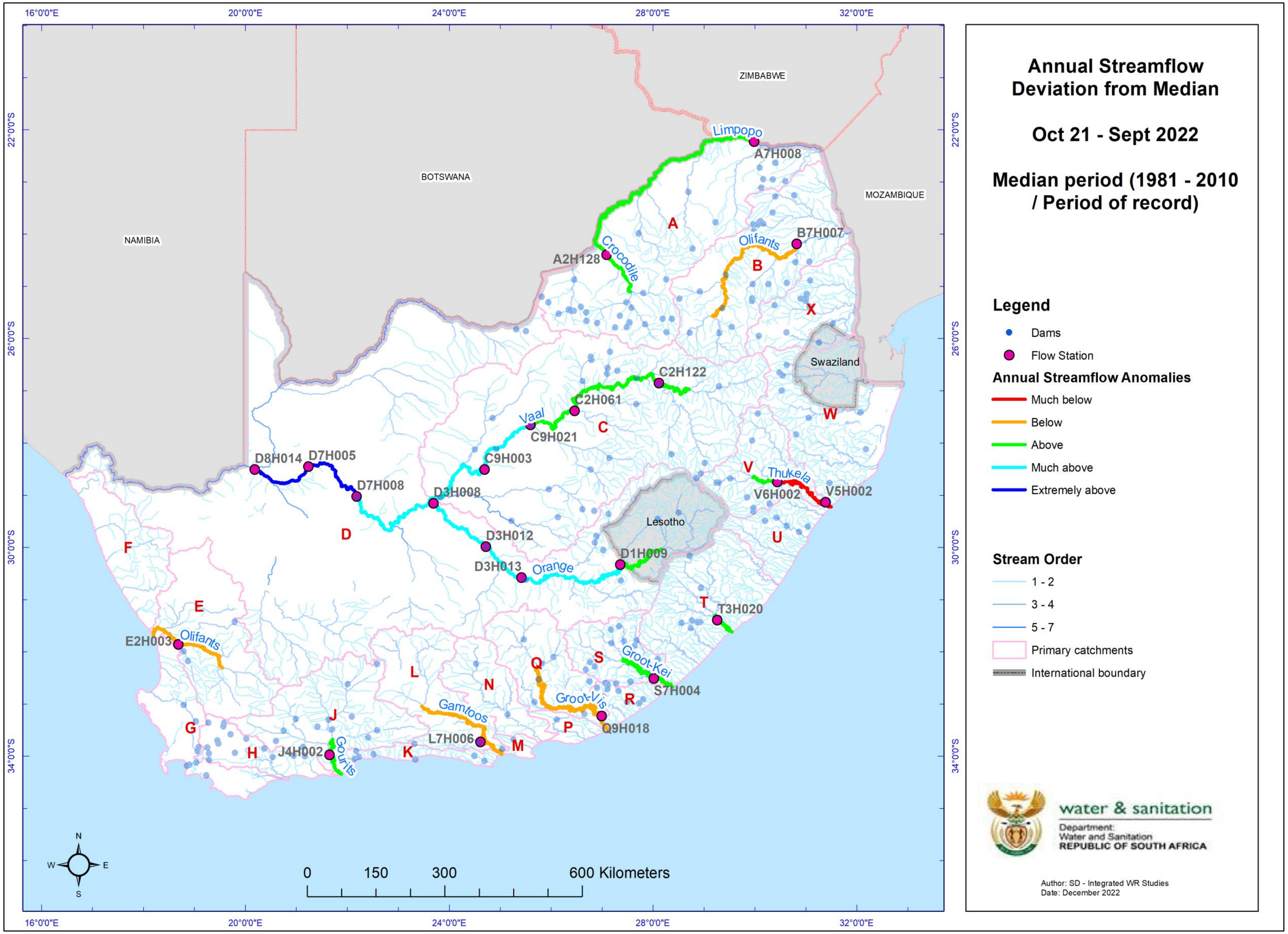


*Figure 4.1: Annual Streamflow Anomaly for Strategic River Flow Monitoring Stations as of November 2022.*

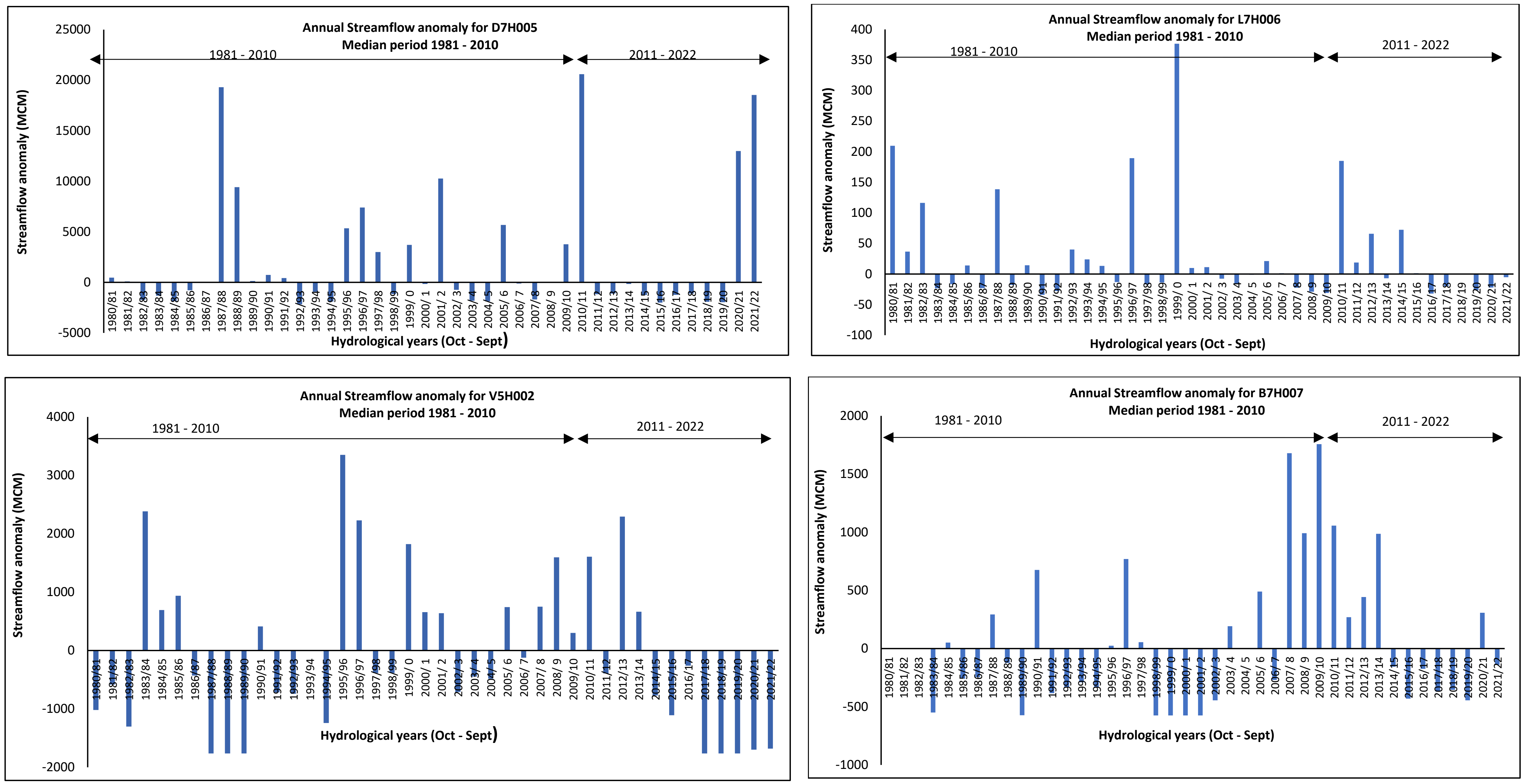


*Figure 4.2: Annual streamflow anomaly for some strategic river flow stations using the median period of 1981-2010*

### *Case Study: A focus on the Northern Drakensberg Strategic Water Source Area*

Strategic water source areas contribute a disproportionate amount of water relative to their area which makes them crucial for meeting South Africa’s water resources needs. However, most of these areas are poorly monitored due to inaccessibility. The South African Environmental Observation Network (SAEON) re-established a dense network of climate, hydrological, biodiversity and carbon monitoring in 2012 in the Cathedral Peak research catchments which form part of the Northern Drakensberg Strategic Water Source Area (SWSA) in the upper uThukela catchment. These catchments were previously monitored from 1949 – 1995. The detailed monitoring in these catchments provide insights into the impacts of global change in this strategic water source area on which there is a heavy dependence on the ecosystem services this landscape provides at national, regional and local scales with the livelihoods of the local population linked to the natural resources and ecosystem integrity.

The landscape includes a vast tract of the protected, near pristine UNESCO World Heritage Ukhahlamba Drakensberg Park which falls under the management of Ezemvelo KZN Wildlife (EKZNW). Further, the complex terrain and high levels of endemism make the landscape sensitive to global change. The high soil carbon stocks and the catchment's substantive contribution to the country's water resources, coupled with trends in land transformation impacting on these ecosystem functions provide a development context of national significance in which to understand global change impacts on ecosystem functioning along a river course from point and plot scale to cumulative downstream impacts.

The long-term annual rainfall records for the hydrological year (October – September) from the catchments are shown as a deviation from the historical mean (1951 – 1980), in Figure 4.3. The rainfall during the 2018/2019 hydrological year was the lowest on record for the catchments, and further the length of the dry period (spanning 8 years) was the longest dry period on record. The annual mean temperature has been greater than the long-term average for the site consistently during the current monitoring period. Although the rainfall for the 2020 and 2021 hydrological years have been wetter than average, the temperatures remain greater meaning a higher evaporation demand.

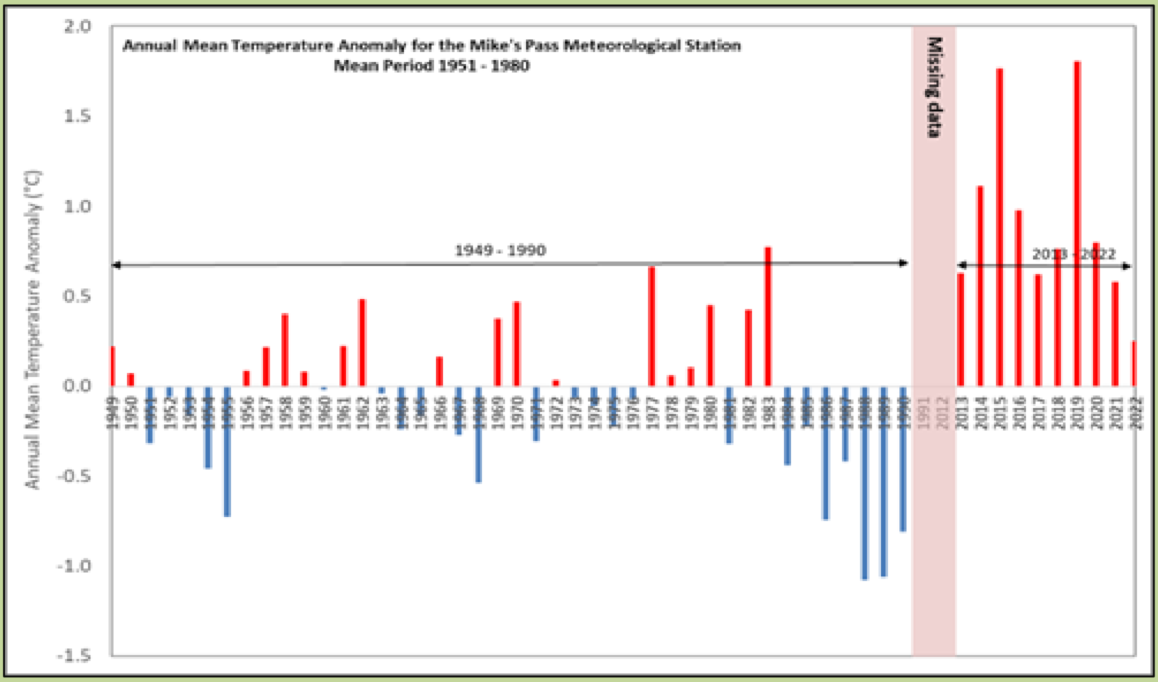


*Figure 4.3 Deviations of the (a) annual rainfall and (b) annual mean temperature from the long-term historical means (1951 – 1980*

SAEON also investigated the land use and landcover change impacts on water resources in the Cathedral Peak research catchment. The land use and land cover change have significant impacts on the water resources provided by a catchment or area. Any changes in land use or land cover alter the water resources provided by a catchment. The reason for this is that a land use or land cover change alters how the rainfall is partitioned into the different components of the hydrological cycle, such as evaporation, runoff and soil water. With global change, a key concern is how land use and land cover change driven by human impacts such as changes in fire management, $CO_2$ levels, changes to meet food, fodder and shelter needs will influence the water resources provided by a catchment.

The impacts of land cover change on water resources investigated are the emerging concern of the increase in woody plant species driven by anthropogenic activities. The results demonstrated that the total evaporation from the woody species is significantly higher than the total evaporation from the nearby grassland catchment (Figure 4.4). This implies that the streamflow from the woody encroached catchment is lower than the streamflow from the grassland catchment (Figure 4.5) despite them receiving the same amount of rainfall.

*The concern is that should the grasslands in the Northern Drakensberg strategic water source area become encroached with woody species, the water available for downstream communities will be reduced. The decrease in streamflow will affect the immediate local downstream communities but also at a provincial and national scale as this area feeds irrigation schemes in an important agricultural area, supplies water for the uThukela catchment with downstream towns of Richards Bay, and through the Drakensberg pumped storage scheme has national implications.*

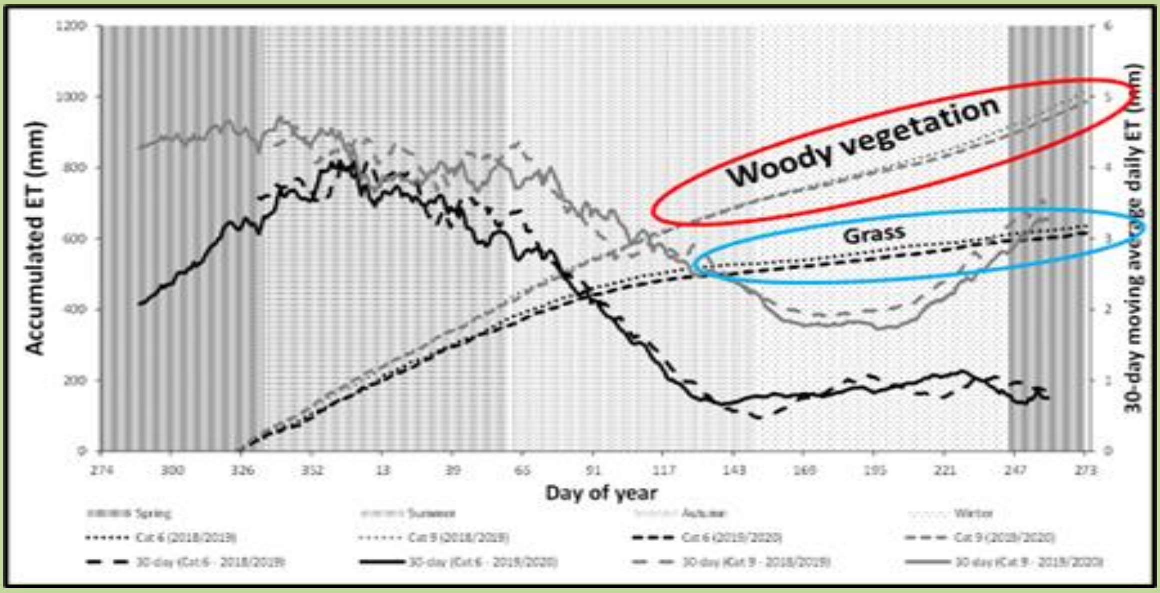


*Figure 4.4* Measured total evaporation over a grassland catchment (Catchment 6, black lines) and a woody encroached catchment (Catchment 9, grey lines)

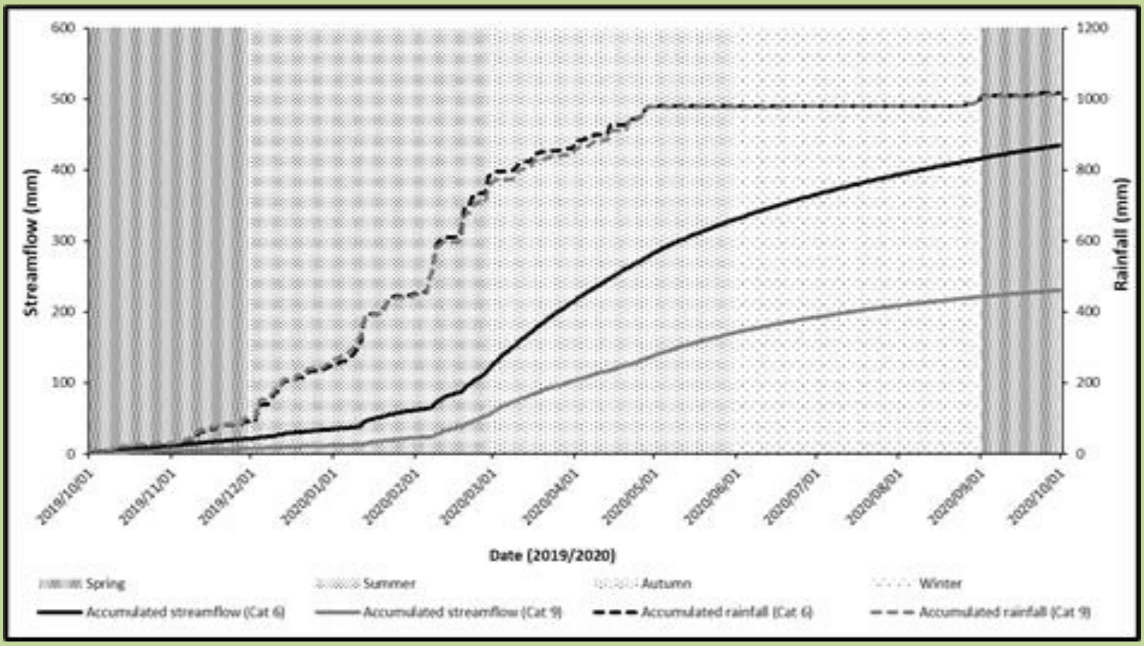


*Figure 4.5* Accumulated rainfall (dotted lines) and accumulated streamflow (solid lines) from the grassland catchment (Catchment 6, grey lines) and woody encroached catchment (Catchment 9, black lines) for the hydrological year 2019/2020.

## 4.3 Surface Water Resource Quality

### 4.3.1 Eutrophication

Eutrophication is the process of excessive nutrient enrichment of water that typically results in problems associated with excessive macrophyte, algal, or cyanobacterial growth. The trophic status of the water body provides a measure and description of the degree of eutrophication (nutrient enrichment) and the extent of plant growth that can be sustained. The trophic status of water resources is not only affected by nutrient concentrations but also by other factors, including abiotic, biotic, Physico-chemical, and biological factors. The four trophic status classes and colour coding used to describe trophic status are provided in Table 4-1 below, and the criterion used to assign a trophic status for the dams in South Africa is outlined in Table 4-2.

*Table 4-1 Trophic status classes used for assessment of dams in South Africa*

| | |
|---|---|
| 1. **Oligotrophic** | low in nutrients and not productive in terms of aquatic and animal plant life; |
| 2. **Mesotrophic** | intermediate levels of nutrients, fairly productive in terms of aquatic animal and plant life and showing emerging signs of water quality problems; |
| 3. **Eutrophic** | rich in nutrients, very productive in terms of aquatic animal and plant life and showing increasing signs of water quality problems; and |
| 4.**Hypertrophic** | Very high nutrient concentrations where plant growth is determined by physical factors. Water quality problems are serious and can be continuous. |

*Table 4-2: Criterion used to assign trophic status for the dams in South Africa*

| **Statistic** | **Unit** | **Current trophic status** | | | |
|---|---|---|---|---|---|
| Median annual Chl *a* | µg/l | 0<x<10 | 10<x<20 | 20<x<30 | >30 |
| | | Oligotrophic (low) | Mesotrophic (Moderate) | Eutrophic (significant) | Hypertrophic (serious) |
| % of time Chl a> 30µg/l | % | 0 | 0<x<8 | 8<x<50 | >50 |
| | | Negligible | Moderate | Significant | Serious |
| **Potential for algal and plant productivity** | | | | | |
| Median annual Total Phosphorus (TP) | mg/l | x<0.015 | 0.015<x<0.047 | 0.047<x<0.130 | >0.130 |
| | | Negligible | Moderate | Significant | Serious |

The trophic status and eutrophication potential were calculated for 65 of the 119 sites monitored. The sites with four or more data sets were considered for trophic status and potential eutrophication calculation, as shown in Figure 4.6.

The trophic status calculation demonstrated that fourteen sites were hypertrophic, one eutrophic, nine mesotrophic, and 32 oligotrophic. The other nine sites did not have chlorophyll-*a* data and could not be assigned a trophic status. Eutrophication potential was also calculated (based on total phosphorous (TP) concentration) as serious (26 sites), significant (13 sites), moderate (10 sites), and negligible (14 sites). Two sites did not have TP data.

The hypertrophic sites included the Rietvlei Dam, Hartbeespoort Dam, Roodekopjes Dam, Olifantsnek Dam, Roodeplaat Dam, Bospoort Dam, Klipvoor Dam, Klein-Maricopoort Dam, Lotlamoreng Dam, Modimola Dam, and Florida Lake as shown in Figure 4.6. The Bon Accord Dam was assigned a eutrophic state. The hypertrophic sites and eutrophic sites were characterised by high nutrient levels with serious potential for continued algae and plant productivity. Several sites of concern had significant to seriously high levels of nutrients even though they had mesotrophic to oligotrophic statuses. The trophic status in the sites may change rapidly for the worse should the ideal eutrophication conditions prevail.

In the Eutrophication Management Strategy for South Africa, the challenges of eutrophication are identified as being exacerbated by insufficient wastewater treatment infrastructure maintenance and investment; deteriorating ecological infrastructure; recurrent droughts driven by climatic variation, and an inescapable need for water resource development; inequities in access to safe sanitation, against the backdrop of a growing population; water use regulation that is not consistently and adequately protecting South Africa's water resources against eutrophication; and a lack of skilled water scientists and engineers. Whilst poor water quality, including eutrophication, is observed to have already significant impacts on economic growth and the well-being of South Africans. This situation, therefore, requires urgent intervention to slow the trend.

The sites characterised by serious eutrophication problems are characterised by catchments hosting densely populated urban developments and poorly functioning sewer networks, and wastewater treatment works.

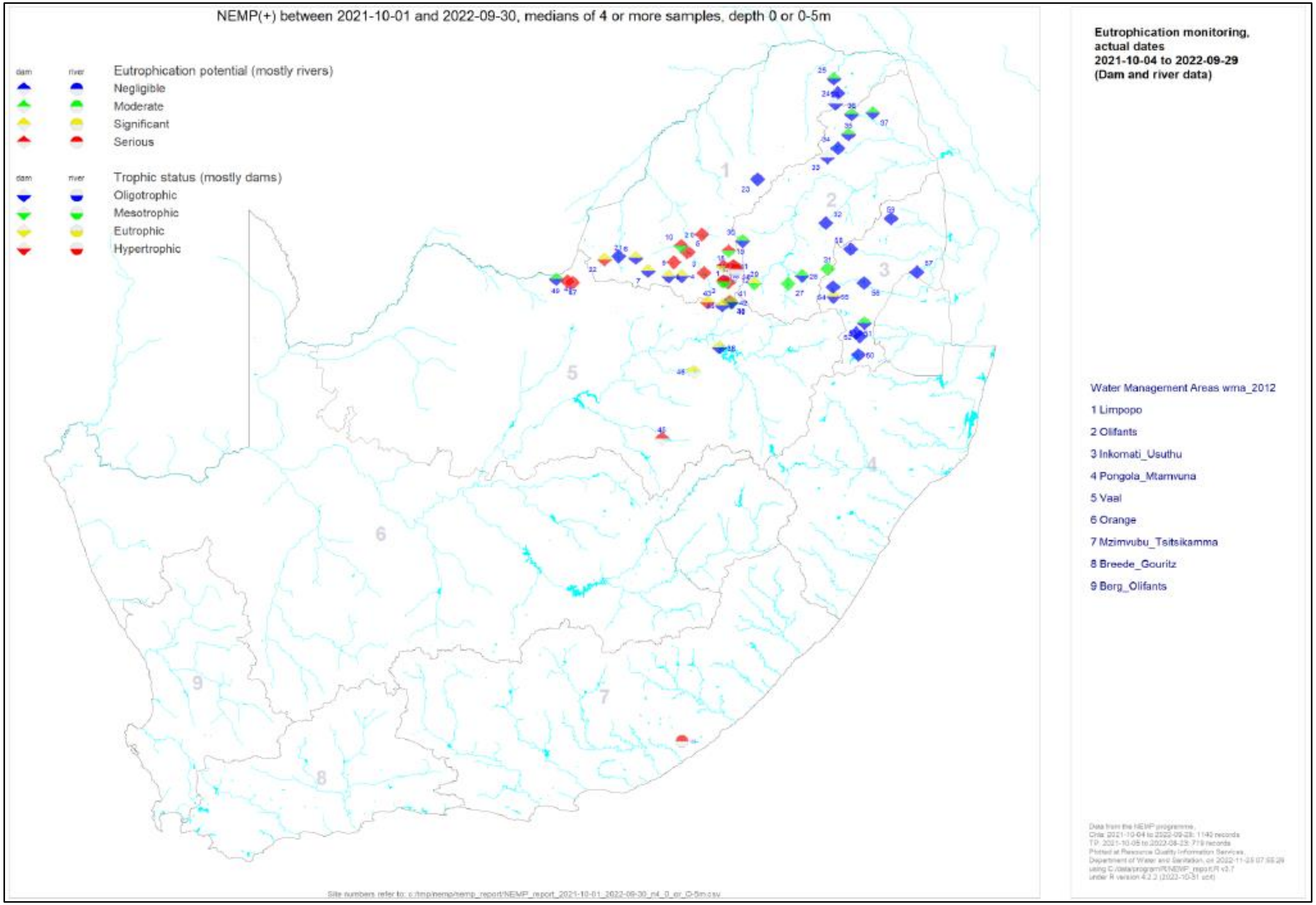


*Figure 4.6: Eutrophication monitoring results based on 65 stations that were monitored.*

### *Case Study: Long-term Hartbeespoort Dam versus the Vaal Dam eutrophication data*

The graph showing a comparison of the annual chlorophyll-*a* averages of the Hartbeespoort Dam and the Vaal Dam for January 1981 to October 2022 is presented in Figure 4.7. Both dams demonstrated an increasing trend in terms of Chlorophyll-*a* concentration. A significant variation in Chlorophyll-*a* concentrations was noted for the two dams. The Hartbeespoort Dam was hypertrophic for most of the period whilst the Vaal Dam was mostly mesotrophic. A comparison of the nutrient data, particularly total phosphorous and orthophosphate, provided in Figure 4.8 and Figure 4.9 demonstrate that both TP and PO4 were higher at the Hartbeespoort Dam than Vaal Dam, with the high phosphates being the cause for higher biomass at the Hartbeespoort Dam.

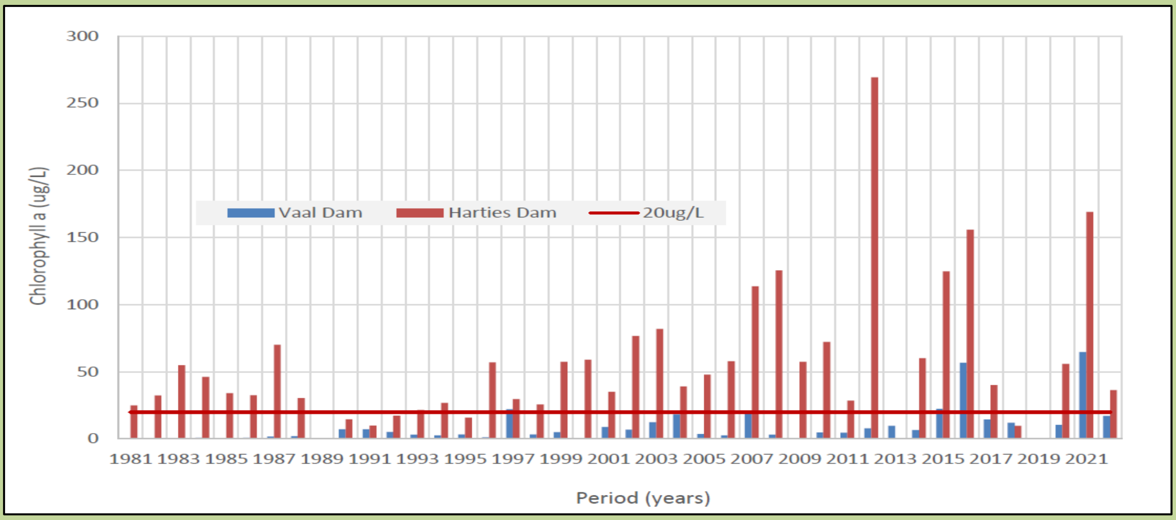


Figure 4.7: Chlorophyll-a data for the Hartbeespoort and Vaal Dams

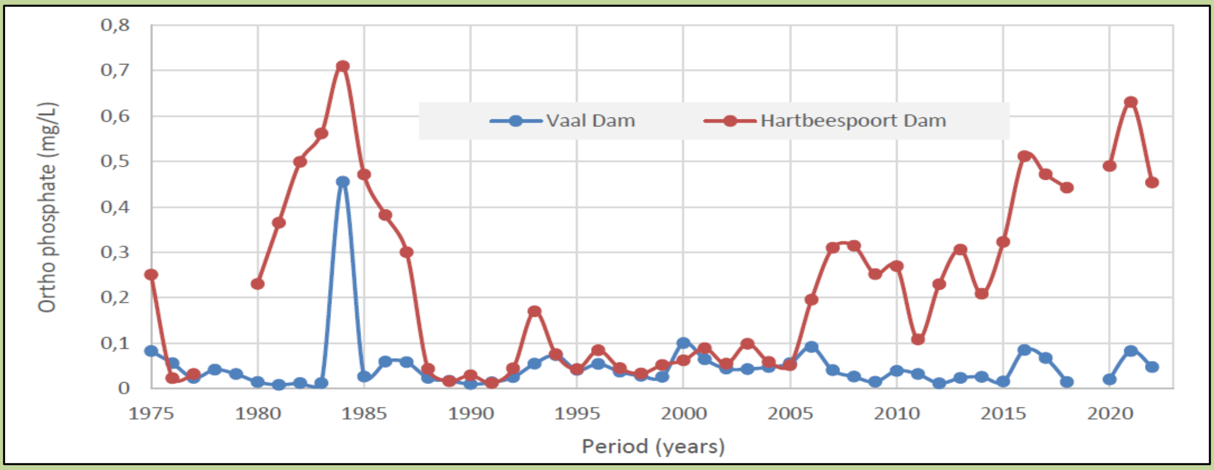


Figure 4.8: PO4 data for the Hartbeespoort and Vaal Dams

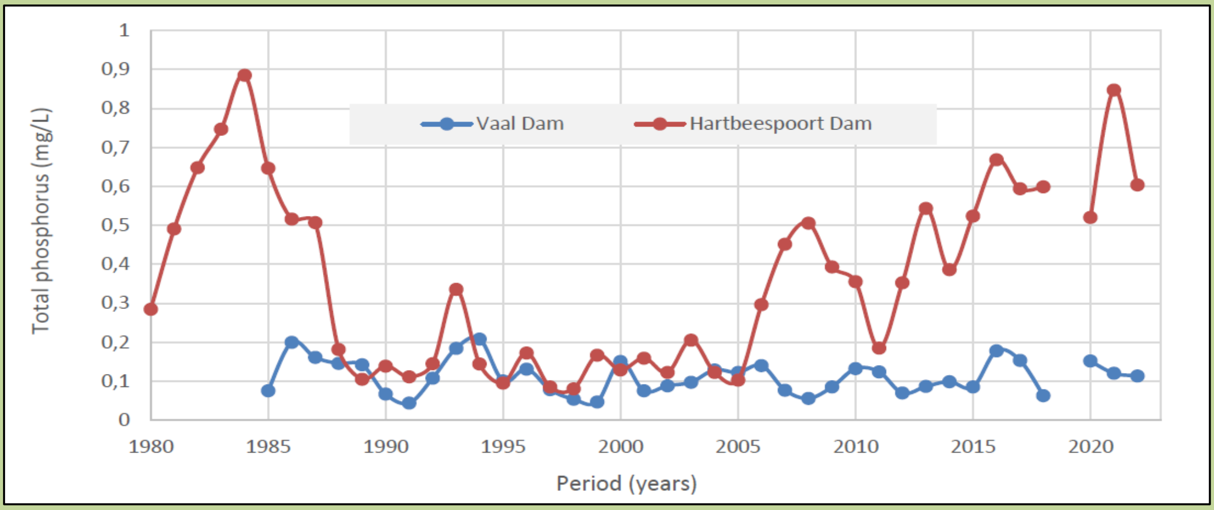


*Figure 4.9: TP data for the Hartbeespoort and the Vaal Dams*

The TP, PO4, and chlorophyll-*a* data for Hartbeespoort Dam follows an increasing trend for all variables (Notably from 2005 to the present for TP and P04). The chlorophyll-*a* data at the Vaal Dam exceeded the management objective on two occasions, and phosphate data showed variability with time. Chlorophyll -*a* concentrations were high at the Vaal Dam in 2007, 2016, 2017, and 2021. At the Hartbeespoort Dam chlorophyll, *a* was high in all the years except in 1990, 1991, 1992, and 1995. The Hartbeespoort Dam shows an increasing trend for eutrophication, while the Vaal Dam varies over time and does not show a defined trend.

### 4.3.2 Microbial Pollution

The contamination of water resources by faecal pollutants poses significant risks to human and animal health since numerous pathogens are often associated with faeces. Microbial water quality measures the microbiological conditions of water to human health. The overall purpose of the microbial monitoring programme is to assess and manage the health risks to water users due to faecal pollution of water resources.

Faecal coliforms and *E. coli* are the best indicators for the assessment of recent faecal pollution, and they also indicate the potential presence of pathogenic bacteria, viruses, and parasites. Faecal coliform and *E.coli* are measured, and results are compared to the South African Water Quality Guidelines shown in Table 4-3.

*Table 4-3: Guidelines for assessing the potential health risk for the four water uses*

| | **Potential health risk** | | |
|---|---|---|---|
| | **Low** | **Medium** | **High** |
| **Water use** | ***E. coli*** **counts/ 100ml** | | |
| 1. Drinking untreated water | 0 | 1 - 10 | > 10 |
| 2. Drinking partial treated water | < 2 000 | 2000 – 20 000 | > 20 000 |
| 3. Full contact recreational | < 130 | 130 – 400 | > 400 |
| 4. Irrigation of crops to be eaten raw | < 1 000 | 1 000 – 4 000 | > 4 000 |

Surface water resources are usually not suitable for domestic activities such as drinking without any sort of treatment, and this is evident in the data represented in Figure 4.10. The microbiological results indicate that all the collected samples had high microbial contamination and the water from that source was not suitable for drinking. This would pose a high risk of infections to human health if water was consumed directly from the source. However, treating the water at the household level can reduce the potential health risk in some cases where water is not severely polluted with faecal contamination.

There was a low risk of infection if water was consumed after limited treatment in 42% of the sampled sites. More than half (53%) of the sampled sites presented a high health risk if water from the source was used for irrigating crops that were eaten raw and only 42% indicated a low risk. Full-contact recreational activities such as swimming, washing laundry, and activities such as baptisms should be discouraged in these water resources that are highly polluted. The results also revealed that 64% of the sampled sites were unsuitable for recreational activities and using these sites for such activities would be associated with a high risk of infections.

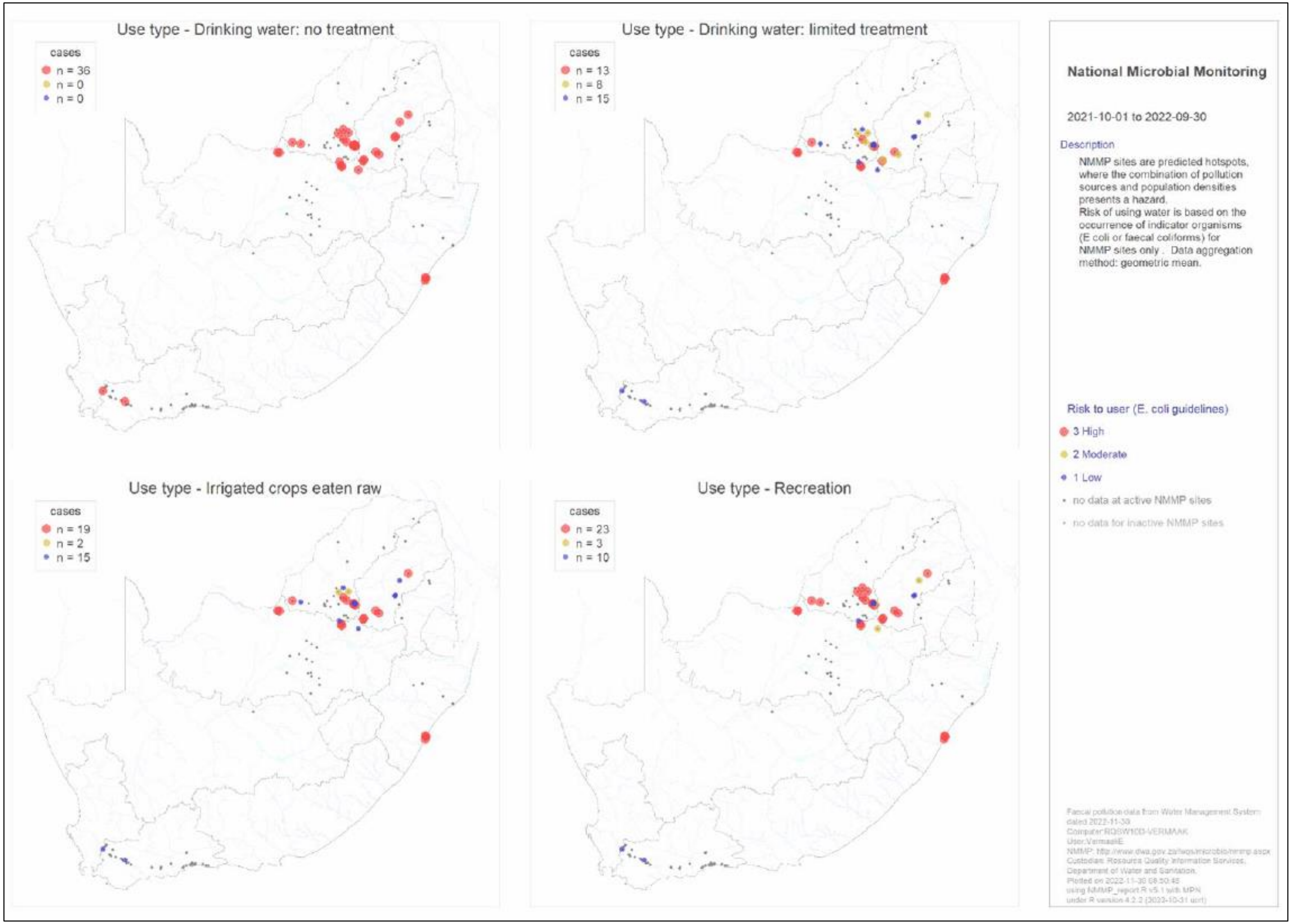


*Figure 4.10: representation of Faecal pollution data (October 2021 - September 2022)*

### 4.3.3 Chemical Pollution

The main inorganic water quality issues of concern on a country-wide basis include elevated salinity, the perception of failing wastewater treatment works in some municipalities, and acid mine drainage. However, high salinity may also be the result of natural processes due to the geological formations in the catchment and the dissolution of rocks and is also influenced by surface water and groundwater that also contains salts. These levels can also be elevated due to urban and agricultural run-off, domestic wastewater effluents, and mining or industrial effluent discharges.

The National Chemical Monitoring Programme (NCMP) provides data for interpretation into information on the inorganic chemical quality of the country's surface water. Since the NCMP is a national-scale programme, issues that are known and experienced at a local (fine-scale) level may not be reflected at the sites selected to show the overall situation in South Africa. This finer scale is beyond the scope of a national programme and needs to be reported on in catchment and situation-specific assessments, that is, at regional and site-specific water quality management levels. The location of the programme's sampling sites is depicted in Figure 4.11.

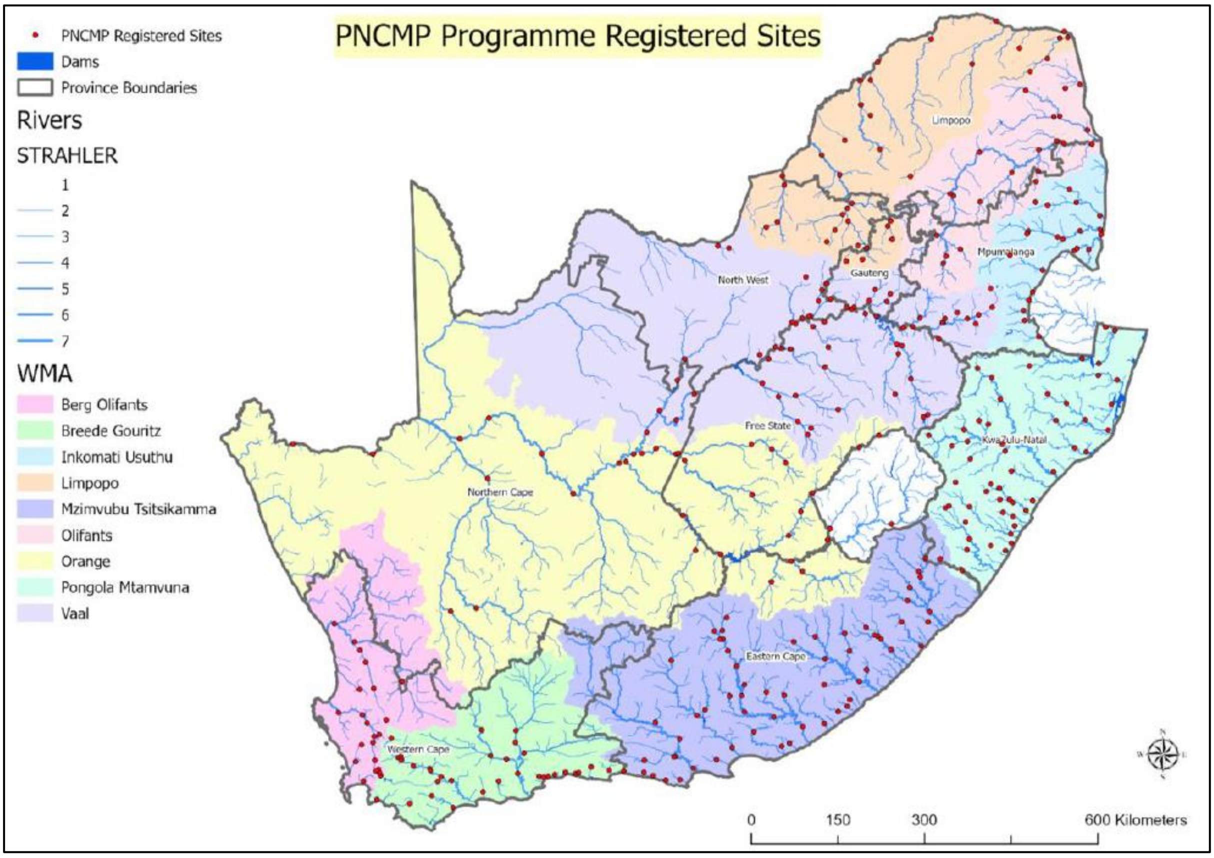


*Figure 4.11: The location of priority NCMP sampling sites is situated across South Africa.*

Due to various constraints, the water quality picture able to be represented is currently lacking in many areas of the country. Figure 4.12 represents the chemical water quality condition of **2017-2018** as the most recent period for which there was adequate data to provide a water quality depiction of the situation across South Africa. To show any water quality fitness-for-use on the presented map, a less stringent requirement of data points per site for the entire year had to be implemented in the assessment, as mentioned above.

- *Salinity*

The salinity level of water resources is calculated as Total Dissolved Solids (TDS, also termed Dissolved Major Salts or DMS) or is measured as electrical conductivity (EC) and is also gauged from the concentrations of individual ions such as sodium, chloride, and magnesium, potassium and sulfate, amongst others. Elevated salinity may be the result of natural processes due to the geological structure of the catchment and the dissolution of rocks. It is also influenced by surface water and groundwater, which also contains salts. The levels of these can, however, also be elevated due to urban and agricultural run-off, domestic wastewater effluents, mining (*i.e.* sulfate ions from acid mine drainage) or industrial effluent discharges, and others.

Increased salinity affects the taste and perceived *freshness* of water. When salt levels are high and the water is used for domestic purposes, such as drinking, it can lead to serious health risks in infants under the age of one year (Blue Baby Syndrome); individuals with heart or kidney disease who have been put on a salt-restricted diet; and those with chronic diarrhoea. Excessively high levels of salts in water can also affect water infrastructure by corroding water distribution pipes leading to increased maintenance and replacement costs.

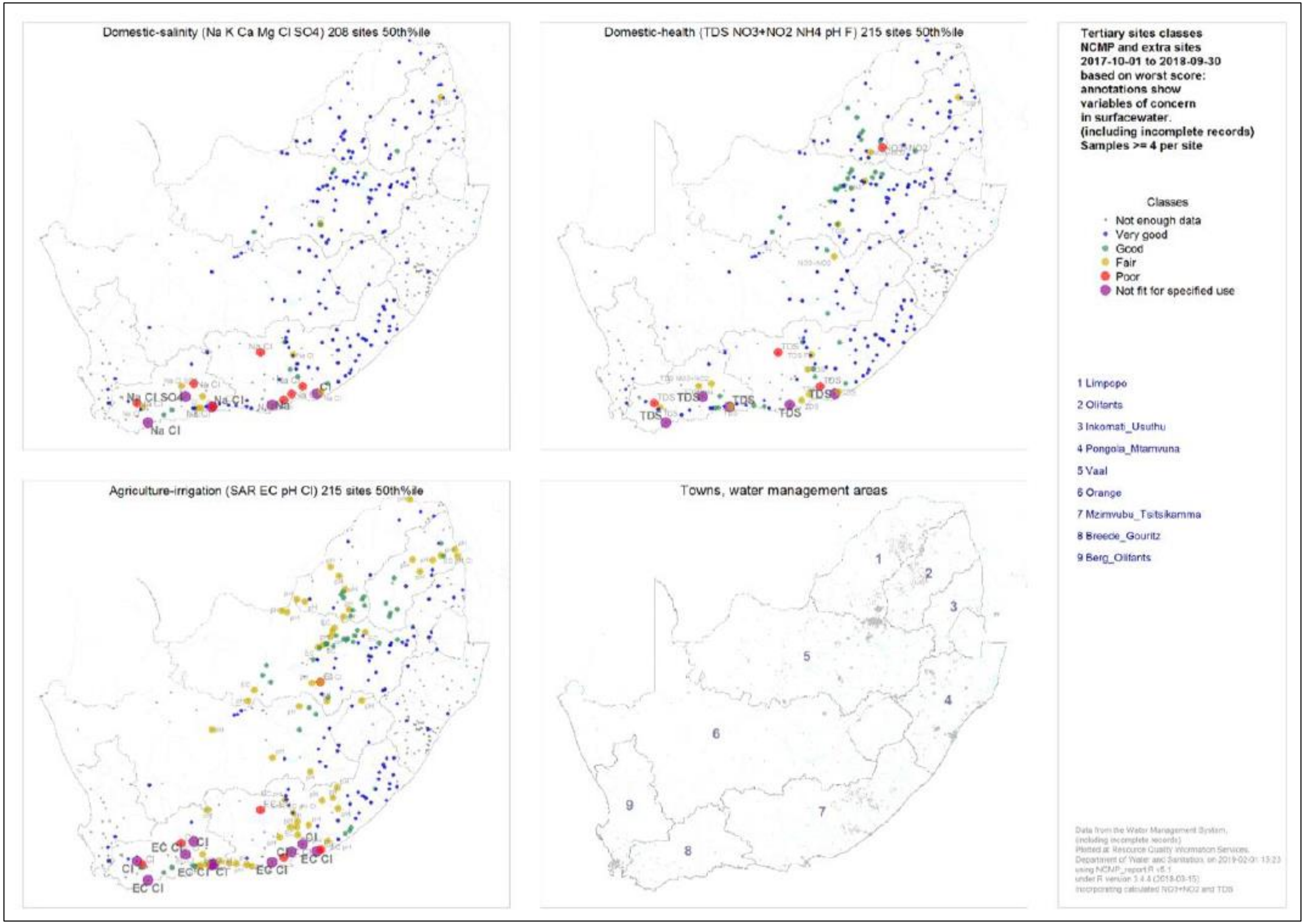


*Figure 4.12: The inorganic chemical water quality situation in South Africa during the 2017/2018 period is an example that is still likely to be broadly true of the current situation for conservative water quality attributes.*

Figure 4.12 reflects the situation evident in 2017-2018, high salinity levels are concentrated around the Southern and Western Cape regions of the country due most likely to marine geology, with a limited occurrence of elevated chloride in the Vaal WMA. There was an isolated pocket of elevated magnesium, chloride, and fluoride in the Olifants Water Management Area (WMA) in the Ga-Selati River at Google-Foskor (at a Fair level for Domestic Use), and elevated sulphate levels at selected sites within the Breede-Gouritz WMA.

For irrigated agricultural use, high levels of salts (chloride, EC, and the irrigation suitability indicator, the Sodium Adsorption Ratio –SAR) in water can have an impact on sensitive crops resulting in reduced crop yields and hence negatively affect profitability. The result clearly showed poor to non-acceptable levels of variables impacting irrigated agricultural use in the Southern and Western Cape. There were many instances of elevated EC throughout the Vaal River WMA and Lower Olifants River WMA, where EC and chloride were seen to be within the Fair range. Throughout the rest of the country, there were also incidences of pH levels that were not ideal for irrigated agriculture. In practical terms, though, the real-life situation may not be as severe as the water quality guidelines would suggest, and this is due to the abruptness of the transition between the Very Good and the Not Very Good water quality ranges that is not realistic. There should be a more gradual transition for it to be meaningful and realistic.

- *Potential Problems with Wastewater Treatment Works*

Elevated ammonium ($NH_4^+$) and nitrate-nitrite ($NO_3+NO_2$) levels could be indicative of poorly achieving wastewater treatment works (WWTW), or direct discharge of untreated or minimally treated human or animal waste or agricultural return flows entering the water resource. Two sites within the upper Crocodile-Marico WMA had elevated nitrate-nitrite levels, as well as a site in the Upper, reaches of the Orange River WMA and a site in the Breede-Gouritz WMA. A site in the Upper reaches of the Vaal River WMA had ammonium ($NH_4^+$) elevated into the Fair range for domestic use purposes. Instances of poorly functioning or non-functional WWTW have been reported in the media, including the contamination of the Vaal River in the vicinity of Parys. This affects all classes of water use and has significant negative impacts. Ammonium was also elevated in a site in the Breede-Gouritz WMA.

- *Acid Mine Drainage Hotspots and mitigation strategies*

Acid Mine Drainage (AMD) is a consequence of mining activities and is not unique to South Africa. In the past, it was common practice to abandon mines without implementing adequate pollution control measures after mineral extraction was no longer financially viable. There was little concern for the environment since mine closures before the promulgation of the Water Act of 1956 were not subject to legislative closure requirements. The possible risks of AMD include contamination of shallow groundwater and surface water if mines decant contaminated water. This can affect the suitability of the water resources required for domestic, agricultural, and other uses. Sulphate in combination with low pH (acidic) conditions, can be an indicator of Acid Mine Drainage (AMD).

In 2002 the South African government realised the extent of the negative impact that mine effluent has on the environment and the threat that it poses to our natural resources such as water, especially with concerns about mines in the Western, Central, and Eastern Basins largely within the Vaal River catchment. There are also initiatives in the KwaZulu-Natal Province to rehabilitate numerous coal mine discard dumps and defunct or ownerless opencast coal mine sites in the Klip River coalfields. The aim is to mitigate the impacts of post-coal mining activities and improve water quality in the affected catchments.

AMD occurs when abandoned mines are exposed to water, especially due to inundation by groundwater that then fills up the voids left by mining operations and liberates sulphate and metals from the exposed rock into the water. Suppose the water levels rise and reach the surface. In that case, the polluted water can be decant into the surface water resources, reducing the pH levels of the receiving water and contaminating it with high levels of sulphate and metals. This can represent a risk to downstream users and can impact very negatively on the environment.

On a national scale, reduced pH levels are not necessarily seen to coincide with those areas (the Breede-Gouritz WMA) indicated in Figure 4.12 that have elevated sulphate (SO4) levels. A finer scale and more rigorous sampling can reveal a different picture. The isolated elevated salinity (as depicted by chloride) levels within the Vaal River may be partially due to AMD, together with irrigation return flows and the effects of discharge from urban areas. It must be borne in mind that due to the limited number of samples in many cases across the country, water quality problems are revealed due to data limitations.

### 4.3.4 Sampling for SDG Reporting

The need to provide data to service national and international commitments, such as for SDG (Sustainable Development Goals) reporting where monitoring had come to a halt, has resulted in a major effort to rejuvenate sample collection. The potential sites to represent GEMS/SDG sampling shown in Figure 4.13 were flagged for consideration by the respective programme coordinators. They were then workshopped to arrive at the desired list to report on inorganic water quality in South Africa at an international level. The samplers of those sites were communicated with to attempt to obtain assurance that those samples at least would be collected on no less than a quarterly basis and maintained frozen or chilled. A programme for the GEMS/SDG sampling has been registered on the WMS, and it has been consolidated. Sampling materials are being couriered to samplers.

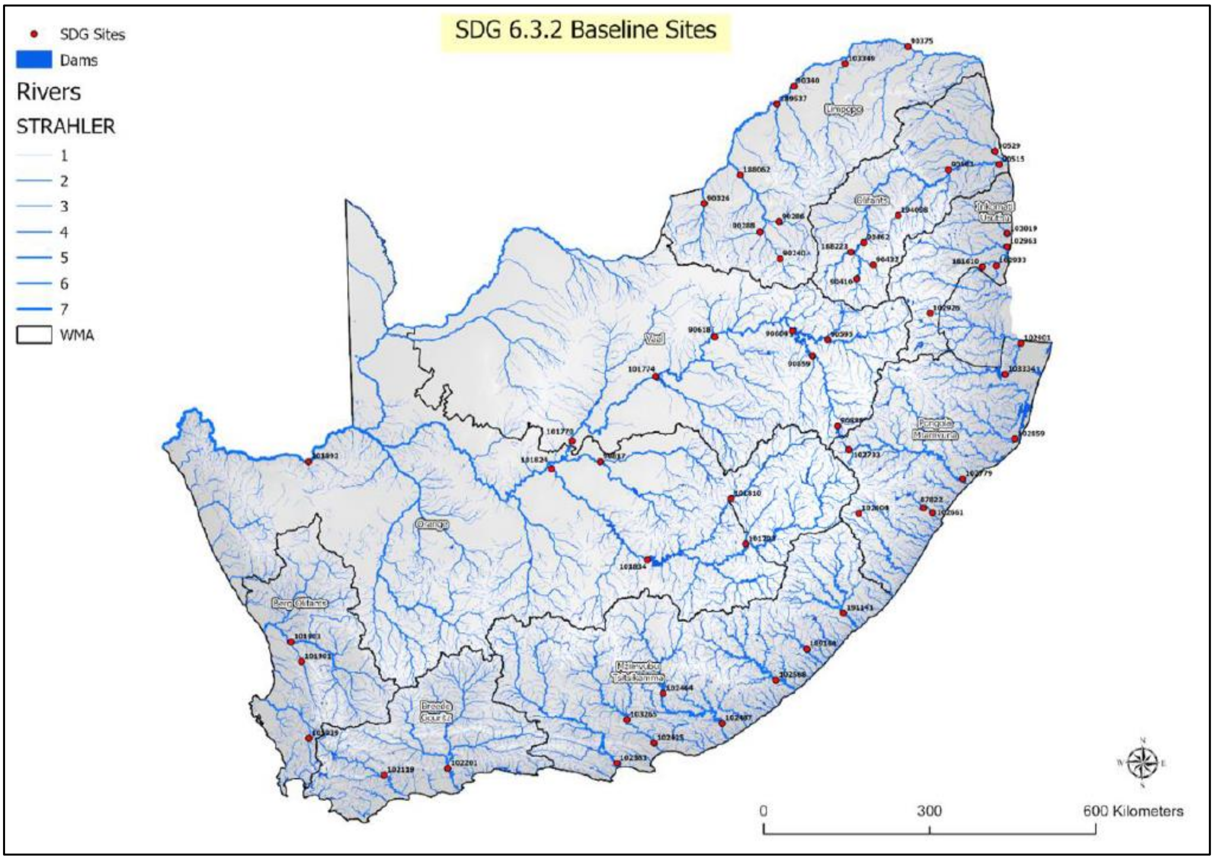


*Figure 4.13: The distribution of GEMS/SDG sites – also referred to as the SDG 6.3.2 Baseline Sites - across South Africa. The number accompanying each site is its WMS reference number.*