3

CLIMATIC ENVIRONMENT

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3.1 Climate

3.1.1 Background South African Climate

Climate is one of the most important drivers of the hydrological response of a catchment. It includes indicators such as rainfall, temperature, solar radiation, relative humidity, wind speed, and evaporation, and these are characterised by temporal and spatial variability, which in turn does affect and impact water availability, and water supply for drinking, rain-fed agriculture, groundwater, forestry, biodiversity,

Climate change puts additional pressure on the naturally stressed water resources of South Africa. This puts pressure on water availability, accessibility, quality, and demand. Climate change can have an exaggerated effect on runoff, and the complex response of the hydrological system worsens the impacts.

The South African Weather Services (SAWS) is the custodian of meteorological data in South Africa, and the data presented in this chapter is based on data and information provided by the SAWS.

3.1.2 Temperature

The maximum monthly temperature deviations from the normal period (1981 – 2010) for the summer season and winter seasons are presented in Figure 3.1 and Figure 3.2, respectively.

During the summer season months, the maximum temperature deviations were above-normal (positive) by up to 4^{0}c in some areas mostly in the Western Cape Province and southern parts of the Eastern Cape Province from January to March 2022. The country's eastern half also experienced higher-than-normal maximum temperatures during November 2021 and February 2022.

During the winter months, an observation is again made that the Western Cape Province has, for the months of May to September 2022, experienced maximum temperatures above normal.

Generally, the whole country experienced below-normal maximum temperatures during December 2021 and April 2022. These correlate with months when the eastern half of the country received high amounts of rainfall (Figure 3.4 and Figure 3.5).

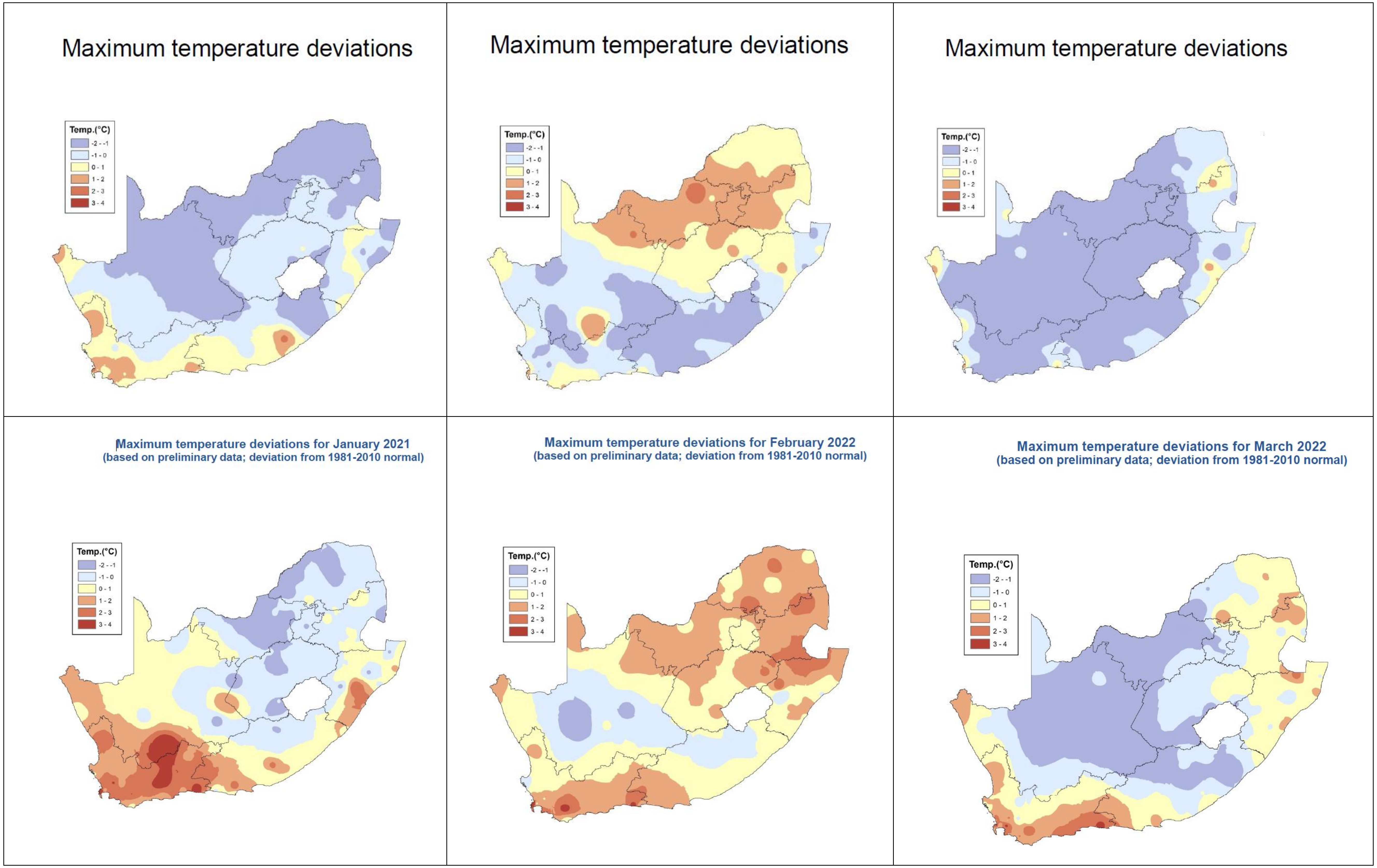


Figure 3.1 Maximum temperature deviations for the summer season months (October 2021 to March 2022) (SAWS, 2022)

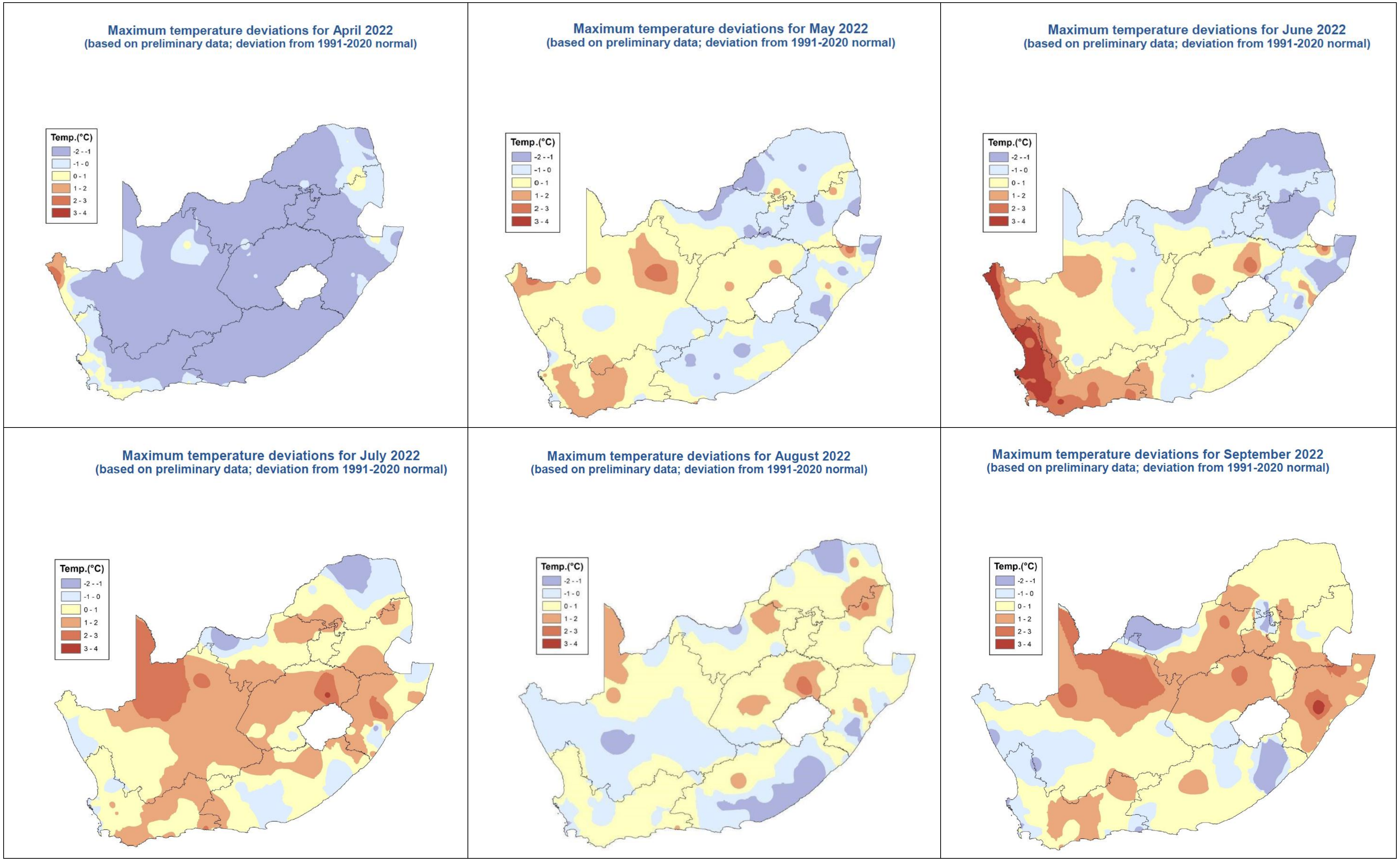


Figure 3.2 Maximum temperature deviations for the winter season months (April 2022 to September 2022) (SAWS, 2022)

3.1.3 Rainfall

A significant feature of the rainfall received during the hydrological year 2021/22, presented in Figure 3.3, is above-normal rainfall received for almost all parts of South Africa, apart from a strip on the southwestern coastline of the Western Cape Province. Rainfalls were significantly above (>200% from normal) for the Northern Cape Province, covering the Orange WMA, Middle, and Lower Vaal WMAs.

The eastern half of the country, characterised by summer rainfalls, has received significantly above-normal rainfall in the past two hydrological years (2020/21 & 2021/2022). These have resulted in areas in the country experiencing drought conditions decreasing over the past four hydrological years.

The monthly rainfall distribution during the hydrological year for the summer and winter seasons are presented in Figure 3.4 and Figure 3.5, respectively. During the summer, significant rainfalls mostly covering the eastern half of the country were received during December and January 2022. During the winter season, again, the eastern half of the country received significant rainfalls in April 2022, with a strip along the coastal line of KwaZulu-Natal receiving significant amounts, between **200 mm to 500 mm** of rain just in April 2022.

The long-term rainfall trend analysis per water management area is presented in Figure 3.6, Rainfall (% of Normal) for October 1981 - September 2022. The Normal Period used is October 1981 to September 2010.

Highlights from the anomaly's plots presented in Figure 3.6 is that for the 2021/22 hydrological year, most WMAs were classified as having experienced an above-average year. These are the Mzimvubu-Tsitsikamma WMA, Pongola-Umzimkulu WMA, Vaal and Orange WMA. Surface storage Dam levels are expected to have been the highest in these water management areas during the reporting period.

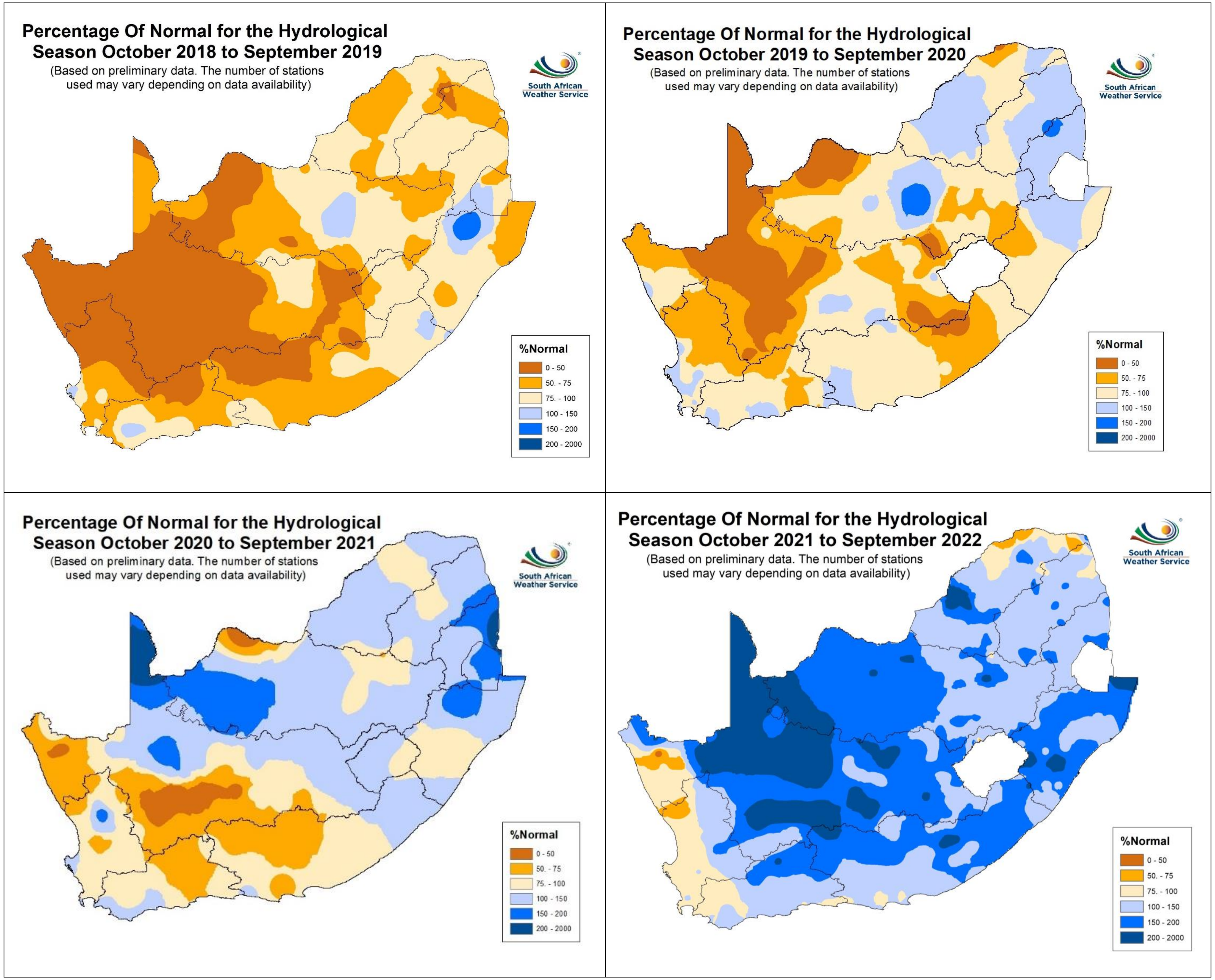


Figure 3.3 Rainfall % anomalies for the past three hydrological years in comparison to 2021-2022. Blue shades are indicative of above-normal rainfall, and the darker yellow shades of below-normal rain ((Source: SAWS https://www.weathersa.co.za/home/historicalrain)

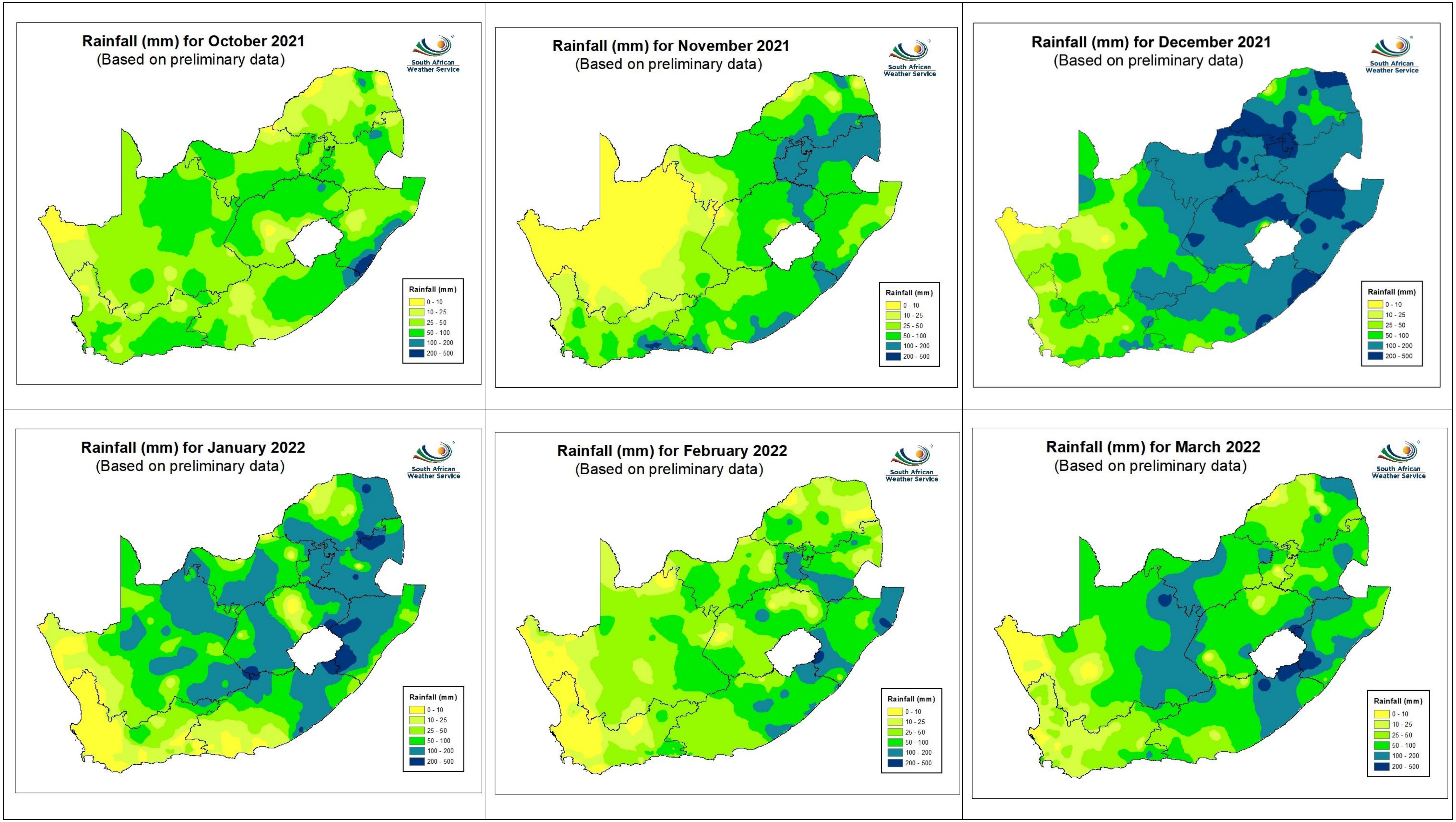


Figure 3.4 Summer season monthly rainfall distribution (Source: SAWS https://www.weathersa.co.za/home/historicalrain)

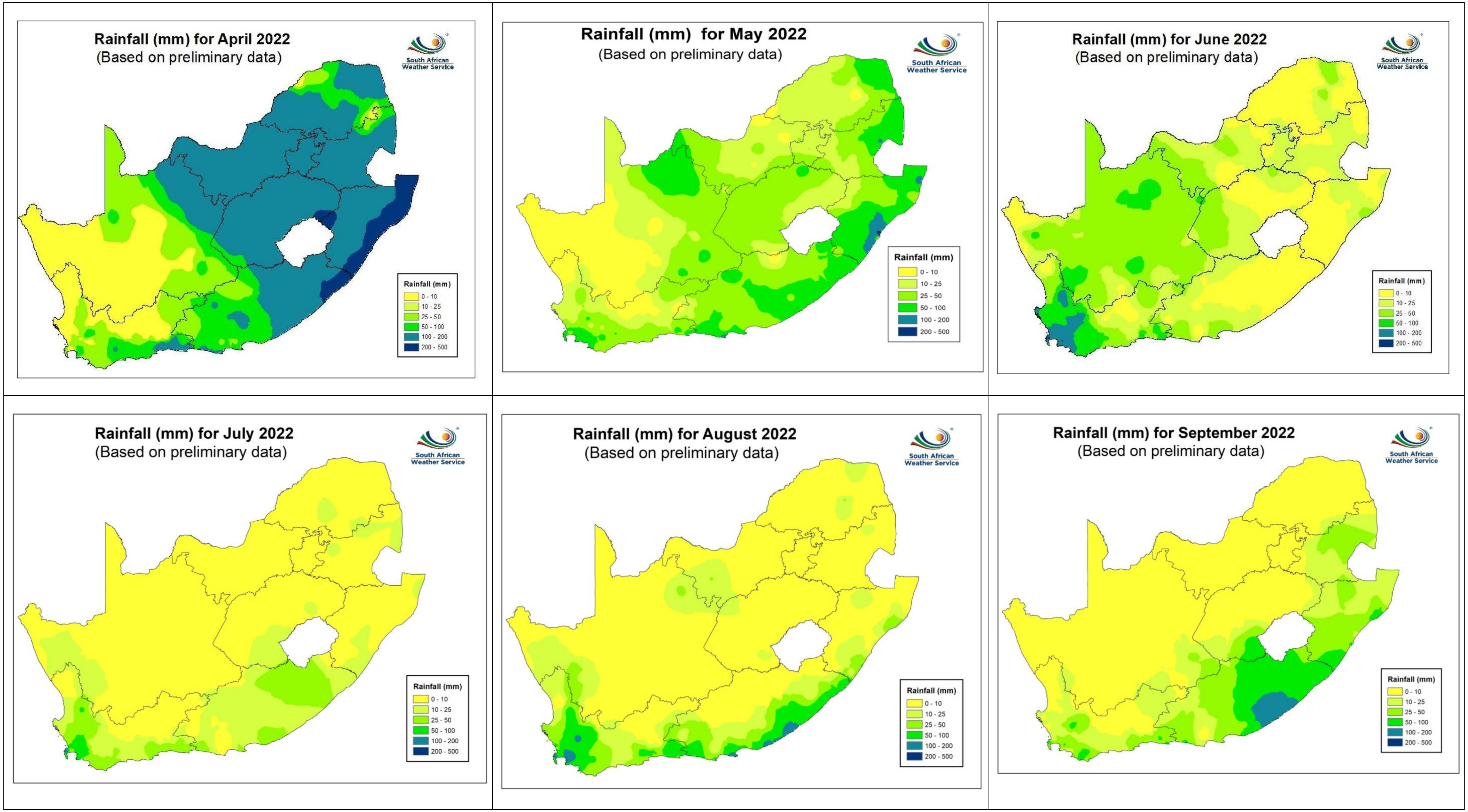


Figure 3.5 Winter season monthly rainfall distribution (Source: SAWS https://www.weathersa.co.za/home/historicalrain)

Figure 3.6 Hydrological year long-term trends of Rainfall Anomalies: > 125% (wet) & < 75% (dry) (Data Source: SAWS)

3.2 Indicators of Drought

The definition of meteorological drought is based on precipitation's departure from normal (long-term average) over time. Hydrological drought refers to deficiencies in surface and subsurface water supplies due to prolonged meteorological drought. It is measured using indicators derived from streamflow, reservoir, and groundwater levels. When precipitation is low for a long time, it is reflected in declining surface and subsurface water levels.

The Standardised Precipitation Index (SPI) is an index based on the probability of rainfall for any time scale and can assist in assessing the severity of any drought. The 12- and 24-month SPI maps give an indication of areas where prolonged droughts exist, in other words, where below-normal rainfall occurred over a period of one year or longer.

The 24-months (long-term) SPI for the end of the hydrological year (September 2022) is presented in Figure 3.7. Based on the SPI, 5 Provinces have been affected by drought in the last 24 months. Table 3-1 lists drought-affected Provinces, District Municipalities, and Local Municipalities.

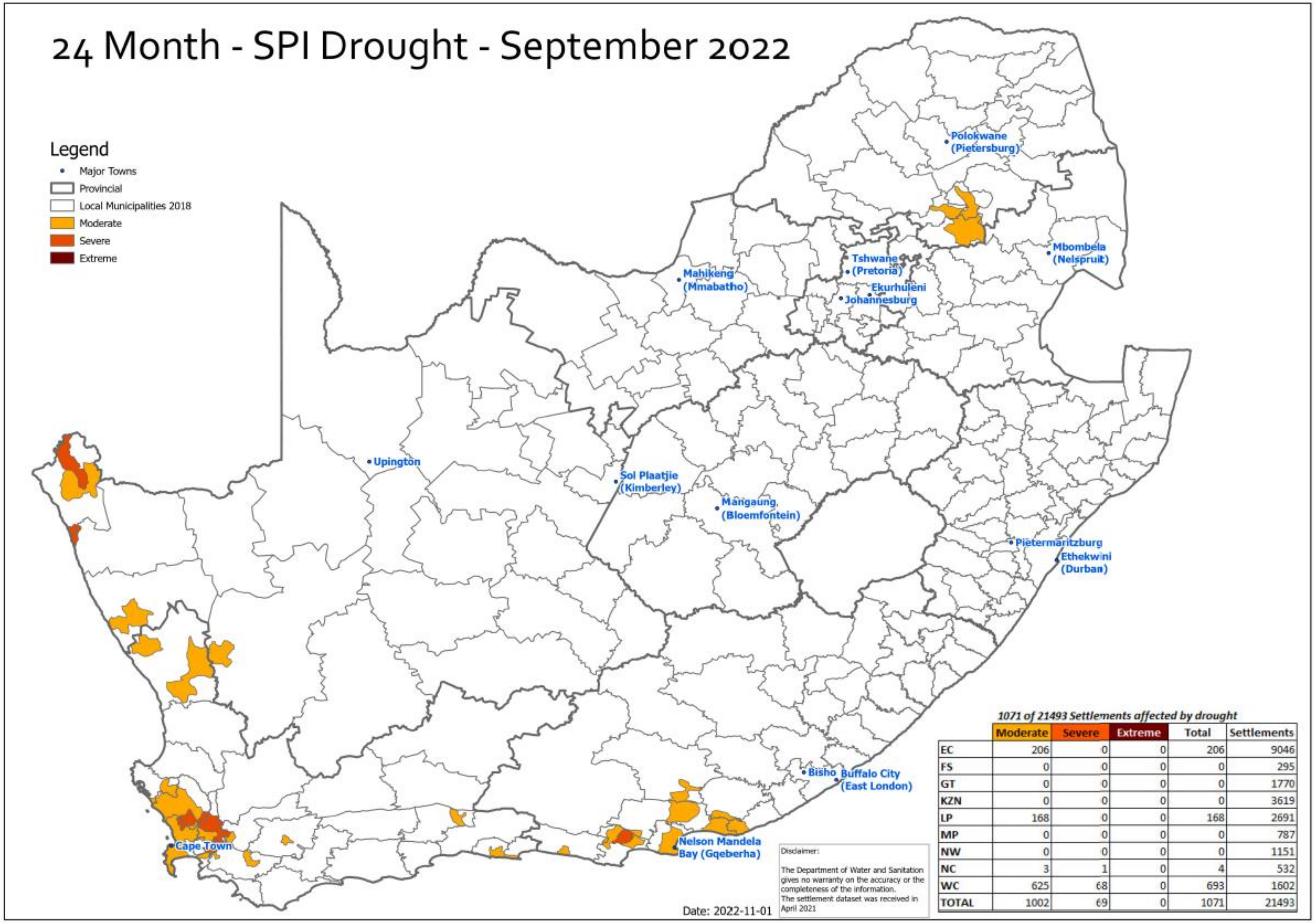
Table 3-1 Drought Affected Areas September 2022

Province	Affected District Municipalities	Affected Local Municipalities
Eastern Cape	Nelson Mandela Bay	Nelson Mandela Bay Local Municipality
	Sarah Baartman	Kou-Kamma Local Municipality
	Sarah Baartman	Ndlambe Local Municipality
	Sarah Baartman	Sundays River Valley Local Municipality
Limpopo	Sekhukhune	Elias Motsoaledi Local Municipality
	Sekhukhune	Ephraim Mogale Local Municipality
	Sekhukhune	Fetakgomo/Greater Tubatse Local Municipality
	Sekhukhune	Makhuduthamaga Local Municipality
Northern Cape	Namakwa	Kamiesberg Local Municipality
	Namakwa	Richtersveld Local Municipality
Western Cape	Cape Winelands	Breede Valley Local Municipality
	Cape Winelands	Drakenstein Local Municipality
	Cape Winelands	Langeberg Local Municipality

Province	Affected District Municipalities	Affected Local Municipalities
	Cape Winelands	Stellenbosch Local Municipality
	City of Cape Town	City of Cape Town Local Municipality
	Eden	Bitou Local Municipality
	Eden	Knysna Local Municipality
	Eden	Oudtshoorn Local Municipality
	Overberg	Theewaterskloof Local Municipality
	West Coast	Matzikama Local Municipality
	West Coast	Saldanha Bay Local Municipality
	West Coast	Swartland Local Municipality

3.2.1 Temporal Patterns of the SPI

Presented as a time series, the SPI shows its evolution of the SPI over time. SPI values of these longer timescales help determine the persistence, magnitudes of drought events, and flash points where hydrological droughts (low streamflow, reservoir levels, and even groundwater levels) are likely. This time series also makes it possible to analyse and visualise the intensity of the drought in an area of interest. Figure 3.8. presents the variation in SPI values for each of the South African Provinces over the past six years.



	Moderate	Severe	Extreme	Total	Settlements
EC	206	0	0	206	9046
FS	0	0	0	0	295
GT	0	0	0	0	1770
KZN	0	0	0	0	3619
LP	168	0	0	168	2691
MP	0	0	0	0	787
NW	0	0	0	0	1151
NC	3	1	0	4	532
WC	625	68	0	693	1602
TOTAL	1002	69	0	1071	21493

Figure 3.7 24-months Spatial Precipitation Index – September 2022 (DWS - NIWIS - Disaster Management - (dwa.gov.za)

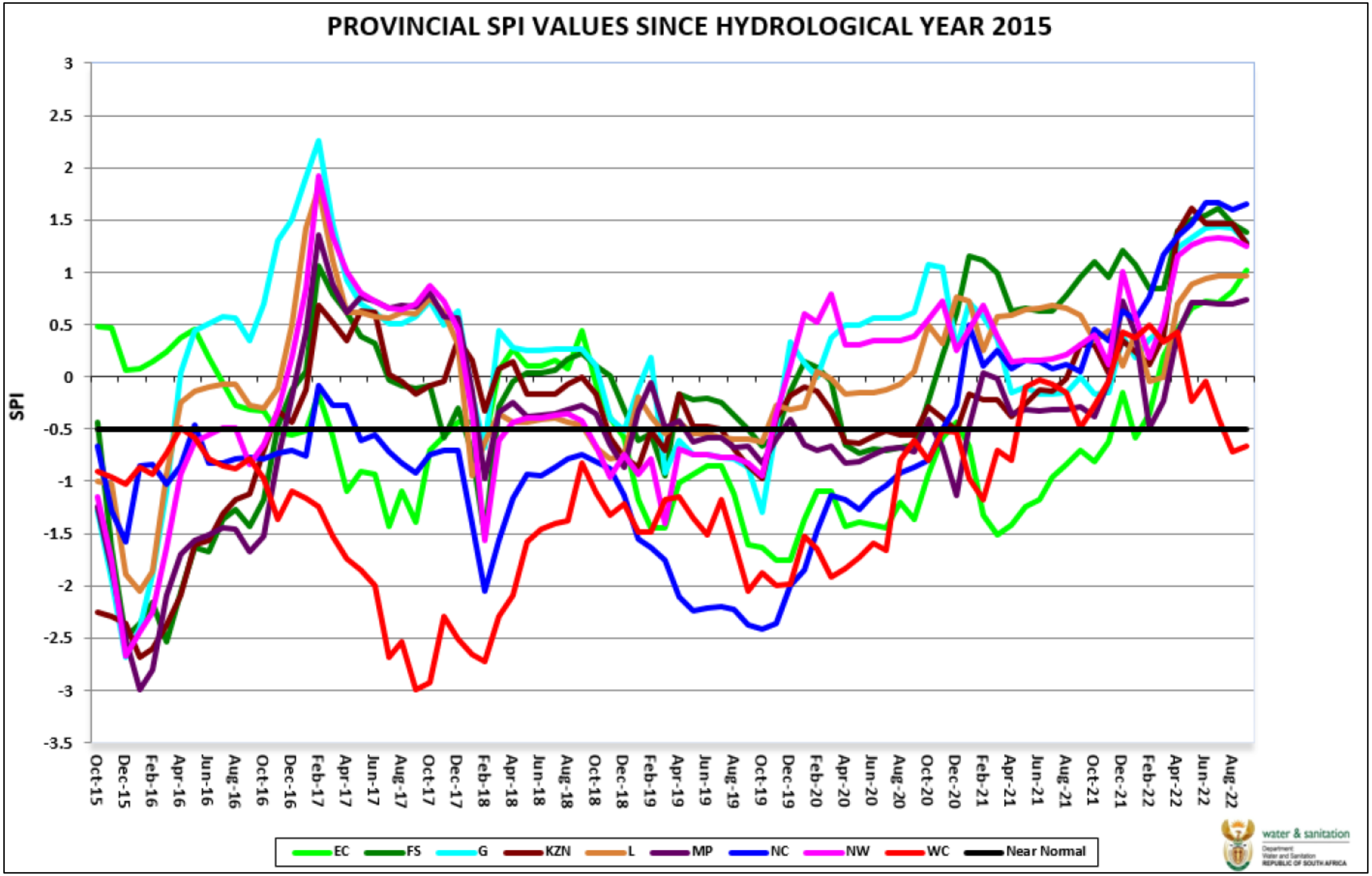


Figure 3.8 Provincial SPI time series from October 2015 – September 2022

Drought conditions had already manifested by October 2015 over all the provinces, except for the Eastern Cape, as the SPI values were below the -0.5-threshold line on the graph. These provinces experienced extreme drought conditions from December 2015 to April 2016, resulting in severe water shortages.

In 2016, most Provinces except the Western Cape Provinces had good rains during the summer rainfall season, easing the drought briefly for about a year. In early October 2017, following a below-normal winter rainfall season, Cape Town had estimated five months of storage left before water supplies were depleted. By December 2018, the drought had spread to all provinces except Gauteng, Limpopo, and Mpumalanga, whose SPI values were above the near-normal line. Winter rains led to a rise in dam levels in the Western Cape in 2018. It was a dry year from March to November, but the severity of the drought varied across provinces.

The Northern Cape experienced arid conditions. The dry conditions eased in Free State, Gauteng, Limpopo, and KwaZulu-Natal in December 2019 but persisted in Mpumalanga, Northern Cape, Western Cape, and Eastern Cape until November 2020.

Since December 2020, conditions have been near-normal in most provinces, with the Western Cape, Eastern Cape, and Mpumalanga crossing the near-normal line only in March, June, and November 2021, respectively. The summer rainfall region was usually wet from October 2021 to April 2022, with some areas experiencing rain well into June. Over that time, the SPI for provinces has increased, confirming the wet conditions. There are parts of the summer rainfall region where SPIs have exceeded 1.0 and reached levels last touched five years ago.

Based on ARC data, the winter rainfall region received between 25-75% of its normal rainfall again in September, following a similar observation for August. This reflects a drying phase in response to successive months of below-normal rainfall. The SPI generally showed a drying trend throughout the winter season, which ended in September. In this region, closer monitoring is needed because the SPI indicates a deepening dry phase that may intensify drought conditions.

3.3 Extreme Events

3.3.1 Floods

An upper-air cut-off low was situated over the southern parts of the country on the **11** to **12** of **April 2022** (Figure 3.9**)**, and with a high southeast of the country, cold to cool conditions with thundershowers and showers as well as light rain, occurred over the eastern half of the country. Heavy falls were measured in KwaZulu-Natal.

Diagrams below show cut off low-pressure system experienced by KZN Province

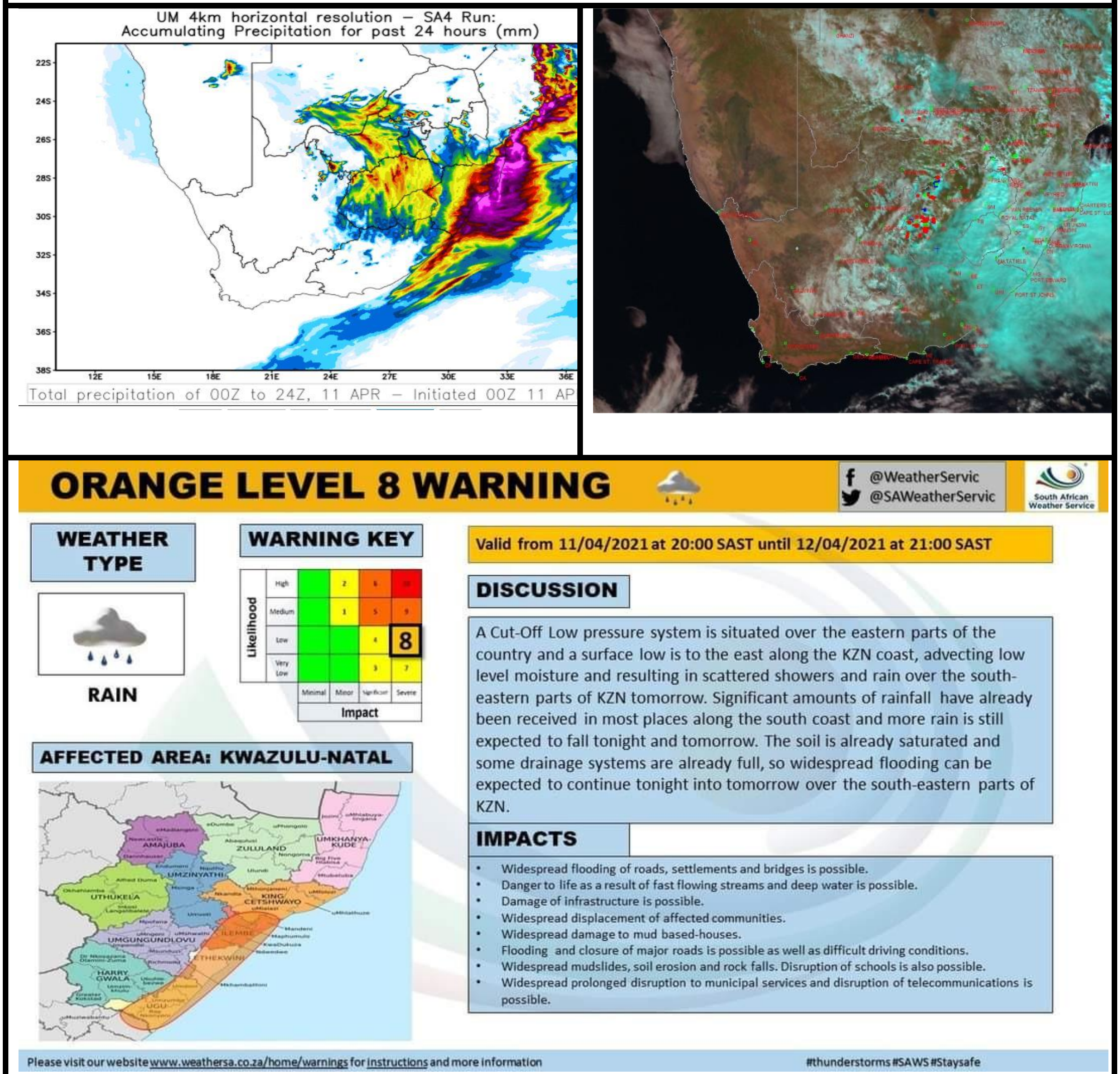


Figure 3.9 Cut off low-pressure system experienced by KZN Province April 2022

A surface trough was situated over the eastern parts of the country between the **20** and **22** of **May 2022**. Heavy rainfalls were measured over the KwaZulu-Natal coastal areas and in places over Mpumalanga. The South African Weather Services again issued a warning of high rainfall between 20 and 22 May, which resulted in more damage to infrastructures and loss of lives (Figure 3.10)

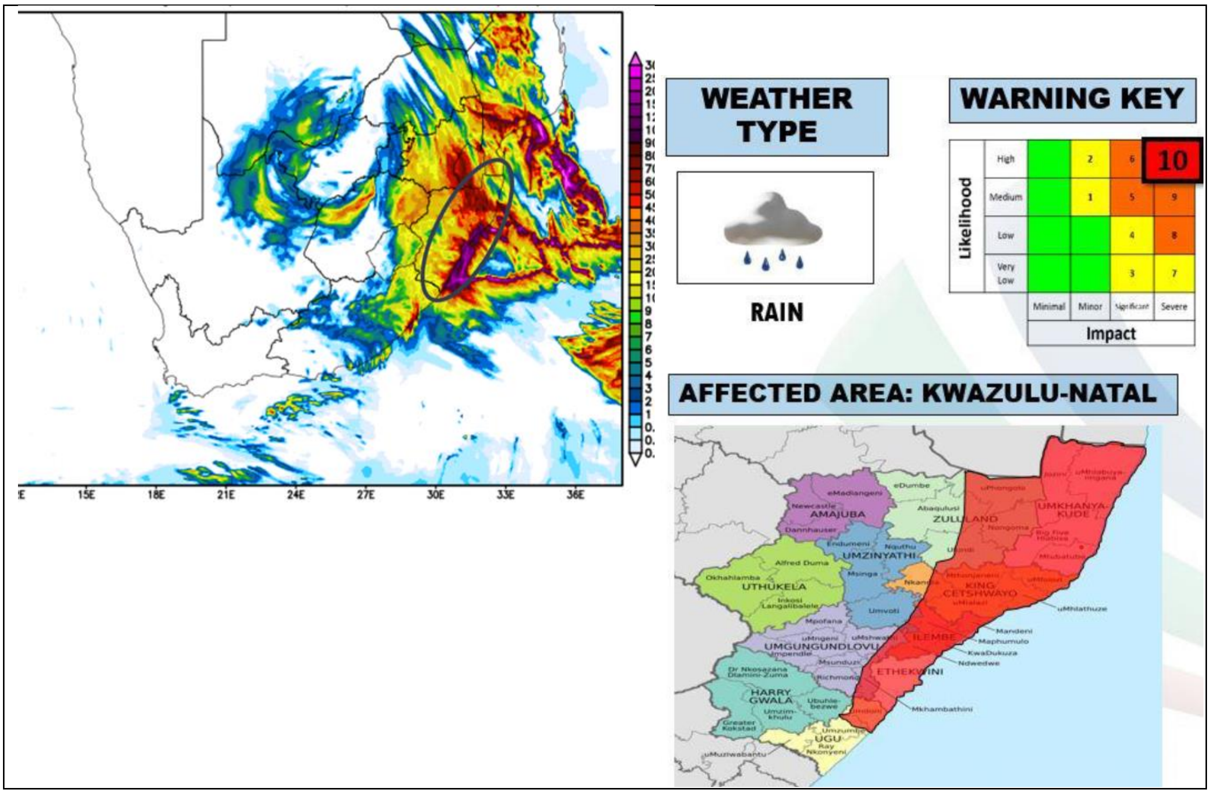


Figure 3.10 Flood Warning for KZN issued by SAWS for the May 2022 Storm

The rainfall ranging between (200-500 mm) was accumulated in KwaZulu-Natal in April and May 2022 (SAWS), and it has led to localised flooding in the area. A strong cut-off low weather system off the east coast of southern Africa caused the rain. Cut-off lows frequently occur in KZN during the autumn months.

Rainfall recorded within eThekwini areas between 11 and 12 April 2022 ranged from **60mm** to **311mm** (Schulze, 2022). The heavy rains led to a rapid increase in dam levels in the KwaZulu-Natal since most of the dams were almost at their full supply level before heavy rains between 11 and 12 April 2022, resulting in damage to infrastructure and loss of lives.

3.3.2 Impacts of Floods

The KwaZulu-Natal floods were declared a provincial disaster on the 13 of April 2022. On the 17 of April 2023, 435 fatalities were reported, and the homes, businesses, roads, bridges, and electricity and water infrastructure were damaged or destroyed. An estimated 130000 people have been affected, with more than 19182 houses and 264 schools destroyed (Table 3-2 and Figure 3.12). The worst affected districts include Ugu, eThekwini, King Cetshwayo, uMgungundlovu, and iLembe. (Figure 3.11)

Table 3-2 Number of incidents and impact per District/Metro Municipality

Municipalities	Number of Incidents	Households Affected	Houses Destroyed		Homeless	People Affected	Fatalities	Injuries	Missing Person
			Totally Destroyed	Partially Damaged					
uMkhanyakude	03	86	78	08	10	273	00	01	00
uThukela	05	224	192	131	15	1480	00	03	00
uMzinyathi	04	206	153	124	21	1208	02	01	02
uMgungundlovu	07	687	242	796	97	3705	02	04	02
Zululand	05	360	171	264	00	2348	00	00	00
eThekwini	505	11492	3000	7200	5423	±100 000	386	01	39
iLembe	20	3000	1391	1178	365	8006	31	21	00
Harry Gwala	17	650	297	252	250	1856	03	02	00
King Cetshwayo	155	490	242	501	172	2762	04	03	01
Ugu	35	1769	1049	910	288	7437	07	04	04
Amajuba	29	218	111	157	14	1022	00	00	00
TOTAL	**785**	**19182**	**6926**	**11521**	**6655**	**130097**	**435**	**40**	**48**

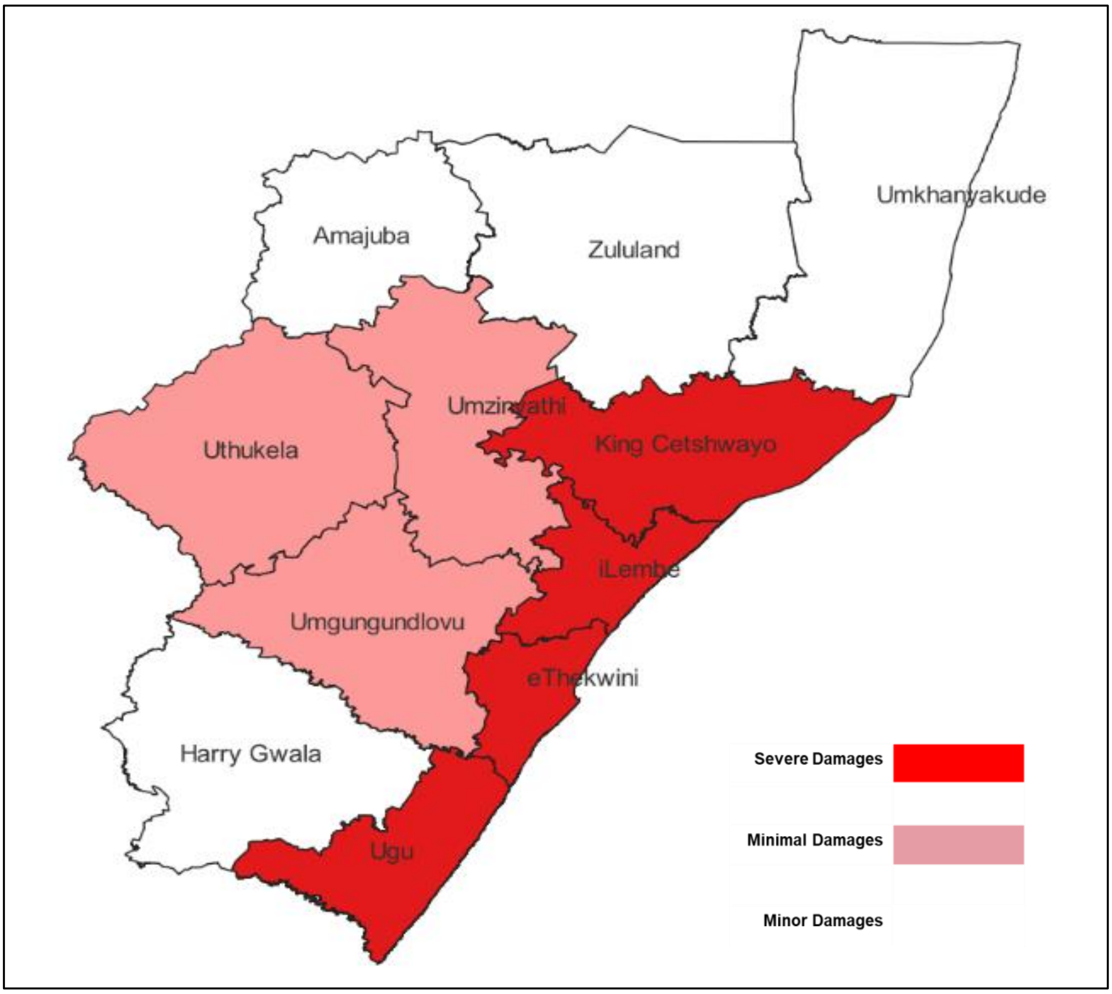


Figure 3.11 Map showing the affected municipality in KZN

Figure 3.12 Infrastructure damage caused by Floods in KZN South Africa April 2022

At the end of May 2022, approximately 448 fatalities were reported, and the homes, businesses, roads, bridges, as well as electricity and water infrastructure, have been damaged or destroyed. An estimated 130 000 people have been affected, with more than 19 182 houses and 264 schools destroyed.

The most affected areas in May 2022 were Hluhluwe, eThekwini, Jozini, KwaDukuza, Mandeni, Maphumulo, Mkhambathini, Mthonjaneni, Mtubatuba, Ndwedwe, Nongoma, Ulundi, Umdoni, Umhlabuyalingana, uMhlathuze, uMlalazi and uPhongolo District Municipal areas.

The worst infrastructure damage in eThekwini was observed at the Surfside residential complex, which suffered significant damage due to a lack of stormwater infrastructure in development under construction upstream of the complex. The May floods also washed away the various repairs underway at the Umdloti Water Treatment Works.

3.3.3 KZN Surface Water Resource Quality (Post Flood)

The river water quality has declined because of untreated sewage discharging directly to the watercourses between March to April 2022, as shown in Figure 3.13 River water quality March and April 2022 in KZN (Pieterson, 2022)
A few rivers remain at acceptable levels (shown in green), while most rivers are at critical levels recording E.coli counts greater than ***10 000 cfu/100ml*** (shown in red). The Amanzimyama, Umbilo, Umkhumbane, Umgeni, Mlaas, Umhlatuzana, Isipingo, and Amanzimtoti Rivers are severely impacted, recording E.coli counts greater than ***800 000 cfuf/100ml***. The orange colour refers to rivers that are in poor condition, where the E.coli counts are between ***2000 – 10 000 cfu/100ml.***

The eThekwini Municipality issued a public awareness notification released jointly with the Health Department on 18 May 2022.This notice highlighted beach closures, hot spot rivers, dangers of using contaminated waters, and what the city was doing to fast-track infrastructure repairs.

The flood-related damage has resulted in the failure of the entire sewerage infrastructure network, posing a severe threat to water quality. Reports have been received of fish kills in the Durban Harbour due to pollution from the feeder streams. As river levels subside and the concentration of wastewater increases, the impacts of overflowing and untreated sewage discharges to the environment are likely to be exacerbated.

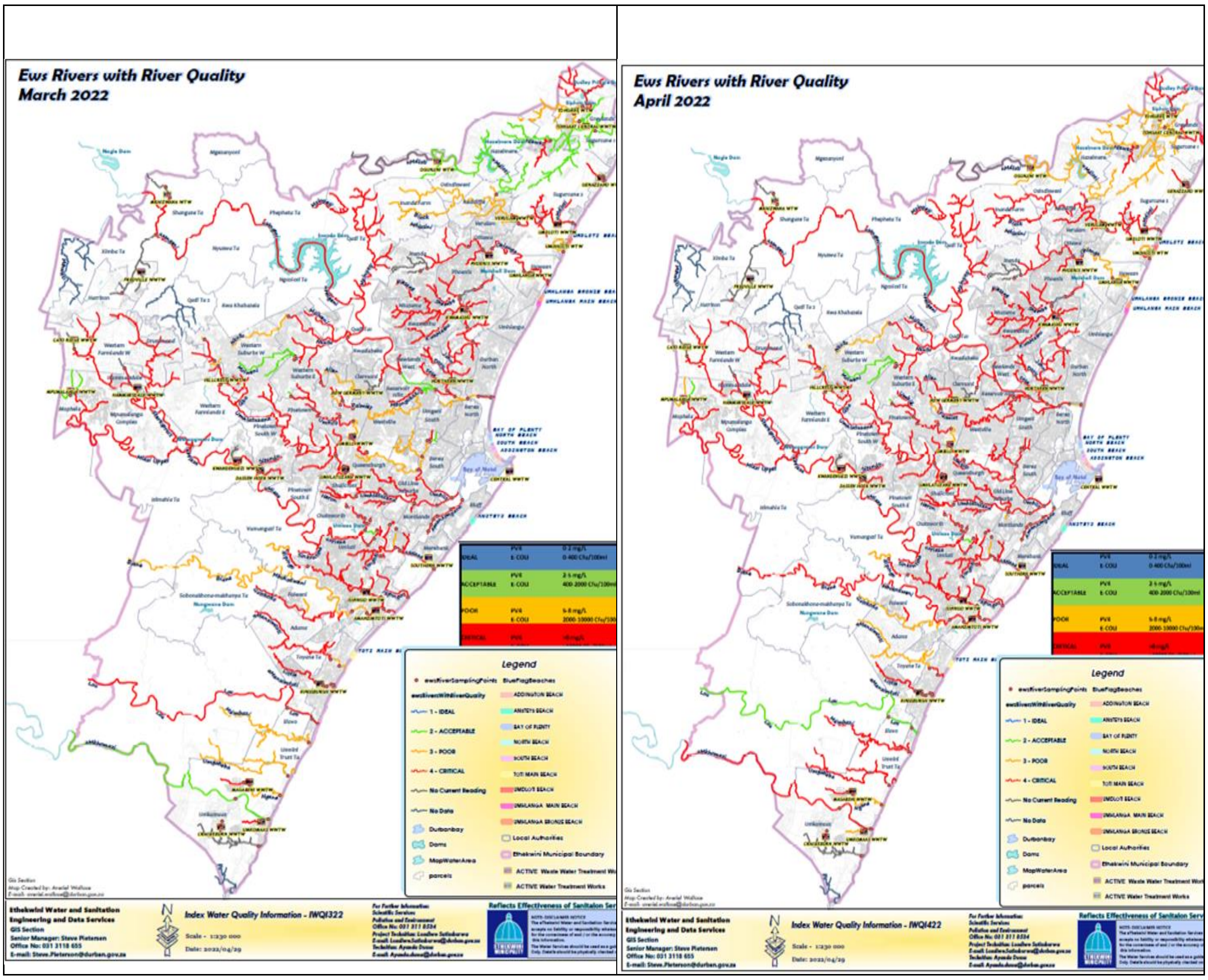


Figure 3.13 River water quality March and April 2022 in KZN (Pieterson, 2022)

The KZN flood disaster has impacted water resource quality as damaged wastewater treatment infrastructure (i.e., wastewater treatment works, pump stations, trunk sewer line, leaks, breakages, etc.) effluent overflows into the rivers. Some of the major rivers affected are Thongathi, Umdloti, Ohlanga, Umngeni, Umbilo, Umhlathuzana, Umlazi, Isipingo, Imbokodweni, Amanzimtoti and Amahlongwana in eThekwini Metro; Mvoti, Uthukela, Mbizana, Nonoti, in iLembe District; Uvongo, Nkhongweni in Ugu District.

More storm events pictures for April and May floods are given in (Figure 3.14), while the historical flood events magnitudes and hydrograph for the April 2022 event are presented in (Figure 3.15).

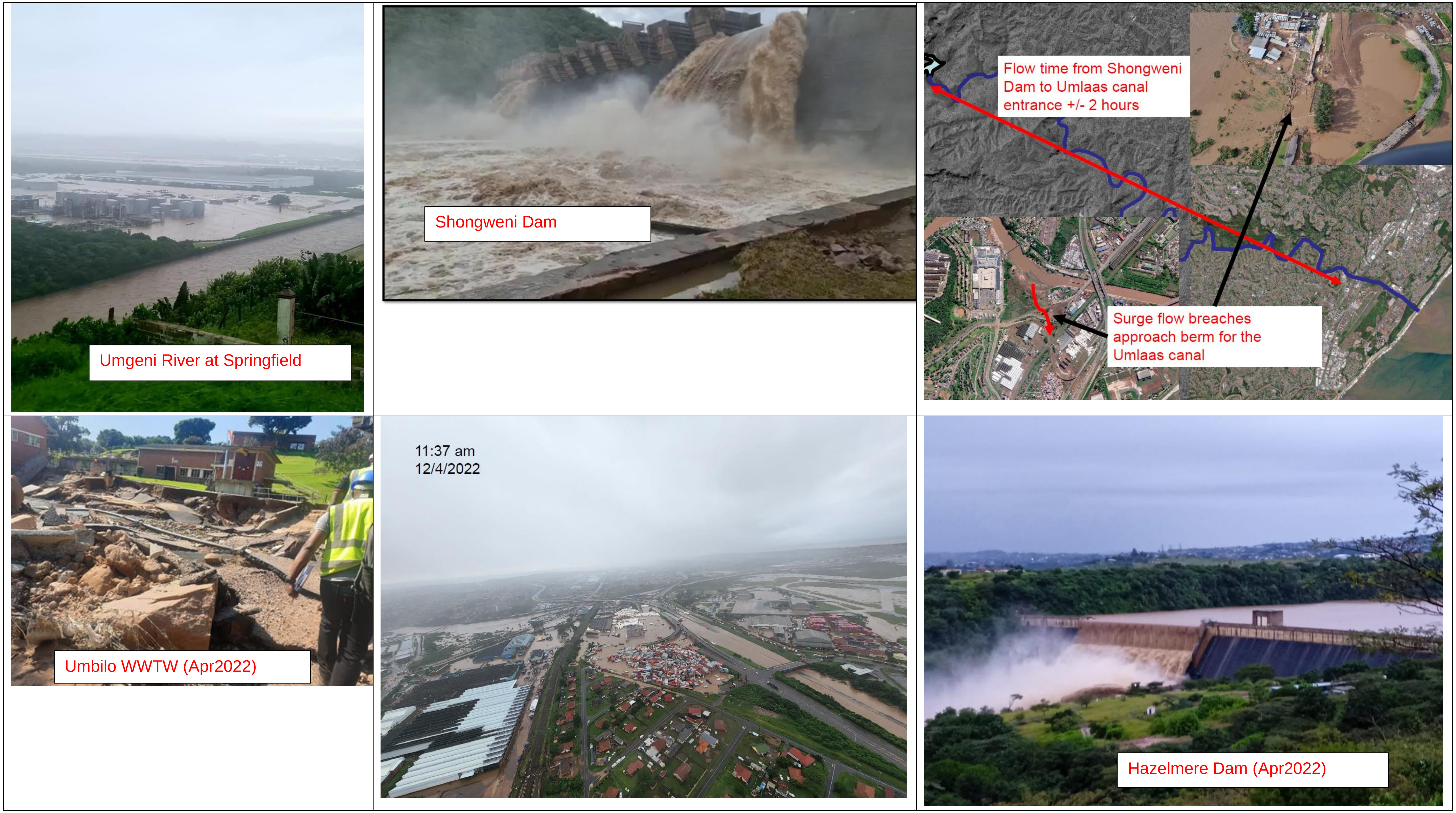


Figure 3.14 April and May 2022 KZN Storm Events Gallery

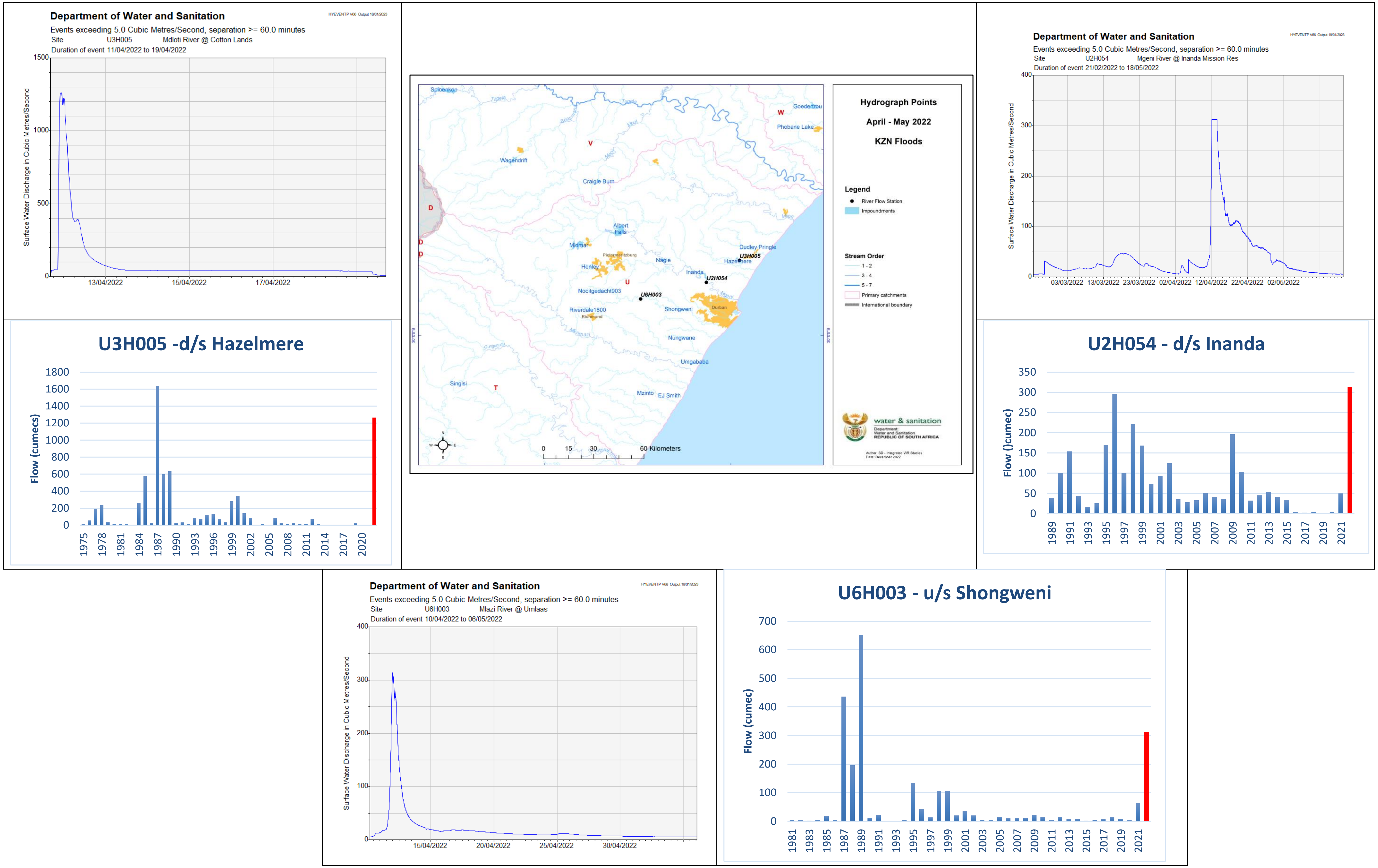


Figure 3.15 Historical flow events and hydrographs