CLOSEOUT REPORT ON IMPLEMENTATION OF THE GROUNDWATER STRATEGY

Report prepared for the

Inkomati-Usuthu Water Management Agency

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1. PURPOSE

This is a closeout report to the Executive Committee of the Governing Board on the Implementation of the Groundwater strategy.

2. BACKGROUND

The Inkomati-Usuthu Catchment Management Agency (IUCMA) is the water resource management authority established in terms of Section 78 of the National Water Act 36 of 1998 (NWA). The mandate of the IUCMA is to perform water resource management at local level within the Inkomati-Usuthu Water Management Area (WMA). As promulgated by Section 80 of the NWA, the initial functions of the IUCMA include investigation and advise on the protection, use, development conservation, management, and control of the water resources in its WMA.

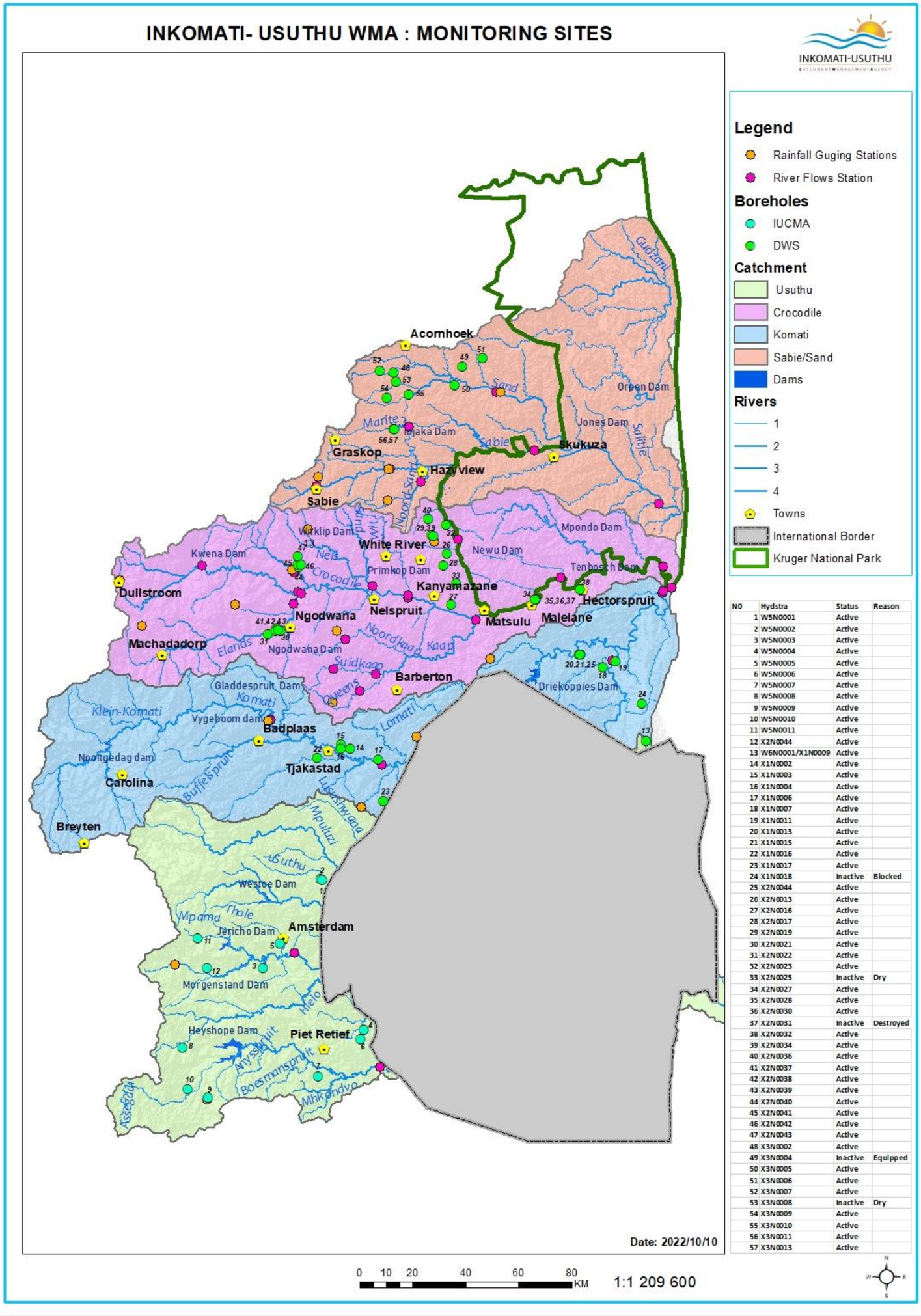
As per Peter Drucker's (Drucker 2015) infamous say that one cannot manage and plan what they cannot measure, groundwater management requires quantitative estimates which is a prerequisite step for devising informed groundwater management. A pioneering study that resulted in quantitative estimates of groundwater resource availability in South Africa (SA) was the 1995 Groundwater Resource Assessment One (GRA I) which also covered Inkomati-Usuthu WMA. The study was updated in 2006 through GRA II; consequently, the year 2022 marks a sixteen-year anniversary of the GRA II.

In between 2006 and 2022, SA experienced what was termed the worst drought in the last 50 years and groundwater reliance has increased drastically. For example, in response to the 2015/2016 drought, farmers, households, businesses and national governments adopted reactive approach which involved extensive "panic" drilling of boreholes across the country. This increased use of groundwater inevitably continued after the said drought because installation of wells and the infrastructure for delivery of groundwater are a considerable investment. Consequently, it was imperative that the groundwater availability within the Inkomati-Usuthu WMA be updated. To this end, catchments groundwater resource accounting project was initiated to provide updated estimates and the groundwater balance is a key input in the development of groundwater resource management as per the prescripts of the South African National Water Act (NWA) (act 36 of 1998) and other guiding documents.

According to Section 137 of the NWA, the Minister must establish national monitoring systems on water resources, which must provide for the collection of appropriate data and information necessary to assess, amongst others, the quantity of water in the various water resources (e.g., groundwater and surface water). Consequently, the IUCMA undertakes a routine groundwater monitoring within the Inkomati-Usuthu WMA using a hydrometeorological

monitoring network comprising fifty-seven (57) geo-sites (boreholes), 31 river flow and 25 rainfall gauges (*Figure 1*).

Observations that are being made from the monitoring data is that historic groundwater levels in some catchment areas are recovering from the impacts of the 2015/2016 drought, whilst some have continued to decline. For example, post the 2015/2016 drought, groundwater levels in the Sabie-Sand catchment continued the decreasing trajectory whilst, in some parts of the Crocodile catchment, the water levels continued to decrease whilst other parts are characterised by the recovering water levels (Figure 2 and Figure 3). Against this information, a study was initiated to delineate groundwater resource units (GRUs) and undertake groundwater balances for respective GRUs within the Inkomati-Usuthu WMA.



NO	Hydstra	Status	Reason
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4	W5N0004	Active	
5	W5N0005	Active	
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7	W5N0007	Active	
8	W5N0008	Active	
9	W5N0009	Active	
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12	X2N0044	Active	
13	W6N0001/X1N0009	Active	
14	X1N0002	Active	
15	X1N0003	Active	
16	X1N0004	Active	
17	X1N0006	Active	
18	X1N0007	Active	
19	X1N0011	Active	
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29	X2N0019	Active	
30	X2N0021	Active	
31	X2N0022	Active	
32	X2N0023	Active	
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34	X2N0027	Active	
35	X2N0028	Active	
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37	X2N0031	Inactive	Destroyed
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45	X2N0041	Active	
46	X2N0042	Active	
47	X2N0043	Active	
48	X3N0002	Active	
49	X3N0004	Inactive	Equipped
50	X3N0005	Active	
51	X3N0006	Active	
52	X3N0007	Active	
53	X3N0008	Inactive	Dry
54	X3N0009	Active	
55	X3N0010	Active	
56	X3N0011	Active	
57	X3N0013	Active	

Figure 1: Map showing hydrometeorological monitoring network within the Inkomati-Usuthu WMA

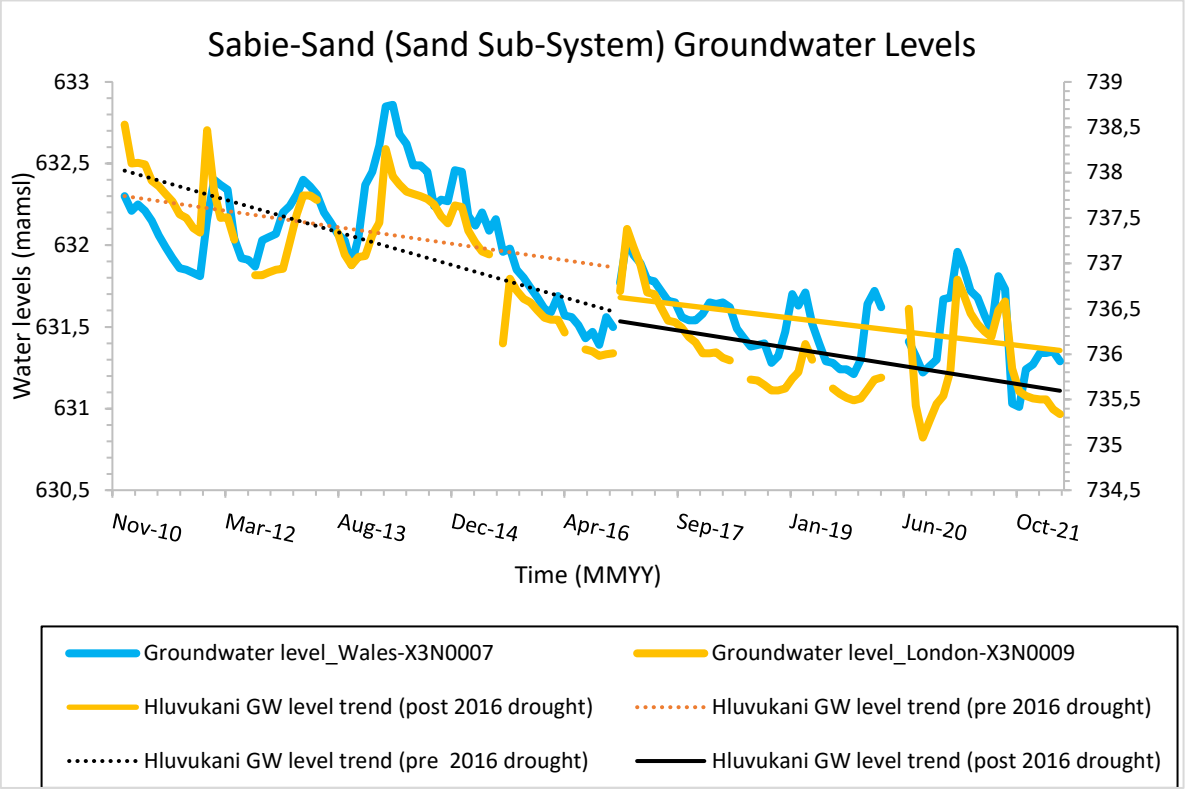

Figure 2: A composite hydrograph of groundwater levels in the Sabie-Sand Catchment (Sand River Sub-System)

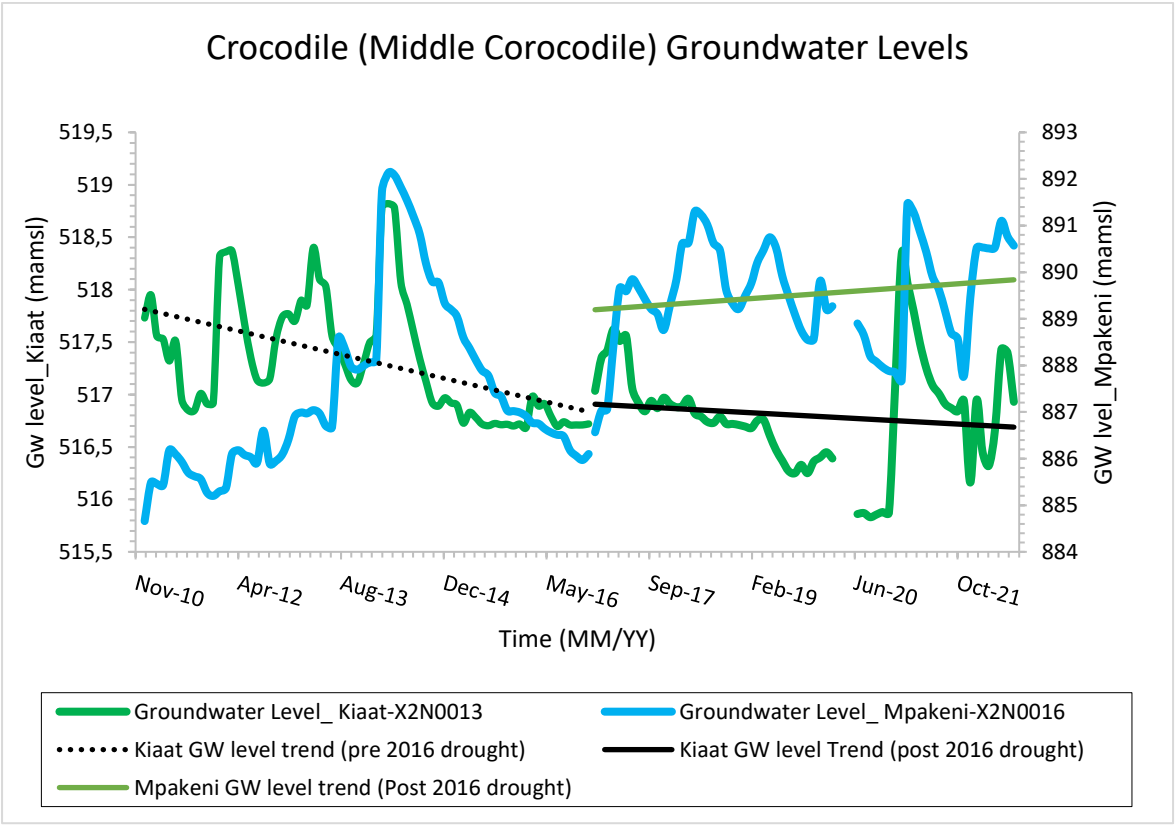

Figure 3: A composite hydrograph of groundwater levels in the Crocodile Catchment (Middle Crocodile Sub-System)

3. APPROACH

3.1. Groundwater Units, stress conditions and water quality

The groundwater project was undertaken to establish the spatial pattern of groundwater resource availability following a phased approach:

- PHASE I: Reconnaissance study
    - Hydrocensus which included collecting information on existing boreholes (e.g., location, abstraction rates, water quality and etcetera).
    - Sampling and water quality analysis
    - Delineation of groundwater resource units (GRUs) [1] based on a combination of hydrogeological characteristics (e.g., geology, water quality water levels and etcetera).
- PHASE II: Groundwater Resource Assessment (Groundwater availability)
    - Groundwater recharge,
    - Groundwater abstraction,
    - Groundwater balance, and
    - Groundwater change in storage.

The ultimate dataset was used by IUCMA to produce groundwater situation information in a form of stress index[2] maps for all the four catchments (Usuthu, Komati, Crocodile and Sabie-Sand).

3.2. Catchment Groundwater Balance

The Catchment Groundwater Accounting (CGA) study involved estimation of the following input parameters:

- groundwater contribution to stream flow (Baseflow[3]) or environmental flows[4],
- groundwater recharge[5],
- groundwater change in storage, and
- groundwater use (draft)[6].
- groundwater potential.

[1] A groundwater body that has been delineated or grouped into a single significant water resource based on one or more characteristics that are similar across that unit.
[2] Measure of the ratio of groundwater withdrawal and environmental flow relative to its recharge rate over a given aquifer where values above a given threshold indicate where unsustainable groundwater consumption could affect groundwater availability and groundwater-dependent ecosystems.
[3] The portion of stream /river flow that comes from groundwater.
[4] Amount of water flowing in a river over time to maintain the health of river ecosystem.
[5] Addition of water to groundwater storage
[6] A combined groundwater use by borehole abstraction and transpiration

4. RESULTS

4.1. Catchment groundwater balance

The NWA (act 36 of 1998) promulgates that after allocating groundwater to environmental flows, basic human needs, existing users, the remaining groundwater can be deemed as a groundwater potential. Adhering to this prescript, the results of the current groundwater potential (2022 estimates) are shown in *Figure* 4 against which the following key notes are made:

- Komati catchment is characterised by the highest groundwater potential of about 865.31 Mm^3/a followed by Usuthu at 357.79 Mm^3/a.
- The least groundwater potentials are 156.87 Mm^3/a and 93.83 Mm^3/a in the Crocodile and Sabie-Sand, respectively.
- Based on the above estimates, the entire Inkomati-Usuthu WMA has groundwater potential of 2 930.540 Mm^3/a.
- Compared to the year 2006 estimates by the GRA II,
    - Komati exhibits the lowest groundwater potential decrease of about 78.72 Mm^3/a which is about 8% decrease,
    - Usuthu is characterised by groundwater potential decrease of 40% (239.66 Mm^3/a), and
    - Crocodile and Sabie-Sand are characterised by the highest decreases of about 78% (550.84 Mm^3/a) and 86% (588.52 Mm^3/a) respectively.
- The total decrease in groundwater resource potential across the entire Inkomati-Usuthu WMA is 1 456.74 Mm^3/a which is a 50% decrease from the 2006 estimates.

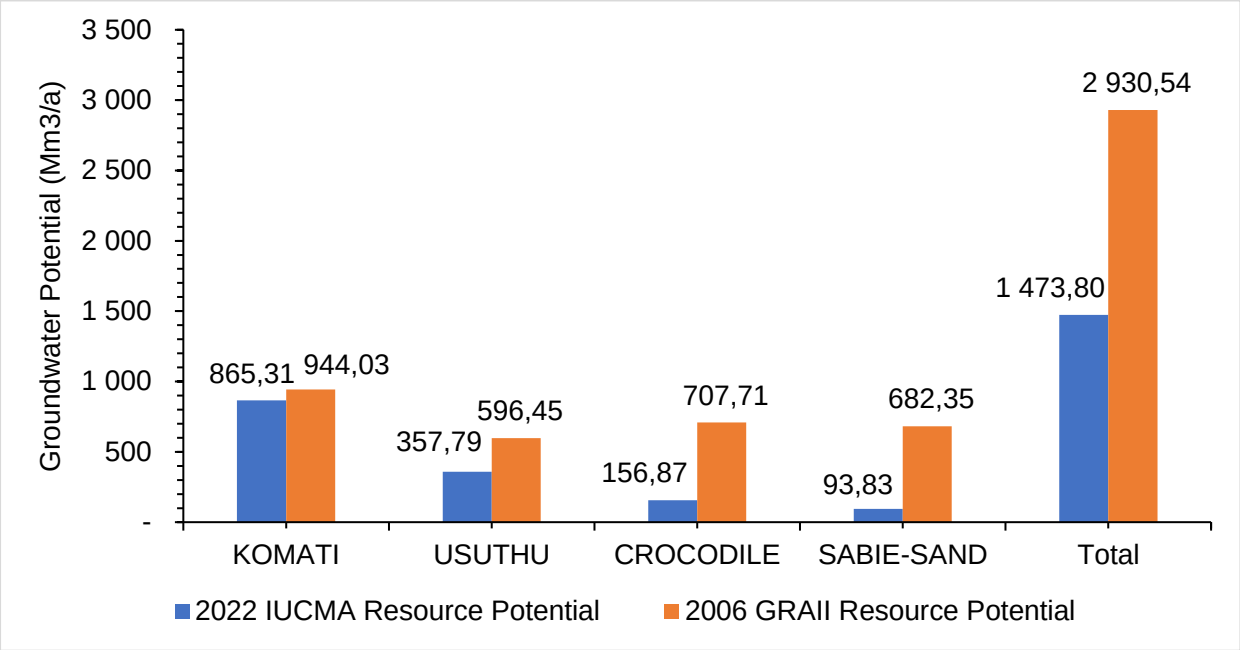

Figure 4: The Inkomati-Usuthu WMA groundwater potential calculations for the year 2022 compared to the 2006 GRA II estimates.

4.2. Groundwater units and stress conditions

The catchment wide groundwater balance indicated that Usuthu and Komati catchments are generally stable whilst Crocodile and Sabie-Sand catchments are characterised by groundwater stress. However, this conditions are lumped, that is, they do not discriminate between and do not give any spatial pattern of the groundwater stress condition because even if the catchment might be stressed or undressed, that is not ubiquitous. To circumvent this limitation, the delineation of groundwater resource units (GRUs) and calculation of their respective stress indices will give a better spatial picture of which areas of the catchments are stressed against those that are not.

4.2.1. Crocodile catchment

The groundwater stress index map for Crocodile Catchment is shown in Figure *5* wherein the following key notes are made:

- The catchment is divided into 150 Groundwater Units (GUs); however, only 115 GU (79%) have current data. About 21% of the GUs are situated within grey areas where there is no data yet.
- About 38 percent of the groundwater resource units are stressed to critically stressed whilst 62% are unstressed to moderately stressed.
- The groundwater stress condition within major towns and subsystems is summarised in Table 2 against which the following notes are made:

- The most critically stressed subsystem is the Kaap River System within which Barberton town is situated.
- The Kaap River system comprises of 79% critically stressed GUs and 20% unstressed GUs,
- The three (3) river subsystems (namely Lower Kwena, Elands and Upper Crocodile) are predominantly characterised by a mixture of moderate stressed to unstressed GRUs; this covers major towns such as Ngodwana, Machadadorp eNtokozweni, Emnothweni and Dullstroom.

Table 1 Percent stress conditions for towns in Crocodile catchment

Town	**GU Stress Level**	**Sub-system**
Malalane	Unstressed	Lower Crocodile
Hectorspruit	Unstressed	Lower Crocodile
Machadodorp (eNtokozweni)	Unstressed	Elands River
Dullstroom (Emnothweni)	Unstressed	Upper Crocodile
Ngodwana	Unstressed to Moderate stress	Elands River
Barberton	Critically stressed	Kaap River
Matsulu	Critically stressed	Middle Crocodile
Mbombela	Critically stressed	Middle Crocodile

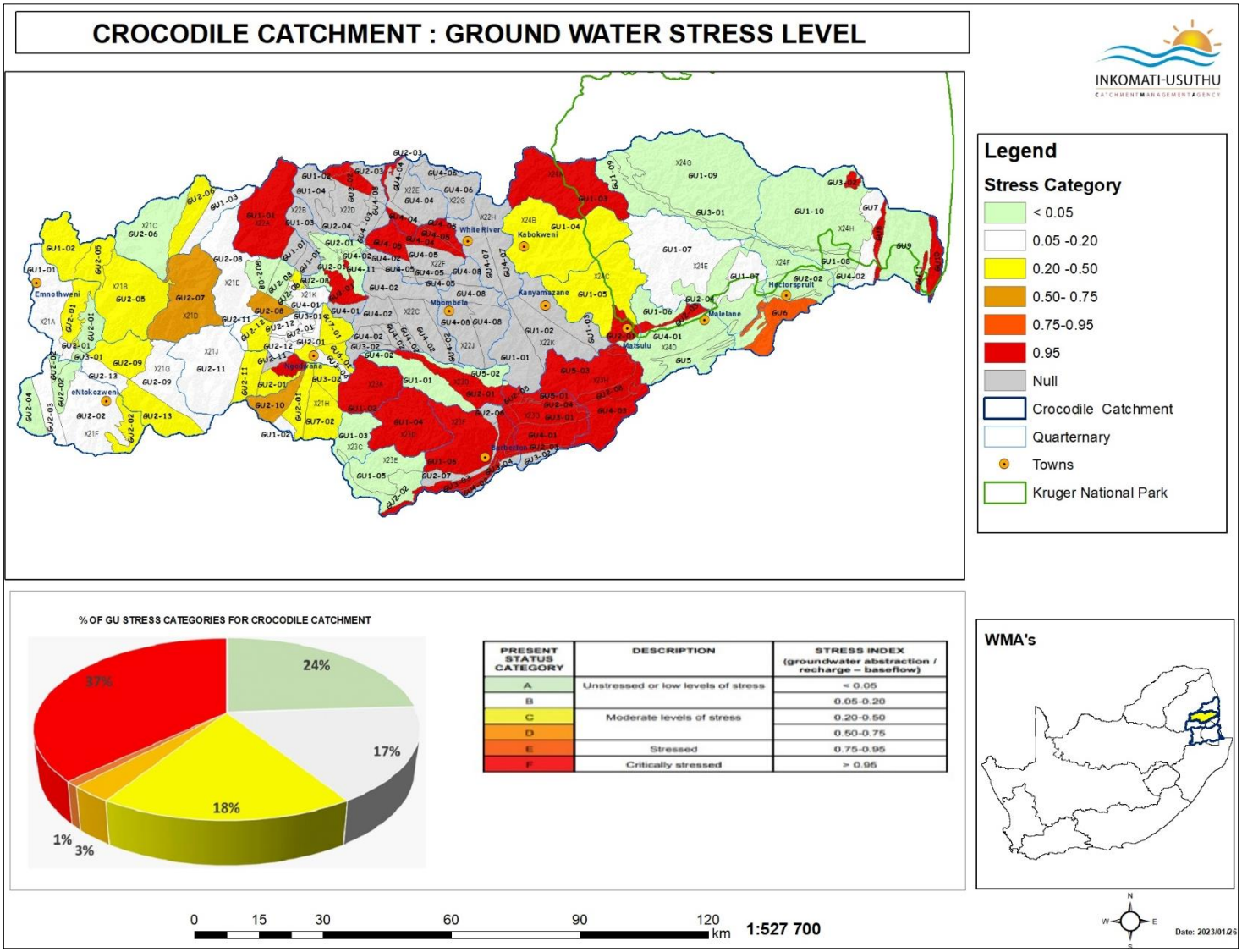

Figure 5 Groundwater stress situation map for Crocodile catchment

4.2.2. Komati catchment

The groundwater stress index map for Komati catchment is shown in **Error! Reference source not found.** wherein the following key notes are made:

- Komati catchment is divided into 94 GUs, of which 81% are unstressed to moderately stressed.
- Approximately 38% of the GUs are stressed to critically stressed.
- The groundwater stress condition in terms of towns and subsystems is summarised in Table 2 against which the following notes are made:
    - The Komati upstream sub systems (where Breyten, Caqrolina, Tjakastad, Alukwatibni and Badplaas towns are situated) is predominantly characterised by moderately stressed to unstressed condition.
    - The lower parts of Komati (comprising Lower Komati, Komati West and Lomati sub-systems) are predominantly stressed with few moderately stressed GRUs.
    - Except for Jeppe's Reef, most of the major towns (e.g., Carolina, Badplaas, and Komatipoort) are predominantly situated within the moderately stressed GRUs.
    - The most critically stressed subsystem is the area covering the southeastern part of the Lower Komati Subsystem; this is precisely the area south of Komatipoort.

Table 2 Percent stress conditions around major towns and Sub-Systems in Komati catchment

Town	GU Stress Level	Sub-system
Carolina	Unstressed to Moderate stress	Komati Upstream
Jeppe's Reef	Unstressed to Moderate stress	Lomati
Komatipoort	Moderate stress	Lower Komati
Breyton	Moderate stress	Komati Upstream
Badplaas	Moderate stress	Komati Upstream
Tonga town	Critically stressed	Komati West

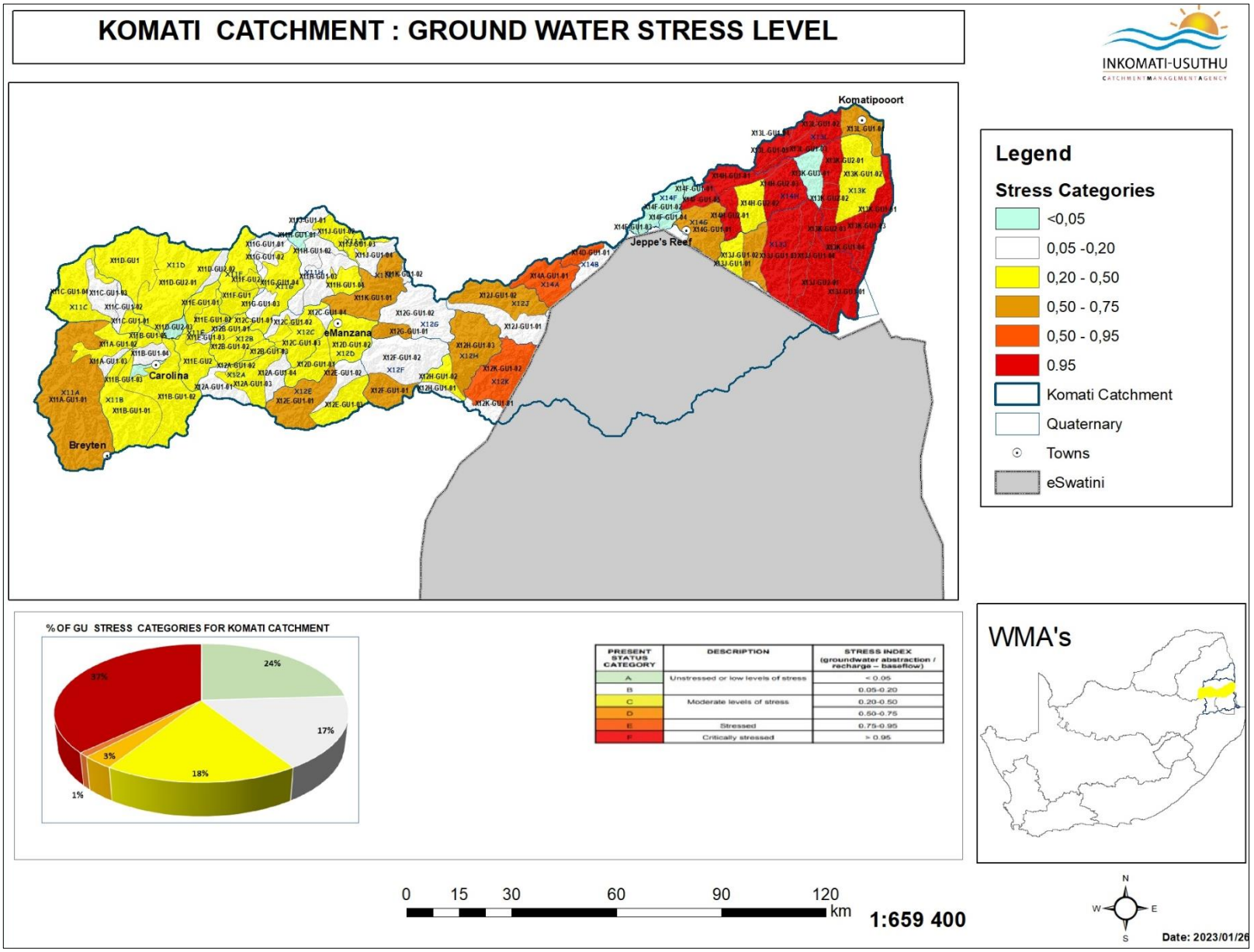

Figure 6 Groundwater stress situation in the Komati catchment

4.2.3. Sabie-Sand catchment

The groundwater stress index map for Sabie-Sand catchment is shown in *Figure 7* wherein the following key notes are made:

- Sabie-sand catchment is divided into 60 GUs of which:
    - 12% are unstressed,
    - 38% are moderately stressed,
    - 3% are stressed with the remaining 47% being critically stressed.

The groundwater stress condition around major towns and subsystems is summarised in Table 3 against which the following notes are made:

- Sand sub-system comprises 95% of stressed to critically stressed GUs, whilst 5% of the Gus are moderately stressed.
- Sabie-Sub system comprises 80% of unstressed to moderately stressed GUs.
- Maritsane/Inyaka sub-system is made up of 53% of critically stressed GUs and 47% of unstressed to moderately stressed GUs.

Table 3 Percent stress conditions major towns and Sub-Systems in the Sabie-sand catchment

Town	**GU Stress Level**	**Sub-system**
Graskop	Lo-level stress	Sabie
Sabie	unstressed stress to Moderate stress	Sabie
Accornhoek	Critically stressed	Sand
Hazyview	Critically stressed	Maritsane/Inyaka
Bushbuckridge	Critically stressed	Maritsane/Inyaka

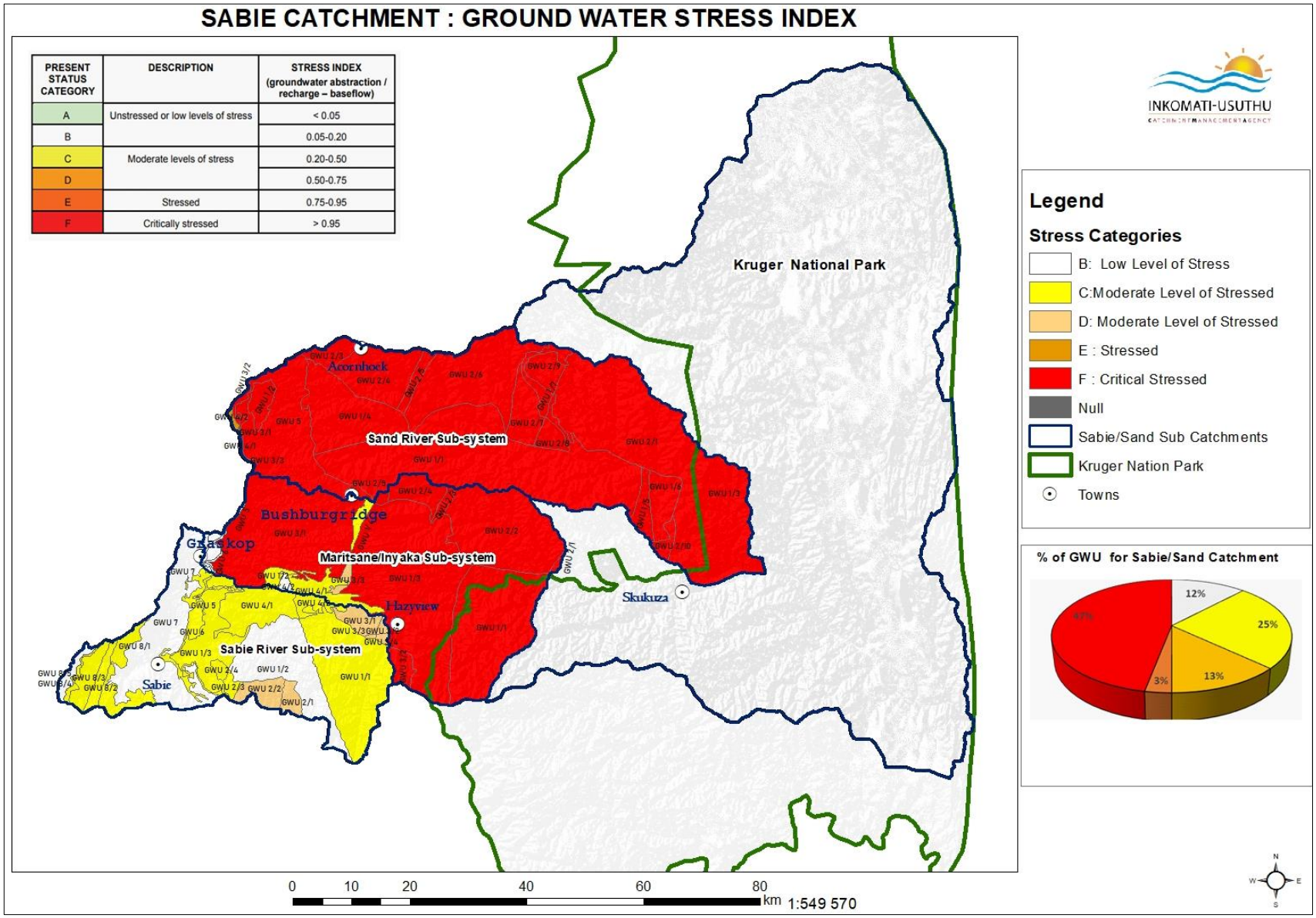

Figure 7 Groundwater stress situation in the Sabie-Sand catchment

4.2.4. Usuthu catchment

The stress condition map for Usuthu catchment is presented in *Figure 8* against which the following key notes are made.

- Usuthu catchment is divided into 63 GUs, of which 98% are unstressed to moderately stressed, and
- Only 2% GUs are critically stressed.

The conclusion drawn from the above key points is that Usuthu is predominantly unstressed signaling a stable groundwater condition. As shown in Table 4, towns (like Lochiel, Piet Retief, Driekopies, Oshoek and Amsterdam) are situated within unstressed groundwater units:

Other towns (like Chrissiemeer, Lothair and Sheepmoor) are situated in groundwater units characterised by moderate stress condition.

Table 4 Percent stress conditions in major towns and Sub-Systems in the Usuthu catchment

Town	Stress Level	Sub-system
Lochiel	Unstressed	Lusushwane
Piet Retief	Unstressed	Assegai
Driekopies	Unstressed	Assegai
Osheok	Unstressed	Lusushwane
Amsterdam	Unstressed	Ngwempisi
Chrissiemeer	Moderate stress	Mpuluzi
Lothair	Moderate stress	Usuthu
Sheepmoor	Moderate stress	Ngwempisi

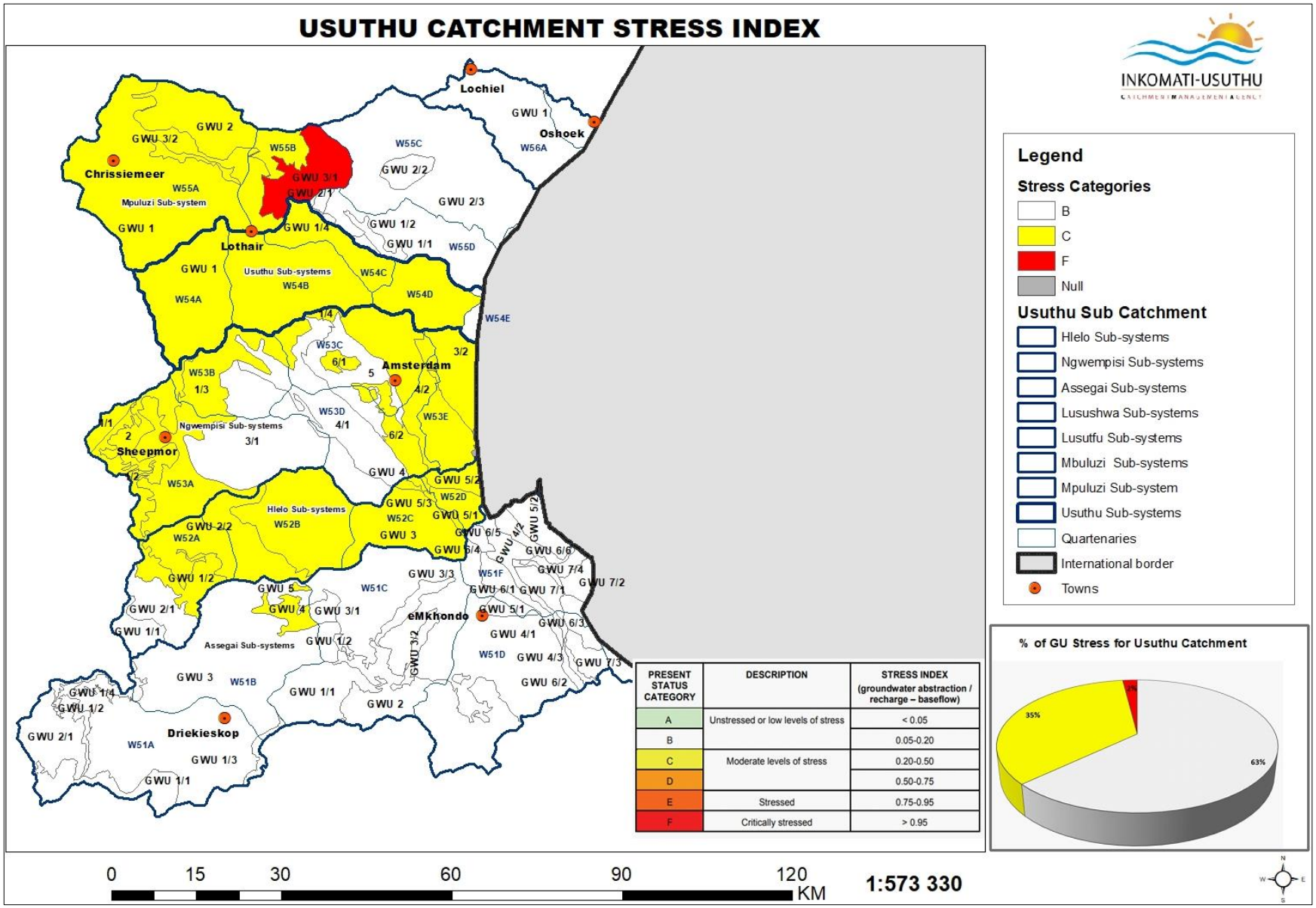

Figure 8 Groundwater stress situation in the Usuthu catchment

4.3. Groundwater quality Index

Using the South African National Standard (SANS) 241 Drinking Water Specification, a Water Quality Index calculator[7] was used to classify the groundwater quality based on a sample of parameters that were analysed.

4.3.1. Crocodile catchment and Sabie sand

- Crocodile
  - Water quality in Lower Kwena, Upper Crocodile and Elands Sub-systems is **excellent**; this means that the water has no threat and the conditions very close to natural levels.
  - White River, Middle Crocodile and Lower Crocodile sub-systems have **good** implying that the water has a minor degree of threat, and the conditions rarely depart from natural or desirable levels.
  - Kaap Sub-system's water quality is **fair** which means that the water is occasionally threatened, and conditions sometimes depart from natural or desirable levels.
- Sabie-Sand
  - Groundwater quality in Sabie River Subsystem and Maritsane/Injaka Subsystem is **excellent**; that is, the water has no threat, and the conditions are very close to natural levels.
  - Groundwater quality in the Sand River Subsystem is **good**, implying that the water has a minor degree of threat, and the conditions rarely depart from natural or desirable levels.

Table 5 Groundwater quality in major towns and Sub-Systems in the Crocodile and Sabie-Sand catchments

<table>
<tr><th colspan="3">Crocodile catchment</th></tr>
<tr><th>Town</th><th>Groundwater quality</th><th>Sub-system</th></tr>
<tr><td>Malalane</td><td rowspan="6">Good: Minor degree of threat</td><td rowspan="2">Lower Crocodile</td></tr>
<tr><td>Hectorspruit</td></tr>
<tr><td>Matsulu</td><td rowspan="4">Middle Crocodile</td></tr>
<tr><td>Kanyamazana</td></tr>
<tr><td>Kabokweni</td></tr>
<tr><td>Nelspruit</td></tr>
<tr><td>White River</td><td>Good: Minor degree of threat</td><td>White River</td></tr>
</table>

[7] *The Water Quality Index (CWQI) calculator was developed under the Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines Task Group. The programme was used under permission granted by Canadian Department of Environment and Climate Change through Shibly Rahman and Dr Hongjin Wu. All rights are reserved.*

Barberton	Fair: Occasionally threatened	Kaap River
Ngodwana	Excellent: No Threat	Elands
Machadadorp		
Dullstroom	Excellent: No threat	Upper Crocodile
Sabie-Sand		
Town	**Groundwater Quality**	**Sub-system**
Graskop	Excellent: No threat	Sabie
Sabie		
Accornhoek	Good: Minor degree of threat	Sand
Bushbuckridge		
Hazyview	Good: Minor degree of threat	Maritsane/Inyaka
Graskop		Maritsane/Inyaka

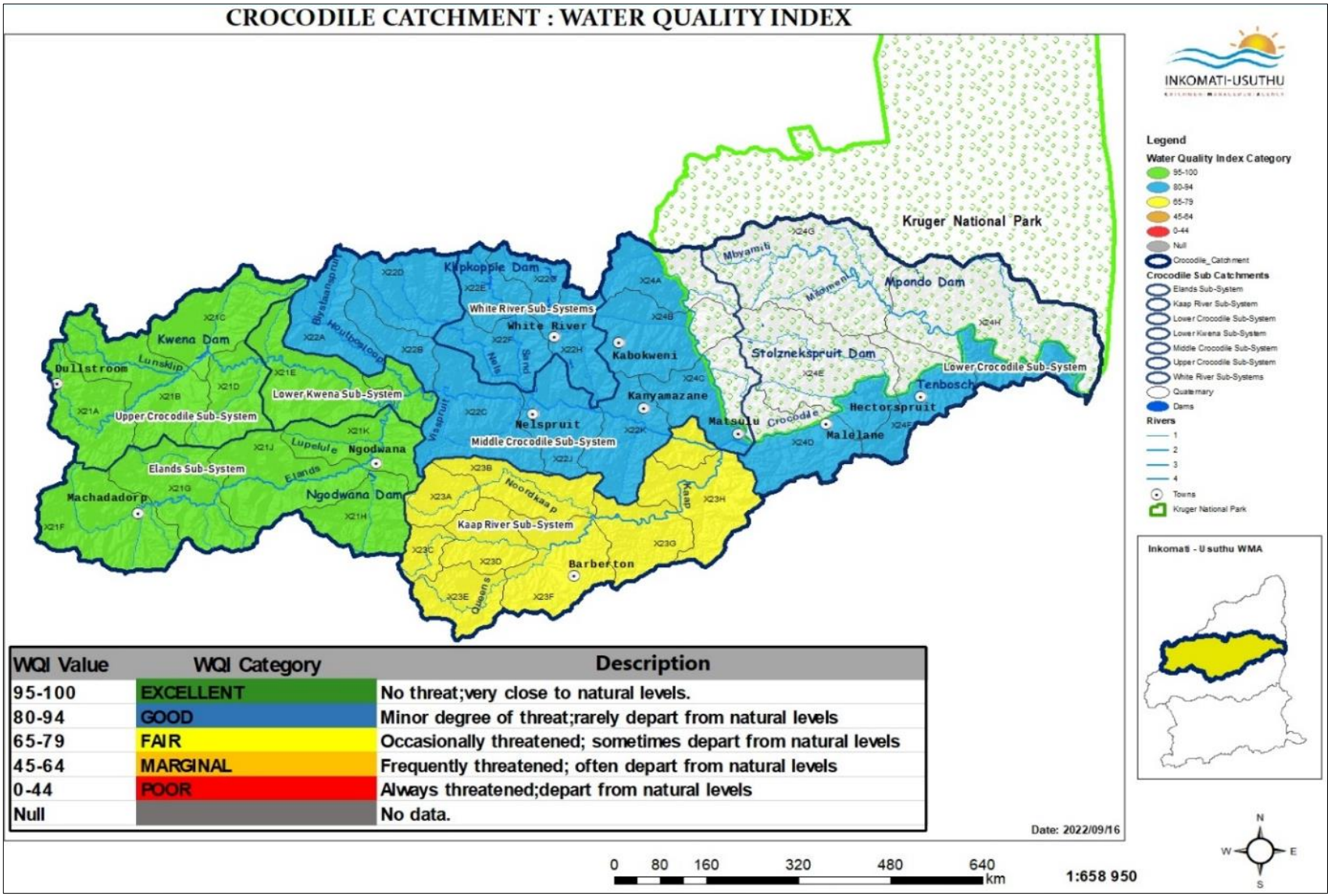

Figure 9: Groundwater quality in the Crocodile River Catchment

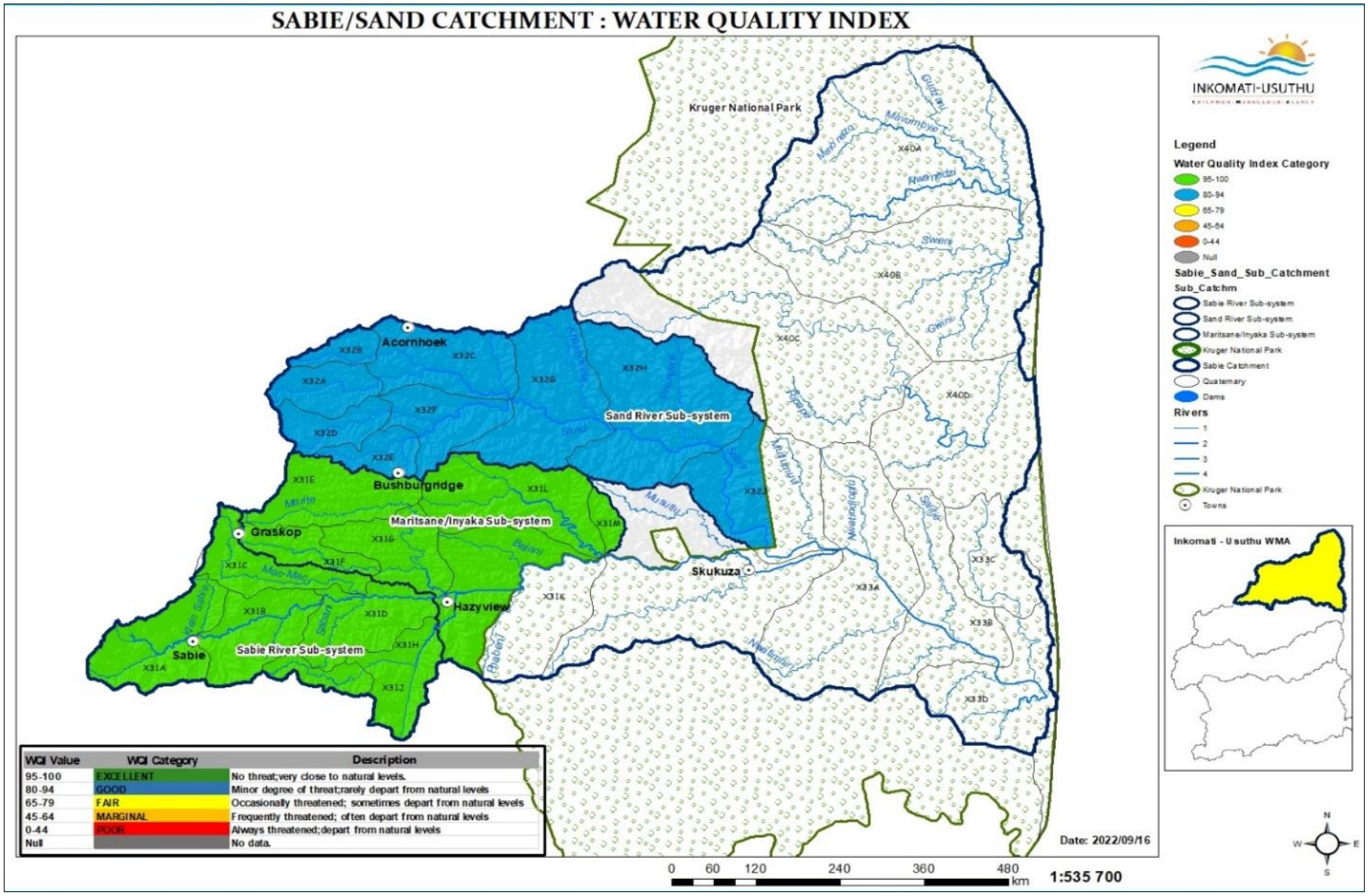

Figure 10: Groundwater quality in the Sabie-Sands River Catchment

4.3.2. Komati catchment and Usuthu

- Komati
    - Komati Upstream and Lower Komati Subsystems is **good**, which means that the water has a minor degree of threat wherein the conditions rarely depart from natural or desirable levels.
    - Lomati and Komati West water subsystems have **fair** wherein the water is occasionally threatened with conditions sometimes departing from natural or desirable levels.
- Usuthu catchment
    - Assegai and Ngwempisi have **excellent**, meaning that the water has no threat and the conditions very close to natural levels.
    - Hlelo has **good**, meaning the water has a minor degree of threat, and the conditions rarely depart from natural or desirable levels.
    - Groundwater quality in Mpuluzi Subsystem is **poor** which means that the water is always threatened, and conditions depart from natural or desirable level.

Table 6 Groundwater quality in major towns and Sub-Systems in the Komati and Usuthu catchments

Komati catchment		
Town	**GU Stress Level**	**Sub-system**
Jeppe's Reef	Fair: Occasionally threatened	Lomati
Komatipoort	Good: Minor degree of threat	Lower Komati
Tonga town	Fair: Occasionally threatened	Komati West
Breyton	Good: Minor degree of threat	Komati Upstream
Badplaas		Komati Upstream
Carolina	Unstressed to Moderate stress	Komati Upstream
Usuthu Catchment		
Town	**Stress Level**	**Sub-system**
Piet Retief	Excellent: No threat	Assegai
Driekopies		
Sheepmor	Excellent: No threat	Ngwempisi
Amsterdam		
Chrissiemeer	Poor: Always threatened	Mpuluzi
Lothair		

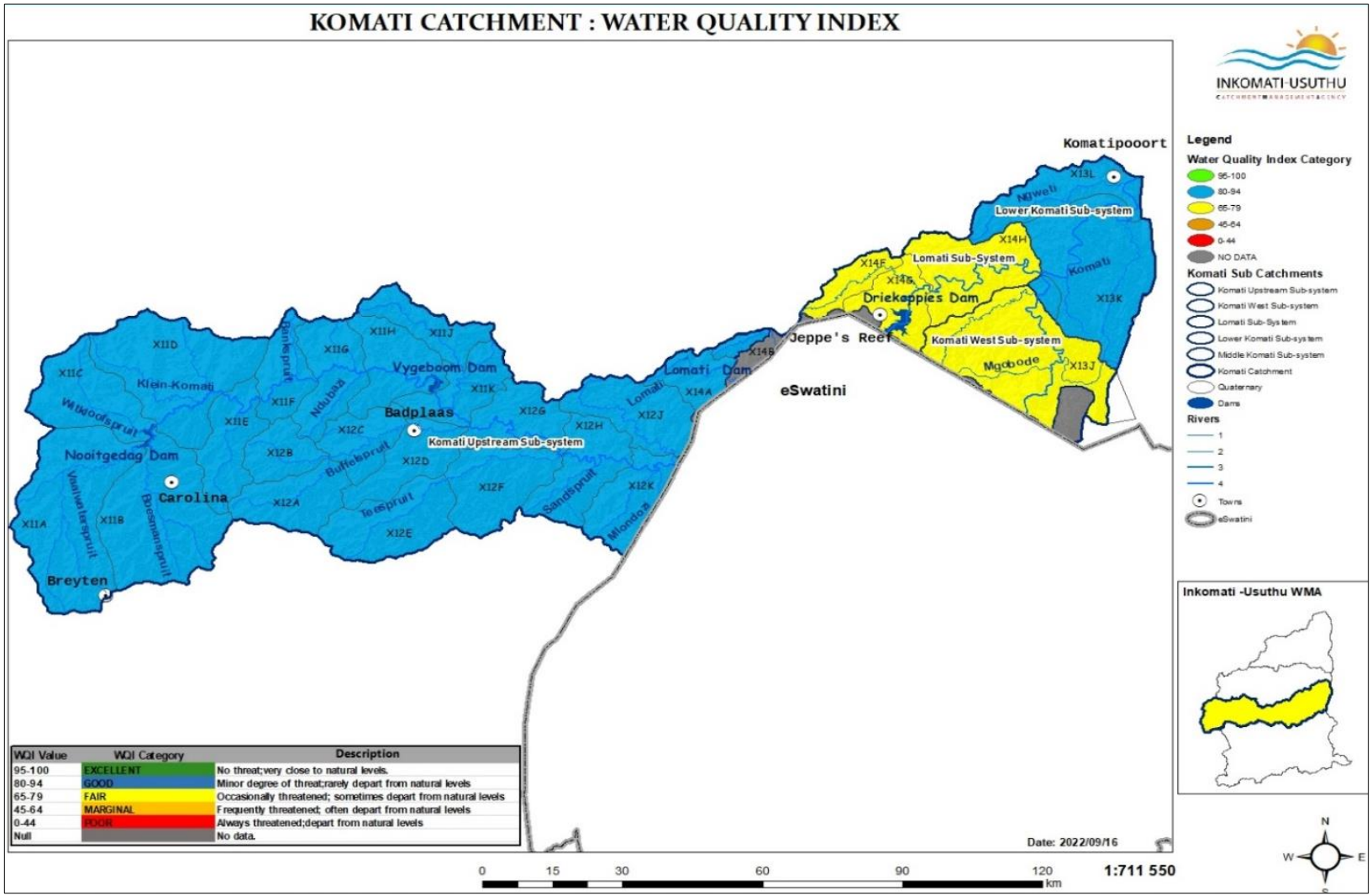

Figure 11: Groundwater quality in the Komati River Catchment

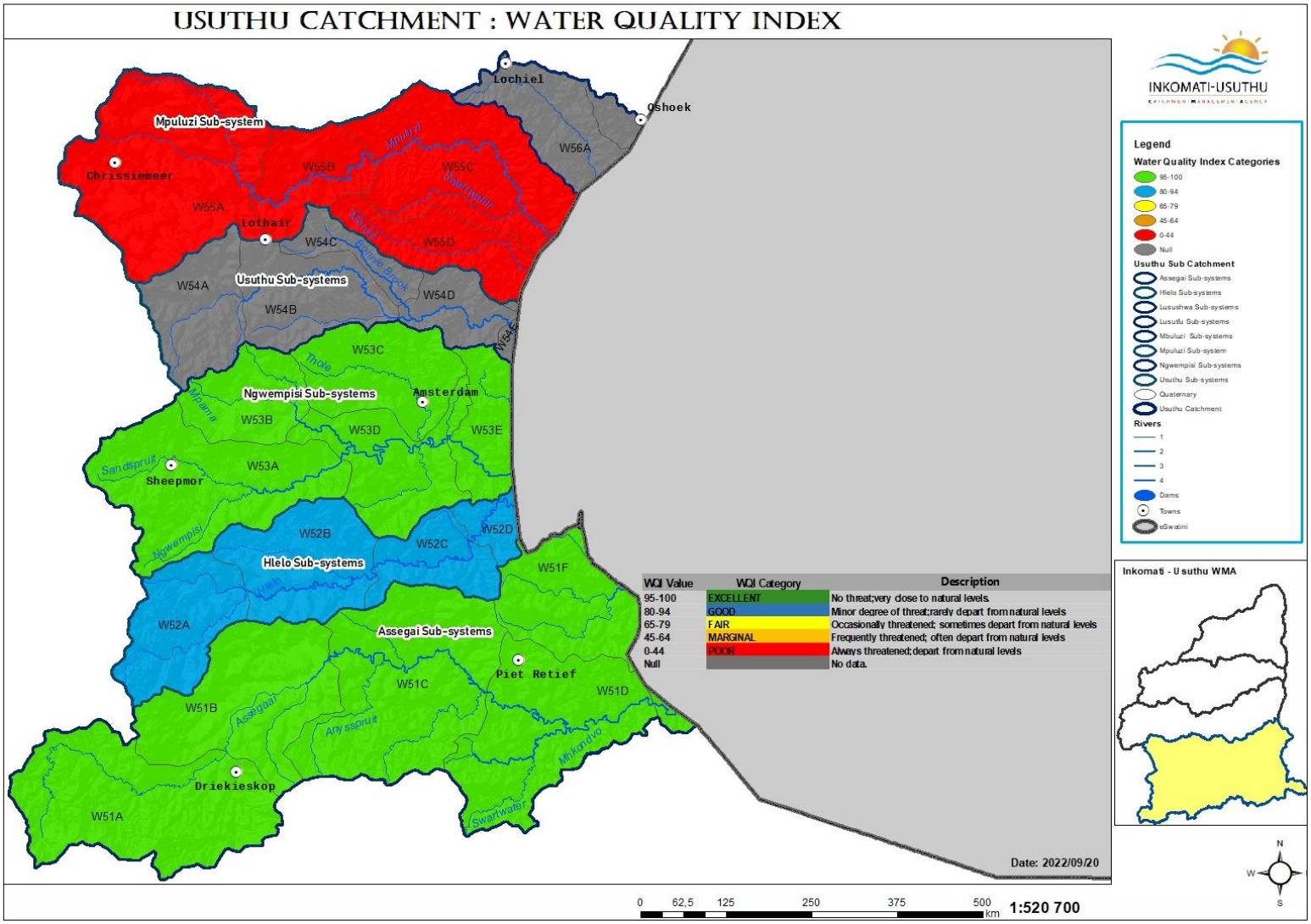

Figure 12: Groundwater quality in the Usuthui River Catchment

5. CONCLUSIONS

5.1. Catchment groundwater balance

The following concluding remarks are made against the results from the catchment groundwater balance:

- Komati catchment has the highest groundwater potential of about 865.31 Mm3/a followed by Usuthu at 357.79 Mm3/a.
- The least groundwater potentials are 156.87 Mm3/a and 93.83 Mm3/a in the Crocodile and Sabie-Sand respectively.
- In the Crocodile and Sabie-Sand catchments, the observed high groundwater draft is a threat to streamflow and sustainability of available groundwater resources.

5.2. Groundwater units and stress conditions

The stress condition of the four catchments is summarized in Sabie-Sand catchment

    - Sabie-Sand is under severe stress condition; therefore, groundwater cannot be developed as a potential viable bulk-water supply source. Nevertheless, the resource can still be developed for schedule one use.
- Crocodile catchment
    - Crocodile is under incipient stress condition. For the middle Crocodile, groundwater cannot be developed as a potential viable bulk-water supply source.
- Komati catchment
    - there are still groundwater resources development opportunities in the upper Komati catchment.
- Usuthu catchment
    - There are greater groundwater resources development opportunities in the Usuthu catchment.

Table 7 against which the following notes are made:

- Sabie-Sand catchment

- Sabie-Sand is under severe stress condition; therefore, groundwater cannot be developed as a potential viable bulk-water supply source. Nevertheless, the resource can still be developed for schedule one use.

- Crocodile catchment
  - Crocodile is under incipient stress condition. For the middle Crocodile, groundwater cannot be developed as a potential viable bulk-water supply source.
- Komati catchment
  - there are still groundwater resources development opportunities in the upper Komati catchment.
- Usuthu catchment
  - There are greater groundwater resources development opportunities in the Usuthu catchment.

Table 7 Percent stress conditions of the four catchments within the Inkomati-Usuthu WMA

Stress Category	SABIE-SAND	CROCODILE	KOMATI	USUTHU
A: Unstressed	12%	41%	35%	63%
B: Low-level stress				
C : Moderate stress level	38%	21%	44%	35%
D: Moderate stress level				
E: Stressed	**3%**	**1%**	**2%**	**0%**
F: Critically stressed	**47%**	**37%**	**19%**	**2%**

5.3. Groundwater Quality

Groundwater quality in the water management is as follows:

- Crocodile catchment
  - Groundwater quality ranges between excellent and fair which means water with no threat to water that is occasionally threatened.
  - Groundwater that is occasionally threatened (fair) is in the Kaap subsystem.
- Sabie-Sand catchment

    - Groundwater quality ranges between excellent and good which means water with no threat to minor degree.
- Komati catchment
    - Groundwater quality ranges between Good and fair which means water with minor degree of threat to water that is occasionally threatened.
    - Water that is occasionally threatened (fair) is the Lomati and Komati west subsystem.
- Usuthu catchment
    - Groundwater quality ranges between excellent and poor which means water with no threat to water that is always threatened.
    - Groundwater that is always threatened (poor) is in the Mpuluzi subsystem.