High Confidence Groundwater Reserve Determination Study for the Berg Catchment

Groundwater Reserve Determination – PSC 06

Presented by: Umvoto
Date: 16 February 2024

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Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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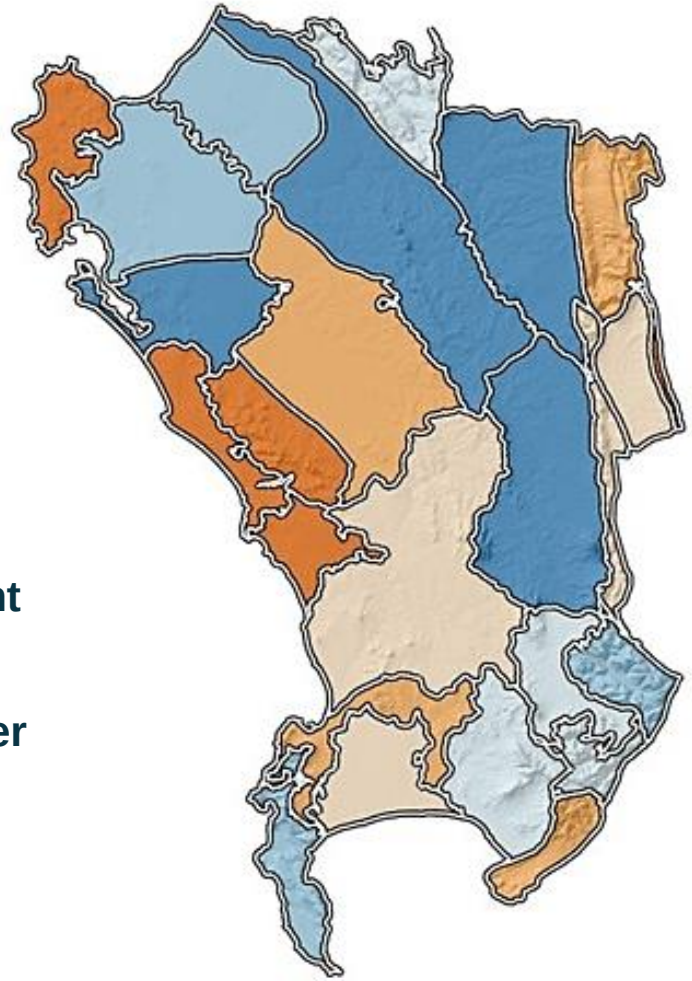
PRESENTATION OUTLINE

1. Summary of the Project
2. Step 1 – 8 of the Groundwater Reserve Determination
3. Groundwater Reserve Determination Report
    a) Report Structure
    b) The Groundwater Reserve
        - Groundwater Quantity Component
        - Groundwater Quality Component
    c) Example of the Groundwater Reserve per GRU
4. The Groundwater Reserve Database



SUMMARY OF PROJECT PHASES, TASKS AND DELIVERABLES

Phase 1	**Project inception**		
Task 1	Inception		Deliverable 1: Inception Report
Phase 2	**Review of water resource information and data**		
Task 2.1	Data collection and collation		Deliverable 2.1: Gap Analysis Report Deliverable 2.2: Inventory of Water Resource Models
Phase 3	**Reserve determination**		
Task 3.1	Step 1	Initiate Groundwater Reserve Study	Recorded in Deliverable 2.1 and Deliverable 2.2
Task 3.2	Step 2	Water RU Delineation	Deliverable 3.1: Delineation of Water RUs
Task 3.3	Step 3	Ecological Status and Reference Conditions per RU	Deliverable 3.2: Ecological Reference Conditions
Task 3.4	Step 4	Determine BHN and EWR	Deliverable 3.3: BHN and EWR Requirement Report
Task 3.5	Step 5	Operational Scenarios & Socio-economic	Deliverable 3.4: Operational Scenarios & socio-economic and ecological consequences
Task 3.6	Step 6	Evaluate scenarios with Stakeholders	Deliverable 3.5: Stakeholder engagement of operation scenarios
Task 3.7	Step 7	Monitoring Programme	Deliverables 3.6: Monitoring Programme Report
Task 3.8	**Step 8**	**Gazette & implement Reserve**	**Deliverable 3.7: Groundwater Reserve Determination Report** **Deliverable 3.8: Database** **Deliverable 3.9: Gazette Template**

OBJECTIVES OF THE STUDY

The ultimate outcomes of this study can be broken down into 3 overarching objectives:

1. To **provide insights into the groundwater resources** within the Berg catchment, considering both the established conservation status of priority water resources and the complex geological and hydrogeological features of the study area.

2. To **offer aquifer-specific information** to facilitate well-informed management decisions concerning stressed or over-utilized groundwater resources.

3. To **complete the Resource Directed Measures (RDM)** process for the Berg catchment and support the gazette Water Resource Classes (WRCs) and Resource Quality Objectives (RQOs) - (Gazette No.42451:121).

OBJECTIVES OF STEP 8

The objective of this report was to provide a **comprehensive summary of the findings and recommendations** resulting from the Groundwater Reserve Determination (GRD) process conducted for the Berg catchment.

1) **The methodology applied for each step of the GRD process (i.e., Steps 1 – 8)**

2) **Presenting a summary of the GRU-specific information necessary for determining the groundwater components of the Reserve:**

   a) **Groundwater Quantity Component**
      I. The Groundwater Contribution to the BHN and EWR Reserve

   a) **Groundwater Quality Component**
      I. Groundwater Quality Reserve
      II. Groundwater Quality BHN Reserve / Requirement

GROUNDWATER RESERVE DETERMINATION

Step 1: Data and Water Resource Models

Key Projects:

- The Berg Catchment WRCs and RQOs Study (DWS, 2016)
- The Berg Water Availability Assessment Study (Berg WAAS) project (DWAF, 2008)

Key Datasets:

- National Groundwater Archive (NGA)
- Water Management System (WMS)
- Water Use Authorization & Registration Management System (WARMS)
- Hydstra
- Geological Maps for CGS (1:50 000)

Key Water Resource Models:

- Cape Flats Aquifer (Vol 5a and b) - DWAF (2008d)
- Langebaan Road Aquifer System, Elandsfontein Aquifer System (Vol 6) - DWAF (2008e)
- Breede River Alluvium Aquifer (Vol 9) - DWAF (2008f)
- Steenbras TMG Aquifer system (Nardouw Aquifer) - City of Cape Town (2021)
- Atlantis Aquifer - City of Cape Town (2020a)
- Cape Flats Aquifer - City of Cape Town (2020b)
- Lower Berg model (the Langebaan Road Aquifer system, Elandsfontein Aquifer and Adamboerkraal Aquifer) -WRC (2020)

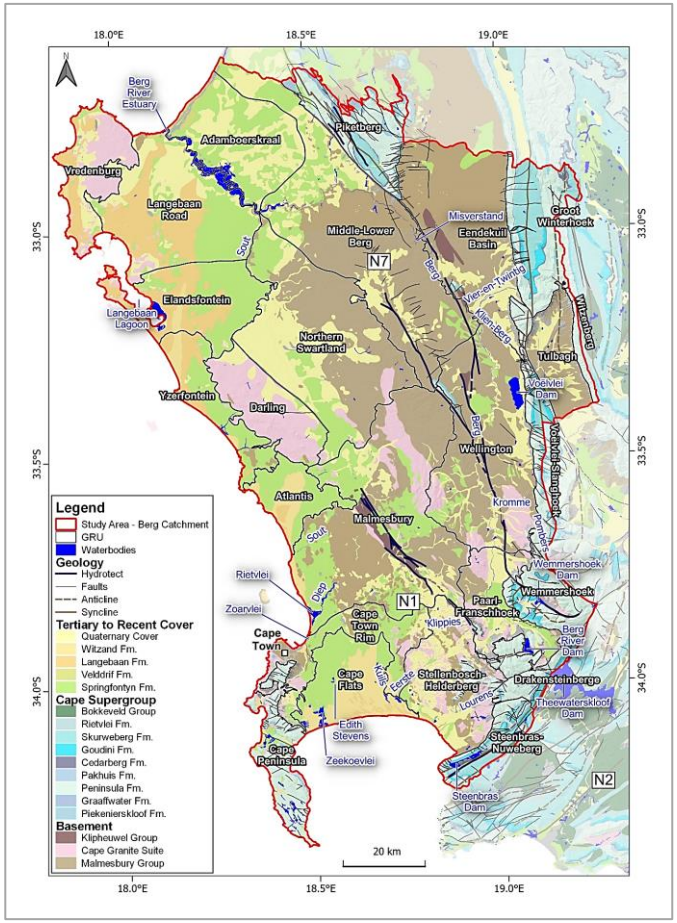
Step 2: Delineation of Groundwater Resource Units

Previous GRUs:

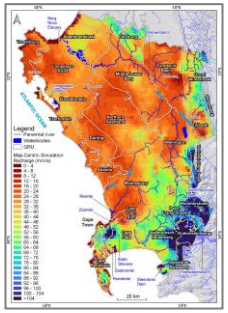
- GRUs (DWS, 2016) were **initially delineated based on surface water catchments**, resulting in the grouping of various aquifer systems into single GRUs to integrate them with surface water systems. Unfortunately, **this approach had limitations**, leading to potential groundwater management issues for the catchment, such as the **exclusion of significant aquifer systems** like the Table Mountain Group Aquifers (TMGA) in the Steenbras area.

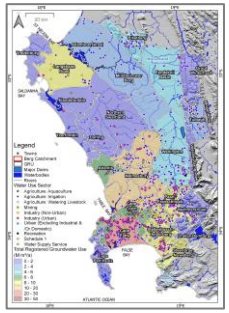
Updated GRUs:

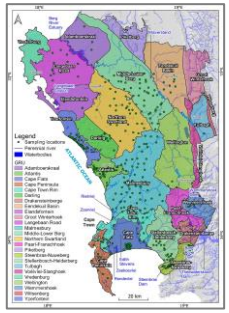
- Main Criteria
  - Geology
  - Existing Aquifer Boundaries
  - Topography and Recharge Areas
  - Structural Geology (Faults, Folds, Hydrotects)
  - Potential Discharge Areas
  - Integrated Units of Analysis (IUAs)
  - Water Resource Class (WRCs)
  - Resource Quality objectives (RQOs)
  - Strategic Water Source Areas (SWSA)
  - Subterranean Government Water Control Areas (SGWCA)
  - Groundwater-Surface Water Interactions

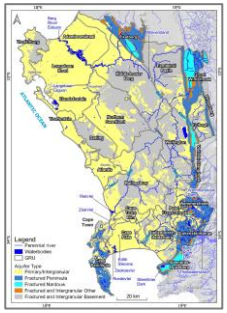


Step 3: Ecological Reference Conditions & Present Status

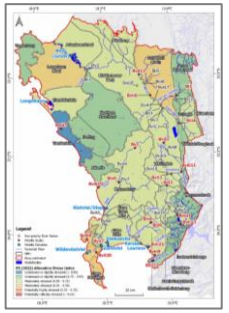

RECAHRGE


WATER USE


WATER QUALITY


AQUIFER TYPE


GEOLOGY


PRESENT STATUS

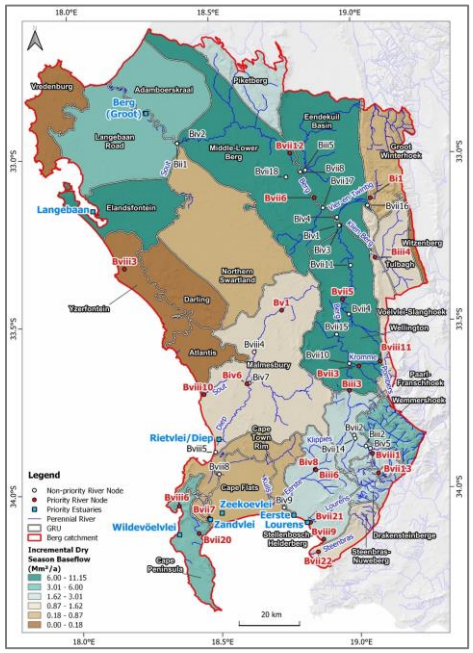
Step 3 re-evaluated the Ecological Reference Conditions (**ambient or natural state**) and present status (**current state in terms of groundwater utilization and water quality**) of the catchment:

Revised assessment of the groundwater status quo encompassed five critical hydrogeological components:

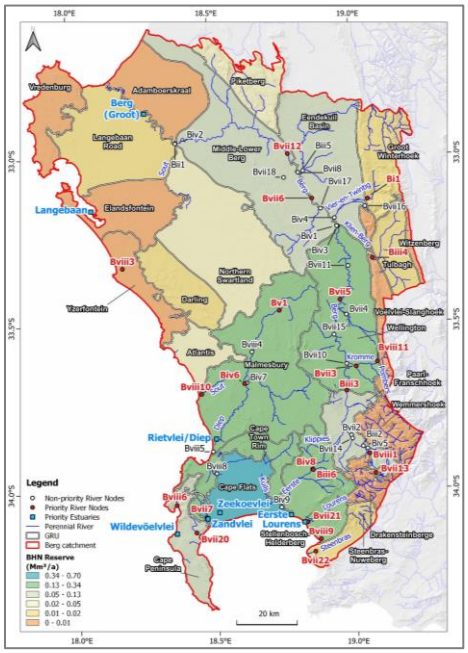
1) Recharge,
2) Groundwater Use
3) Groundwater Quality
4) Aquifer Type
5) Geology

	Groundwater Availability Present Status Category	Water Quality Present Status Category
	Stress Index (GW use / Recharge)	Percentage Exceedance
A	<0.05	<16.7 %
B	0.05 – 0.20	16.7 – 33.4 %
C	0.20 – 0.40	33.4 – 50.1 %
D	0.40 – 0.65	50.1 – 66.8 %
E	0.65 – 0.95	66.8 – 83.5 %
F	>0.95	>83.5 %

Step 4: BHN and EWR Requirements



Groundwater Contribution to EWR



Groundwater Contribution to BHN

Basic Human Needs

The BHN addresses individuals without access to a formal water supply and residing beyond 500m from a perennial river, with a daily water demand set at a fixed value of 25 ℓ/p/d.

Ecological Water Requirements

The EWR involved using baseflow separation, wherein groundwater discharge was calculated using monthly flow data calibrated to meet Target Ecological Categories (TECs) for each node and factoring in cumulative flow effects downstream. A recharge ratio was applied to the total dry season contribution of groundwater to baseflow per GRU and associated aquifer types.

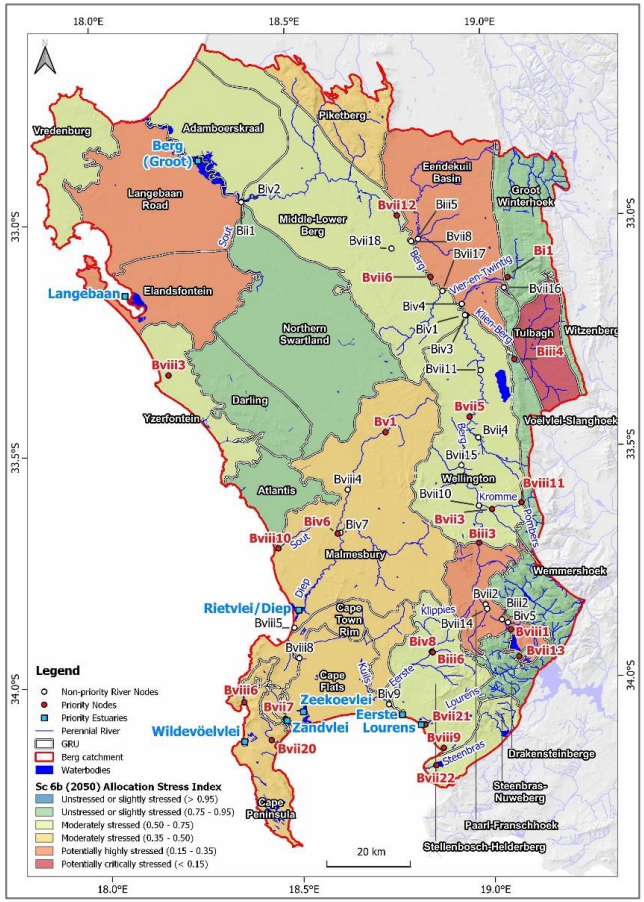
Step 5: Operational Scenarios

Steps 5 involved developing operational scenarios aimed at assessing the socio-economic and ecological impacts on the Groundwater Reserve.

The scenarios offered valuable insights into both current and future trends of GRUs in the Berg catchment for both the Sc 6a (**Worst Case**) and Sc 6b (**Most-Likely Case**).

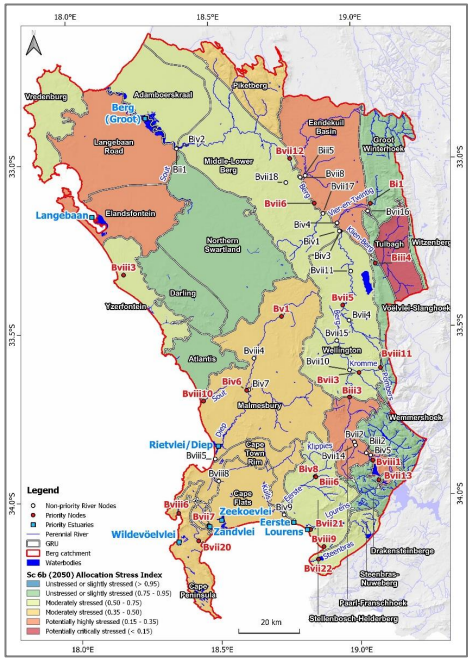
Scenario No.	Scenario Name
Sc 1	Population Growth
Sc 2	Sectoral Water Demand
Sc 3	Groundwater Developments
Sc 4	Climate Change
Sc 5	Alien and Invasive Species
Sc 6a	**Combination Scenario (Worst Case)**
Sc 6b	**Combination Scenario (Most-Likely Case)**

Allocation Category	Description	Allocation Factor
A	Unstressed or slightly stressed	>0.95
B	Unstressed or slightly stressed	0.75 – 0.95
C	Moderately stressed	0.5 – 0.75
D	Moderately stressed	0.35 – 0.50
E	Potentially highly stressed	0.15 – 0.35
F	Potentially critically stressed	<0.15



Step 6: Stakeholder Engagement

The discussions focused on **additional operational scenarios**, updated datasets, and the selection of the preferred scenario for future implementation. Stakeholder input centered around **groundwater control areas**, the **inclusion of GDEs**, an evaluation of the potential increase in **groundwater reliance should WWTW infrastructure deteriorate**, and the consideration of **updated climate models**.



FUTURE SCENARIO (2050)

Stakeholders:

Officials from the DWS
Representatives from CMAs
Members of WUAs
Public and Private Entities
Other water users

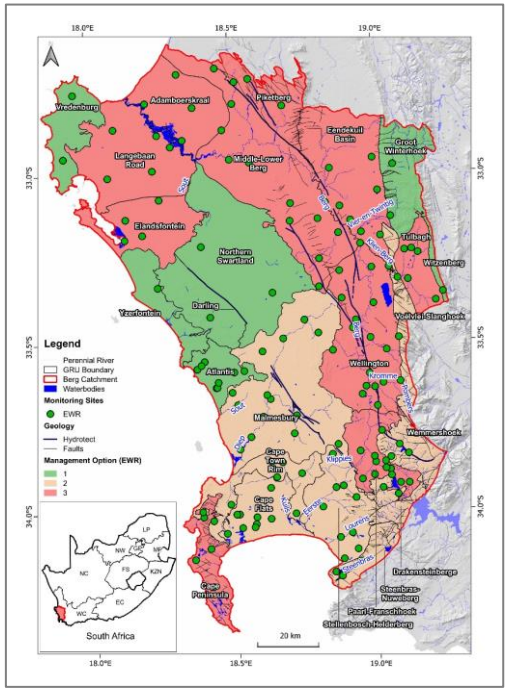
Scenario No.	Scenario Name
Sc 1	Population Growth
Sc 2	Water System Evaluation
Sc 3	Sectoral Water Demand
Sc 4	Groundwater Developments
Sc 5	Climate Change
Sc 6	Alien and Invasive Species
Sc 7a	Combination Scenario (Worst Case)
Sc 7b	Combination Scenario (Most-Likely Case)

Step 7: Monitoring Programme

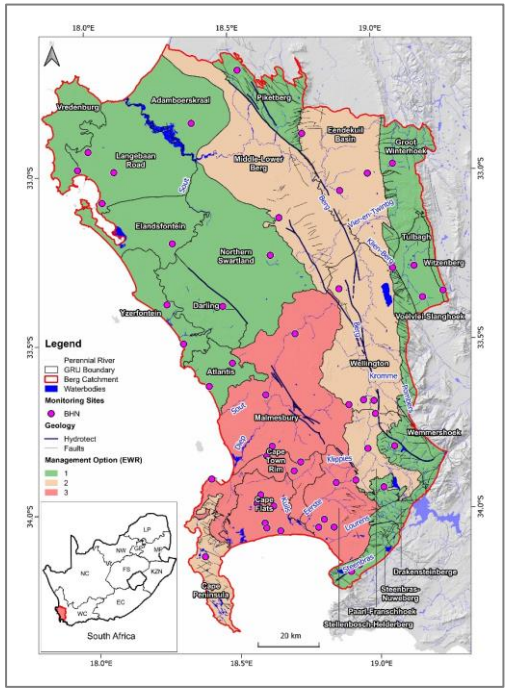
Step 7 focused on designing a Monitoring Programme, considering:

1. **Existing monitoring sites**
2. **Spatial distribution**
3. **Target aquifer unit**

GW Contribution to EWR



GW Contribution to BHN



GW Contribution to Baseflow (Mm^3/a) \ Allocation Factor (Still Allocable Volume / Recharge)	A (>0.95)	B (0.75 – 0.95)	C (0.50 – 0.75)	D (0.35 – 0.50)	E (0.15 – 0.35)	F (<0.15)
0.00 - 0.18						
0.18 - 0.87						
0.87 - 1.62						
1.62 - 3.01						
3.01 - 6.00						
6.00 - 11.15						

GW contribution to BHN (Mm^3/a) \ Population Density (pop/km^2)	0.00 – 7.29	2.29 – 20.09	20.09 – 43.00	43.00 – 62.68	62.68 – 100.31	100.31 – 329.43
0.00 – 0.05						
0.05 – 0.10						
0.10 – 0.30						
0.30 – 0.50						
0.50 – 1.00						
1.00 – 1.29						

Management Options were assigned, using an **Impact vs. Influence Matrix**.

'Impact' Factors

- 'Allocation Factor'
- 'Qualifying Population Density'

'influence' factors

- 'Groundwater Contribution to Baseflow'
- 'Groundwater Contribution to the BHN Reserve'

Step 8: Groundwater Reserve Determination

Step 8 offers comprehensive summary of findings and recommendations resulting from the GRD process and provides aquifer-specific information for various hydrogeological components considered for the Groundwater Reserve, specifically the groundwater contribution to the BHN and EWR.

The Reserve components are outlined below:

1. **Groundwater Quantity Component**

   It was calculated by considering the total groundwater contribution (i.e., volume) to both the EWR and BHN Reserves.

2. **Groundwater Quality Component**

   Groundwater Quality Reserve
   The Groundwater Quality Reserve was determined based on statistical analysis of the baseline and median chemical concentration within specific aquifers in all GRUs.

   Groundwater Quality Requirement for BHN
   Upper limit of Class I Water Quality [Drinking] - South African Water Quality Guidelines, Volume 1: Domestic Water Use, 2nd Ed. 1996. Department of Water Affairs, Pretoria, South Africa.

REPORT STRUCTURE

Chapter 1: Introduction

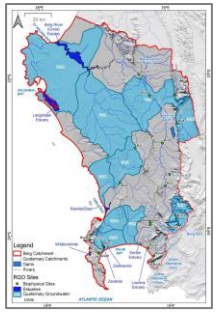
- Study Area
- Overview of GRD Methodology

Chapter 2: Summary of the eight-step GRD procedure

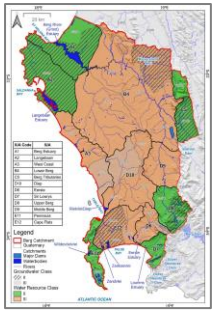
- Data and Water Resource Models
- Delineation of GRUs
- Present Status & Ecological Reference Conditions
- Requirements for BHN and EWR
- Operational Scenarios
- Monitoring Programme

Chapter 3: Groundwater Reserve

- GRU-specific information and the components of the Groundwater Reserve (i.e., the Quantity & Quality components).

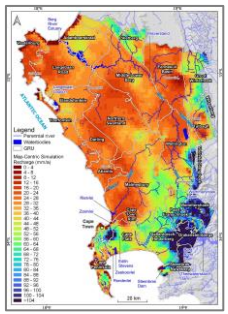


WRCs & RQOs

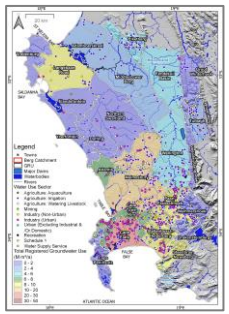


IUAs & NODES

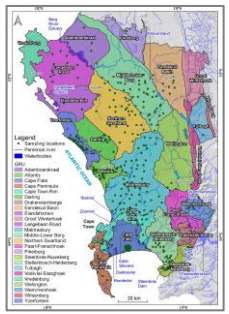
SWSA & GDEs



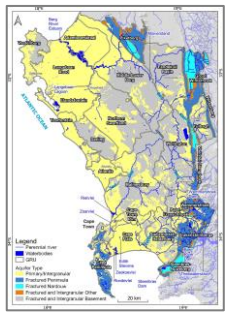
RECAHRGE



WATER USE

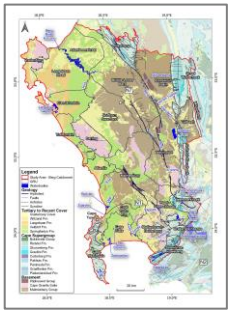


WATER QUALITY

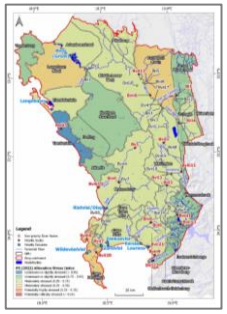


AQUIFER TYPE

GEOLOGY



GRUs



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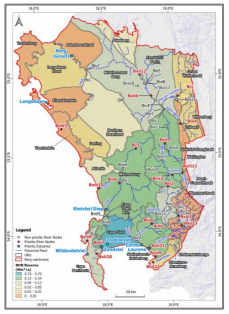
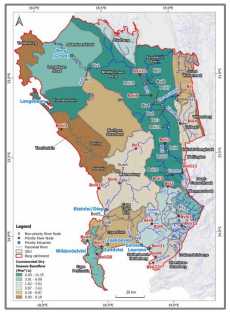
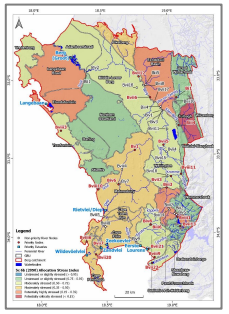


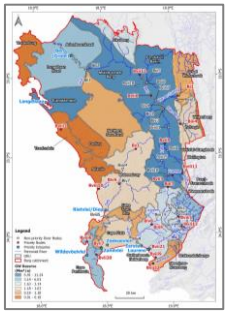
GW TO BHN



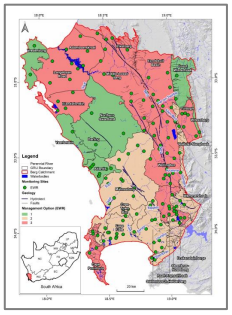
GW TO EWR

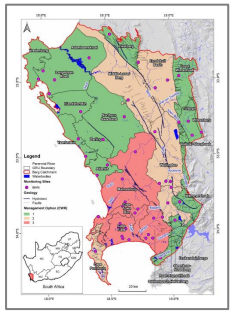


SCENARIO



GW RESERVE





MONITORING PROGRAMME

GROUNDWATER QUANTITY COMPONENT

GROUNDWATER QUANTITY COMPONENT

The Berg catchment encompasses a total of **44 Quaternary Catchments**, delineated into **25 GRUs**.

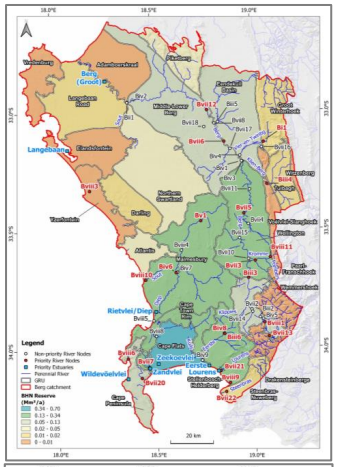
Groundwater systems may not always correspond directly to surface water catchments i.e., GRUs can encompass one or more quaternary catchments, or portions thereof (depending on their hydrogeological characteristics)

The Groundwater Quantity Component was calculated considering the total groundwater contribution to both the EWR and the BHN Reserves.

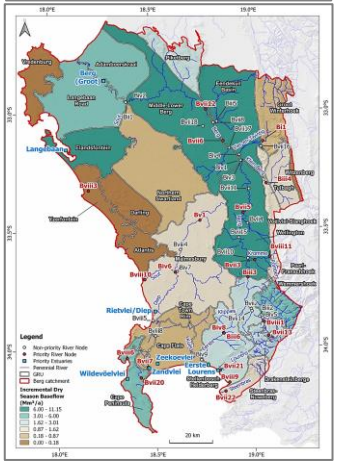
1. **Basic Human Needs**
   The BHN addresses individuals without access to a formal water supply and residing beyond 500m from a perennial river, with a daily water demand set at a fixed value of 25 ℓ/p/d.

2. **Ecological Water Requirements**
   The EWR involved using baseflow separation, wherein groundwater discharge was calculated using monthly flow data calibrated to meet Target Ecological Categories (TECs) for each node, and factoring in cumulative flow effects downstream. A recharge ratio was applied to the total dry season contribution of groundwater to baseflow per GRU and associated aquifer types.

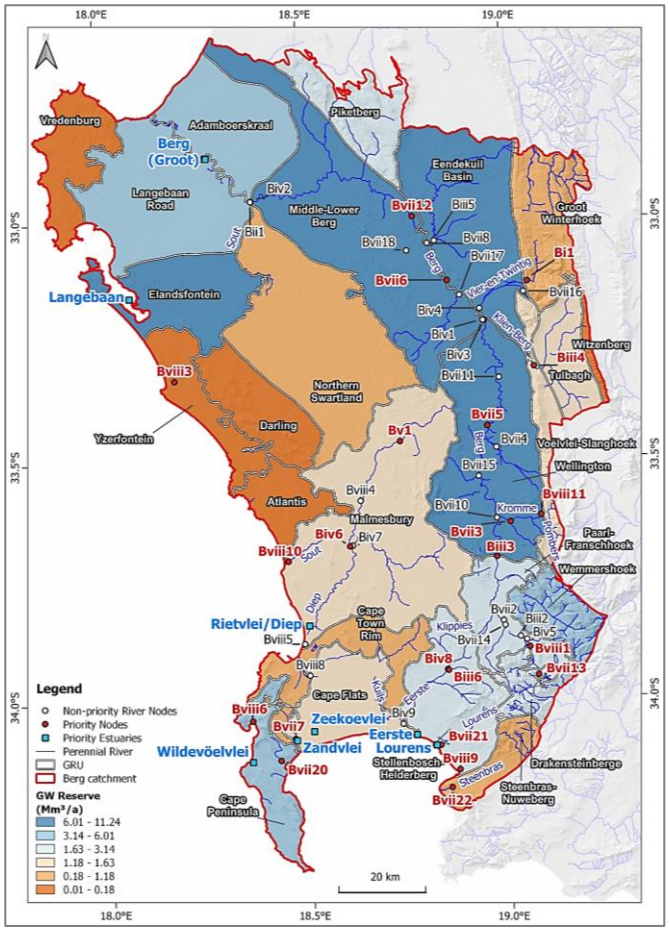
GROUNDWATER QUANTITY COMPONENT



The Quantity (i.e., Volume) of Groundwater Contribution to the BHN



The Quantity (i.e., Volume) of Groundwater Contribution to the EWR



The Groundwater Quantity Component of the Reserve

Groundwater Reserve Determination

GRU	Associated Quaternary Catchments	Area	Recharge	GW Baseflow	Water Use	EWR Reserve	BHN Reserve	GW Contribution to the Reserve	GW Contribution to the Reserve
		(Km^2)	(Mm^3/a)	(Mm^3/a)	(Mm^3/a)	(Mm^3/a)	(Mm^3/a)	(Mm^3/a)	(% MAR)
PRIMARY / INTERGRANULAR AQUIFERS									
Cape Flats	G22C,G22D,G22E,G22H	421.94	41.25	0.51	12.00	0.51	0.70	1.21	3%
Atlantis	G21A,G21B,G21D	255.68	22.74	0.08	1.70	0.08	0.03	0.11	0%
Yzerfontein	G10L,G10M,G21A	320.33	9.20	0.02	0.26	0.02	0.01	0.03	0%
Elandsfontein	G10L,G10M,G21A	532.57	15.47	6.95	1.09	6.39	0.01	6.40	41%
Langebaan Road	G10L,G10M	903.71	23.28	5.52	8.59	5.52	0.02	5.54	24%
Adamboerskraal	G10K,G10L,G10M,G30A	612.30	21.61	6.00	2.13	6.00	0.01	6.01	28%
FRACTURED TABLE MOUNTAIN GROUP AQUIFERS									
Cape Peninsula	G22A,G22B,G22C,G22D	292.53	10.99	5.43	0.07	5.43	0.09	5.52	50%
Steenbras- Nuweberg	G22J,G22K,G40A,G40B,G40C,G40D,H60A	150.24	58.76	1.16	8.00	1.16	0.02	1.18	2%
Drakensteinberge	G10A,G10C,G22F,G22J,H60A,H60B	164.95	27.60	2.88	0.05	2.88	0.00	2.88	10%
Wemmershoek	G10A,G10B,G10C,H10J,H10K,H60B	229.13	26.83	3.59	0.81	3.59	0.00	3.59	13%
Voëlvlei-Slanghoek	G10D,G10E,G10F,G10J,H10E,H10F,H10J	184.26	14.10	1.62	0.13	1.62	0.01	1.63	12%
Witzenberg	G10E,G10G,H10C,H10D,H10F	39.95	2.78	0.18	0.08	0.18	0.00	0.18	7%
Groot Winterhoek	E10B,E10C,G10E,G10G,G10H,G10J	379.26	22.50	0.77	1.39	0.77	0.02	0.79	3%
Piketberg	G10H,G10K,G10M,G30A,G30D	298.29	20.33	2.07	5.58	2.07	0.04	2.11	10%
FRACTURED AND INTERGRANULAR BASEMENT									
Cape Town Rim	G21E,G21F,G22A,G22B,G22C,G22D,G22E,G22G,G22H	814.62	18.60	0.87	6.21	0.87	0.20	1.07	6%
Stellenbosch-Helderberg	G10C,G21E,G22E,G22F,G22G,G22H,G22J,G22K,H60A	570.58	41.52	2.34	8.81	2.34	0.24	2.58	6%
Paarl-Franschhoek	G10A,G10B,G10C,G10D,G21E,G22F,H10J,H60B	368.50	26.61	3.01	9.82	3.01	0.13	3.14	12%
Malmesbury	G10D,G10F,G10L,G21B,G21C,G21D,G21E,G21F,G22C,G22	1600.36	52.65	1.18	14.75	1.18	0.34	1.52	3%
Wellington	G10D,G10F,G10J,G21E	1068.81	39.49	6.75	4.48	6.75	0.24	6.99	18%
Tulbagh	G10E,G10G,H10F	291.38	10.87	1.28	3.78	1.28	0.02	1.30	12%
Eendekuil Basin	G10F,G10H,G10J,G10K	936.94	21.88	6.95	4.85	6.95	0.09	7.04	32%
Middle-Lower Berg	G10F,G10J,G10K,G10L,G10M,G30A	1485.40	42.49	11.15	2.23	11.15	0.09	11.24	26%
Northern Swartland	G10J,G10K,G10L,G21A,G21C,G21D	1257.65	31.85	0.20	1.79	0.20	0.05	0.25	1%
Darling	G10L,G21A,G21B,G21D	408.82	9.95	0.03	0.76	0.03	0.02	0.05	0%
Vredenburg	G10M	376.18	7.43	0.00	1.16	0.00	0.01	0.01	0%

GROUNDWATER QUALITY COMPONENT

GROUNDWATER QUALITY COMPONENT

Data from various sources were collected and analyzed to **evaluate baseline water quality** and identify **potential sources of contamination** across GRUs. The evaluation also included an assessment of selected groundwater parameters for **compliance with gazette RQOs**.

*Data primary source was the Water Management System (WMS). CoCT data was used in GRUs where WMS monitoring points were lacking. A total of **358 unique monitoring** locations were considered across the 25 GRUs, with **six GRUs lacking monitoring data**, primarily within the fractured Table Mountain Group Aquifers (TMGA).*

The Groundwater Quality Component of the Reserve was determined by assessing two primary components:

1. **Groundwater Quality Reserve**
   - Determined based on statistical analysis of baseline and median concentrations within specific aquifers in GRUs

2. **Groundwater Quality Requirement for BHN**
   - Upper limit of Class I Water Quality [Drinking]

GROUNDWATER QUANTITY COMPONENT

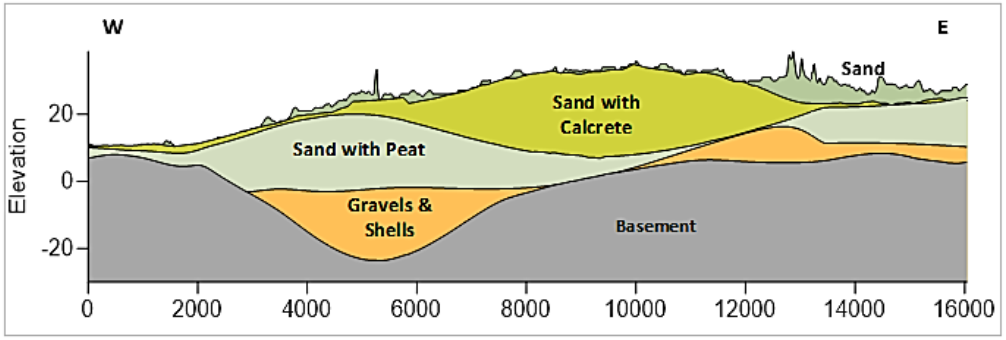
EXAMPLE: Cape Flats GRU

GRU	AQU	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	Groundwater Quality Reserve	BHN Threshold
Cape Flats	Primary / Intergranular Aquifer	pH		37	581	8.30	5.07	8.55	7.84	8.55	5 – 9
		Electrical Conductivity	mS/m	37	581	113.72	13.00	578.00	88.85	113.72	150
		Sodium as Na	mg/l	37	581	111.36	3.30	784.00	58.90	111.36	200
		Calcium as Ca	mg/l	37	581	112.16	3.81	266.50	101.50	112.16	150
		Magnesium as Mg	mg/l	37	581	14.62	1.00	124.70	11.60	14.62	70
		Chloride as Cl	mg/l	37	581	209.22	5.00	1993.00	100.00	209.22	200
		Nitrate + Nitrite	mg/l	37	581	8.35	0.02	23.20	1.12	8.35	400
		Fluoride as F	mg/l	37	581	0.26	0.05	3.05	0.15	0.26	10
		Ammonia as NH3	mg/l	37	581	0.08	0.02	31.89	0.06	0.08	1.5
		Orthophosphate as PO4	mg/l	37	581	0.03	0.00	1.35	0.01	0.03	-
		Potassium as K	mg/l	37	581	2.95	0.15	53.66	1.90	2.95	-
		Sulphate as SO4 as SO4	mg/l	37	581	44.40	2.00	326.00	45.40	49.94	-

- True **Baseline** concentrations, unaffected by human activities, was challenging due to diverse anthropogenic influences. Therefore, an approximation of the baseline was made using monitoring sites in areas with minimal human impact. To mitigate outliers, the 95th percentile statistical method was favoured over maximum concentrations, capturing the majority of data while excluding extreme values.
- The **Groundwater Quality Reserve** was determined by taking the Median concentration plus 10%. If this value was lower than the Baseline concentration, the Baseline value was chosen. If it exceeded the Maximum concentration, then the Maximum value was selected.
- The **BHN threshold** was selected based on the upper limit of Class I water quality [Drinking] (WRC et al. 2nd Edition, 1998, Volume 1: Assessment Guide).

EXAMPLE OF SUMMARY PER GRU

GRU	GRU Name: Cape Flats Main Suburbs: Philippi, Bellville and Kuilsriver Total Area (km²): 421.94
GRU Boundary Description	The Cape Flats GRU was delineated using the City of Cape Town's CFA model boundary (CoCT, 2018; 2020a). The aquifer model employed a slope separation criterion (<2 degrees) to distinguish the Cape Flats area from the adjacent hills and mountains. Additionally, it incorporated an interpolated geological extent of the basement, encompassing the Cape Granite Suite (CGS) and the Malmesbury Group rocks, along the GRU periphery. The southern boundary of the GRU was defined by the False Bay coastline (refer to **Figure 3-1** and DWS, 2022d and 2023a).
Quaternary Catchments	G22C, G22D, G22E and G22H (see **Figure 3-1**)
Resource Unit	Primary / Intergranular Aquifer
Description	Geologically, the Cape Flats GRU comprises the Tertiary and Quaternary sedimentary deposits of the Sandveld Group, including fluvial, marine, and aeolian formations. These deposits unconformably overlie weathered Neoproterozoic to early Cambrian Malmesbury Group and CGS basement rocks (see **Figure 3-1** and the cross section below). Hydrostratigraphically, the major aquifer units within the larger CFA are the Elandsfontyn, Varswater, and Springfontyn Fm. The CFA itself is a large, heterogeneous, stratified, intergranular, or primary (i.e., porous sedimentary/sandy) aquifer within the Sandveld Group. The primary aquifer thickens to approximately 50 m towards the centre of the GRU and fills the paleochannels carved into the basement topography (see **Figure 3-1** and the cross section below). One of these paleochannels coincides with the Philippi Horticultural Area (PHA; DWAF, 2008a; DWS, 2022d and 2023a).



GRU	GRU Name: Cape Flats Main Suburbs: Philippi, Bellville and Kuilsriver Total Area (km²): 421.94

Surface Water System

The primary rivers in the area are the Kuils, Lotus, and Elsieskraal rivers. Notable surface water bodies include Zandvlei, Zeekoevlei, Rondvlei, and the Eerste Estuary (see **Figure 3-1**). These rivers and wetlands are expected to be hydraulically linked to the relatively shallow groundwater. In cases where the aquifer is semi-confined, such as within the deep gravels in the paleochannels, or on a smaller local scale where the aquifer is semi-confined by laterally discontinuous calcrete or clay lenses, rivers and wetlands are likely to be connected hydraulically only with the uppermost unconfined sand unit (CoCT, 2021). Wetlands spread across the Cape Flats GRU are predominantly duneslack wetlands associated with interflow from surrounding dunes and perched aquifer systems (refer to DWS, 2022d and 2023a).

Water Resource Classes & RQOs

The GRU is entirely located within the Cape Flats IUA (E12) and has a Water Resource Class III. Within catchments G22C and G22D, the GRU is assigned Groundwater Resource Class II, while the remaining portions lack a Groundwater Resource Class designation. This IUA does not host any EWR sites, but it features three priority biophysical nodes, comprising two estuary nodes and one river node (see **Figure 3-1** and the table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
E12 Cape Flats	III	G22D	E12-R15	Keysers	Bvii7	D	93
		G22K	E12-E05	Zandvlei	Bxi9	C	93
		G22K	E12-E05	Zeekoevlei	Bxi9	D	N/A

Recharge

An estimated recharge of 41.25 M m³/a was obtained from a model-based calibrated recharge (CoCT, 2018) for the Cape Flats Primary/Intergranular Aquifer (see table below). The average recharge rate was calculated at 97.76 mm/a based on the total GRU area. A first-order recharge calculation was performed for the GRU which differs from the CoCT (2018) estimations because the model calibration considers both natural recharge and Irrigation Return Flow (IRF). Refer to DWS (2022a, 2022e and 2023a) for further details.

Method	Area (km²)	Recharge Volume (M m³/a)	Average Recharge Rate (mm/a)
Model-based calibrated recharge (after CoCT, 2018)	421.94	41.25	97.76

Groundwater Use

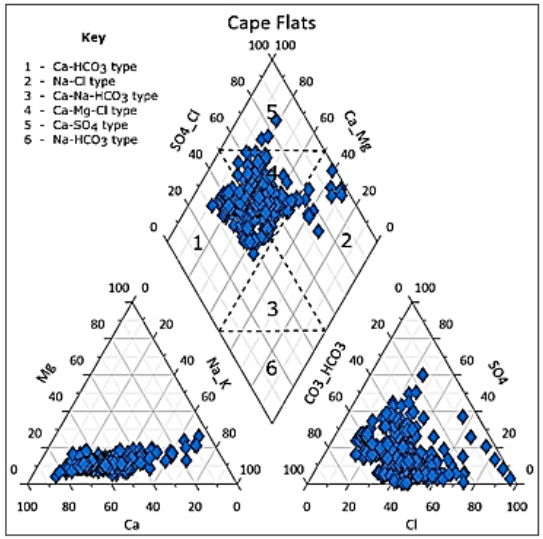
There are 95 registered groundwater users in the Cape Flats GRU, collectively utilizing 12.00 M m³/a of groundwater (note that there is a Managed Aquifer Recharge component of -14.6 M m³/a [9]). The primary sectors contributing to groundwater use are Water Supply Services and Agriculture (irrigation), constituting 75.4% and 15.32%, respectively, of the total groundwater use in the area (it's important to note that these percentages do not account for Managed Aquifer Recharge). It is acknowledged that farmers likely extract double their registered volume (see **Figure 3-1** and the table to the right).

The registered groundwater use is concentrated in the PHA, with additional industrial use in the northern section of the GRU, as well as on the lower eastern slopes of the Peninsula Mountain range (i.e., Southern Suburbs). Importantly, none of the settlements within the GRU depend solely on groundwater as their water supply.

Primary / Intergranular Aquifer		
Agriculture: Irrigation	50	4.08
Agriculture: Watering Livestock	2	0.05
Industry (Non-Urban)	2	1.05
Industry (Urban)	31	0.97
Mining	1	0.39
Schedule 1	1	0
Urban (Excluding Industrial And/Or Domestic)	3	0.02
Water Supply Service	5	20.09
Managed Aquifer Recharge	-	-14.6
Total	95	12.0

GRU	GRU Name: Cape Flats Main Suburbs: Philippi, Bellville and Kuilsriver Total Area (km²): 421.94

Water Quality



The primary water types in the CFA are Ca-Mg-HCO_3 and Ca-HCO_3. Ca-HCO3 waters which are more concentrated in the southern part of the aquifer, influenced by the shelly material along the coastline that dissolves, releasing Ca and HCO_3 ions.

The Philippi area, the northwestern section of the aquifer, is dominated by sodium-chloride type waters. These areas are associated with high organic-rich and clay contents, potentially influencing the water character. It has been previously observed that irrigation waters in the PHA impact groundwater salinization and may contribute to the presence of Na-Cl water types.

Among the 581 samples collected, 2, 14, and 40 samples exceeded the RQOs for EC, pH, and NO_3 + NO_2, respectively. The adjusted water quality category is D, signifying the presence of moderate levels of widespread contamination, attributable to various known contaminating activities in the Cape Flats (see DWS, 2022d, 2022e and 2023a for details).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'D', indicating a moderately stressed aquifer, and a Groundwater Quality Present Status of 'D', indicating moderate levels of widespread contamination, which limit the potential use of the aquifer.

Recharge Volume ($M m^3/a$)	Groundwater Use ($M m^3/a$)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
41.25[10]	12.00[11]	0.29	C	D

GRU	GRU Name: Cape Flats Main Suburbs: Philippi, Bellville and Kuilsriver Total Area (km²): 421.94

Groundwater Reserve

Groundwater Quality Component

The groundwater quality component of the Reserve, detailed in the table below and described in Section 2.3 & 2.4, is determined as two components 1) the Groundwater Quality Reserve, and 2) the Groundwater Quality BHN Reserve / Requirement

GRU	AQU	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	Groundwater Quality Reserve	BHN Threshold
Cape Flats	Primary / Intergranular Aquifer	pH	°	37	581	8.30	5.07	8.55	7.84	8.55	5 – 9
		Electrical Conductivity	mS/m	37	581	113.72	13.00	578.00	88.85	113.72	150
		Sodium as Na	mg/l	37	581	111.36	3.30	784.00	58.90	111.36	200
		Calcium as Ca	mg/l	37	581	112.16	3.81	266.50	101.50	112.16	150
		Magnesium as Mg	mg/l	37	581	14.62	1.00	124.70	11.60	14.62	70
		Chloride as Cl	mg/l	37	581	209.22	5.00	1993.00	100.00	209.22	200
		Nitrate + Nitrite	mg/l	37	581	8.35	0.02	23.20	1.12	8.35	400
		Fluoride as F	mg/l	37	581	0.26	0.05	3.05	0.15	0.26	10
		Ammonia as NH3	mg/l	37	581	0.08	0.02	31.89	0.06	0.08	1.5
		Orthophosphate as PO4	mg/l	37	581	0.03	0.00	1.35	0.01	0.03	-
		Potassium as K	mg/l	37	581	2.95	0.15	53.66	1.90	2.95	-
		Sulphate as SO4 as SO4	mg/l	37	581	44.40	2.00	326.00	45.40	49.94	-

Groundwater Quantity Component

The groundwater quantity component of the Reserve, detailed in the table below and described in Section 2.3 & 2.4, is calculated by considering the total groundwater contribution to both the EWR and BHN Reserves.

Recharge (Mm³/a)	EWR Reserve (Mm³/a)	BHN Reserve (Mm³/a)	GW Reserve (Mm³/a)	Total Allocable Volume (Mm³/a)	Water Use (Mm³/a)	Still Allocable (Mm³/a)
41.25[12]	0.51	0.70	1.21	40.04	12.00[13]	28.04

Future Scenario 2050 (Scenario 7b)

In Scenario 7b, which projects conditions for the year 2050 and considers the 'Most-Likely Case' for the GRU, the analysis focused on two key factors: Recharge and Water Use. These factors directly influenced the parameters used to determine the Groundwater Reserve, specifically the groundwater contribution to the BHN and EWR. The scenario involved a decrease in recharge from 41.25 to 38.70 M m³/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 12.00 to 23.02 M m³/a due to sectoral growth and the implementation of groundwater development schemes in the area. Furthermore, the groundwater contribution to the BHN Reserve rose from 0.70 to 1.29 M m³/a, primarily attributed to population growth. In light of these changes, the Allocation Category shifted from C to D (refer to Section 2.5 and the table below).

Recharge (Mm³/a)	EWR Reserve (Mm³/a)	BHN Reserve (Mm³/a)	GW Reserve (Mm³/a)	Total Allocable Volume (Mm³/a)	Water Use (Mm³/a)	Still Allocable (Mm³/a)
38.70	0.51	1.29	1.80	36.90	23.02	13.88

GRU	GRU Name: Cape Flats Main Suburbs: Philippi, Bellville and Kuilsriver Total Area (km²): 421.94

Monitoring Programme

The Cape Flats GRU was assigned a Management Option 2 for monitoring the groundwater contribution to the EWR and a Management Option 3 for monitoring the groundwater contribution to the BHN. A total of 9 monitoring sites for the EWR and 6 for the BHN were strategically selected within the Cape Flats GRU (see **Figure 3-1** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 2						
G2N0008	HYDSTRA	Zeekoevlei	EWR	-34.01008	18.50937	Frequency: Quarterly 1) Groundwater level: o Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality: o Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 o Site specific additions for EWR: NO_2, NO_3, NH_4 o Site specific additions as per RQO [19]: Bxi20 (Zeekoevlei): Nutrients (Dissolved Inorganic Nutrients [DIN] and Dissolved Inorganic Phosphate [DIP]); Salts; Pathogens (Enterococci & Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen, etc)
G2N0104	HYDSTRA	Zeekoevlei	EWR	-34.050078	18.51937	
G2N0612	HYDSTRA	GRU	EWR	-34.01902	18.57068	
G2N0649	HYDSTRA	GRU	EWR	-34.03966	18.56788	
G2N0653	HYDSTRA	GRU	EWR	-34.04875	18.56313	
G2N0108	HYDSTRA	GRU	EWR	-34.02465	18.62082	
G2N0619	HYDSTRA	GRU	EWR	-33.9331	18.62162	
G2N0059	HYDSTRA	Zeekoevlei	EWR	-34.01008	18.49937	
3418AB00077	NGA	Bvii7	EWR	-34.06602	18.46429	
BHN Management Option 3						
3318DC00004	NGA	GRU	BHN	-33.97801	18.56871	Frequency: Monthly or Quarterly 1) Groundwater level: o Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 2) Groundwater Quality (Background water quality and BHN): o Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 Site specific additions for BHN: E coli, Total Coliforms, and Faecal Coliforms
3318DC00114	NGA	GRU	BHN	-33.95301	18.5826	
3318DC00163	NGA	GRU	BHN	-33.98717	18.6276	
3418BA00026	NGA	GRU	BHN	-34.03686	18.59568	
3418BA00346	NGA	GRU	BHN	-34.06075	18.65068	
88847	WMS	GRU	BHN	-34.051389	18.601389	

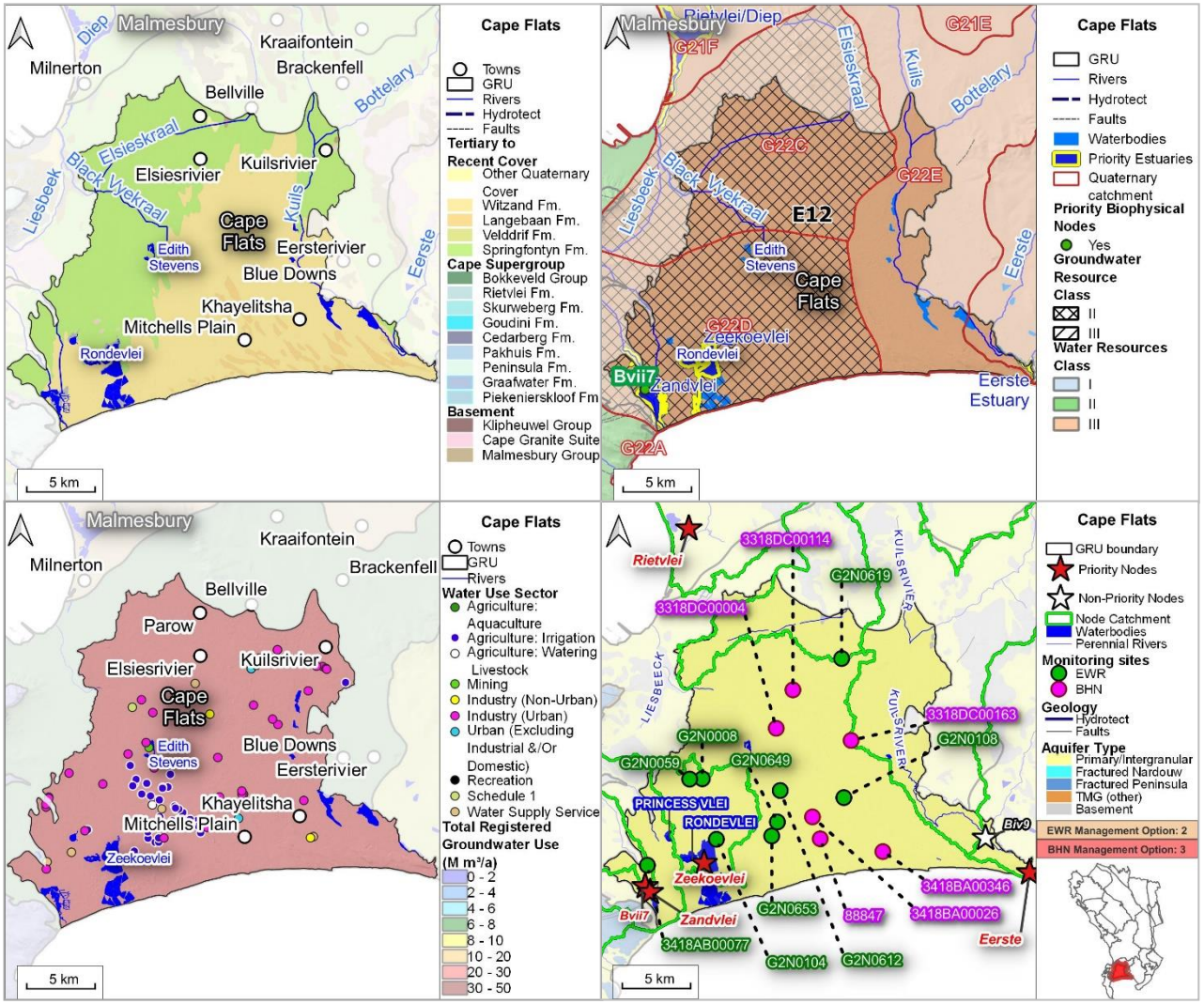


Figure: **A series of maps for the Cape Flats GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

GROUNDWATER RESERVE DATABASE

DATABASE STRUCTURE & OUTLINE

- Index
- Mapping
  - Jpegs
  - Shp. & Raster
- Project Management
  - PMC meetings & Minutes
  - Progress Reports
- Reports
  - Specialist Reports for GRD
  - Report Tables (xlsx) & Images
- Gazetting
  - Letter to Region & Gazette Draft
  - Report Tables (xlsx) & Images
- Stakeholders
  - PSC meetings & Minutes
  - Stakeholder Database & Comments
- Capacity Building
  - Presentations
  - Coursework Materials

THANK YOU