High Confidence Groundwater Reserve Determination Study in the Berg Catchment

WP11398
Groundwater Reserve Determination Report

Report Number: RDM/WMA19/02/CON/COMP/0124

February 2024

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

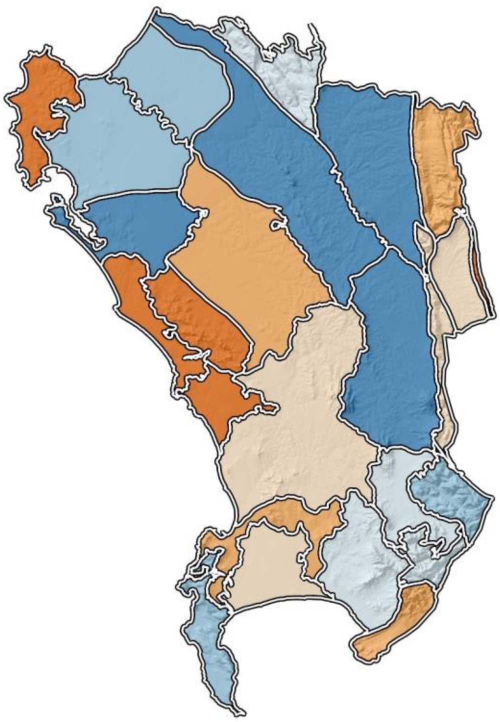
EARTH | WATER | SCIENCE | LIFE

UMVOTO.COM

High Confidence Groundwater Reserve Determination Study in the Berg Catchment

WP11398

Groundwater Reserve Determination Report



Report Number: RDM/WMA19/02/CON/COMP/0124

Version 1 – Final Draft

Prepared for:

Department of Water and Sanitation

Chief Directorate: Water Ecosystems Management

PROJECT	**:**	**High Confidence Groundwater Reserve Determination Study in the Berg Catchment**
REPORT TITLE	**:**	**Groundwater Reserve Determination Report**
CLIENT	**:**	**Department of Water and Sanitation, Chief Directorate: Water Ecosystems Management**
AUTHORS	**:**	**Matthew Misrole** **Eddie Wise**
REPORT STATUS	**:**	**Final Draft**
VERSION	**:**	**1**
UMVOTO REPORT NUMBER	**:**	**1001/1/1/2024**
CLIENT REPORT NUMBER	**:**	**RDM/WMA19/02/CON/COMP/0124**
DATE	**:**	**February 2024**
APPROVED BY	**:**	

UMVOTO South Africa (Pty) Ltd
Director
Kornelius Riemann

UMVOTO South Africa (Pty) Ltd
Technical Reviewer
David McGibbon

Department of Water and Sanitation
Chief Directorate: Water Ecosystems Management
Project Manager
Philani Khoza

Department of Water and Sanitation
Chief Directorate: Water Ecosystems Management
Scientific Manager
Kwazikwakhe Majola

Department of Water and Sanitation
Chief Directorate: Water Ecosystems Management
Director
Yakeen Atwaru

Umvoto South Africa (Pty) Ltd
Registration Number: 2017/377090/07
Directors: K Riemann, D Blake, DC McGibbon, LC Towers

SABS ISO 9001

Referencing

This report is to be referred to in bibliographies as:

Department of Water and Sanitation (DWS) (2023). High Confidence Groundwater Reserve Determination Study in the Berg Catchment –Groundwater Reserve Determination Report. Prepared by M. Misrole, and E. Wise of Umvoto South Africa Pty (Ltd.) on behalf of DWS. Version 1 / Final Draft; Report No. 1001/1/1/2024, pg. 146.

Report Status

Version	Status	Reviewed By	Date
1	Draft	D McGibbon	02/02/2024
1	Final Draft	K Riemann	06/02/2024

Distribution List

Version	Name	Institution	Date
1 – Final Draft	Philani Khoza	DWS	06/02/2024
1 – Final Draft	Kwazikwakhe Majola	DWS	06/02/2024

Report Index

Index	DWS Report Number	Deliverable Table
1	RDM/WMA19/02/CON/COMP/0122	Inception Report and Capacity Building Programme
2.1	RDM/WMA19/02/CON/COMP/0222	Gap Analysis Report
2.2	RDM/WMA19/02/CON/COMP/0322	Inventory of Water Resource Models
3.1	RDM/WMA19/02/CON/COMP/0422	Delineation of Water Resource Units Report
3.2	RDM/WMA19/02/CON/COMP/0522	Ecological Reference Conditions Report
3.3	RDM/WMA19/02/CON/COMP/0123	BHN and EWR Requirement Report
3.4	RDM/WMA19/02/CON/COMP/0223	Operational Scenarios & Socio-Economic and Ecological Consequences Report
3.5	RDM/WMA19/02/CON/COMP/0323	Stakeholder Engagement of Operational Scenarios Report
3.6	RDM/WMA19/02/CON/COMP/0423	Monitoring Programme Report
3.7	**RDM/WMA19/02/CON/COMP/0124**	**Groundwater Reserve Determination Report**
3.8	RDM/WMA19/02/CON/COMP/0224	Database of All Information and Data (including spatial)
3.9	RDM/WMA19/02/CON/COMP/0324	Gazette Template

Executive Summary

In response to the increasing number of Water Use Licence Applications (WULAs) in the Berg catchment and the potential impacts of proposed developments on water resource quantity and quality, the Department of Water and Sanitation (DWS), Chief Directorate: Water Ecosystems Management (CD: WEM), initiated a 'High Confidence Groundwater Reserve Determination Study for the Berg Catchment'.

The National Water Act (NWA, No. 36 of 1998) establishes a legal framework for the effective and sustainable management of significant water resources in South Africa. The Resource Directed Measures (RDM; see **Figure 1**), aimed at balancing the protection, use, conservation, management, and control of water resources, is an important tool within the NWAs framework and consist of three main components: Classification, Reserve, and Resource Quality Objectives (RQOs). The Reserve, designated as the water 'set aside' to fulfil Basic Human Needs (BHN) and Ecological Water Requirements (EWR), is the only right to water in the NWA, and takes precedence over all other water uses. These requirements, coupled with other critical water demands on these water resources, are safeguarded by the RQOs identified for priority sites in the Berg catchment.

Given that two components of the RDM (i.e., the 'Classification' and the 'RQOs') have already been completed and gazetted (Gazette No.42451:121) for the Berg catchment, this study sought to conclude the RDM process and align with the gazetted water requirements. It is noteworthy that while the NWA explicitly includes groundwater in the definition of a 'water resource', the distinctive characteristics of groundwater systems sometimes require a unique management approach. Therefore, in determining the groundwater Reserve for the Berg catchment, careful consideration was given to the volume of groundwater that can be sustainably abstracted without adversely affecting its contribution to surface water flow.

The primary objective of this study was to provide insights into the groundwater resource systems 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. The overarching goal was to offer aquifer-specific information to facilitate well-informed management decisions concerning stressed or over-utilized groundwater resources.

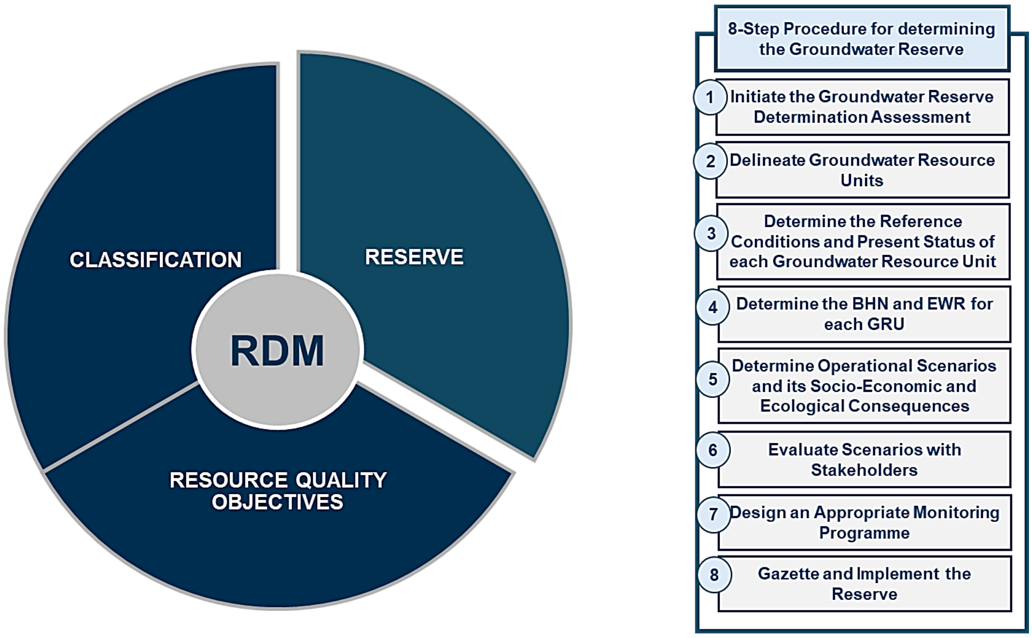


Figure 1 **The overarching components of the RDM and the 8-step procedure for determining the Groundwater Reserve (after WRC, 2013).**

As per Regulation 2(4) of the NWA (No. 36 of 1998), the Groundwater Reserve Determination (GRD) process must follow the eight-step procedure outlined and published in the RDM manuals. This report, represents Step 8 of the GRD procedure (see **Figure 1**), and provides a comprehensive summary of the findings and recommendations resulting from the High Confidence Groundwater Reserve Determination process. The report is broken down into 3 chapter, detailing the following:

- **Chapter 1:** serves as an introduction, providing insights into the study area and the GRD methodology.
- **Chapter 2:** provides a summary of the eight-step GRD procedure for the Berg Catchment, including Step 1: Data and Water Resource Models, Step 2: the Delineation of Groundwater Resource Units (GRUs), Step 3: the Assessment of Ecological Reference Conditions, Step 4: the Groundwater Requirements for BHN and EWR, Step 5 and 6: Defining Operational Scenarios and Analysing the Socio-Economic and Ecological Consequences, and Step 7: the Monitoring Programme to be implemented for the Reserve.
- **Chapter 3:** concludes the report with the outcomes GRD process per GRU and provides summary tables of the key hydrogeological components of the Groundwater Reserve.

Table of Contents

List of Tables

List of Figures

List of abbreviations, acronyms, symbols and units of measurement

~	Approximately
<	Less than
a	annum
Berg WAAS	Berg Water Availability Assessment
BH	Borehole
BHN	Basic Human Needs
CD: WEM	Chief Directorate: Water Ecosystems Management
CFA	Cape Flats Aquifer
CGS	Cape Granite Suite
CoCT	City of Cape Town
Conc.	Concentration
DWS	Department of Water and Sanitation
e.g.	For example
Et al.	and others
etc.	etcetera
EWR	Ecological Water Requirement
Fm	Formation
GDE	Groundwater Dependent Ecosystems
GIS	Geographic Information System
GRD	Groundwater Reserve Determination
GRDM	Groundwater Resource Directed Measure
GRU	Groundwater Resource Unit
GW	Groundwater
i.e.	That is.
IAP	Invasive Alian Plants
IRF	Irrigation Return Flow
IUA	Integrated Unit of Analysis
km	Kilometres
ℓ/p/d	Litres per person per day
Ltd.	Limited Liability
m	Metres
M m^3	Million Cubic Metres
m^3	Cubic Metres
MAP	Mean Annual Precipitation
MAT	Mean Annual Temperature
mm	Millimetres
mm/a	Millimetres per annum
N	North
NGA	National Groundwater Archive
No.	Number
NWA	National Water Ac
pg.	Page
PHA	Philippi Horticulture Area
PS	Present Status
PSP	Professional Service Provider
Pty.	Proprietary
RDM	Resource Directed Measure
Ref	Reference
RQO	Resource Quality Objective

RU	Resource Unit
Sc	Scenario
SGWCA	Subterranean Government Water Control Areas
SI	Stress Index
SWSA	Strategic Water Source Areas
TEC	Target Ecological Category
TMG	Table Mountain Group
TMGA	Table Mountain Group Aquifer
TOR	Terms of Reference
WARMS	Water Use Authorization & Registration Management System
WCWSS	Western Cape Water Supply System
WMA	Water Management Area
WMS	Water Management System
WQ	Water Quality
WR2012	Water Resources of South Africa Study (2012)
WRC	Water Research Commission
WRCs	Water Resource Classes
WUL	Water Use Licence
WULA	Water Use Licence Application

1. INTRODUCTION

1.1. Background of the Study

In response to the increasing number of Water Use Licence Applications (WULAs) in the Berg catchment and the potential impacts proposed developments may have on water resource quantity and quality, the Department of Water and Sanitation (DWS): Chief Directorate: Water Ecosystems Management (CD: WEM) initiated a "High Confidence Groundwater Reserve Determination Study for the Berg Catchment". This study aimed to complete the Resource Directed Measures (RDM) process (**Figure 1-1**) for the Berg catchment and support the Water Resource Classes (WRCs) and Resource Quality Objectives (RQOs) gazetted on the 10th of May 2019 (Gazette No.42451:121, hereafter referred to as 'DWS, 2019b: 121').

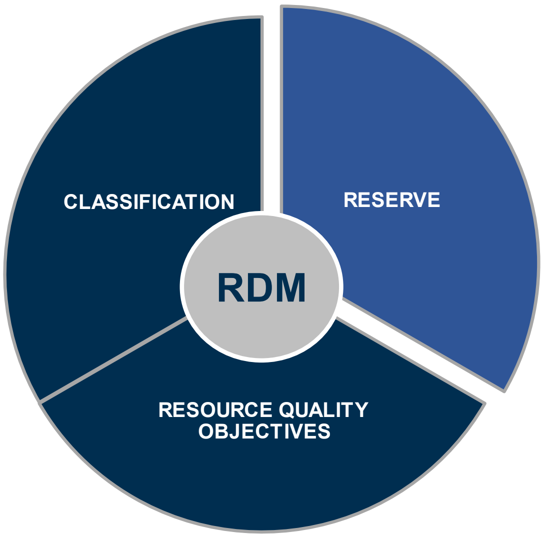


Figure 1-1 The three main components of the Resource Directed Measures (RDM) process as defined by Regulation 2(4) of the National Water Act (NWA; No. 36 of 1998).

The primary objective of this study was to offer insights into the groundwater resource systems within the Berg catchment, taking into account both the conservation status of priority water resources and the complex geological and hydrogeological features of the study area. The overarching goal was to provide aquifer-specific information with a high level of confidence to facilitate well-informed management decisions concerning stressed or over-utilized groundwater resources. This study therefore aimed to align with the gazetted requirements for the Berg catchment and to determine the necessary groundwater contribution to the Reserve. Specifically, the focus was on the groundwater contribution to Basic Human Needs (BHN) and Ecological Water Requirements (EWR), as outlined in the project's Terms of Reference (TORs) (refer to **Section 1.2**).

For the Berg catchment, WRCs and. RQOs were officially gazetted as an outcome of the 'Determination of Water Resource Classifications and Resource Quality Objectives in the Berg Catchment' study (hereafter referred to as 'DWS, 2016' or 'The Berg Catchment WRCs and RQOs Study'). The WRCs were completed in accordance with Section 13(4)(a)(i)(aa) of the National Water Act (NWA) of 1998 and the RQOs were completed for prioritized Resource Units (RUs) in accordance with Section 13(4)(a)(i)(bb) of the NWA of 1998. A summary of the information presented in the Gazette is provided in DWS (2022e).

1.2. Terms of Reference

The Terms of Reference (TOR), as provided by the DWS CD: WEM, and outlined in the projects Inception Report (DWS, 2022a), stipulates the aims and objectives for this study as follows:

"The objective of this study is to determine a high confidence groundwater Reserve requirements (quantity and quality) to satisfy the basic human needs and to protect aquatic ecosystems in priority water resources within the Berg catchment".

- BID no. WP 11398

"Detailed determinations aim to produce high-confidence results, are based on site-specific data collected by specialists and are used for all compulsory licensing exercises, as well as for the individual licence applications that could have a large impact on any catchment, or a relatively small impact on ecologically important and sensitive catchments".

- BID no. WP 11398

1.3. The Study Area

The Berg catchment, delineated in the 19 Water Management Area (2004), serves as the primary study area boundary, and is situated within the Western Cape Province of South Africa. It covers approximately 13,891 km^2 and includes secondary drainage regions G1 and G2 (**Figure 1-1**).

This catchment experiences a Mediterranean climate characterized by winter rainfall, where the mean annual precipitation (MAP) varies significantly due to the region's topography, ranging from 300 mm in the low-lying coastal plains (northwest) to 3,000 mm in the high mountain ranges (east). Mean annual temperature's (MAT) also exhibits variation, with cooler temperatures in mountainous areas (10 - 14°C) and warmer temperatures along the coastal lowlands (16 - 20°C). Evaporation rates increase with latitude, particularly northwards (approximately 2200 – 2600 mm), while southern areas, around Cape Town, experience lower evaporation rates (approximately 1800 – 2200 mm).

Hydrologically, the Berg River (G1) catchment is the largest within the study area, covering approximately 8908 km^2. The study area includes 22 estuaries, with the Berg River estuary and Langebaan Lagoon among them, both receiving contributions from groundwater. Significant wetlands, such as the Edith Stephens Wetland Park, Zeekoevlei, Rondevlei, Zoarvlei, and Rietvlei, are also present. Additionally, six major dams are situated in the catchment, namely the Upper and Lower Steenbras, Wemmershoek, Voëlvlei, Theewaterskloof, and Berg River Dam.

Geologically, the majority of the Berg catchment is underlain by Klipheuwel and Malmesbury Group rocks. These basement rocks were intruded by the Cape Granite Suite (CGS), leading to a prolonged period of uplift and erosion. This geological process resulted in the deposition of sandstones forming the Table Mountain Group (TMG). The Peninsula and Nardouw Aquifers (TMG), arising from these formations, contribute to deep fractured rock aquifers. Further erosion of these formations, particularly the softer Malmesbury Group, shaped eroded valleys, leading to sediment deposition in the western and coastal portions of the catchment (see **Figure 1-2**). These sand deposits form the Bredasdorp Group, Sandveld Group, and Quaternary age deposits, comprising major primary sedimentary/intergranular aquifers such as the Cape Flats Aquifer (CFA), Atlantis/Silwerstroom aquifers, and the West Coast Aquifers (Yzerfontein, Adamboerskraal, Elandsfontein, and Langebaan Road Aquifers) (DWS, 2022a).

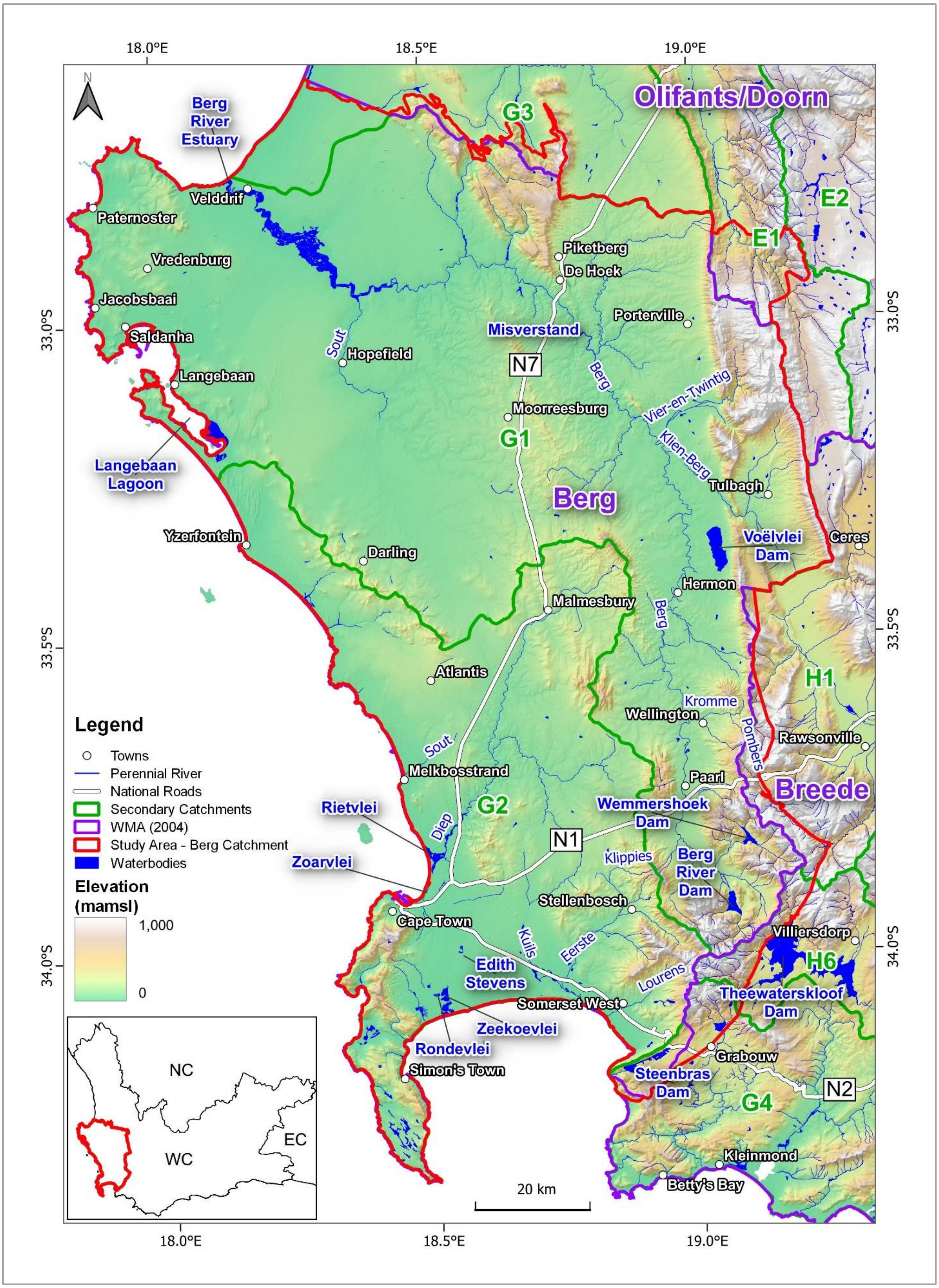


Figure 1-2 **The Berg catchment and the project study area.**

1.4. Study Methodology & Approach

As outlined in **Section 1.5**, the Groundwater Reserve Determination process followed the eight-step GRD procedure outlined GRDM (WRC, 2013). Consequently, the project was subdivided into three phases, each further split into tasks and key deliverables. These are summarized in **Table 1-1** and **Figure 1-3** as well as in the Inception Report (DWS, 2022a).

Table 1-1 Summary of project phases, tasks, and associated deliverables for the study.

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 Report
Task 3.3	Step 3	Ecological Reference Conditions of RUs	Deliverable 3.2: Ecological Reference Conditions Report
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 Report
Task 3.6	Step 6	Evaluate Operational Scenarios with Stakeholders	Deliverable 3.5: Stakeholder Engagement of Operational Scenarios Report
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

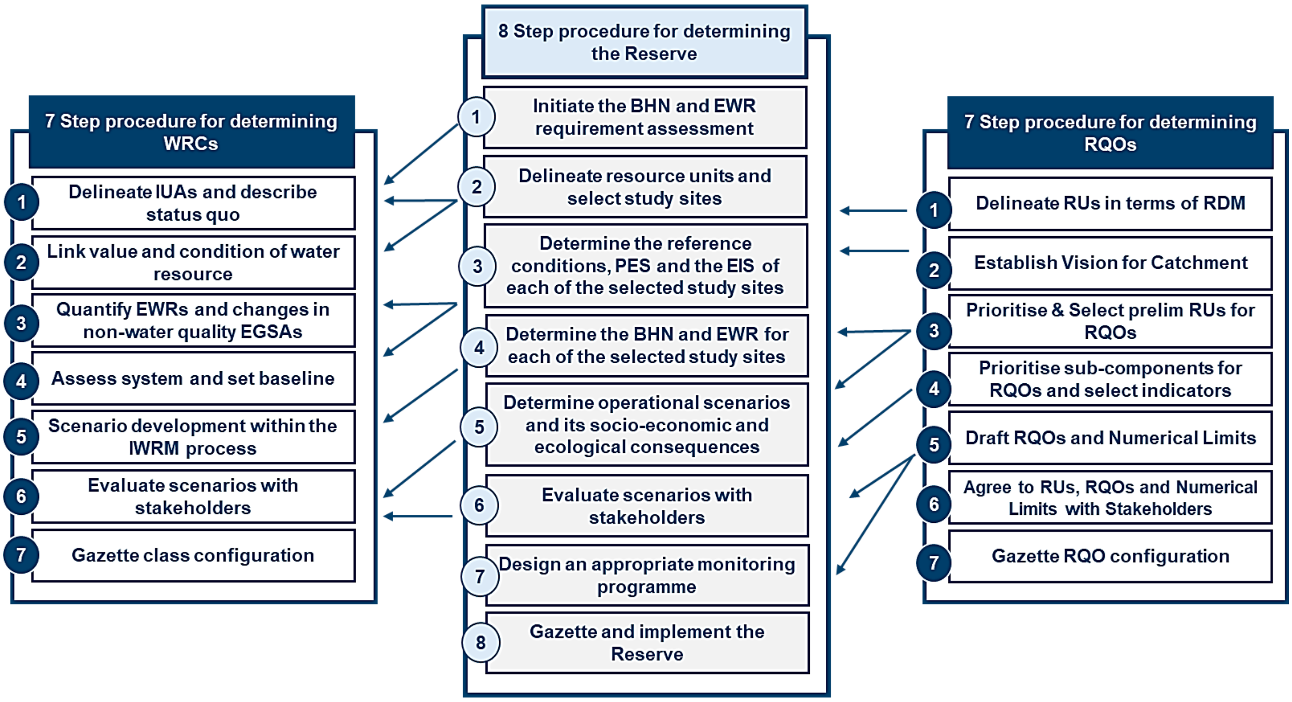


Figure 1-3 The eight-step GRD procedure and its alignment with the seven-step WRCs & RQO procedure (after WRC, 2013).

1.5. Aim of this Report

As per Regulation 2(4) of the NWA (No. 36 of 1998), the Reserve determination process must follow the eight-step procedure outlined in the RDM manuals. To differentiate between the general RDM and RDM specifically related to groundwater, the term Groundwater Resource Directed Measures (GRDM) is utilized. The GRDM manuals referenced in this report include WRC (2007), WRC (2013), and preliminary findings from an ongoing review of GRDM manuals conducted by the Water Research Commission (WRC).

The purpose of this report is to present a comprehensive summary of the findings and recommendations resulting from the Groundwater Reserve Determination (GRD) process conducted for the Berg catchment. Each section in this report presents a summary of the information and outputs of the detailed reports for each step of the eight-step GRD procedure.

In terms of the report structure, **Chapter 1** serves as an introduction, providing insights into the study area and the GRD methodology. **Chapter 2** provides a summary of the eight-step GRD procedure for the Berg Catchment, including the delineation of Groundwater Resource Units (GRUs), the assessment of ecological reference conditions, the requirements for BHN and EWR, operational scenarios and an analysis of the socio-economic and ecological consequences, and the proposed monitoring programme to be implemented for the Reserve. Finally, **Chapter 3** concludes the report with the outcomes of the study per GRU.

It must be noted that the perspectives, expertise, and concerns of stakeholders played an important role in shaping outcomes of this study, ensuring that the results of the assessment were well-informed, balanced, and reflective of the interests and needs of all involved parties.

2. RESERVE DETERMINATION

The National Water Act (No. 36 of 1998) establishes a legal framework for the effective and sustainable management of significant water resources in South Africa. The RDM, required to balance the protection, use, conservation, management, and control of water resources, comprises three main components: Classification, Reserve, and Resource Quality Objectives (RQOs) as detailed in **Section 1.1**. The Reserve, i.e., the water “set aside” to provide for BHN and EWR, is the **only** right to water in NWA, taking precedence over all other water use. Simply put, the Reserve's water requirements must be fulfilled before allocating water resources to other users. These requirements, along with other demands on water resources, are safeguarded by RQOs identified for priority sites in the Berg catchment.

Although the NWA explicitly includes groundwater in the definition of a "water resource", the distinctive characteristics of groundwater systems a sometimes necessitate a unique management approach. Consequently, in determining the groundwater Reserve for the Berg catchment, consideration was given to the volume of groundwater that can be sustainably abstracted without adversely affecting its contribution to surface water flow (WRC, 2013).

The following subsections offer a summary of the key outcomes of each step in the eight-step GRD process outlined in **Section 1.4.**

2.1. Step 1: Data and Water Resource Models

Following an extensive literature review, multiple data sources were collated and utilised in this GRD study. The Berg Catchment WRCs and RQOs Study (DWS, 2016) and the Berg Water Availability Assessment Study (Berg WAAS) project (DWAF, 2008) formed a crucial foundation, contributing information on aquifer type classification, aquifer boundaries, general hydrogeologic characteristics, regional groundwater flow, recharge, and groundwater quality. Additional studies, including the Pre-Feasibility and Feasibility Studies for the Augmentation of the Western Cape Water Supply System (WCWSS) (DWA, 2012), the Water Reconciliation Strategy for the WCWSS (DWS, 2016f), the Water Resources of South Africa Study (WRC, 2012), the Groundwater Projects associated with City of Cape Town’s New Water Programme, and the Berg River Baseline Monitoring Programme (DWAF, 2007a & b), also provided valuable inputs.

After reviewing the available data and information, it became clear that a significant re-evaluation of surface water RUs was unnecessary within the defined project scope. The DWS (2016) conducted a comprehensive review of surface water data, which was effectively integrated into this GRD assessment. The study revealed no significant gaps in surface water information. Information on the spatial extent and groundwater dependency of wetlands was lacking sufficient regional mapping, and therefore additional data was integrated into an updated understanding of surface-groundwater interactions (DWS, 2022b).

Groundwater data was collated from national databases such as the National Groundwater Archive (NGA), Water Management System (WMS), Water Use Authorization & Registration Management System (WARMS), and Hydstra database and then underwent a rigorous quality check. Smaller scale geological maps (1:50 000) were used, with preference given to finer resolution maps in certain areas. Water resource models were also assessed and categorized, encompassing various model types such as desktop feasibility, conceptual, water balance, yield/storage, and numerical models. While aquifer-scale groundwater numerical models were developed for major aquifers, proprietary constraints limited access to the datafiles.

Detailed information on data and water resource models were provided in both the Gap Analysis Report (DWS, 2022b) and the Inventory of Water Resource Models Report (DWS, 2022c). These reports correspond to Step 1 in the eight-step GRD procedure, as illustrated in **Table 1-1** and **Figure 1-3**.

2.2. Step 2: Delineation of Groundwater Resource Units

The delineation of GRUs in the Berg Catchment WRCs and RQOs Study (DWS, 2016) was initially 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.

The geology of the Berg catchment strongly influences topography, recharge (drainage, and orogenic control over precipitation), and groundwater chemistry. Due to the complex geological characteristics of different aquifers (i.e., the Sandveld Group, Table Mountain Group (TMG), and Basement Aquifers) and the strong compartmentalization of TMG formations due to major faults or fault zones, the existing GRU extents did not align with the actual aquifer boundaries.

To address these issues, Step 2 of the GRD process focused on delineating aquifer-specific GRUs and identifying areas requiring further investigation. This step aimed to refine the delineation process, ensuring the inclusion of overlooked aquifers and improving mapping accuracy for groundwater Reserve determination.

Three main criteria—physical, management, and functional—were used to re-delineate aquifer-specific GRUs. The approach involved analysing physical aquifer geometry, existing aquifer boundaries, recharge areas, topography, structural geology (faults, folds, hydrotects), and potential discharge areas. Functional and management criteria considered existing Integrated Units of Analysis (IUAs), WRCs, RQOs, Strategic Water Source Areas (SWSAs), Subterranean Government Water Control Areas (SGWCA), groundwater use, aquifer reliance, and groundwater-surface water interactions.

The updated GRU extents are presented in **Table 2-1** and displayed on a geological map in **Figure 2-1**. Comprehensive details on the approach, methodology, and results can be found in the Delineation of Groundwater Resource Units Report (DWS, 2022d).

Table 2-1 Summary of revised GRUs for the Berg catchment.

GRU Name	Associated Quaternary Catchment
Primary / Intergranular Aquifers	
Cape Flats	G22C, G22D and G22E
Atlantis	G21A, G21B and G21D
Yzerfontein	G21A
Elandsfontein	G10M and G10L
Langebaan Road	G10M and G10L
Adamboerskraal	G10M, G10K and G30A
Fractured Table Mountain Group Aquifers	
Cape Peninsula	G22A, G22B, G22C and G22D
Steenbras-Nuweberg	G40B, G40A, G40D, G22J, G22K, H60A and G40C
Drakensteinberge	G10A, G10C, G22F, G22J, H60A and H60B
Wemmershoek	G10B, G10A, G10C, H10J, H60B and H10K
Voëlvlei-Slanghoek	G10E, G10J, G10D, G10F, H10E, H10F and H10J
Witzenberg	G10E
Groot Winterhoek	G10J, G10E, G10H, E10C and G10G
Piketberg	G10M, G30D, G10K, G30A and G10H
Fractured and Intergranular Basement	
Cape Town Rim	G22C, G22E, G22B and G22D
Stellenbosch-Helderberg	G22G, G22H, G22F, G22J and G22K
Paarl-Franschoek	G10C, G10A and G10B
Malmesbury	G201E, G21C, G21D, G21F and G21B
Wellington	G10D and G10F
Tulbagh	G10E and G10G
Eendekuil Basin	G10H, G10J, G10F and G10K
Middle-Lower Berg	G10J, G30A, G10K and G10M
Northern Swartland	G10L
Darling	G10L and G21A
Vredenburg	G10M

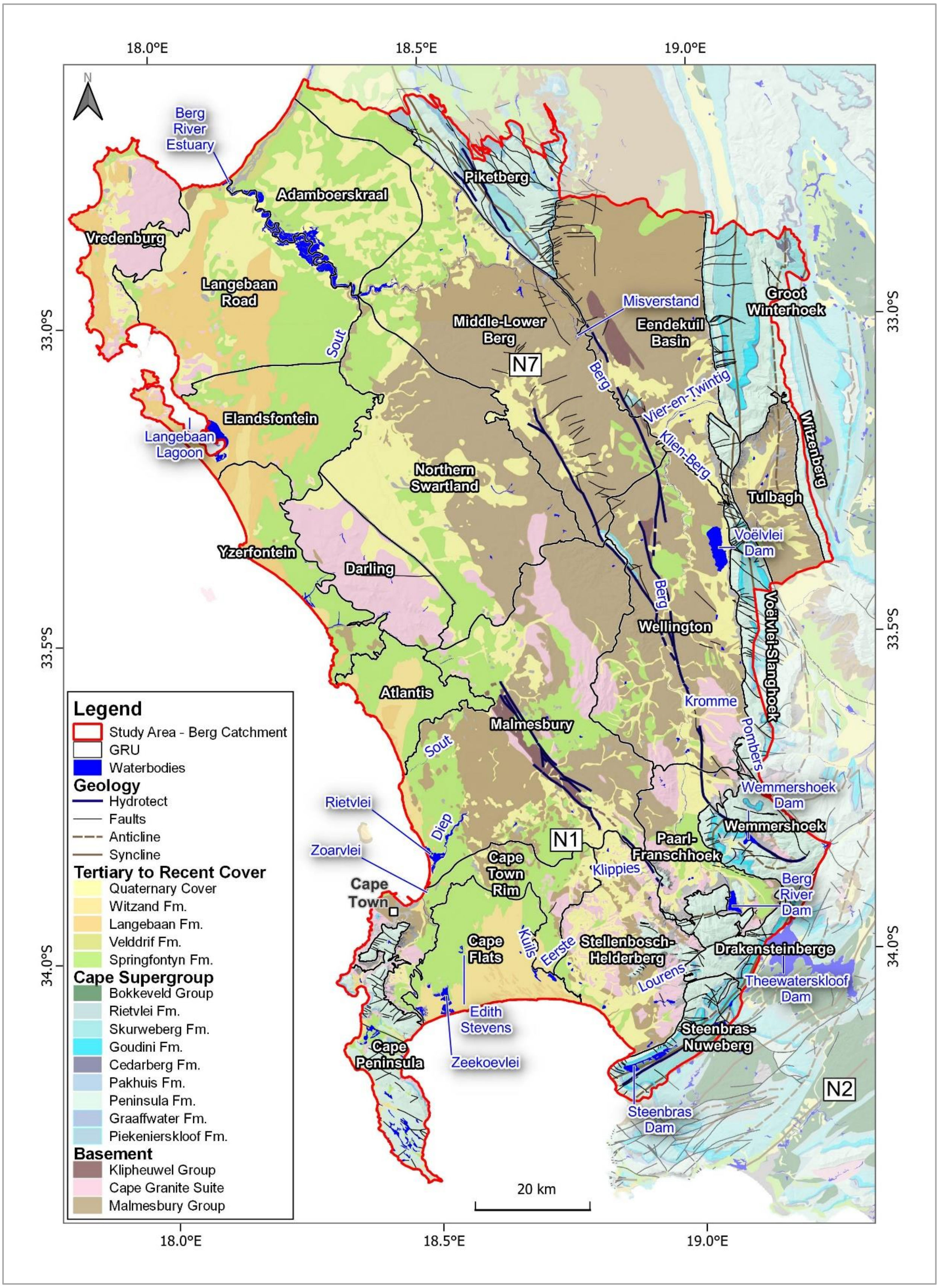


Figure 2-1 Summary of revised GRUs extents for the Berg catchment with associated geology and relevant structural features.

2.3. Step 3: Ecological Reference Conditions

To ensure alignment with the aquifer-specific GRUs identified in Step 2 (**Section 2.2**) as well as the information related to the gazetted WRCs and RQOs (DWS, 2019b: 121), Step 3 of the GRD process re-evaluated the ecological reference conditions and present status (PS) of the catchment. In the context of this study, 'ecological reference conditions' referred to the ambient or natural state of groundwater systems, while 'present status' referred to the current state in terms of groundwater utilization and water quality.

The objective of this step was to establish a correlation between the earlier assessments of the groundwater status quo in the Berg catchment (following DWS, 2016). This involved providing insights into the updated approach and criteria considered for a revised assessment of the groundwater status quo. This encompassed five critical hydrogeological components: 1) Recharge, 2) Groundwater Use, 3) Discharge, 4) Groundwater Quality, and 5) Aquifer Stress.

1. **RECHARGE**

   Various recharge estimation techniques were used based on the hydrogeological characteristics of specific GRUs. The selection considered the confidence level and associated limitations of the technique; the amount, spread, and availability of data across the GRU; and the applicability of published datasets. The assessment took into account artificial recharge and lateral recharge (where applicable).

2. **GROUNDWATER USE**

   Various data sources were collated to assess current groundwater use in the study area, providing a quantitative means of assessment per GRU as input to the groundwater Stress Index (SI). The index considered both groundwater availability (natural/artificial recharge) and groundwater use, aiming to quantify Aquifer Stress by assigning an associated PS category.

3. **DISCHARGE**

   Groundwater discharge represented the outflow of groundwater from aquifers to the surface or surface water systems, either directly or laterally via an adjacent aquifer unit. Groundwater contribution to baseflow was calculated to provide aquifer-specific estimates.

4. **GROUNDWATER QUALITY**

   Data from various sources were collated to provide a hydrochemical summary per GRU. Baseline water quality was assessed for each GRU (for select parameters), and potential sources of contamination were identified. Selected groundwater parameters were also evaluated for compliance with RQOs (DWS, 2019b:121), and groundwater quality PS categories were assigned per GRU.

5. **AQUIFER STRESS**

   Three guidance tables were used in the aquifer stress assessment including 1) sustainable use, 2) level of stress, and 3) contamination / water quality, to define PS Category for both groundwater availability and groundwater quality per GRU.

A guide for determining Groundwater Availability and Water Quality PS Category is outline in **Table 2-6** while a summary of the results is presented per GRU in **Table 2-3**. Comprehensive details regarding the approach, methodology, and associated results can be found in the Ecological Reference Conditions Report (DWS, 2022e).

Table 2-2 Guide for determining both Groundwater Availability and Water Quality PS Categories (after WRC, 2007).

	Groundwater Availability Present Status Category		Water Quality Present Status Category	
	Stress Index (GW use / Recharge)	Description	Percentage Exceedance	Description
A	<0.05	Unstressed or slightly stressed	<16.7 %	Unmodified, pristine conditions
B	0.05 – 0.20	Unstressed or slightly stressed	16.7 – 33.4 %	Localised, low levels of contamination, but no negative impacts apparent
C	0.20 – 0.40	Moderately stressed	33.4 – 50.1 %	Moderate levels of localised contamination, but little or no negative impacts apparent
D	0.40 – 0.65	Moderately stressed	50.1 – 66.8 %	Moderate levels of widespread contamination, which limit the use of potential use of the aquifer
E	0.65 – 0.95	Highly stressed	66.8 – 83.5 %	High levels of local contamination which render parts of the aquifer unusable
F	>0.95	Critically stressed	>83.5 %	High levels of widespread contamination which render the aquifer unusable

Table 2-3 Summary of the PS Category per GRU for both Groundwater Availability and Groundwater Quality.

GRU	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
Primary / Intergranular Aquifers		
Cape Flats	C	D
Atlantis	B	C
Yzerfontein	A	A
Elandsfontein	B	B
Langebaan Road	C	B
Adamboerskraal	B	B
Fractured Table Mountain Group Aquifers		
Cape Peninsula	B	B
Steenbras-Nuweberg	B	B
Drakensteinberge	A	-
Wemmershoek	A	A
Voëlvlei-Slanghoek	A	-
Witzenberg	A	-
Groot Winterhoek	B	-
Piketberg	C	-
Fractured and Intergranular Basement		
Cape Town Rim	C	C
Stellenbosch-Helderberg	C	C
Paarl-Franschhoek	C	-
Malmesbury	C	B
Wellington	B	B
Tulbagh	C	-
Eendekuil Basin	C	C
Middle-Lower Berg	B	C
Northern Swartland	B	C
Darling	B	C
Vredenberg	B	-

2.4. Step 4: BHN and EWR Requirements

Step 4 of the GRD involved determining the groundwater component of both the BHN and EWR for the aquifer-specific GRUs updated in Step 2 (**Section 2.2**). These components were calculated as independent volumes, collectively constituting the Groundwater Reserve.

1. **Basic Human Needs**

   The groundwater component of the BHN addresses individuals without access to a formal water supply and residing beyond 500 meters from a perennial river (here after referred to as the "Qualifying Population"). The Qualifying Population was calculated as 257,331 individuals within the Berg catchment, with a daily water demand set at a fixed value of 25 ℓ/p/d. Therefore, the groundwater component of the BHN was determined to be 2.35 Mm^3/a. The Cape Flats (0.70 Mm^3/a), Malmesbury (0.34 Mm^3/a), Stellenbosch-Helderberg (0.24 Mm^3/a), and Wellington (0.24 Mm^3/a) GRUs collectively account for about 65% of the total groundwater component of the BHN Reserve (**Table 2-4** and **Figure 2-2**).

2. **Ecological Water Requirements**

   Quantifying the groundwater component of the EWR involved using a baseflow separation technique, wherein groundwater discharge was calculated using monthly flow data calibrated to meet Target Ecological Categories (TECs) for all river nodes and priority estuaries in the study area. A "balancing and routing" tool factored in cumulative flow downstream, allowing calculations of changes in flow and TECs for downstream river nodes and estuaries. To assess the groundwater contribution to the EWR per GRU accurately, a detailed GIS-based catchment analysis re-evaluated incremental contributing catchments based on local topography, flow direction, aquifer model extents, and available literature. A recharge ratio was then applied to the total dry-season contribution of groundwater to baseflow per GRU and associated aquifer types.

   The groundwater component of the EWR Reserve was calculated as 69.98 Mm^3/a, with the Middle-Lower Berg (11.15 Mm^3/a), Wellington (6.75 Mm^3/a), Adamboerskraal (6.00 Mm^3/a), Elandsfontein (6.39 Mm^3/a), Langebaan Road (5.52 Mm^3/a), and Eendekuil Basin (6.95 Mm^3/a) GRUs accounting for approximately 61% of the total groundwater component of the EWR Reserve (**Table 2-4** and **Figure 2-2**).

The Groundwater Reserve, supporting both BHNs and EWRs, was therefore determined to be 72.33 Mm^3/a. While groundwater is more widely distributed than surface water, this component is just part of the larger geohydrological system considered under the RDM. Once the volume of the Groundwater Reserve is quantified and RQOs have been met, the remaining water resource can be allocated to users. Since RQOs were defined for the Berg catchment before this high-confidence groundwater Reserve study, it is likely that RQOs will require adjustment or updating to accommodate the Groundwater Reserve.

Table 2-4 and the associated maps displayed in **Figure 2-2** present a summary of the groundwater contribution to the BHN and EWR, while the comprehensive details regarding the approach, methodology, and results can be found in the BHN and EWR Requirements Report (DWS, 2023a).

Table 2-4 Summary of the groundwater contribution to BHN and EWR per GRU.

GRU	The groundwater contribution to EWR (Mm^3/a)	The groundwater contribution to BHN (Mm^3/a)	The groundwater contribution to Reserve (Mm^3/a)
Primary / Intergranular Aquifers			
Cape Flats	0.51	0.701	1.211
Atlantis	0.08	0.026	0.106
Yzerfontein	0.02	0.009	0.029
Elandsfontein	6.39	0.005	6.395
Langebaan Road	5.52	0.017	5.537
Adamboerskraal	6.00	0.008	6.008
Fractured Table Mountain Group Aquifers			
Cape Peninsula	5.43	0.085	5.515
Steenbras-Nuweberg	1.16	0.016	1.176
Drakensteinberge	2.88	0.003	2.883
Wemmershoek	3.59	0.002	3.592
Voëlvlei-Slanghoek	1.62	0.007	1.627
Witzenberg	0.18	0.002	0.182
Groot Winterhoek	0.77	0.017	0.787
Piketberg	2.07	0.036	2.106
Fractured and Intergranular Basement			
Cape Town Rim	0.87	0.195	1.065
Stellenbosch-Helderberg	2.34	0.242	2.582
Paarl-Franschhoek	3.01	0.127	3.137
Malmesbury	1.18	0.343	1.523
Wellington	6.75	0.235	6.985
Tulbagh	1.28	0.023	1.303
Middle-Lower Berg	11.15	0.085	11.235
Northern Swartland	0.20	0.047	0.247
Darling	0.03	0.015	0.045
Vredenburg	0.00	0.011	0.011
TOTAL	**69.98**	**2.35**	**72.33**

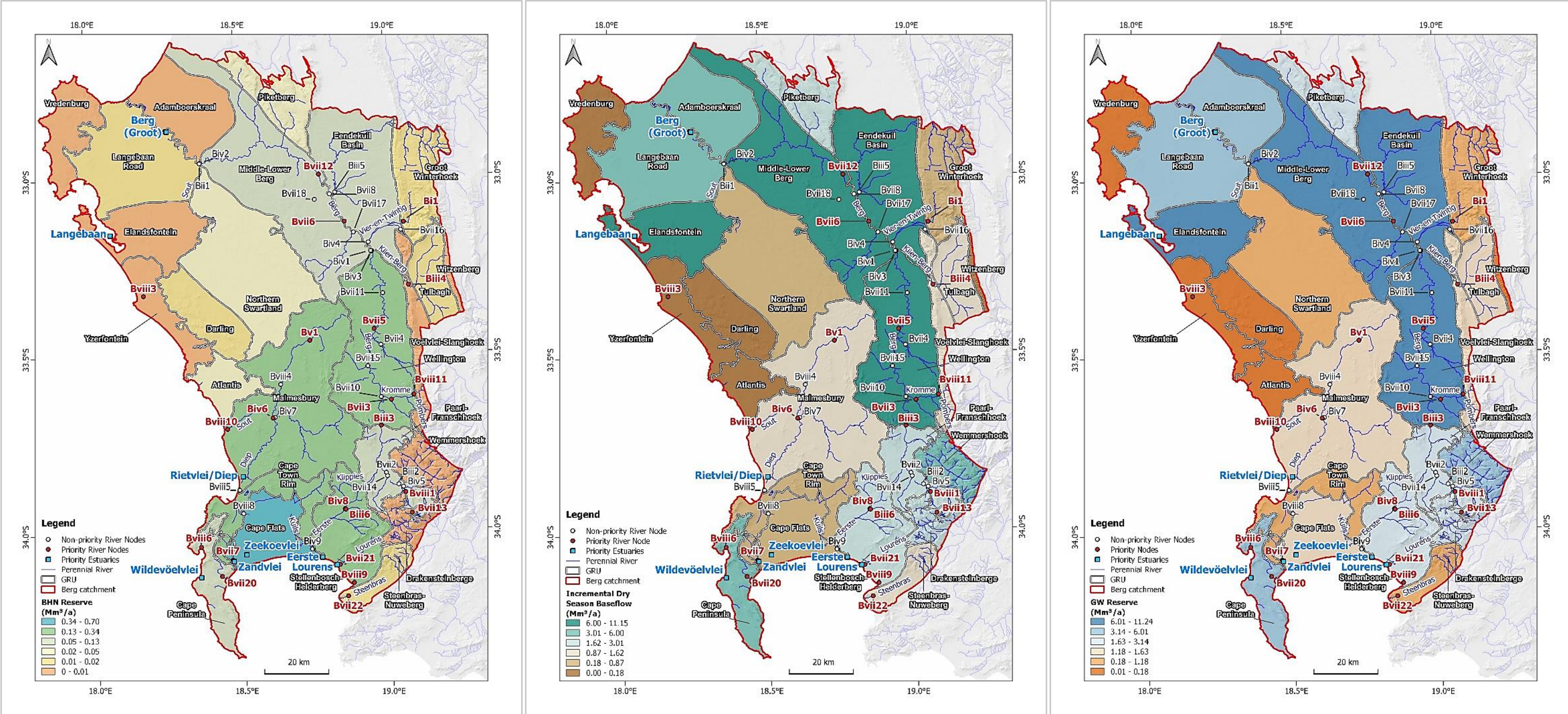


Figure 2-2 **Left: the groundwater contribution to BHN per GRU; Middle: the groundwater contribution to EWR per GRU; and Right: Groundwater Reserve per GRU.**

2.5. Step 5 & Step 6: Operational Scenarios

Steps 5 and 6 of the GRD process involved developing operational scenarios (refer to **Table 2-5**) aimed at assessing the socio-economic and ecological impacts on the Groundwater Reserve. These scenarios took into account inputs from relevant stakeholders which ensured that the assessment results were well-informed, balanced, and reflective of the diverse interests and needs of all parties involved (**Section 1.5**).

The scenarios offered valuable insights into both current and future trends of GRUs in the Berg catchment, focusing on aspects such as climate change, population growth, water supply scheme development, water conveyance, water sectoral growth, and the impact of invasive alien plants (IAPs). By integrating hydrogeological data, climate projections, and socio-economic trends, these scenarios provided a comprehensive understanding of the potential outcomes and challenges that may arise in maintaining the Groundwater Reserve and estimating allocable groundwater volumes.

By synthesizing findings from scenarios Sc 1 to Sc 6, two combined scenarios were developed: Sc 7a (Worst Case) and Sc 7b (Most-Likely Case). The Most-Likely Case (Sc 7b) considered factors such as the reduction in recharge due to climate change, the removal of all IAPs, the increase in groundwater contribution to the BHN Reserve based on population growth rate, and the augmented groundwater usage resulting from sectoral growth and the implementation of groundwater development schemes. These scenarios directly influenced the parameters used in determining the Groundwater Reserve, consequently impacting the still-allocable groundwater volumes[1]. A comparative analysis of projected volumes in 2050 with baseline values from the Present Status (PS) provided valuable insights into the cumulative effects of the identified factors.

Table 2-5 Description of the scenarios considered in modelling the impacts on the groundwater Reserve and the associated allocable groundwater volume in the Berg catchment.

Scenario No.	Scenario Name	Scenario Description
Sc 1	**Population Growth**	Assess the impact of population growth on the groundwater component of the BHN Reserve and estimate volumes by projecting the qualifying population.
Sc 2	**Water System Evaluation**	Evaluate the national assessment of municipal wastewater conveyance and treatment systems, to estimate potential increase in groundwater reliance based on the deterioration of the water system.
Sc 3	**Sectoral Water Demand**	Explore historical trends in groundwater demand per sector, focusing on agriculture, industry, and other sectors, to understand future water use.
Sc 4	**Groundwater Developments**	Evaluate scheduled groundwater developments and strategies for the Berg catchment, calculating their impact on the Reserve and allocable volumes.
Sc 5	**Climate Change**	Investigate the impact of climate change, particularly under warmer conditions, on groundwater recharge rates and its effects on the Reserve.
Sc 6	**Alien and Invasive Species**	Examine the impacts of Invasive Alien Plants (IAPs) on groundwater recharge (Sc 6a – Clearing vs Sc 6b – Left Unchecked) and evaluate their effects on the Reserve and allocable volumes.
Sc 7a	**Combination Scenario (Worst Case)**	Integrate population growth, sectoral growth, groundwater developments, climate change, increased groundwater reliance based on the improvement of water system, and absence of clearing alien vegetation for impact assessment.
Sc 7b	**Combination Scenario (Most-Likely Case)**	Integrate population growth, groundwater developments, climate change, increased groundwater reliance based on the improvement of water system, and clearing alien vegetation for impact assessment.

[1] *Still Allocable Groundwater: This term denotes the volume of groundwater that remains available for allocation or distribution after accounting for Reserve requirements and current water usage (WRC, 2013).*

To evaluate the potential impact on GRUs, an "Allocation Factor" was developed which represents the ratio of still-allocable groundwater volume to the total recharge for the GRU. The Allocation Factor was categorized into six groups, labelled 'A' through 'F', reflecting a spectrum from unstressed to potentially critically stressed conditions (**Table 2-6**). As the ratio approaches zero, the stress level potentially increases, indicating minimal remaining volumes that are still allocable and posing a potential threat to the groundwater Reserve.

Table 2-6 Guide for determining the Allocation Factor.

Allocation Category	Description	Allocation Factor (Still Allocable Volume / Recharge Volume)
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

Table 2-7 presents a summary of the results of the Sc 7b (Most-Likely Case) for the Berg catchment while the comprehensive details regarding the approach, methodology, and results of the operational scenario analysis can be found in the Operational Scenarios & Socio-Economic and Ecological Consequences Report (DWS, 2023c) and the Stakeholder Engagement of Operational Scenarios Report (DWS, 2023d).

It is important to highlight that Scenarios 1 to 6, which provided the necessary inputs for determining Scenario 7a (the Worst Case) and Scenario 7b (the Most-Likely Case), were thoroughly discussed and updated through stakeholder engagement.

Table 2-7 Summary table comparing parameters for calculating Groundwater Reserve and allocable volume per GRU, including results and parameters for Scenario 7b: Combination Scenario – Most-Likely Case.

GRU	Groundwater Reserve								Combination Scenario – Most-Likely Case							
	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)	Allocable Factor	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)	Allocable Factor
Primary / Intergranular Aquifers																
Cape Flats	41.25[2]	0.51	0.70	1.21	40.04	12.00[3]	28.04	0.68	38.70	0.51	1.29	1.80	36.90	23.02	13.88	0.36
Atlantis	22.74[4]	0.08	0.03	0.11	22.63	1.7[5]	20.93	0.83	21.63	0.08	0.05	0.13	21.50	3.31	18.19	0.84
Yzerfontein	9.2	0.02	0.01	0.03	9.17	0.26	8.91	0.97	7.60	0.02	0.02	0.04	7.56	2.26	5.30	0.70
Elandsfontein	15.47	6.39	0.01	6.40	9.08	1.09	7.99	0.52	13.17	6.39	0.01	6.40	6.77	2.70	4.07	0.31
Langebaan Road	23.28	5.52	0.02	5.54	17.74	8.59	9.15	0.39	20.18	5.52	0.03	5.55	14.63	11.09	3.55	0.18
Adamboerskraal	21.61	6.00	0.01	6.01	15.60	2.13	13.47	0.62	20.83	6.00	0.01	6.01	14.81	3.69	11.13	0.53
Fractured Table Mountain Group Aquifers																
Cape Peninsula	10.99	5.43	0.09	5.52	5.48	0.07	5.41	0.49	9.19	5.43	0.16	5.59	3.60	0.15	3.45	0.38
Steenbras- Nuweberg	58.76[6]	1.16	0.02	1.18	57.58	8.00[7]	49.58	0.84	57.97	1.16	0.02	1.18	56.79	24.52	32.26	0.56
Drakensteinberge	27.6	2.88	0.00	2.88	24.72	0.05	24.67	0.89	26.86	2.88	0.01	2.89	23.97	1.21	22.77	0.85
Wemmershoek	26.83	3.59	0.00	3.59	23.24	0.81	22.43	0.84	25.60	3.59	0.00	3.59	22.01	1.56	20.45	0.80
Voëlvlei-Slanghoek	14.1	1.62	0.01	1.63	12.47	0.13	12.34	0.88	12.87	1.62	0.01	1.63	11.24	0.31	10.93	0.85
Witzenberg	2.78	0.18	0.00	0.18	2.60	0.08	2.52	0.91	2.60	0.18	0.00	0.18	2.42	0.16	2.26	0.87
Groot Winterhoek	22.5	0.77	0.02	0.79	21.71	1.39	20.32	0.90	20.11	0.77	0.03	0.80	19.31	3.27	16.04	0.80
Piketberg	20.33	2.07	0.04	2.11	18.22	5.58	12.64	0.62	19.02	2.07	0.06	2.13	16.89	9.80	7.09	0.37
Fractured and Intergranular Basement																
Cape Town Rim	18.6	0.87	0.20	1.07	17.54	6.21	11.33	0.61	16.26	0.87	0.36	1.23	15.03	8.71	6.32	0.39
Stellenbosch-Helderberg	41.52	2.34	0.24	2.58	38.94	8.81	30.13	0.73	38.49	2.34	0.46	2.80	35.69	11.30	24.39	0.63
Paarl-Franschhoek	26.61	3.01	0.13	3.14	23.47	9.82	13.65	0.51	24.60	3.01	0.21	3.22	21.38	15.50	5.88	0.24
Malmesbury	52.65	1.18	0.34	1.52	51.13	14.75	36.38	0.69	44.42	1.18	0.64	1.82	42.61	25.12	17.49	0.39
Wellington	39.49	6.75	0.24	6.99	32.51	4.48	28.03	0.71	33.07	6.75	0.39	7.14	25.92	8.79	17.13	0.52

[2] Rainfall recharge value is from a model-based calibrated recharge estimation (after CoCT, 2020).
[3] Includes city municipal abstraction of 20 Mm³/a as per NWA Section 21(a). The total volume includes Managed Aquifer Recharge (as per NWA Section 21(e)WUL) of up to 14.6 Mm³/a (as a negative water use).
[4] Rainfall recharge value is from a model-based calibrated recharge estimation (after CoCT, 2018).
[5] Includes city municipal abstraction of 5 Mm³/a as per NWA Section 21(a). The total volume includes Managed Aquifer Recharge (as per NWA Section 21(e) WUL) of up to 4.2 Mm³/a (as a negative water use).
[6] Rainfall recharge value is from the first order GRAII Spatial Distribution (modified after CoCT, 2022).
[7] Includes city municipal abstraction of 8 Mm³/a in development (phase 1) as per NWA Section 21(a).

GRU	Groundwater Reserve								Combination Scenario – Most-Likely Case							
	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)	Allocable Factor	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)	Allocable Factor
Tulbagh	10.87	1.28	0.02	1.30	9.57	3.78	5.79	0.53	9.34	1.28	0.05	1.33	8.01	6.66	1.35	0.14
Eendekuil Basin	21.88	6.95	0.09	7.04	14.84	4.85	9.99	0.46	17.31	6.95	0.16	7.11	10.21	6.57	3.64	0.21
Middle-Lower Berg	42.49	11.15	0.09	11.24	31.26	2.23	29.03	0.68	36.88	11.15	0.16	11.31	25.57	5.09	20.48	0.56
Northern Swartland	31.85	0.20	0.05	0.25	31.60	1.79	29.81	0.94	26.11	0.20	0.09	0.29	25.82	2.92	22.90	0.88
Darling	9.95	0.03	0.02	0.05	9.91	0.76[8]	9.15	0.92	8.02	0.03	0.03	0.06	7.97	1.40	6.56	0.82
Vredenburg	7.43	0.00	0.01	0.01	7.42	1.16	6.26	0.84	6.63	0.00	0.02	0.02	6.61	1.97	4.64	0.70
TOTAL	**620.78**	**69.98**	**2.35**	**72.33**	**548.45**	**102.66**	**445.79**		**557.47**	**69.98**	**4.27**	**74.25**	**483.23**	**181.06**	**302.16**	

[8] *The WARMS dataset places Yzerfontein's municipal abstraction of 0.26 Mm³/a in the Darling GRU. It has been updated to reflect for the Yzerfontein GRU.*

2.6. Step 7: Monitoring Programme

Step 7 of the GRD process focused on designing a Monitoring Programme for the Berg catchment aimed at the sustainable management of the groundwater contribution to the Reserve. To achieve this, the report evaluated existing monitoring sites, considering both their spatial distribution and their relevance to the target aquifer unit, in order to determine their suitability for monitoring site-specific parameters. This effort built upon insights gained from The Berg Catchment WRCs and RQOs Study (DWS, 2016) as well as the other literature and data sources listed in **Section 2.1**, specifically the Groundwater Projects associated with City of Cape Town's New Water Programme, and the Berg River Baseline Monitoring Programme (DWAF, 2007).

Specific "Management Options" for the groundwater contribution to both the EWR and BHN Reserve, were developed, assigned, and prioritised using an Impact vs. Influence Matrix. Based on the outcomes of Steps 1-7 of the GRD process, the matrix integrated 'impact' factors, such as the 'Allocation Factor' (i.e., still allocable volume / recharge) and the 'Qualifying Population Density per GRU', as well as 'influence' factors such as the 'Groundwater Contribution to Baseflow' and the 'Groundwater Contribution to the BHN Reserve per GRU' (see **Figure 2-3** and **Table 2-8**).

While this matrix provided the overall prioritization framework, an additional layer of complexity was introduced to select aquifer-specific monitoring sites. Two key factors were considered: 1) the spatial misalignment between GRUs and surface water catchments, and 2) the need to monitor catchment-specific baseflow contributions.

To overcome these challenges, the groundwater contribution to baseflow (and by extension, its contribution to the EWR) was disaggregated to the respective river or estuary node's catchment area, aquifer type, and GRU. This approach identified catchments with the most significant influence on baseflow and therefore allowed for more representative monitoring site selection (**Figure 2-4**).

Similarly, for monitoring the groundwater contribution to the BHN Reserve, a higher resolution dataset for the 'Qualifying Population Density' was used to identify specific high-density areas within a GRU. This information guided the site selection in those areas (**Figure 2-4**).

Once the monitoring network was established, guidelines for monitoring activities, frequency, and the specific data collection at selected sites, were defined. Unique objectives were set for the groundwater contribution to both the EWR and BHN and was tailored to each GRU's respective Management Option. In instances where existing boreholes were inactive or no longer effective as a monitoring site (e.g., inaccessible or targeting the wrong aquifer unit, etc), recommendations on the locations of proposed new boreholes were provided.

Comprehensive details about the approach, methodology, and results can be found in the Monitoring Programme Report (DWS, 2023e).

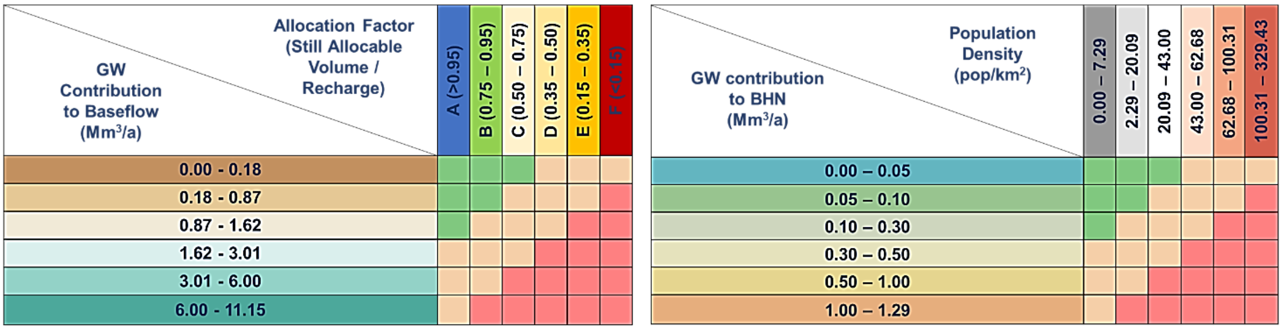


Figure 2-3 The Impact vs. Influence Matrix for groundwater contribution to the EWR Reserve (left) and for groundwater contribution to the BHN Reserve (right).

Table 2-8 Summary table of the Management Options per GRU for groundwater contribution to both the EWR and BHN, including the associated 'impact' and 'influence' variables considered in the Impact vs. Influence Matrix.

GRU	Allocation Factor per GRU	Groundwater Contribution to Baseflow per GRU (M m³/a)	Management Options for Groundwater Contribution to EWR	Groundwater Contribution to the BHN Reserve (M m³/a)	Qualifying Population Density per GRU (pop/km²)	Management Options for Groundwater Contribution to BHN
Primary / Intergranular Aquifers						
Cape Flats	0.36	0.51	2	1.29	329.43	3
Atlantis	0.84	0.08	1	0.05	20.09	1
Yzerfontein	0.70	0.02	1	0.02	5.84	1
Elandsfontein	0.31	6.39	3	0.01	1.97	1
Langebaan Road	0.18	5.52	3	0.03	4.00	1
Adamboerskraal	0.53	6.00	3	0.01	2.50	1
Fractured Table Mountain Group Aquifers						
Cape Peninsula	0.38	5.43	3	0.16	56.44	2
Steenbras- Nuweberg	0.56	1.16	2	0.02	13.11	1
Drakensteinberge	0.85	2.88	2	0.01	3.94	1
Wemmershoek	0.80	3.59	2	0.00	1.27	1
Voëlvlei-Slanghoek	0.85	1.62	2	0.01	6.11	1
Witzenberg	0.87	0.18	1	0.00	11.22	1
Groot Winterhoek	0.80	0.77	1	0.03	7.68	1
Piketberg	0.37	2.07	3	0.06	17.57	1
Fractured and Intergranular Basement						
Cape Town Rim	0.39	0.87	2	0.36	100.31	3
Stellenbosch-Helderberg	0.63	2.34	2	0.46	87.79	3
Paarl-Franschhoek	0.24	3.01	3	0.21	62.68	2
Malmesbury	0.39	1.18	2	0.64	43.46	3
Wellington	0.52	6.75	3	0.39	39.70	2
Tulbagh	0.14	1.28	3	0.05	17.74	1
Eendekuil Basin	0.21	6.95	3	0.16	18.16	2
Middle-Lower Berg	0.56	11.15	3	0.16	11.82	2
Northern Swartland	0.88	0.20	1	0.09	7.90	1
Darling	0.82	0.03	1	0.03	7.72	1
Vredenburg	0.70	0.00	1	0.02	6.24	1
TOTAL		**69.98**		**4.27**		

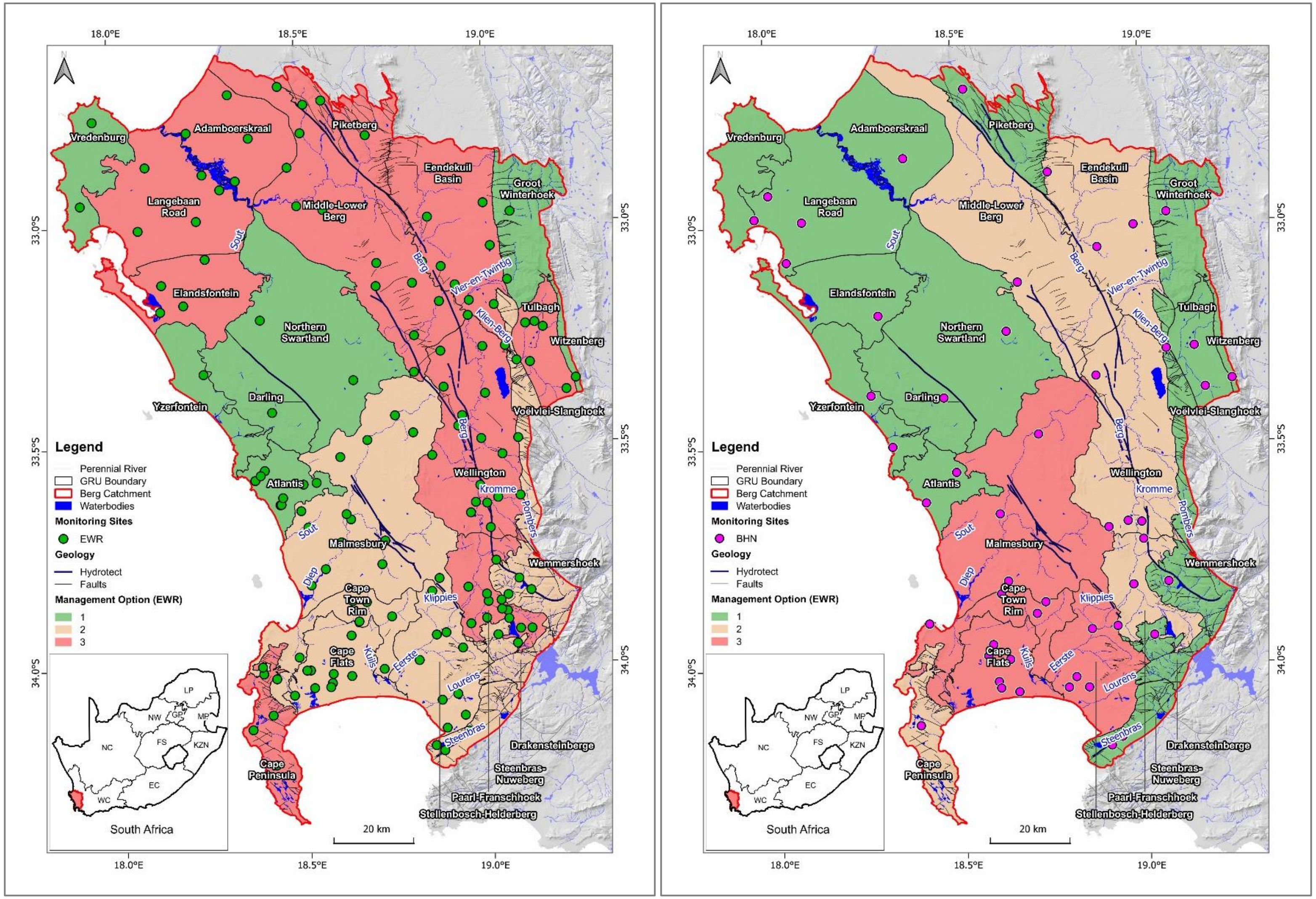


Figure 2-4 **Summary maps (left) illustrating Management Options for the groundwater contribution to the EWR and associated monitoring locations (left); and (right) illustrating Management Options for the groundwater contribution to BHN Reserve and associated monitoring locations.**

3. SUMMARY

Step 8 of the GRD process involved initiating the Gazetting process and implementing the Groundwater Reserve (see **Section 1.4**). This phase included the compilation of a single Groundwater Reserve Determination Report (i.e., Deliverable 3.7), offering a comprehensive summary of findings and recommendations resulting from the GRD process conducted for the Berg catchment. The overarching goal was to provide aquifer-specific information for various hydrogeological components considered for the Groundwater Reserve, specifically the groundwater contribution to the BHN and EWR.

The report integrated insights from the Ecological Reference Conditions Report (Step 3 of the GRD process), involving a reassessment of ecological conditions and present status of the catchment. It also correlated the analysis of various hydrogeological components, including Recharge, Groundwater Use, Discharge, Groundwater Quality, and Aquifer Stress. Building on the foundation of Step 3 and incorporating information from Steps 4-7 (see **Section 1.4**), this report offers a holistic perspective on the hydrogeological components for the catchment, with organized tables describing the Groundwater Reserve per GRU. The Reserve components are outlined below:

1. **Groundwater Quantity Component**

   The groundwater quantity component of the Reserve was outlined in the GRU-specific tables provided below (refer to **Section 3.1** - **3.3**) and further discussed in **Sections 2.3** and **2.4**. It was calculated by considering the total groundwater contribution to both the EWR and BHN Reserves.

2. **Groundwater Quality Component**

   The groundwater quality component of the Reserve was outlined in the GRU-specific tables provided below (refer to **Section 3.1** - **3.3**) and further discussed in **Sections 2.3** and **2.4**. It was determined by assessing two primary components:

   A. **Groundwater Quality Reserve**

      I. The groundwater quality reserve is selected based on the higher concentration of either the baseline concentration or the 95th percentile within the specific aquifer in a GRU.

         i) Baseline Concentration: This signifies the baseline concentration, reflecting the ambient or natural state of the aquifer system, for a specific parameter in a representative borehole (please refer to DWS, 2022d, 2022e, and 2023a for detailed information).

         ii) 95th Percentile Concentration: This is calculated from all available data within a GRU and for the specific aquifer.

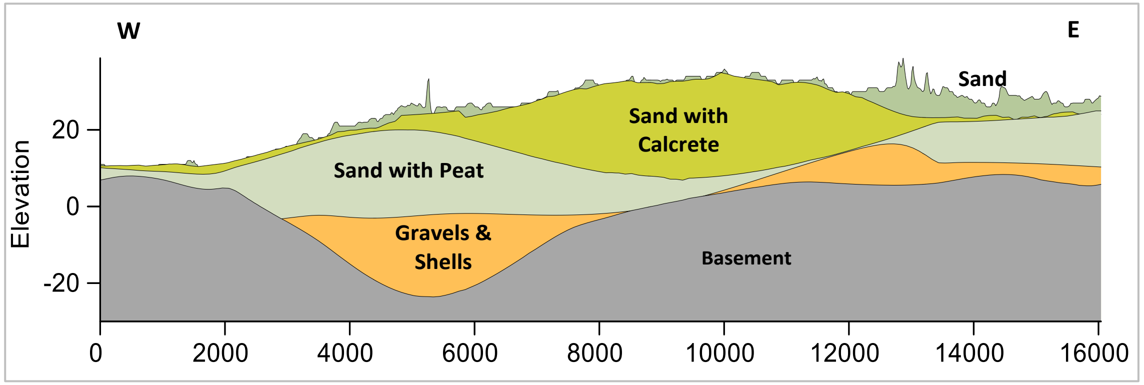
   B. **Groundwater Quality BHN Reserve**

      I. TBC (To Be Confirmed): Further confirmation is required for this component.

In essence, the Groundwater Reserve Determination Report signified the culmination of the High Confidence Groundwater Reserve Determination project for the Berg catchment, aligning with the gazetted requirements for the region as outlined in Gazette No. 42451:121.

3.1. Primary / Intergranular GRUs

3.1.1. Cape Flats GRU

GRU	GRU Name: Cape Flats Main Suburbs: Philippi, Bellville and Kuilsriver Total Area (km^2): 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 (km^2): 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 m^3/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 (km^2)	Recharge Volume (M m^3/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 m^3/a of groundwater (note that there is a Managed Aquifer Recharge component of -14.6 M m^3/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).

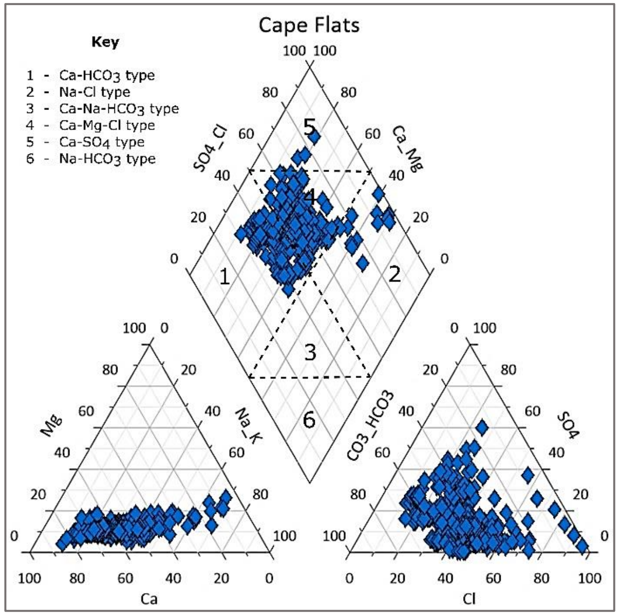
The registered groundwater use is concentrated in the PHA, with additional industrial use in the northern section of the GRU, as well as on the lower eastern slopes of the Peninsula Mountain range (i.e., Southern Suburbs). Importantly, none of the settlements within the GRU depend solely on groundwater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

[9] *Includes city municipal abstraction of 20 Mm^3/a as per NWA Section 21(a). The total volume includes Managed Aquifer Recharge (as per NWA Section 21(e) WUL) of up to 14.6 Mm^3/a (as a negative water use).*

GRU	GRU Name: Cape Flats Main Suburbs: Philippi, Bellville and Kuilsriver Total Area (km^2): 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

[10] *Rainfall recharge value is from a model-based calibrated recharge estimation (after CoCT, 2020).*
[11] *Includes city municipal abstraction of 20 Mm³/a as per NWA Section 21(a). The total volume includes Managed Aquifer Recharge (as per NWA Section 21(e)WUL) of up to 14.6 Mm³/a (as a negative water use).*

GRU	GRU Name: Cape Flats Main Suburbs: Philippi, Bellville and Kuilsriver Total Area (km^2): 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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Primary / Intergranular Aquifer	Sulphate	mg/l	37	581	44.40	2.00	326.00	45.40	100.80	100.80	
	Electrical conductivity	mS/m			113.72	13.00	578.00	88.85	111.19	113.72	
	pH				8.30	5.07	8.55	7.84	8.27	8.30	
	Ammonia	mg/l			0.08	0.02	31.89	0.06	0.82	0.82	
	Nitrate + nitrite	mg/l			8.35	0.02	23.20	1.12	11.92	11.92	
	Fluoride	mg/l			0.26	0.05	3.05	0.15	0.28	0.28	
	Orthophosphate	mg/l			0.03	0.00	1.35	0.01	0.07	0.07	
	Calcium	mg/l			112.16	3.81	266.50	101.50	128.50	128.50	
	Magnesium	mg/l			14.62	1.00	124.70	11.60	16.40	16.40	
	Sodium	mg/l			111.36	3.30	784.00	58.90	94.80	111.36	
	Potassium	mg/l			2.95	0.15	53.66	1.90	5.72	5.72	
	Chloride	mg/l			209.22	5.00	1993.00	100.00	173.50	209.22	

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 (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/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 m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 12.00 to 23.02 M m^3/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 m^3/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 (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
38.70	0.51	1.29	1.80	36.90	23.02	13.88

[12] *Rainfall recharge value is from a model-based calibrated recharge estimation (after CoCT, 2020).*
[13] *Includes city municipal abstraction of 20 Mm^3/a as per NWA Section 21(a). The total volume includes Managed Aquifer Recharge (as per NWA Section 21(e) WUL) of up to 14.6 Mm^3/a (as a negative water use).*

GRU	GRU Name: Cape Flats Main Suburbs: Philippi, Bellville and Kuilsriver Total Area (km^2): 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).

<table>
<tr><th>Site Name</th><th>Data Source</th><th>Monitoring Area</th><th>Monitoring Objective</th><th>Latitude</th><th>Longitude</th><th>Monitoring Description</th></tr>
<tr><td colspan="7">EWR Management Option 2</td></tr>
<tr><td>G2N0008</td><td>HYDSTRA</td><td>Zeekoevlei</td><td>EWR</td><td>-34.01008</td><td>18.50937</td><td rowspan="9">Frequency: Quarterly
1) Groundwater level:
○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger.
2) Groundwater Quality:
○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4
○ Site specific additions for EWR: NO_2, NO_3, NH_4
○ 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)</td></tr>
<tr><td>G2N0104</td><td>HYDSTRA</td><td>Zeekoevlei</td><td>EWR</td><td>-34.050078</td><td>18.51937</td></tr>
<tr><td>G2N0612</td><td>HYDSTRA</td><td>GRU</td><td>EWR</td><td>-34.01902</td><td>18.57068</td></tr>
<tr><td>G2N0649</td><td>HYDSTRA</td><td>GRU</td><td>EWR</td><td>-34.03966</td><td>18.56788</td></tr>
<tr><td>G2N0653</td><td>HYDSTRA</td><td>GRU</td><td>EWR</td><td>-34.04875</td><td>18.56313</td></tr>
<tr><td>G2N0108</td><td>HYDSTRA</td><td>GRU</td><td>EWR</td><td>-34.02465</td><td>18.62082</td></tr>
<tr><td>G2N0619</td><td>HYDSTRA</td><td>GRU</td><td>EWR</td><td>-33.9331</td><td>18.62162</td></tr>
<tr><td>G2N0059</td><td>HYDSTRA</td><td>Zeekoevlei</td><td>EWR</td><td>-34.01008</td><td>18.49937</td></tr>
<tr><td>3418AB00077</td><td>NGA</td><td>Bvii7</td><td>EWR</td><td>-34.06602</td><td>18.46429</td></tr>
<tr><td colspan="7">BHN Management Option 3</td></tr>
<tr><td>3318DC00004</td><td>NGA</td><td>GRU</td><td>BHN</td><td>-33.97801</td><td>18.56871</td><td rowspan="6">Frequency: Monthly or Quarterly
1) Groundwater level:
○ 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):
○ 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</td></tr>
<tr><td>3318DC00114</td><td>NGA</td><td>GRU</td><td>BHN</td><td>-33.95301</td><td>18.5826</td></tr>
<tr><td>3318DC00163</td><td>NGA</td><td>GRU</td><td>BHN</td><td>-33.98717</td><td>18.6276</td></tr>
<tr><td>3418BA00026</td><td>NGA</td><td>GRU</td><td>BHN</td><td>-34.03686</td><td>18.59568</td></tr>
<tr><td>3418BA00346</td><td>NGA</td><td>GRU</td><td>BHN</td><td>-34.06075</td><td>18.65068</td></tr>
<tr><td>88847</td><td>WMS</td><td>GRU</td><td>BHN</td><td>-34.051389</td><td>18.601389</td></tr>
</table>

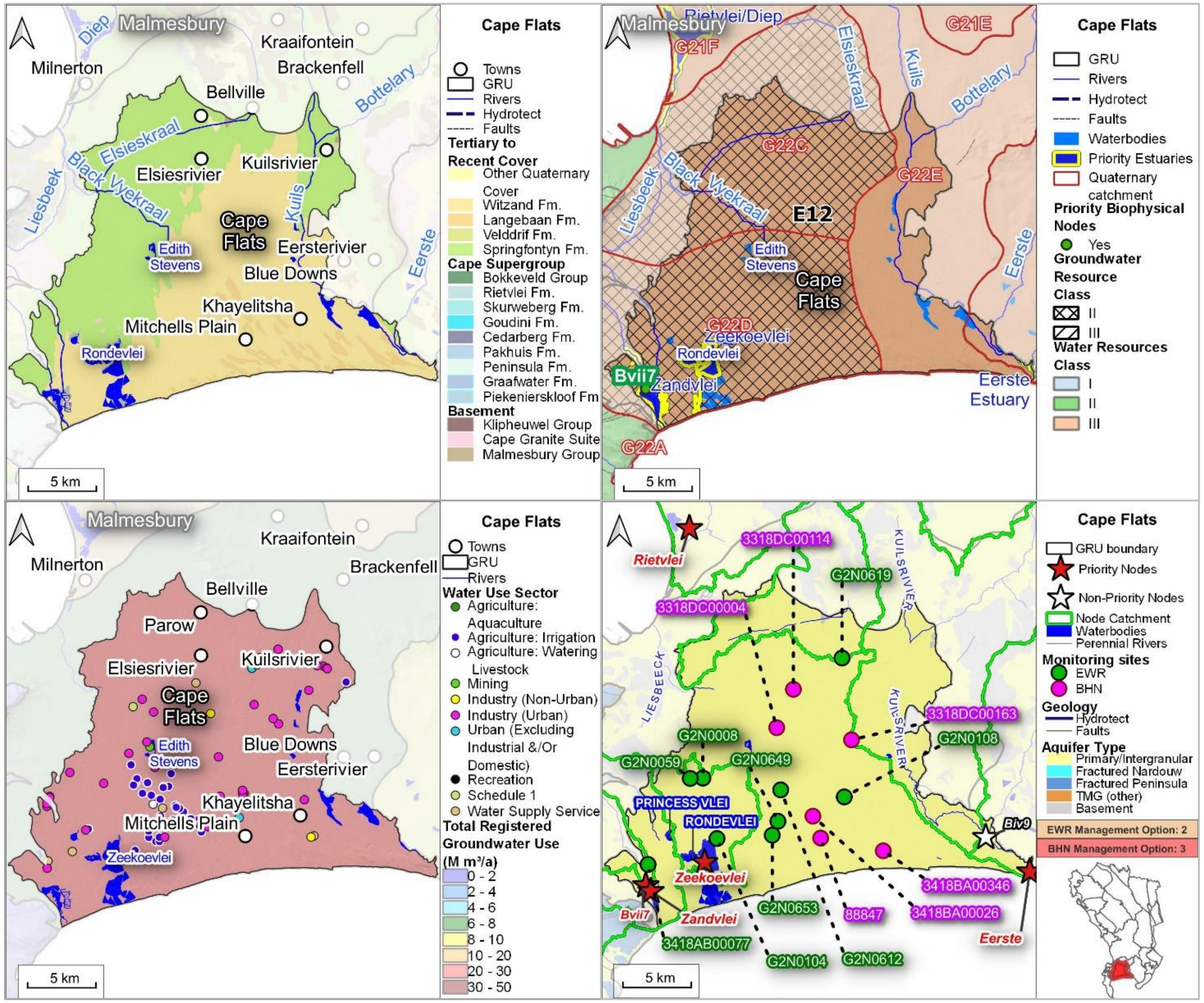
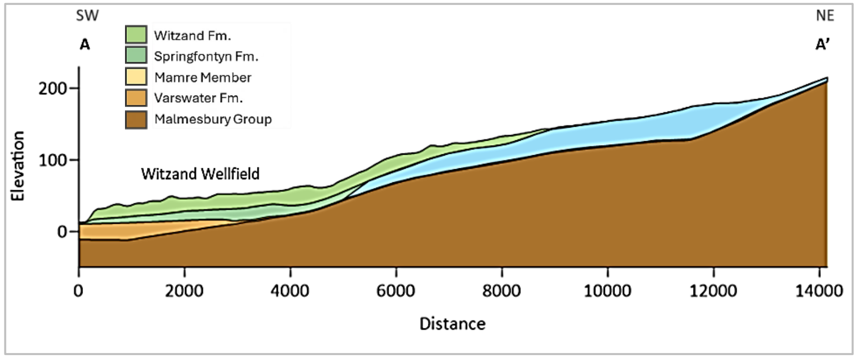
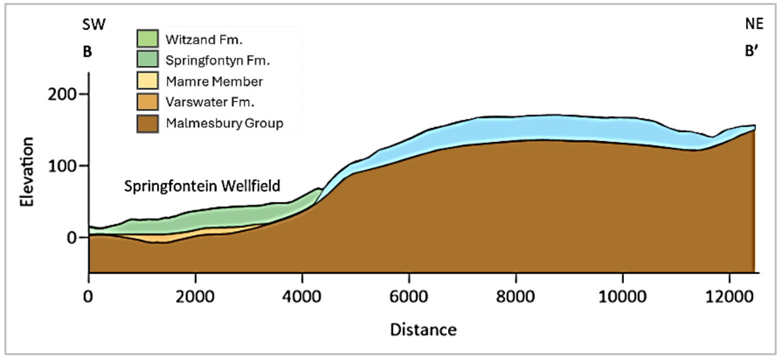


Figure 3-1 A series of maps for the Cape Flats GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.1.2. Atlantis GRU

GRU	GRU Name: Atlantis Main Towns: Atlantis and Melkbosstrand Total Area (km^2): 255.68
GRU Boundary Description	The aquifer model boundary for the GRU, as outlined by CoCT (2020b), delineates the Atlantis GRU's extent (refer to **Figure 3-2** and DWS, 2022d and 2023a). This boundary was established by considering areas with a marginal thickness of 0 m, indicating where the aquifer pinches out. The northeast and southeast boundaries are further refined by the outcrop extent of low-permeability basement lithologies, namely the Malmesbury Group and the CGS. To the north, the Modder and Louwskloof rivers define the boundary, while the southwestern extent is bounded by the Sout River, and the western edge is constrained by the coastline. Additionally, the boundary accounts for preferential flow directions towards the coastline on the eastern edge of the GRU (refer to **Figure 3-2** and DWS, 2022d and 2023a).
Quaternary Catchments	G21A, G21B and G21D (**Figure 3-2**)
Resource Unit	Primary / Intergranular Aquifer
Description	The Atlantis Aquifer consists of Tertiary to Quaternary aged marine and aeolian sedimentary deposits belonging to the Sandveld Group. In the Atlantis area, these deposits, including the Langebaan, Witzand, Springfontyn, and Varswater Fms, unconformably overlie the Neoproterozoic to early Cambrian Tygerberg Fm (Malmesbury Group) and Darling Pluton (CGS). The Cenozoic aquifer unit, approximately 40-60 meters thick, is classified as a primary, unconsolidated, intergranular aquifer, allowing groundwater movement through the pores between sediment. Although mainly classified as unconfined, the presence of intermittent clay and calcrete lenses in the Springfontyn Fm may lead to semi-confined conditions (see **Figure 3-2**). The basement aquifer includes the Malmesbury Group (i.e., Tygerberg Fm - shales/phyllites) and plutonic CGS basement rocks. Interpolated basement geology from the CoCT (2020b) suggests a westward decrease in bedrock elevation from the Atlantis town region to the coast, potentially influencing groundwater flow parallel to the coast (see the cross sections below). The Malmesbury Group is considered a basal aquiclude to the overlying aquifer. The potential interaction between groundwater and the weathered shales of the Tygerberg Fm and the overlying Sandveld Group is not definitive and may require further investigation (refer to DWS, 2022d and 2023a). Two cross-sections illustrate the spatial variation of geology across the aquifer. Cross-section A shows the presence of the overlying Witzand Fm, while cross-section B highlights the prevalence of the Springfontyn Fm (refer to **Figure 3-2** for the extent of the cross section).





GRU	GRU Name: Atlantis Main Towns: Atlantis and Melkbosstrand Total Area (km^2): 255.68

Surface Water System

The Atlantis GRU comprises of the perennial Silwerstroom River which is fed by the Silwerstroom spring. The Donkergat and Sout Rivers flow to the south of the Atlantis area in winter, while surface drainage to the north and east of Atlantis contributes to the catchment areas of the Modder, Louwskloof and Diep rivers respectively. All these rivers are non-perennial, drying up in summer (Tredoux et al., 2009). Groundwater may discharge and support minor wetlands in coastal dunes, and to submarine discharge (see **Figure 3-2**).

The Atlantis GRU is characterized by the perennial Silwerstroom River, fed by the Silwerstroom spring. During the winter, the Donkergat and Sout Rivers flow to the south of the Atlantis area. Additionally, surface drainage to the north and east of Atlantis contributes to the catchment areas of the Modder, Louwskloof, and Diep rivers. Notably, these rivers are non-perennial, drying up in the summer. In this region, groundwater may discharge and provide support to minor wetlands in coastal dunes, as well as contribute to submarine discharge (refer to DWS, 2022d, 2022e and 2023a for detail).

Water Resource Classes & RQOs

The GRU falls within the West Coast (A3) and Diep (D10) IUAs, both holding a Water Resource Class III and a Groundwater Resource Class of III (only for portions of the GRU within catchments G21B and G21D). This IUA does not contain any EWR sites, nor does it feature any priority biophysical nodes (see **Figure 3-2**).

Recharge

An estimated recharge of 22.74 M m^3/a was obtained from a model-based calibrated recharge (refer to CoCT, 2020b) for the Atlantis Primary/Intergranular Aquifer (refer to the table below). The average recharge rate was calculated as 88.94 mm/a based on the total GRU area. For further details, please refer to DWS (2022e).

Method	Area (km^2)	Recharge Volume ($M m^3/a$)	Average Recharge Rate (mm/a)
Model-based calibrated recharge (after CoCT, 2020b)	255.68	22.74[14]	88.94

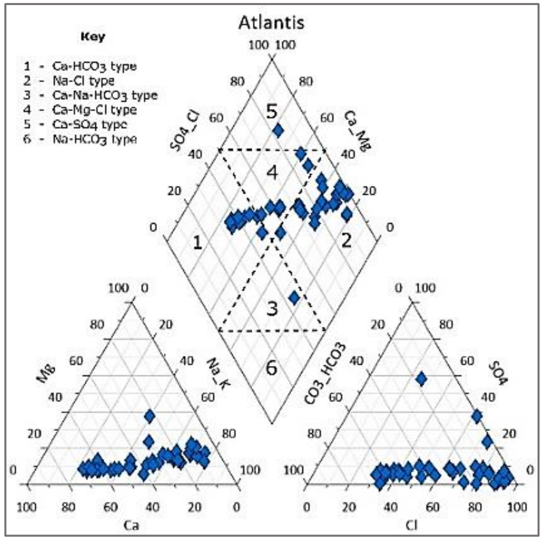
Groundwater Use

In the Atlantis GRU, there are 24 registered groundwater users (see **Figure 3-2** and the table to the right) collectively utilizing 1.7 M m^3/a of groundwater (note that there is a Managed Aquifer Recharge component of -4.2 M m^3/a). According to the WARMS database, Industry (Urban) is the predominant sector for groundwater use, accounting for 86.8% of total water use in the area. Despite this high percentage, it is noted that the Atlantis Water Resource Scheme (Municipal Water Supply) is classified under 'Industrial use' rather than 'Water Supply Service' for Atlantis, therefore, it is a classification discrepancy in the WARMS database.

The Mining and Agricultural Sectors each contribute approximately 0.5 M m^3/a to the annual groundwater use, though it's essential to highlight that these percentages do not incorporate the Managed Aquifer Recharge component. Additionally, it's crucial to mention that the abstraction of 1 M m^3/a by Eskom is not registered in the WARMS database.

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Primary / Intergranular Aquifer		
Agriculture: Irrigation	9	0.16
Agriculture: Watering Livestock	6	0.33
Industry (Non-Urban)	1	0.04
Industry (Urban)	7	5.00
Mining	1	0.37
MAR	-	- 4.2
Total	24	1.7

[14] *Rainfall recharge value is from a model-based calibrated recharge estimation (after CoCT, 2018).*

GRU	GRU Name: Atlantis Main Towns: Atlantis and Melkbosstrand Total Area (km^2): 255.68
Water Quality	 The primary water types in Atlantis are Na-Cl and Ca-HCO_3. Na-Cl waters are predominantly influenced by the deposition of marine aerosols and recharge through coastal rainfall, exhibiting a typical Na-Cl signature. Boreholes situated near shallow basement rocks of the Tygerberg Fm may also contribute to elevated Na and Cl ion concentrations, imparting the Na-Cl character to the groundwater in the primary aquifer above. Ca-HCO_3 waters result from the dissolution of calcium carbonate minerals found in calcareous sands of the Witzands Fm, releasing Ca and HCO_3 ions. Out of the 39 samples collected 3 samples exceeded the RQO for EC, and 4 samples exceeded the RQO for pH. The occurrence of acidic waters in Atlantis (below RQO thresholds) may be attributed to the leaching of basic ions from soils, anthropogenic inputs, and the dissolution of humic compounds from overlying vegetation. The adjusted water quality category is C, indicating the presence of some localized contamination (refer to DWS, 2022d, 2022e and 2023a for details).
Aquifer Stress	The GRU is considered to have a Groundwater Availability Present Status Category of ‘C’, indicating a moderately stressed aquifer, and a Groundwater Quality Present Status Category of ‘C’ indicating moderate levels of widespread contamination, which limit the use of potential use of the aquifer (refer to the table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
22.74[15]	1.7	0.07	B	C

[15] *Includes city municipal abstraction of 5 M m^3/a as per NWA Section 21(a). The total volume includes Managed Aquifer Recharge (as per NWA Section 21(e) WUL) of up to 4.2 M m^3/a (as a negative water use).*

GRU

GRU Name: Atlantis
Main Towns: Atlantis and Melkbosstrand
Total Area (km²): 255.68

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Primary / Intergranular Aquifer	Sulphate	mg/l	31	42	24.70	2	355.7	19.8	125.77	125.77	
	Electrical conductivity	mS/m			99.74	38.1	156.7	85.55	143.43	143.43	
	pH				7.73	2.6	8.35	7.6	8.08	8.08	
	Ammonia	mg/l			1.16	0.02	1.22	0.06	0.3	1.16	
	Nitrate + nitrite	mg/l			0.05	0.02	2.19	0.02	0.41	0.41	
	Fluoride	mg/l			1.16	0.05	1.33	0.15	0.53	1.16	
	Orthophosphate	mg/l			0.10	0.003	1.297	0.0305	0.15	0.15	
	Calcium	mg/l			46.05	4.8	183.5	59.55	96.5	96.5	
	Magnesium	mg/l			17.28	4.9	35.8	9.9	26.89	26.89	
	Sodium	mg/l			116.14	22.6	219.4	95.35	200.31	200.31	
	Potassium	mg/l			5.57	0.35	6.86	2.865	5.92	5.92	
	Chloride	mg/l			240.93	37.1	435.4	145.85	393.83	393.83	

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)
22.74[16]	0.08	0.03	0.11	22.63	1.7[17]	20.93

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 22.74 to 21.63 M m³/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 1.7 to 3.31 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 0.03 to 0.05 M m³/a, primarily attributed to population growth. Under these conditions, the Allocation Category did not change from a category B (refer to Section 2.5).

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)
21.63	0.08	0.05	0.13	21.50	3.31	18.19

[16] *Rainfall recharge value is from a model-based calibrated recharge estimation (after CoCT, 2018).*
[17] *Includes city municipal abstraction of 5 Mm³/a as per NWA Section 21(a). The total volume includes Managed Aquifer Recharge (as per NWA Section 21(e) WUL) of up to 4.2 Mm³/a (as a negative water use).*

GRU	GRU Name: Atlantis Main Towns: Atlantis and Melkbosstrand Total Area (km^2): 255.68
Monitoring Programme	The Atlantis GRU was assigned a Management Option 1 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 9 monitoring sites for the EWR and 2 for the BHN were strategically selected within the Atlantis GRU (**Figure 3-2**).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 1						
G2N0168	HYDSTRA	Bviii10	EWR	-33.58972222	18.50138889	Frequency: Quarterly or Biannual (Summer & Winter) 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Biv6: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen); Toxins (Atrazine and Endusulfan).
G2N0561	HYDSTRA	Biv6	EWR	-33.58638889	18.53666667	
AT-S17	CoCT	Silwerstroom	EWR	-33.57891838	18.37115813	
AT-MON01	CoCT	GRU	EWR	-33.63501833	18.43758444	
AT-EX01	CoCT	GRU	EWR	-33.55694787	18.39766521	
G2N0142	HYDSTRA	Silwerstroom	EWR	-33.57888889	18.37166667	
G2N0662	HYDSTRA	GRU	EWR	-33.5683	18.38632	
G2N0160	HYDSTRA	GRU	EWR	-33.63444444	18.44055556	
AT-MON05	CoCT	GRU	EWR	-33.61920291	18.44525844	
BHN Management Option 1						
91733	WMS	GRU	BHN	-33.628889	18.409722	Frequency: Quarterly or Biannual (Summer & Winter): 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms
3318CB00186	NGA	GRU	BHN	-33.5619	18.49342	

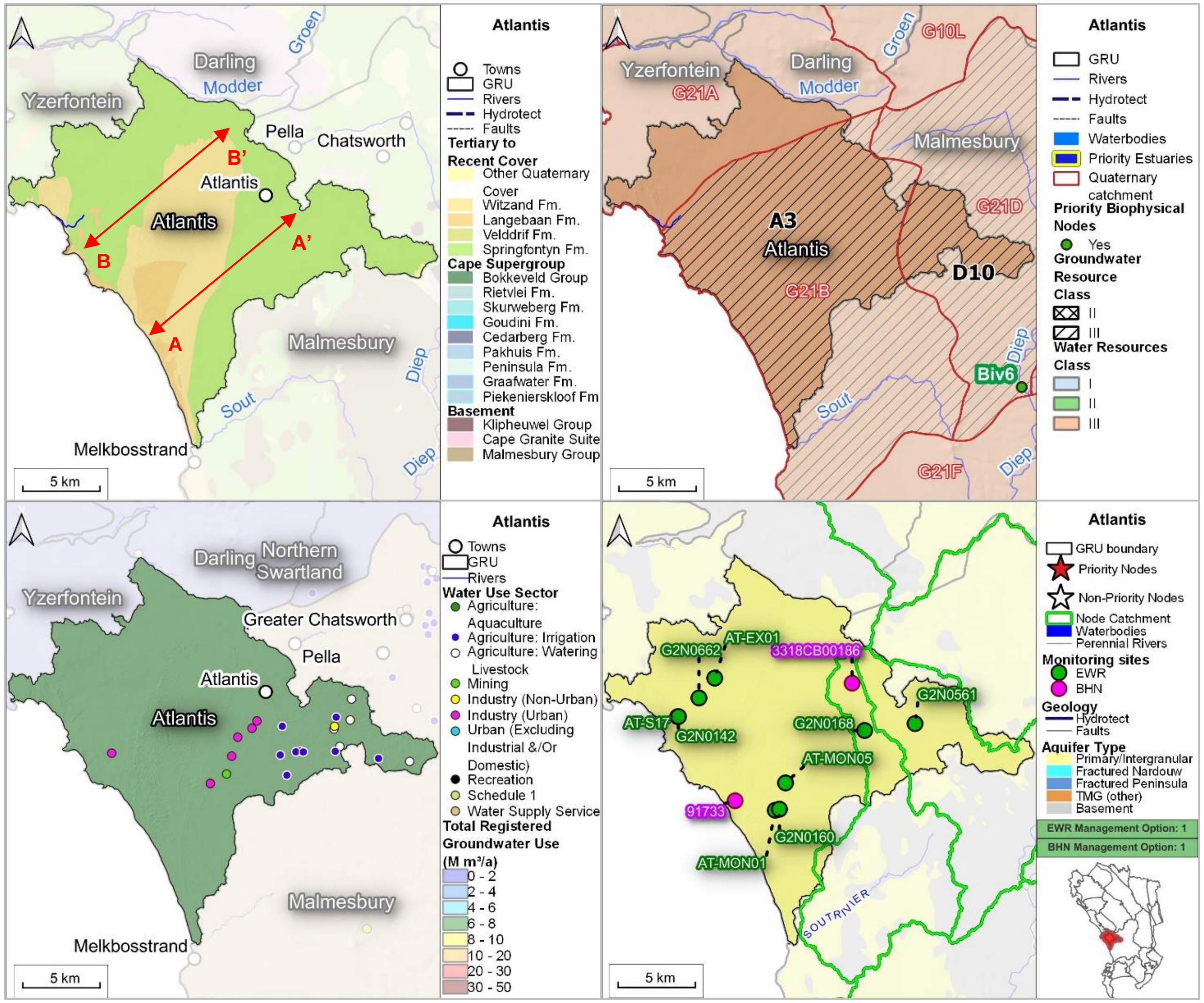


Figure 3-2 **A series of maps for the Atlantis GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

3.1.3. Yzerfontein GRU

GRU	GRU Name: Yzerfontein Main Towns: Yzerfontein Total Area (km²): 320.33
GRU Boundary Description	The Yzerfontein GRU was delineated by the Atlantis aquifer model boundary (CoCT 2020). To the north-east, it was defined by the outcrop of the CGS, while the Modder River marked the southern and south-eastern edges. The demarcation between the Yzerfontein GRU and the Elandsfontein GRU was established along the G10M and G21A surface water quaternary catchment, taking into account the preferential flow and discharge direction in the south-westerly direction. The coastline served as the western boundary of the GRU. It was acknowledged that there may be a hydraulic connection between the two aquifers (refer to **Figure 3-3** and DWS, 2022d and 2023a).
Quaternary Catchments	G21A (**Figure 3-3)**
Resource Unit	Primary / Intergranular Aquifer
Description	The primary aquifer in this region is formed by laterally continuous layers of the Sandveld Group, attaining significant thicknesses. Determining the aquifer depth poses challenges due to the difficulty in distinguishing between unconsolidated deposits and weathered bedrock materials. Various geophysical prospecting methods were employed to estimate the aquifer depth, with an approximation of around 50 meters (Tiimerman, 1985). The Sandveld Group comprises the Springfontyn Fm, which is widespread throughout the majority of the GRU, as well as the Witzand and Langebaan Fms to the northwest. The basement is primarily composed of the Malmesbury Group, which predominantly outcrops in the southern portion around the Modder River and in other intermittent locations within the GRU (see **Figure 3-3** and DWS, 2022d and 2023a).
Surface Water System	Primary surface water bodies in the area consist of the Dwars, Jakkals, and Modder rivers. Groundwater discharge plays a role in sustaining minor wetlands within coastal dunes and contributes to submarine discharge into the ocean (see **Figure 3-3** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls within the West Coast (A3) and is assigned a Water Resource Class III with no Groundwater Resource Class specified. There are no EWR sites within this IUA; however, it includes 1 priority biophysical river node with a TEC of D (see **Figure 3-3** and the table below).
Recharge	An estimated recharge of 9.20 M m³/a was derived from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessment. The average recharge rate was calculated as 28.72 mm/a based on the total GRU area. Additional recharge estimations can be found in the literature. For further details, please refer to DWS (2022e).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
A3 Wast Coast	III	G21A	A3-R01		Bviii3	D	14.6

Method	Area (km²)	Recharge Volume (M m³/a)	Average Recharge Rate (mm/a)
Map-Centric Simulation method	320.33	9.20	28.72

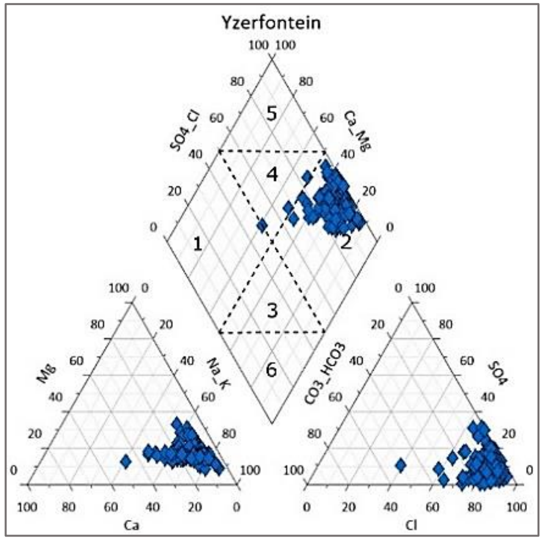
GRU	GRU Name: Yzerfontein Main Towns: Yzerfontein Total Area (km^2): 320.33

Groundwater Use

In the Yzerfontein GRU, there is a single registered groundwater user with a total annual groundwater use of 0.26 M m^3/a in the Water Supply Scheme Service Sector. Notably, the WARMS dataset incorrectly assigns Yzerfontein's municipal abstraction of 0.26 M m^3/a to the Darling GRU (as indicated by the red arrow in **Figure 3-3**). This information has been rectified to accurately represent the Yzerfontein GRU.

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Primary / Intergranular Aquifer		
Water Supply Service	1	0.26
Total	1	0.26

Water Quality



The primary water types in Yzerfontein are Na-Cl and Ca-Mg-Cl. Na-Cl waters are attributed to the deposition of marine aerosols and recharge through coastal rainfall, displaying a typical Na-Cl signature. Ca-Mg-Cl waters result from Na^+ cation exchange between Na-Cl type waters and Ca^{2+} and Mg^{2+} ions in the lithology, primarily sourced from the Langebaan and Witzands Fms.

No RQOs have been gazetted for the G21A drainage region. Nevertheless, exceedance of baseline threshold values is noted for EC and orthophosphate. This could potentially be influenced by the CGS (for EC) and fertilizer use (for orthophosphate) in agriculture. Despite these observations, the adjusted water quality category for this GRU is A, indicating that, on average, the aquifer is considered pristine (refer to DWS, 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'A', indicating an unstressed or slightly stressed aquifer, and a Groundwater Quality Present Status Category of 'A' indicating unmodified, pristine conditions (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
9.20	0.26	0.03	A	A

GRU	GRU Name: Yzerfontein Main Towns: Yzerfontein Total Area (km²): 320.33
Groundwater Reserve	Groundwater Quality Component (see below); Groundwater Quantity Component (see below)
Future Scenario 2050 (Scenario 7b)	See below

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Primary / Intergranular Aquifer	Sulphate	mg/l	49	140	109.04	2.00	277.90	40.13	106.15	109.04	
	Electrical conductivity	mS/m		142	111.70	35.20	588.00	104.10	253.45	253.45	
	pH			142	7.97	1.00	8.76	7.24	8.13	8.13	
	Ammonia	mg/l		139	0.11	0.02	1.16	0.04	0.29	0.29	
	Nitrate + nitrite	mg/l		139	0.51	0.01	4.18	0.09	0.97	0.97	
	Fluoride	mg/l		136	0.44	0.03	0.88	0.20	0.46	0.46	
	Orthophosphate	mg/l		139	0.05	0.00	0.81	0.06	0.38	0.38	
	Calcium	mg/l		140	24.06	6.20	221.70	19.20	93.42	93.42	
	Magnesium	mg/l		139	34.34	7.00	152.80	22.30	44.36	44.36	
	Sodium	mg/l		138	146.72	41.80	864.80	141.65	364.96	364.96	
	Potassium	mg/l		138	4.22	1.17	49.00	4.52	11.99	11.99	
	Chloride	mg/l		140	284.61	55.60	1646.00	263.25	666.04	666.04	

Groundwater Quantity 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 EWR Reserve, which is the groundwater quality required to maintain the EWR; and 2) the Groundwater Quality BHN Reserve, which is the groundwater quality…TBC

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)
9.2	0.02	0.01	0.03	9.17	0.26	8.91

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 9.2 to 7.60 M m³/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 0.26 to 2.26 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 0.01 to 0.02 M m³/a, primarily attributed to population growth. Under these conditions, the Allocation Category did not change from a category C (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)
7.60	0.02	0.02	0.04	7.56	2.26[18]	5.30

[18] *The WARMS dataset places Yzerfontein's municipal abstraction of 0.26 Mm³/a in the Darling GRU. It has been updated to reflect for the Yzerfontein GRU.*

GRU	GRU Name: Yzerfontein Main Towns: Yzerfontein Total Area (km^2): 320.33
Monitoring Programme	The Yzerfontein GRU was assigned a Management Option 1 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 1 monitoring sites for the EWR and 2 for the BHN were strategically selected within the Yzerfontein GRU (see **Figure 3-3** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 1						
3318AC00090	NGA	Bviii3	EWR	-33.33662	18.23898	Frequency: Quarterly or Biannual (Summer & Winter) 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4
BHN Management Option 1						
BG00506	NGA	GRU	BHN	-33.50172	18.32304	Frequency: Quarterly or Biannual (Summer & Winter): 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms
89820	WMS	GRU	BHN	-33.384722	18.267778	

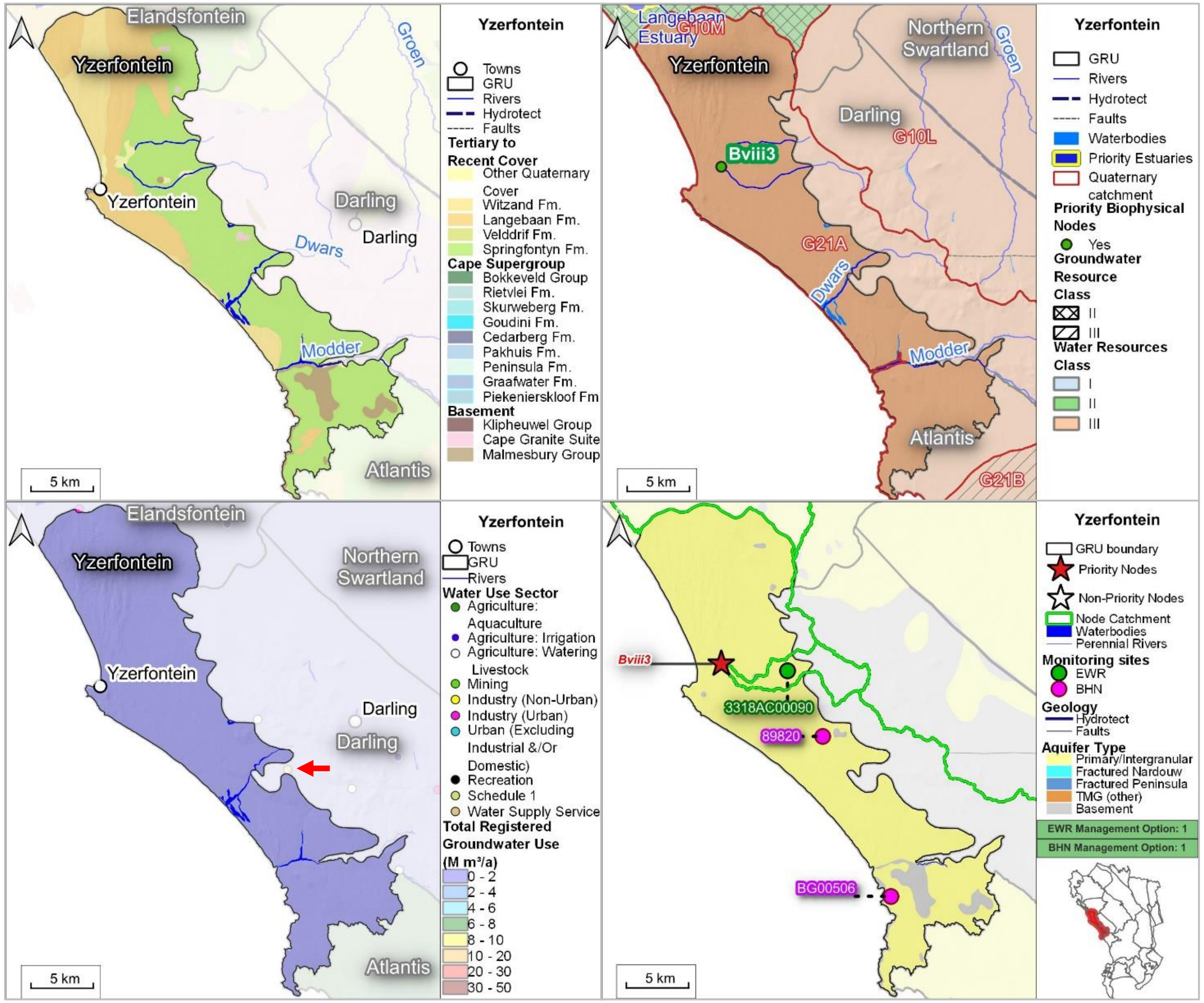


Figure 3-3 **A series of maps for the Yzerfontein GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

3.1.4. Elandsfontein GRU

GRU	GRU Name: Elandsfontein Main Towns: None Total Area (km²): 531.57
GRU Boundary Description	The Elandsfontein GRU was confined by the boundaries of the Springfontyn Fm to the east, encompassing sections of the Sout River. Additionally, its southern extent was determined by an interpolated extension of the CGS outcrop. The surface water quaternary catchment divide, at G10M and G21A, is a shared boundary between the Yzerfontein and Elandsfontein GRUs, taking into consideration the south-westerly preferential flow direction and discharge. The demarcation between the Elandsfontein and Langebaan Road GRUs was established based on an inferred basement high, specifically the Malmesbury Group and CGS, which extended from the eastern edge of the GRU towards the coast. However, it is worth noting that there is a potential hydraulic connection between the Elandsfontein and Langebaan Road aquifers. The western boundary of the GRU was defined by the coastline (see **Figure 3-4** and DWS, 2022d and 2023a).
Quaternary Catchments	G10M and G10L (**Figure 3-4**)
Resource Unit	Primary / Intergranular Aquifer
Description	The primary aquifer in this region consists of laterally continuous layers of the Sandveld Group, with an average thickness of approximately 70 meters. The Sandveld Group includes the Springfontyn Fm, prevalent across the majority of the GRU. This formation is mainly covered with Tertiary and Quaternary unconsolidated to semi-consolidated dune sands and calcrete. The groundwater recharge, flow, and discharge in the Elandsfontein Aquifer System are influenced by basement topography (paleochannels), faults, fissures, contact zones, and the stratigraphy of the Cenozoic deposits, contributing to the aquifer's complexity (see **Figure 3-4** and DWS, 2022d and 2023a). The Elandsfontein Aquifer System comprises a lower and upper sand aquifer separated by a clay unit and is situated between Hopefield and Langebaan Lagoon. Palaeo-courses of the Berg River, as noted by Timmerman (1985a, 1985b, and 1985c) and DWAF (2008e), have created incisions in the basement topography. These incisions are infilled by fluvial sediment of the Elandsfontyn Fm within the Sandveld Group and represent high-yielding zones. The basement of the aquifer is formed by Malmesbury Group shales and granites from the CGS. Granite outcrops are present in various locations, with granite underlying the Tertiary layers in the west and Malmesbury shale in the east (refer to DWS, 2022d and 2023a).
Surface Water System	Surface water availability in the region is constrained due to factors such as low rainfall, gentle topography, and the prevalent permeable sand-dominated geology (**Figure 3-4**). The aquifer primarily discharges into the Langebaan Lagoon, serving as the main surface water system in the GRU (refer to DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls within the Langebaan (A2) and Lower Berg (B4) IUAs, with Water Resource Class II and III, respectively. The segments of the GRU falling within IUA A2 (catchment G10M) are designated Groundwater Resource Class II, while those within IUA B4 (catchment G10L) have no Groundwater Resource Class assigned. Within the GRU, there is 1 priority estuary EWR site – the Langebaan Lagoon, which holds a TEC of A (see table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
A2 Langebaan	II	G10M	A2-E04	Langebaan	Bxi3	A	N/A

GRU	GRU Name: Elandsfontein Main Towns: None Total Area (km²): 531.57

Recharge

An estimated recharge of 15.47 M m³/a was obtained from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessment (see table below). The average recharge rate is 29.05 mm/a based on the total GRU area. For further details, please refer to DWS (2022e). A leaky hydraulic connection is presumed to exist between the upper and lower RU (refer to DWS, 2022d, 2022e and 2023a for detail).

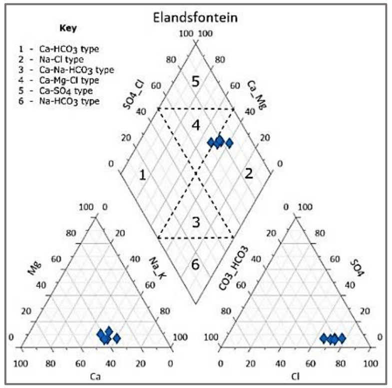
Method	Area (km²)	Recharge Volume (M m³/a)	Average Recharge Rate (mm/a)
Map-Centric Simulation method	532.57	15.47	29.05

Groundwater Use

In the Upper Primary Intergranular Aquifer, there are three registered groundwater users with a collective annual groundwater use of 0.87 M m³/a. The primary sectors driving groundwater consumption in this aquifer are Mining and Agriculture (Irrigation), contributing 80.5% and 18.3%, respectively, to the total annual groundwater use volume. The sole groundwater user in the Lower Primary Intergranular Aquifer is Agriculture (Irrigation), with an abstraction volume of 0.22 M m³/a (see **Figure 3-4** and the table to the right).

Water Use Sector	No. of Users	Total Volume (M m³/a)
Primary / Intergranular Aquifer (Upper)		
Agriculture: Irrigation	1	0.16
Industry (Urban)	1	0.01
Mining	1	0.70
Primary / Intergranular Aquifer (Lower)		
Agriculture: Irrigation	1	0.22
Total	4	1.09

Water Quality



The primary water types in Elandsfontein are Na-Cl and Ca-Mg-Cl. Na-Cl waters arise from the deposition of marine aerosols and recharge through coastal rainfall, exhibiting a typical Na-Cl signature. Ca-Mg-Cl type waters result from Na^{+} cation exchange between Na-Cl type waters and Ca^{2+} and Mg^{2+} ions in the lithology, primarily sourced from the Langebaan and Witzands Fms.

The Elandsfontein GRU falls under the G10L and G10M drainage regions. Four samples were collected from G10L, and 1 from G10M, with all samples meeting RQOs.

The adjusted water quality category is B, indicating that, although some low levels of contamination exist, predominantly natural groundwater quality conditions are present. However, further monitoring of additional locations within the Elandsfontein GRU is necessary to establish a more robust groundwater quality status.

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'B', indicating an unstressed or slightly stressed aquifer, and a Groundwater Quality Present Status Category of 'B' indicating localised, low levels of contamination, but no negative impacts apparent (see table below).

Recharge Volume (M m³/a)	Groundwater Use (M m³/a)	Stress Index	Groundwater Present Status Category (after WRC, 2007)	Adjusted Groundwater Quality Present Status Category
15.47	1.09	0.07	B	B

GRU	GRU Name: Elandsfontein Main Towns: None Total Area (km^2): 531.57
Groundwater Reserve	Groundwater Quality Component (see below)
Future Scenario 2050 (Scenario 7b)	(see below)

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Primary / Intergranular Aquifer	Sulphate	mg/l	3	5	12.90	12.10	29.20	12.10	25.94	25.94	
	Electrical conductivity	mS/m			49.10	45.50	101.90	49.10	91.72	91.72	
	pH				7.49	7.17	7.60	7.35	7.58	7.58	
	Ammonia	mg/l			0.14	0.04	0.14	0.12	0.14	0.14	
	Nitrate + nitrite	mg/l			4.62	0.15	4.62	1.51	4.04	4.62	
	Fluoride	mg/l			0.24	0.17	0.82	0.19	0.70	0.70	
	Orthophosphate	mg/l			0.19	0.01	0.30	0.19	0.29	0.29	
	Calcium	mg/l			37.26	26.50	83.40	34.20	74.24	74.24	
	Magnesium	mg/l			3.50	3.50	12.60	3.50	11.32	11.32	
	Sodium	mg/l			55.93	50.90	109.70	54.40	98.98	98.98	
	Potassium	mg/l			1.99	0.48	2.03	1.02	1.94	1.99	
	Chloride	mg/l			100.82	97.50	195.10	101.00	178.02	178.02	

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)
15.47	6.39	0.01	6.40	9.08	1.09	7.99

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 15.47 to 13.17 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 1.09 to 2.70 M m^3/a due to sectoral growth and the implementation of groundwater development schemes in the area. In light of these changes, the Allocation Category shifted from C to E (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)
13.17	6.39	0.01	6.40	6.77	2.70	4.07

GRU	GRU Name: Elandsfontein Main Towns: None Total Area (km²): 531.57
Monitoring Programme	The Elandsfontein GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 4 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Elandsfontein GRU (see **Figure 3-4** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
G1N0516	HYDSTRA	Langebaan Lagoon	EWRII	-33.19332	18.1269	Frequency: Monthly or Quarterly 1) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Bxi3 (Langebaan): Nutrients (NO_3); Salts; Pathogens (Enterococci & Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen, Secchi depth).
G1N0035	HYDSTRA	Langebaan Lagoon	EWR	-33.180118	18.189366	
G1N0513	HYDSTRA	Langebaan Lagoon	EWR	-33.07631	18.2503	
G1N0269	HYDSTRA	Langebaan Lagoon	EWR	-33.13302	18.13159	
BHN Management Option 1						
93871	WMS	GRU	BHN	-33.204722	18.291944	Frequency: Quarterly or Biannual (Summer & Winter): 1) Groundwater level: ○ Manual groundwater level measurements 3) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms

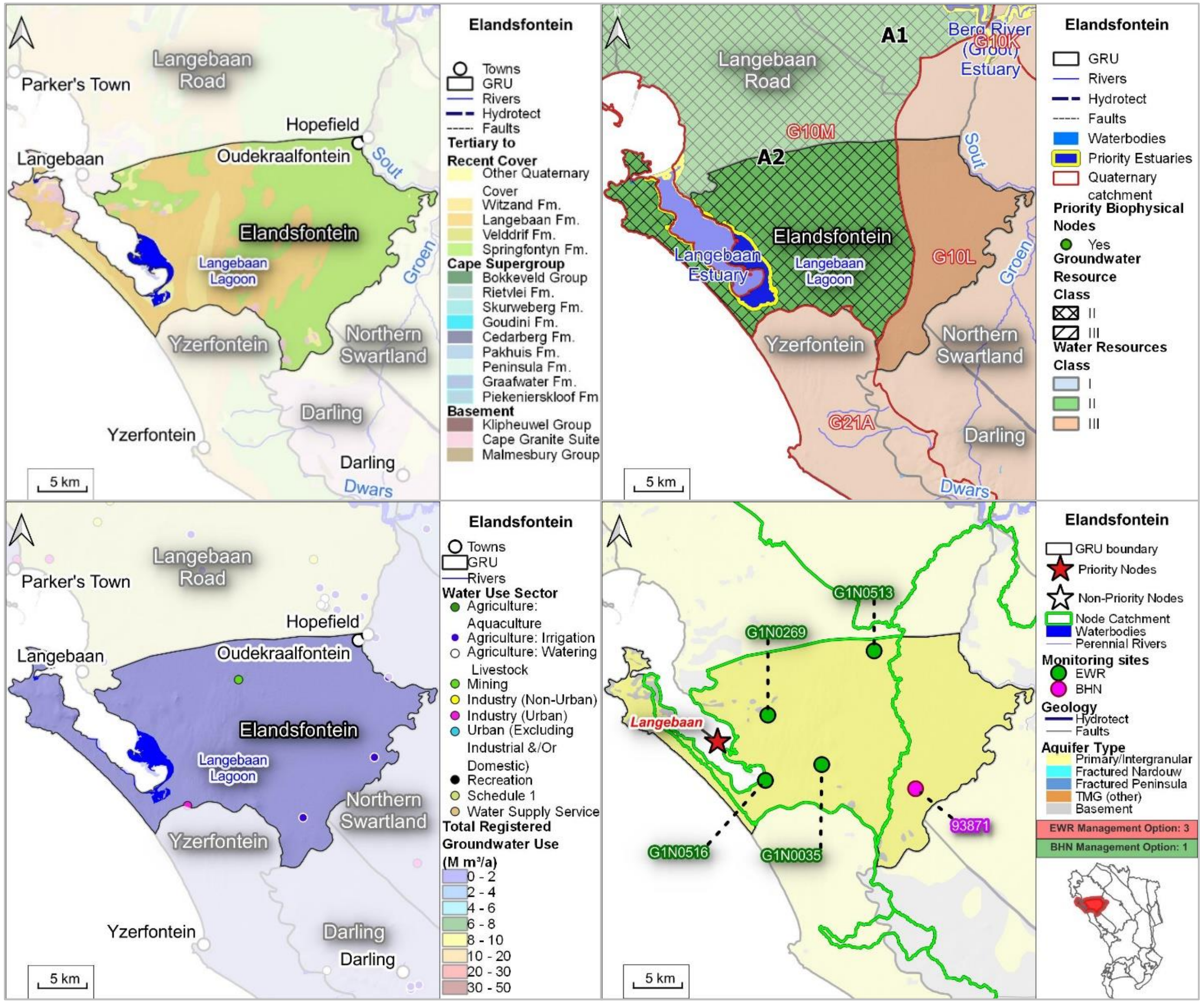


Figure 3-4 **A series of maps for the Elandsfontein GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

3.1.5. Langebaan Road GRU

GRU	GRU Name: Langebaan Road Main Towns: Langebaan Total Area (km^2): 903.71
GRU Boundary Description	The north-western boundary of the Langebaan Road GRU was determined by the interpolated extent of the CGS outcrop. The division between the Elandsfontein and Langebaan Road GRUs was established based on an inferred basement high, encompassing the Malmesbury Group and the CGS, which extended from the eastern edge of the GRU towards the coast of Saldanha Bay. The Berg and Sout rivers served as the boundaries for the eastern and south-eastern edges of the GRU, while the coastlines of Saldanha Bay and St Helena Bay defined the western and northern edges, respectively. The consideration of preferential flow direction towards Saldanha Bay played a role in defining the GRU boundary (see **Figure 3-5 and** refer to DWS, 2022d, 2022e and 2023a for detail).
Quaternary Catchments	G10M and G10L (**Figure 3-5**)
Resource Unit	Primary / Intergranular Aquifer
Description	The Langebaan region is characterized by semi- to unconsolidated Cenozoic sediments, with an average thickness ranging between approximately 50 meters to 70 meters. These sediments, dating from 65 million years ago to the present, unconformably overlie the metamorphosed shales of the Malmesbury Group and the granites of the CGS, which constitute the basement. The division between the Langebaan Road Aquifer System (Upper and Lower) and the Elandsfontein Aquifer System should be viewed primarily as a spatial distinction, as both aquifers are hydraulically connected in both the shallow and deep zones (WRC, 2016a). The Berg River flows roughly parallel to and just east of the regional contact between the Malmesbury Group and CGS, forming the eastern extent boundary of the GRU (**Figure 3-5**). The groundwater recharge, flow, and discharge in the Langebaan Road aquifer system are influenced by basement topography (paleochannels), faults, fissures, contact zones, and the stratigraphy of the Cenozoic deposits, contributing to the overall complexity of the system (refer to DWS, 2022d and 2023a).
Surface Water System	The Langebaan Road Aquifer System releases water into Saldanha Bay, St Helena Bay, and the Berg River/Groot Estuary, constituting the primary surface water system within this GRU (see **Figure 3-5** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls within the Berg Estuary (A1), Langebaan (A2), and Lower Berg (B4) IUAs, with Water Resource Class II, II, and III, respectively. The segments of the GRU within IUAs A1 and A2 (catchment G10M) have a Groundwater Resource Class of II, while those within IUA B4 (catchment G10L) lack a Groundwater Resource Class designation. Within the GRU, there are 2 priority estuaries: 1) the Langebaan Lagoon (an Estuary EWR site) with a TEC of A, and 2) the Berg River (Groot) Estuary, which has a TEC of C (**Figure 3-5** and the table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
A1 Berg Estuary	II	G10M	A1-E01	Berg (Groot)	Bxi1	C	52
A2 Langebaan	II	G10M	A2-E04	Langebaan	Bxi3	A	N/A

GRU	GRU Name: Langebaan Road Main Towns: Langebaan Total Area (km^2): 903.71

Recharge

An estimated recharge of 23.28 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 25.76 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. It is noted that a leaky hydraulic connection is presumed to exist between the upper and lower RU (refer to DWS, 2022e, for further details).

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map-Centric Simulation method	903.71	23.28	25.76

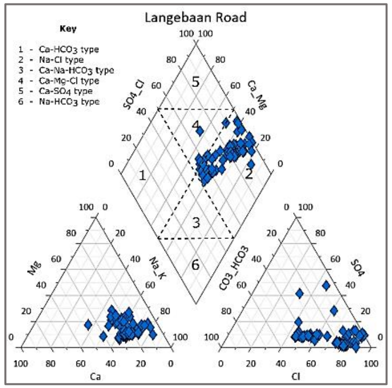
Groundwater Use

In the Upper Primary/Intergranular Aquifer, there are 16 registered groundwater users, collectively utilizing 0.78 M m^3/a. Agriculture (irrigation) stands out as the predominant groundwater user, accounting for 91.0% of the total annual groundwater use volume.

In the Lower Primary/Intergranular Aquifer, there are 17 registered groundwater users, with a cumulative groundwater use of 7.82 M m^3/a. The primary groundwater user in this aquifer is Water Supply Services, representing 87.4% of the total annual groundwater use volume. Please see **Figure 3-5** and the table below for detail.

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Primary / Intergranular Aquifer (Upper)		
Agriculture: Irrigation	9	0.71
Agriculture: Watering Livestock	2	0.02
Industry (Non-Urban)	4	0.01
Industry (Urban)	1	0.04
Primary / Intergranular Aquifer (lower)		
Agriculture: Irrigation	6	0.87
Agriculture: Watering Livestock	8	0.08
Water Supply Service	3	6.87
Total	33	8.59

Water Quality



The primary water type in the Langebaan Road GRU is Na-Cl, primarily resulting from the deposition of marine aerosols and recharge through coastal rainfall, displaying a typical Na-Cl signature. While Ca-HCO_3 waters are expected due to the extensive calcite-rich Langebaan Fm, no samples show this water type. Boreholes situated near shallow basement rocks of the Tygerberg Fm may contribute to the Na-Cl character in the overlying primary aquifer, given the elevated Na and Cl ion concentrations of this lithology.

Out of the 103 samples collected, 9 exceeded the RQO for EC, 18 for pH, and 1 for NO_3 + NO_2. Elevated EC values are likely influenced by the underlying Tygerberg Fm, while the predominantly basic pH is attributed to the dissolution of basic Ca and HCO_3 ions from the extensive Langebaan Fm. The adjusted water quality category is B, indicating that, although some low levels of contamination exist, predominantly natural groundwater quality conditions prevail.

GRU	GRU Name: Langebaan Road Main Towns: Langebaan Total Area (km^2): 903.71
Aquifer Stress	The GRU is considered to have a Groundwater Availability Present Status Category of 'C', indicating a moderately stressed aquifer, and a Groundwater Quality Present Status Category of 'B' indicating localised, low levels of contamination, but no negative impacts apparent (see table below).
Groundwater Reserve	Groundwater Quality Component; Groundwater Quantity Component (see below)

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
23.28	8.59	0.37	C	B

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Primary / Intergranular Aquifer	Sulphate	mg/l	15	89	25.18	0.6	467.6	25.5	122.81	122.81	
	Electrical conductivity	mS/m		92	59.50	59.5	289.5	152	259.25	259.25	
	pH			92	8.41	6.77	8.707	8.11	8.53	8.53	
	Ammonia	mg/l		90	0.14	0	0.553	0.025	0.14	0.14	
	Nitrate + nitrite	mg/l		87	0.25	0.02	9.81	0.055	2.99	2.99	
	Fluoride	mg/l		82	0.70	0.224	2.11	0.6075	1.34	1.34	
	Orthophosphate	mg/l		90	0.04	0	0.239	0.029	0.15	0.15	
	Calcium	mg/l		84	72.80	27	175	68.8905	114.23	114.23	
	Magnesium	mg/l		86	17.90	5.3	97.924	17.7085	62.57	62.57	
	Sodium	mg/l		81	202.80	61	445.3	198.519	320.2	320.2	
	Potassium	mg/l		83	4.81	1	27.747	4.8	12.94	12.94	
	Chloride	mg/l		88	385.60	110	780.8	334.6935	492.965	492.965	

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)
23.28	5.52	0.02	5.54	17.74	8.59	9.15

GRU	GRU Name: Langebaan Road Main Towns: Langebaan Total Area (km^2): 903.71

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 23.28 to 20.18 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 8.59 to 11.09 M m^3/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 0.02 to 0.03 M m^3/a, primarily attributed to population growth. In light of these changes, the Allocation Category shifted from D to E (refer to Section 2.5 and the table below).

Recharge (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
20.18	5.52	0.03	5.55	14.63	11.09	3.55

Monitoring Programme

The Langebaan Road GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 6 monitoring sites for the EWR and 3 for the BHN were strategically selected within the Langebaan Road GRU (see **Figure 3-5** and the table below).

<table>
<tr><th>Site Name</th><th>Data Source</th><th>Monitoring Area</th><th>Monitoring Objective</th><th>Latitude</th><th>Longitude</th><th>Monitoring Description</th></tr>
<tr><td colspan="7">EWR Management Option 3</td></tr>
<tr><td>G1N0050</td><td>HYDSTRA</td><td>Berg (Groot)</td><td>EWR</td><td>-32.86598</td><td>18.09559</td><td rowspan="6">Frequency: Monthly or Quarterly
1) Groundwater level:
○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems.
2) Groundwater Quality:
○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4
○ Site specific additions for EWR: NO_2, NO_3, NH_4
○ Site specific additions as per RQO [19]:
Bxi1 (Berg Groot Estuary):
Nutrients (Dissolved Inorganic Nutrients [DIN] and Dissolved Inorganic Phosphate [DIP]); Salts; Pathogens (Enterococci & Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen, Secchi Depth).</td></tr>
<tr><td>G1N0337</td><td>HYDSTRA</td><td>Berg (Groot)</td><td>EWR</td><td>-32.990127</td><td>18.229369</td></tr>
<tr><td>G1N0507</td><td>HYDSTRA</td><td>Bii1</td><td>EWR</td><td>-33.02503</td><td>18.34761</td></tr>
<tr><td>G1N0237</td><td>HYDSTRA</td><td>Berg (Groot)</td><td>EWR</td><td>-32.91996</td><td>18.2942</td></tr>
<tr><td>G1N0372</td><td>HYDSTRA</td><td>Langebaan Lagoon</td><td>EWR</td><td>-33.00888889</td><td>18.0725</td></tr>
<tr><td>G1N0274</td><td>HYDSTRA</td><td>Berg (Groot)</td><td>EWR</td><td>-32.88552</td><td>18.24774</td></tr>
<tr><td colspan="7">BHN Management Option 1</td></tr>
<tr><td>G1N0158</td><td>HYDSTRA</td><td>GRU</td><td>BHN</td><td>-33.080122</td><td>18.049363</td><td rowspan="3">Frequency: Quarterly or Biannual (Summer & Winter)
1) Groundwater level:
○ Manual groundwater level measurements
2) Groundwater Quality (Background water quality and BHN):
○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4
○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms</td></tr>
<tr><td>3218CC00015</td><td>NGA</td><td>GRU</td><td>BHN</td><td>-32.92805</td><td>18.00483</td></tr>
<tr><td>93873</td><td>WMS</td><td>GRU</td><td>BHN</td><td>-32.989722</td><td>18.093333</td></tr>
</table>

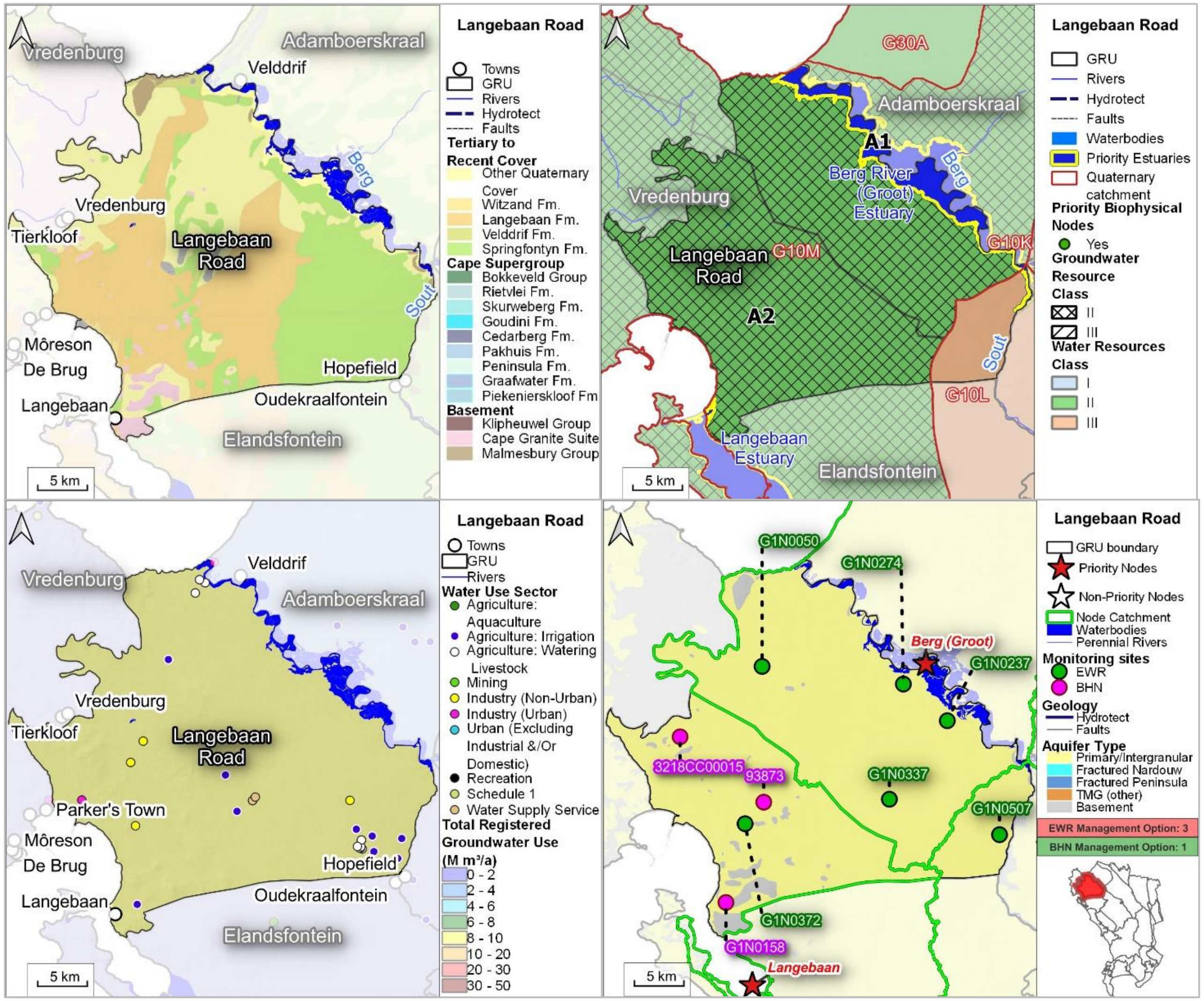


Figure 3-5 **A series of maps for the Langebaan Road GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

3.1.6. Adamboerskraal GRU

<table>
<tr><td rowspan="3">GRU</td><td>GRU Name: Adamboerskraal</td></tr>
<tr><td>Main Towns: Velddrif</td></tr>
<tr><td>Total Area (km²): 612.30</td></tr>
<tr><td>GRU Boundary Description</td><td>The extent of the Adamboerskraal GRU was determined using the Adamboerskraal aquifer model boundary (SRK, 2004). The south-western edge of the GRU was defined by the Berg River, while the eastern and southern boundaries were established by an interpolated basement lithology extent. This extent included the Malmesbury Group and the CGS, overlaid by a thin layer of the Springfontyn Fm. The north-westerly preferential flow direction, particularly at the Berg River Estuary, also contributed to the definition of the eastern and southern boundaries. The northern and north-western edge of the GRU is bounded by the St Helena Bay coastline (see Figure 3-6 and DWS, 2022d and 2023a).</td></tr>
<tr><td>Quaternary Catchments</td><td>G10M, G10K and G30A (Figure 3-6)</td></tr>
<tr><td>Resource Unit</td><td>Primary / Intergranular Aquifer</td></tr>
<tr><td>Description</td><td>The Adamboerskraal region is characterized by the dominance of semi- to unconsolidated Cenozoic sediments, with a thickness ranging from approximately 50 to 70 meters. These sediments, dating from 65 million years ago to the present, unconformably overlie the metamorphosed shales of the Malmesbury Group and the CGS (Figure 3-6). The Berg River flows roughly parallel to and just west of the regional contact between the Malmesbury Group and CGS (refer to DWS, 2022d and 2023a).

The groundwater recharge, flow, and discharge in the Adamboerskraal region are influenced by various factors, including basement topography (paleochannels), faults, fissures, contact zones, and the stratigraphy of the Cenozoic deposits (Figure 3-6). These elements collectively contribute to the complexity of the groundwater dynamics in the area (refer to DWS, 2022d and 2023a).</td></tr>
<tr><td>Surface Water System</td><td>The Adamboerskraal Aquifer discharges into St Helena Bay and the Berg River/Groot Estuary, serving as the principal surface water system within this GRU. There is a probable hydraulic connection between the Adamboerskraal Aquifer System and the Langebaan Road Aquifer System beneath the Berg River, as indicated by WRC (2016a). Refer to Figure 3-6 and DWS, 2022d, 2022e and 2023a for further details.</td></tr>
<tr><td>Water Resource Classes & RQOs</td><td>The GRU falls within the Berg Estuary (A1) and Lower Berg (B4) IUAs, with Water Resource Class II and III, respectively. The segment of the GRU within IUA A1 (catchment G10M) is assigned a Groundwater Resource Class of II, while no Groundwater Resource Class is designated for the portions within IUA A1 (catchment G30A) and IUA B4 (catchment G10K). Within the GRU, there is 1 priority estuary EWR site – the Berg River (Groot) Estuary, with a TEC of C (Figure 3-6 and the table below).

<table>
<tr><th>IUA</th><th>Water Resource Class</th><th>Quaternary Catchment</th><th>RU</th><th>Resource Name</th><th>Biophysical Node</th><th>TEC</th><th>nMAR</th></tr>
<tr><td>A1 Berg Estuary</td><td>II</td><td>G10M</td><td>A1-E01</td><td>Berg (Groot)</td><td>Bxi1</td><td>C</td><td>52</td></tr>
</table></td></tr>
<tr><td>Recharge</td><td>An estimated recharge of 21.61 M m³/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments (see table below). The average recharge rate is 35.29 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to DWS (2022e) for further details.

<table>
<tr><th>Method</th><th>Area (km²)</th><th>Recharge Volume (M m³/a)</th><th>Average Recharge Rate (mm/a)</th></tr>
<tr><td>Map-Centric Simulation method</td><td>612.30</td><td>21.61</td><td>35.29</td></tr>
</table></td></tr>
</table>

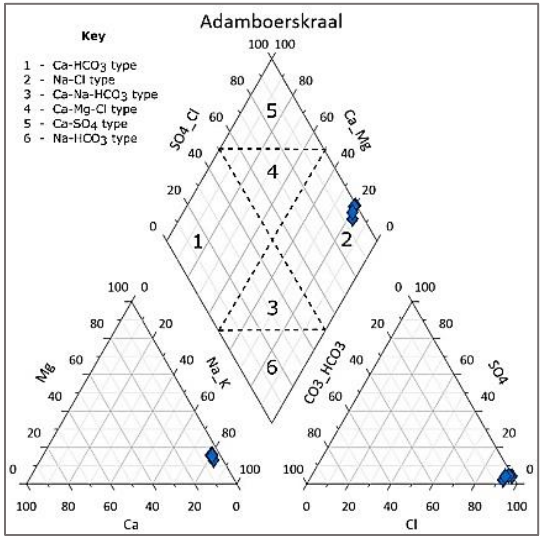
GRU	GRU Name: Adamboerskraal Main Towns: Velddrif Total Area (km^2): 612.30

Groundwater Use

In this GRU, there are 12 registered groundwater users, collectively utilizing 2.13 M m^3/a of groundwater. The primary sectors contributing to groundwater use are Agriculture (Irrigation) and Industry, constituting 62.9% and 37.1%, respectively, of the total annual groundwater use volume (**Figure 3-6** and the table to the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Primary / Intergranular Aquifer		
Agriculture: Irrigation	11	1.34
Industry (Urban)	1	0.79
Total	12	2.13

Water Quality



The primary water type in the Adamboerskraal GRU is Na-Cl, mainly attributed to the deposition of marine aerosols and recharge through coastal rainfall, displaying a typical Na-Cl signature. However, elevated salinity levels suggest that boreholes in this GRU may intersect the underlying basement aquifer, serving as the likely reason for the presence of Na-Cl waters and a high count of exceedances for EC and SO_4.

Out of the 2 samples collected, 1 sample exceeded the RQO for EC. The adjusted water quality category is B, indicating that, although some low levels of contamination exist, predominantly natural groundwater quality conditions prevail in the Adamboerskraal GRU.

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of ‘B’, indicating an unstressed or slightly stressed aquifer, and a Groundwater Quality Present Status Category of ‘B’ indicating localised, low levels of contamination, but no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
21.61	2.13	0.10	B	B

GRU	GRU Name: Adamboerskraal Main Towns: Velddrif Total Area (km^2): 612.30
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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Primary / Intergranular Aquifer	Sulphate	mg/l	3	3	52.20	52.2	164	143.3	161.93	161.93	
	Electrical conductivity	mS/m			499.10	499.1	823.2	752	816.08	816.08	
	pH				7.00	6.5	7	6.6	6.96	7.00	
	Ammonia	mg/l			0.19	0.18	0.62	0.19	0.57	0.57	
	Nitrate + nitrite	mg/l			0.10	0.02	0.1	0.02	0.092	0.1	
	Fluoride	mg/l			0.31	0.3	0.5	0.31	0.48	0.48	
	Orthophosphate	mg/l			0.24	0.036	0.243	0.051	0.224	0.24	
	Calcium	mg/l			42.00	42	67.4	58	66.46	66.46	
	Magnesium	mg/l			73.80	73.8	145.1	140.7	144.66	144.66	
	Sodium	mg/l			874.90	874.9	1374.9	1367.8	1374.19	1374.19	
	Potassium	mg/l			11.28	9.34	11.28	10.95	11.23	11.28	
	Chloride	mg/l			1540.00	1540	2513.3	2442.1	2506.18	2506.18	

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)
21.61	6.00	0.01	6.01	15.60	2.13	13.47

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 21.61 to 20.83 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 2.13 to 3.69 M m^3/a due to sectoral growth and the implementation of groundwater development schemes in the area. Under these conditions, the Allocation Category did not change from C (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)
20.83	6.00	0.01	6.01	14.81	3.69	11.13

GRU	GRU Name: Adamboerskraal Main Towns: Velddrif Total Area (km^2): 612.30

Monitoring Programme

The Adamboerskraal GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 5 monitoring sites for the EWR and 1 for the BHN were selected strategically within the Adamboerskraal GRU (see **Figure 3-6** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
G1N0070	HYDSTRA	Berg (Groot)	EWR	-32.70555556	18.32083333	Frequency: Monthly or Quarterly 2) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 3) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Bxi1 (Berg Groot Estuary): Nutrients (Dissolved Inorganic Nutrients [DIN] and Dissolved Inorganic Phosphate [DIP]); Salts; Pathogens (Enterococci & Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen, Secchi Depth).
G1N0364	HYDSTRA	Berg (Groot)	EWR	-32.80504	18.374	
G1N0239	HYDSTRA	Berg (Groot)	EWR	-32.87268	18.476	
G1N0240	HYDSTRA	Berg (Groot)	EWR	-32.901	18.33653	
3218CC00394	NGA	Berg (Groot)	EWR	-32.79027	18.20829	
BHN Management Option 1						
93313	WMS	GRU & Berg (Groot)	BHN	-32.85	18.368889	Frequency: Quarterly or Biannual (Summer & Winter) 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms

[19] *Contributing catchments to the river or estuary node may extend across multiple GRUs (see DWS, 2023a), however they are still included as important RQO sites to monitor.*

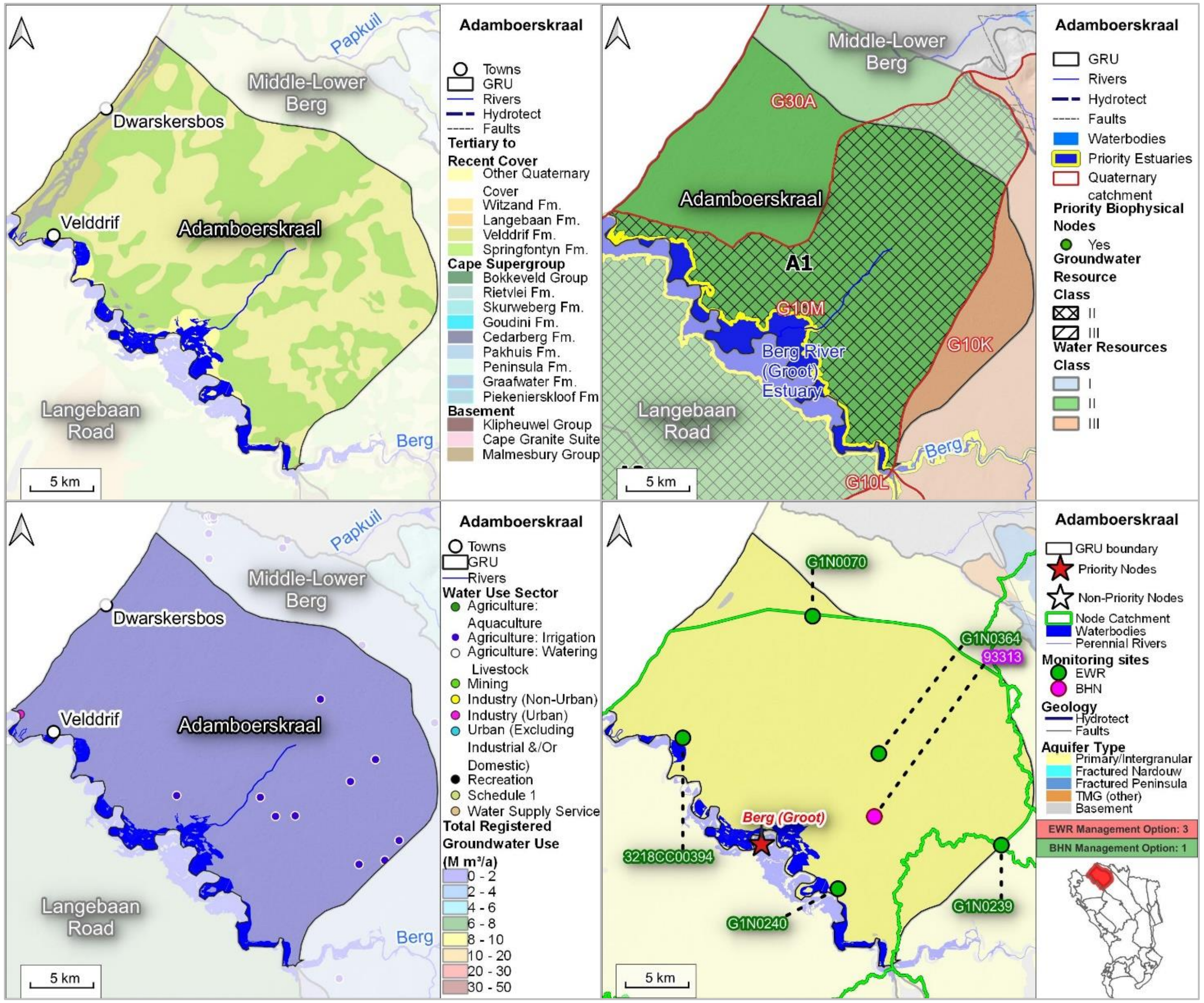


Figure 3-6 **A series of maps for the Adamboerskraal GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

3.2. Fractured Table Mountain Group GRUs

3.2.1. Cape Peninsula GRU

GRU	GRU Name: Cape Peninsula Main Towns: Hout Bay, Kommetjie and Fish Hoek Total Area (km^2): 292.53
GRU Boundary Description	The Cape Peninsula GRU is defined by the extent of the TMG outcrop, predominantly the Peninsula Fm, overlaying the CGS throughout the Cape Peninsula GRU. Additionally, the Malmesbury Group underlies the City Bowl and Devils Peak, incorporating scree aprons on the mountain slopes, particularly around the Table Mountain area. The western extent is bordered by the Atlantic coastline, while the eastern boundary is marked by the False Bay coastline. In the Fish Hoek Valley, Cenozoic sands are present, contributing to high-water tables that support wetlands and streams around the Fish Hoek and Noordhoek area (**Figure 3-7**). Although deep groundwater flows are not expected to be significant, some drainage from the Cape Peninsula may recharge both surface water and groundwater on the Cape Flats (refer to DWS, 2022d and 2023a).
Quaternary Catchments	G22A, G22B, G22C and G22D (**Figure 3-7**)
Resource Unit	Fractured Table Mountain Group Aquifer
Description	The Cape Peninsula is primarily characterized by the presence of TMG outcrops, predominantly represented by the Peninsula Fm. The basement rock along the length of the Peninsula is composed of the CGS. Under the City Bowl and Devils Peak, the basement is constituted by the Malmesbury Group. An unconformity/nonconformity, gently dipping to the south, is observed, descending from approximately 400 meters in the north around the city to below sea level south of Fish Hoek (see **Figure 3-7** and DWS, 2022d and 2023a). The Peninsula Fm exhibits varying thickness, ranging from 60 to 140 meters. The rugged terrain, mostly situated within the Table Mountain National Park, is generated by the outcrops of the TMG, contributing to the distinctive landscape of the Cape Peninsula (**Figure 3-7**).
Surface Water System	Several surface water features are present in this GRU, such as Lake Michelle, Wildevöelvlei, and the Kleinplaas Dam located at the centre of the GRU (**Figure 3-7**). Additionally, the Silvermine, Hout Bay, Liesbeek, and Krom rivers originate from Peninsula Fm outcrops within the GRU (refer to **Figure 3-7** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls within the Peninsula (E1) and Cape Flats (E12) IUAs, with Water Resource Class II and III, respectively. The segment of the GRU within IUA E12 (catchments G22D and G22C) is assigned a Groundwater Resource Class of II, while no Groundwater Resource Class is designated for the portions within IUA E11 (catchments G22A and G22B). This IUA does not contain any EWR sites; however, it includes 3 priority biophysical nodes – 1 estuary node (Wildevöelvlei) with a TEC of C and 2 river nodes (see **Figure 3-7** TEC in table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
E11 Peninsula	II	G22B	E11-R13	Hout Bay	Bviii6	D	97
		G22A	E11-R14	Silvermine	Bvii20	C	98
		G22A	E11-E04	Wildevöelvlei	Bxi14	C	107

GRU	GRU Name: Cape Peninsula Main Towns: Hout Bay, Kommetjie and Fish Hoek Total Area (km²): 292.53

Recharge

Recharge in the GRU primarily comes from rainfall, but cloud moisture, especially from the south-east wind in summer, may also contribute. While recharge on the Peninsula is considerably higher than in the surrounding areas, its thickness results in low aquifer storage, often causing recharge to be discharged as springs in a short time frame. Some of these are permanent seeps that feed mountain streams and wetlands. Scree aprons, found on the slopes of the Peninsula-formed mountain, especially around Table Mountain itself, are recharged by streams cascading off the steep cliffs. Various springs emanating from the scree aquifers, ultimately dependent on the Peninsula Aquifer, cumulatively discharge over 100 l/s to the City Bowl and Newlands areas combined (**Figure 3-7**;GEOSS, 2015).

An estimated recharge of 10.99 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 37.57 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.

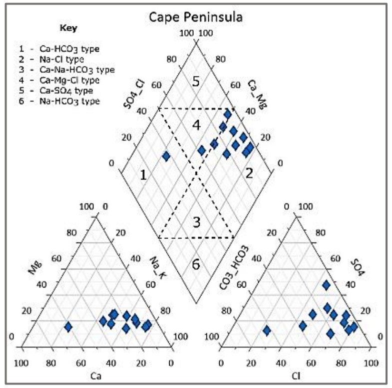
Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	292.53	10.99	37.57

Groundwater Use

In this GRU, there are 8 registered groundwater users collectively utilizing 0.73 M m^3/a of groundwater. The predominant sectors in groundwater use are Agriculture (Irrigation) and Agriculture (Livestock Watering), accounting for a combined 90.7% of the total annual groundwater use volume (**Figure 3-7** and the table on the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured TMG Aquifer (Nardouw)		
Agriculture: Aquaculture	1	0.01
Fractured TMG Aquifer (Peninsula)		
Agriculture: Irrigation	1	0.02
Agriculture: Watering Livestock	1	0.01
Industry (Urban)	1	0.01
Primary / Intergranular Aquifer		
Agriculture: Irrigation	2	0.02
Industry (Urban)	2	0.0003
Total	8	0.073

Water Quality



The primary water types in the Cape Peninsula GRU are Na-Cl and Ca-Mg-Cl. Na-Cl waters result from the deposition of marine aerosols and recharge through coastal rainfall, whereas Ca-Mg-Cl type waters arise from Na+ cation exchange between Na-Cl type waters and Ca^{2}+ and Mg^{2+} ions in the lithology.

Approximately 50% of the samples collected exceeded baselines for sulphate, EC, and nitrate + nitrite, with activities in urbanized areas being potential sources of contamination. The adjusted water quality category is B, indicating that predominantly natural water quality conditions prevail. However, concerns arise from natural factors such as acidic pH, elevated iron, and manganese in the water (see DWS, 2022d, 2022e and 2023a for detail).

GRU	GRU Name: Cape Peninsula Main Towns: Hout Bay, Kommetjie and Fish Hoek Total Area (km²): 292.53
Aquifer Stress	The GRU is considered to have a Groundwater Availability Present Status Category of 'A', indicating an unmodified, pristine conditions aquifer, and a Groundwater Quality Present Status Category of 'B' indicating localised, low levels of contamination, but no negative impacts apparent (see table below).

Recharge Volume (M m³/a)	Groundwater Use (M m³/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Availability Present Status Category
10.99	0.073	0.01	A	B

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured Table Mountain Group Aquifer (Peninsula)	Sulphate	mg/l	12	11	12.20	12.20	107.40	72.20	99.60	99.60	
	Electrical conductivity	mS/m			25.80	25.80	119.00	89.80	107.80	107.80	
	pH				6.96	6.54	7.57	7.10	7.54	7.54	
	Ammonia	mg/l			0.02	0.02	2.51	0.02	1.74	1.74	
	Nitrate + nitrite	mg/l			0.07	0.02	10.89	0.32	10.55	10.55	
	Fluoride	mg/l			0.26	0.05	0.33	0.15	0.30	0.30	
	Orthophosphate	mg/l			1.02	0.01	1.08	0.02	1.05	1.05	
	Calcium	mg/l			3.60	3.60	109.60	30.70	100.40	100.40	
	Magnesium	mg/l			3.50	3.50	31.40	16.70	28.30	28.30	
	Sodium	mg/l			31.30	31.30	115.40	89.10	114.30	114.30	
	Potassium	mg/l			1.79	0.83	46.71	5.95	36.78	36.78	
	Chloride	mg/l			54.70	54.70	207.10	147.20	198.45	198.45	

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)
10.99	5.43	0.09	5.52	5.48	0.073	5.41

GRU	GRU Name: Cape Peninsula Main Towns: Hout Bay, Kommetjie and Fish Hoek Total Area (km^2): 292.53

Future Scenario 2050 (Scenario 7b)

In 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 10.99 to 9.19 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 0.07 to 0.15 M m^3/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 0.09 to 0.16 M m^3/a, primarily attributed to population growth. Under these conditions, the Allocation Category did not change from category D (refer to Section 2.5 and the table below).

Recharge (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
9.19	5.43	0.16	5.59	3.60	0.15	3.45

Monitoring Programme

The Cape Peninsula GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 2 for monitoring the groundwater contribution to the BHN. A total of 4 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Cape Peninsula GRU (see **Figure 3-7** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
3418AB00024	NGA	Wildevöelvlei	EWR	-34.14185	18.34929	Frequency: Monthly or Quarterly 1) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Bxi14 (Wildevöelvlei): Nutrients (Dissolved Inorganic Nutrients [DIN] and Dissolved Inorganic Phosphate [DIP]); Salts; Pathogens (Enterococci & Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen). Bviii6: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen).
G2N0048	HYDSTRA	Bviii6	EWR	-34.0008	18.379366	
Proposed BH		GRU	EWR	-34.10991286	18.40487755	
96073	WMS	GRU	EWR	-34.222778	18.410833	
BHN Management Option 2						
96069	WMS	GRU	BHN	-34.132222	18.380833	Frequency: Quarterly 1) Groundwater level: ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality (Background water quality and BHN): ○ 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

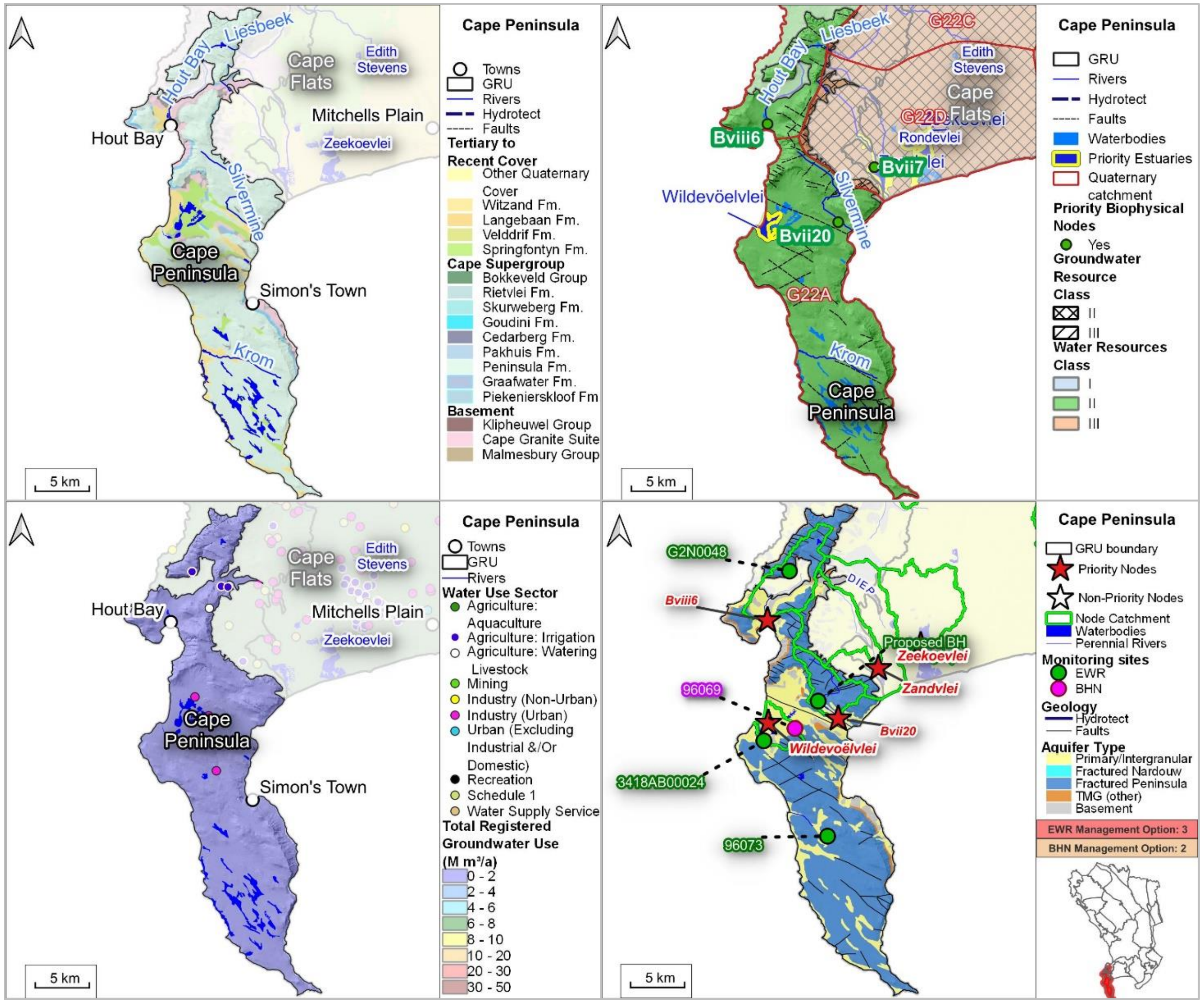
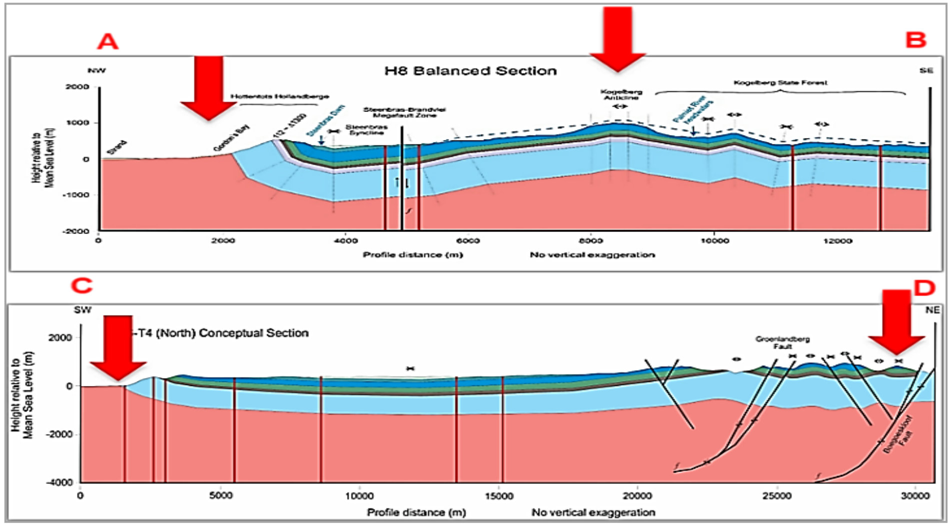


Figure 3-7 A series of maps for the Cape Peninsula GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.2.2. Steenbras-Nuweberg GRU

GRU	GRU Name: Steenbras-Nuweberg Main Towns: Grabouw Total Area (km^2): 150.24
GRU Boundary Description	The aquifer model boundary outlined by CoCT (2021) defines the extent of the Steenbras-Nuweberg GRU. The boundaries of the GRU include the TMG outcrop in the Steenbras and Theewaterskloof areas. The northern recharge area is demarcated by the La Motte Fault (DWAF, 2008a; CoCT, 2004), while the eastern margin is defined by the Kogelberg and Stettyns anticlines, encompassing sections of the G40A surface water catchment boundary. To the north, the GRU's extent is determined by interpolated basement lithologies, specifically the Malmesbury Group and the CGS Suite outcrop, extending to the False Bay coastline in the west. (refer to **Figure 3-8** and DWS, 2022d and 2023a).
Quaternary Catchments	G40C, G40A, G40D, G22J, G22K, H60A and G40B (**Figure 3-8**)
Resource Unit	Fractured Table Mountain Group Aquifer
Description	The TMG Super aquifer in this region comprises the larger Peninsula Aquifer, ranging in apparent thickness from approximately 600 to 700 meters, and the smaller Nardouw Aquifer, which includes its sub-aquifers with an estimated thickness ranging from approximately 700 to 800 meters (**Figure 3-8**). The TMG has undergone folding, forming a syncline that exposes the Peninsula Fm in the limbs and along the steep mountainsides in the valley. On the elevated synclinal/anticlinal limbs in the mountainous regions near the dam area, the Peninsula, Pakhuis, Cedarberg, and Goudini Fms are visible (refer to DWS, 2022d and 2023a). Within the syncline valley, the Nardouw sub-group is exposed as the Goudini, Skuwerberg, and Rietvlei Fms, with the Nardouw Aquifer formed by the Skuwerberg and Rietvlei Fms (see **Figure 3-8** and the cross section below). The confining unit separating the Peninsula Aquifer from the overlying Nardouw Aquifer is characterized by a conformable package of three aquitard units: Goudini, Cedarberg, and Pakhuis. Collectively, these aquitard units are referred to as the Winterhoek Mega-aquitard. Hydrogeologically, the entire Pakhuis–Goudini sequence effectively functions as an aquitard, despite the Goudini Fm being considered part of the Nardouw Subgroup (refer to DWS, 2022d and 2023a). Within this aquifer system, the Peninsula Aquifer and the Skurweberg Sub-aquifer are identified as the primary deep aquifer targets (refer to DWS, 2022d and 2023a). 

GRU	GRU Name: Steenbras-Nuweberg Main Towns: Grabouw Total Area (km^2): 150.24
Surface Water System	The surface water bodies within this GRU encompass the Steenbras Dam, integral to the WCWSS, and the Eikenhof and Nuweberg Dams, in conjunction with the Palmiet River (see **Figure 3-8**). Surface water runoff aligns with the topography, coursing from north-east to south-west, primarily via the Steenbras River (refer to DWS, 2022d and 2023a).
Water Resource Classes & RQOs	Only a portion of the GRU is located within the Sir Lowry's IUA (D7), while the remaining part extends beyond the D7 IUA, as the GRU expands outside of the Berg WMA (2004). The segments of the GRU within the D7 IUA (catchments G40A and G22K) have a Water Resource Class of II and no Groundwater Resource Class. This GRU does not include any EWR sites; however, it does host 1 priority biophysical site – the Steenbras estuary node with a TEC of B/C (see **Figure 3-8** and the table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
D7 Sir Lowry's	II	G40A	D7-R20	Steenbras	Bvii22	B/C	23

Recharge

An estimated recharge of 58.76 M m^3/a was determined from GRAII based on the hydrogeological technical assessment (CoCT, 2022). This recharge value was incorporated into the Aquifer Stress assessments. The average recharge rate is 391.11 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
After (CoCT, 2022) hydrogeological technical assessment for IWULA	150.24	58.76[20]	391.11

Groundwater Use

In this GRU, Water Supply Services stand as the sole registered groundwater user, with a total annual groundwater use of 8 M m^3/a. However, this usage is divided into 1.5 M m^3/a in the Peninsula Aquifer and 6.5 M m^3/a in the Nardouw Aquifer (**Figure 3-8**).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured TMG Aquifer (Peninsula)		
Water Supply Service	0.5	1.5
Fractured TMG Aquifer (Nardouw)		
Water Supply Service	0.5	6.5
Total	1	8

Water Quality

The primary water types in the Peninsula Aquifer are Na-Cl, Ca-Na-HCO3, and Ca-HCO3. Na-Cl waters are a result of the deposition of marine aerosols and recharge through coastal rainfall. Ca-HCO3 type waters arise from the dissolution of carbonate minerals, while Ca-Na-HCO3 type waters are due to ion exchange between Ca+ ions from Ca-HCO3 and Na+ ions in the lithology.

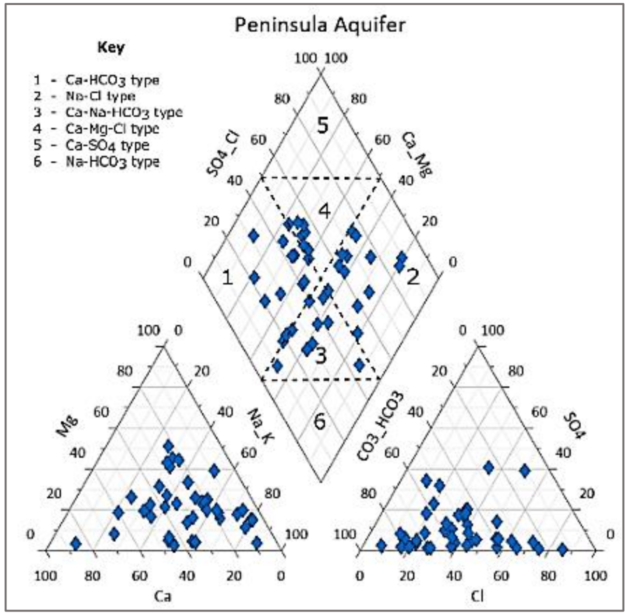
Exceedances of baseline concentrations were observed for all parameters except dissolved arsenic, chromium, lead, and mercury, with 50% of samples exceeding baselines for sulphate and EC. The adjusted water quality category is B, indicating that predominantly natural water quality conditions prevail. However, there are concerns related to natural factors, including acidic pH, elevated iron, and manganese in the water (refer to DWS 2022d, 2022e and 2023a for detail).

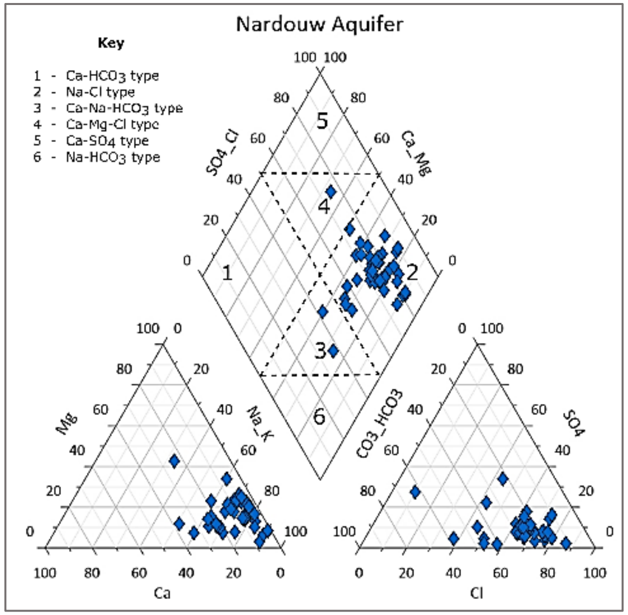
The primary water types in the Nardouw Aquifer are Na-Cl, with 3 samples showing Ca-Na-HCO_3 and Ca-Mg-Cl types. The Na-Cl waters result from the deposition of marine aerosols and recharge through coastal rainfall. Comparatively, the EC and pH in the Nardouw Aquifer are lower than in the Peninsula Aquifer. The more acidic pH is attributed to the dissolution of humic compounds from overlying plants, the dissolution of CO_2 (which forms carbonic acid) in recharge water, and the limited presence of basic ions (compared to the Peninsula Aquifer) to buffer acidic waters.

Exceedances of baseline concentrations were observed for all parameters except fluoride, orthophosphate, dissolved chromium, and mercury. The adjusted water quality category is B, indicating that predominantly natural water quality conditions prevail. However, concerns persist regarding natural factors such as acidic pH, elevated iron, and manganese in the water (refer to DWS 2022d, 2022e and 2023a for detail).

[20] *Rainfall recharge value is from the first order GRAII Spatial Distribution (modified after CoCT, 2022).*

GRU	GRU Name: Steenbras-Nuweberg Main Towns: Grabouw Total Area (km^2): 150.24





Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'B, indicating an unstressed or slightly stressed aquifer, and a Groundwater Quality Present Status Category of 'B' indicating localised, low levels of contamination, but no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
58.76	8	0.14	B	B

GRU	GRU Name: Steenbras-Nuweberg Main Towns: Grabouw Total Area (km^2): 150.24

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured Table Mountain Group Aquifer (Peninsula)	Sulphate	mg/l	16	53	1.49	0.20	61.00	4.20	21.92	21.92	
	Electrical conductivity	mS/m		58	14.00	2.47	38.00	13.00	28.50	28.50	
	pH			54	7.18	4.87	9.35	6.80	8.88	8.88	
	Ammonia	mg/l		58	0.12	0.00	12.00	0.10	1.37	1.37	
	Nitrate + nitrite	mg/l		38	1.05	0.00	1.20	0.10	0.20	1.05	
	Fluoride	mg/l		54	0.28	0.10	0.76	0.50	0.55	0.55	
	Orthophosphate	mg/l		27	0.32	0.00	0.97	0.10	0.47	0.47	
	Calcium	mg/l		4	2.78	0.50	50.10	5.20	25.20	25.20	
	Magnesium	mg/l		38	1.83	0.20	7.60	1.30	7.03	7.03	
	Sodium	mg/l		27	6.60	3.70	79.20	8.15	24.50	24.50	
	Potassium	mg/l		34	0.64	0.20	15.30	2.50	11.96	11.96	
	Chloride	mg/l		27	18.01	1.40	31.00	13.25	18.06	18.06	

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured Table Mountain Group Aquifer (Nardouw)	Sulphate	mg/l	16	54	6.50	0.40	17.70	3.35	8.34	8.34	
	Electrical conductivity	mS/m		38	10.00	2.00	24.20	9.00	19.40	19.40	
	pH			27	5.91	4.63	8.61	5.57	7.13	7.13	
	Ammonia	mg/l		56	2.88	0.01	12.22	0.10	1.71	2.88	
	Nitrate + nitrite	mg/l		61	0.20	0.00	3.66	0.20	1.07	1.07	
	Fluoride	mg/l		54	0.50	0.05	0.50	0.10	0.50	0.50	
	Orthophosphate	mg/l		56	0.20	0.00	0.20	0.10	0.20	0.20	
	Calcium	mg/l		38	5.10	0.32	7.41	1.00	4.47	5.10	
	Magnesium	mg/l		27	5.35	0.20	6.60	1.10	1.74	5.35	
	Sodium	mg/l		38	11.13	2.10	21.90	9.30	16.86	16.88	
	Potassium	mg/l		27	1.00	0.09	14.10	0.93	7.18	7.18	
	Chloride	mg/l		34	19.95	1.00	37.80	17.00	30.60	30.60	

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)
58.76[21]	1.16	0.02	1.18	57.58	8.00[22]	49.58

[21] *Rainfall recharge value is from the first order GRAII Spatial Distribution (modified after CoCT, 2022).*
[22] *Includes city municipal abstraction of 8 Mm³/a in development (phase 1) as per NWA Section 21(a).*

GRU	GRU Name: Steenbras-Nuweberg Main Towns: Grabouw Total Area (km^2): 150.24

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 58.76 to 57.97 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 8.00 to 24.52 M m^3/a due to sectoral growth and the implementation of groundwater development schemes in the area. In light of these changes, the Allocation Category shifted from B to C (refer to Section 2.5 and the table below).

Recharge (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
57.97	1.16	0.02	1.18	56.79	24.52	32.26

Monitoring Programme

The Steenbras-Nuweberg GRU was assigned a Management Option 2 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 5 monitoring sites for the EWR and 2 for the BHN were strategically selected within the Steenbras-Nuweberg GRU (see **Figure 3-8** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 2						
H1A12	CoCT	Bvii22 & GRU	EWR (Nardouw Aquifer)	-34.15341755	18.93619208	Frequency: Quarterly 1) Groundwater level ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Bvii22 Nutrients (Phosphate [PO4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen); Toxins (Iron, Manganese).
H2A1	CoCT	Bvii22 & GRU	EWR (Nardouw Aquifer)	-34.18480149	18.84681274	
H2A4	CoCT	Bvii22 & GRU	EWR (Peninsula Aquifer)	-34.18503396	18.84628454	
H3A2	CoCT	Bvii22 & GRU	EWR (Peninsula Aquifer)	-34.19704511	18.86919689	
H3A3	CoCT	Bvii22 & GRU	EWR (Nardouw Aquifer)	-34.19697736	18.86914539	
BHN Management Option 1						
H1A3b	CoCT	Bvii22 & GRU	BHN (Nardouw Aquifer)	-34.16604336	18.92808478	Frequency: Quarterly or Biannual (Summer & Winter) 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms
H8A1_Ope	CoCT	Bvii22& GRU	BHN (Peninsula Aquifer)	-34.18547483	18.89892773	

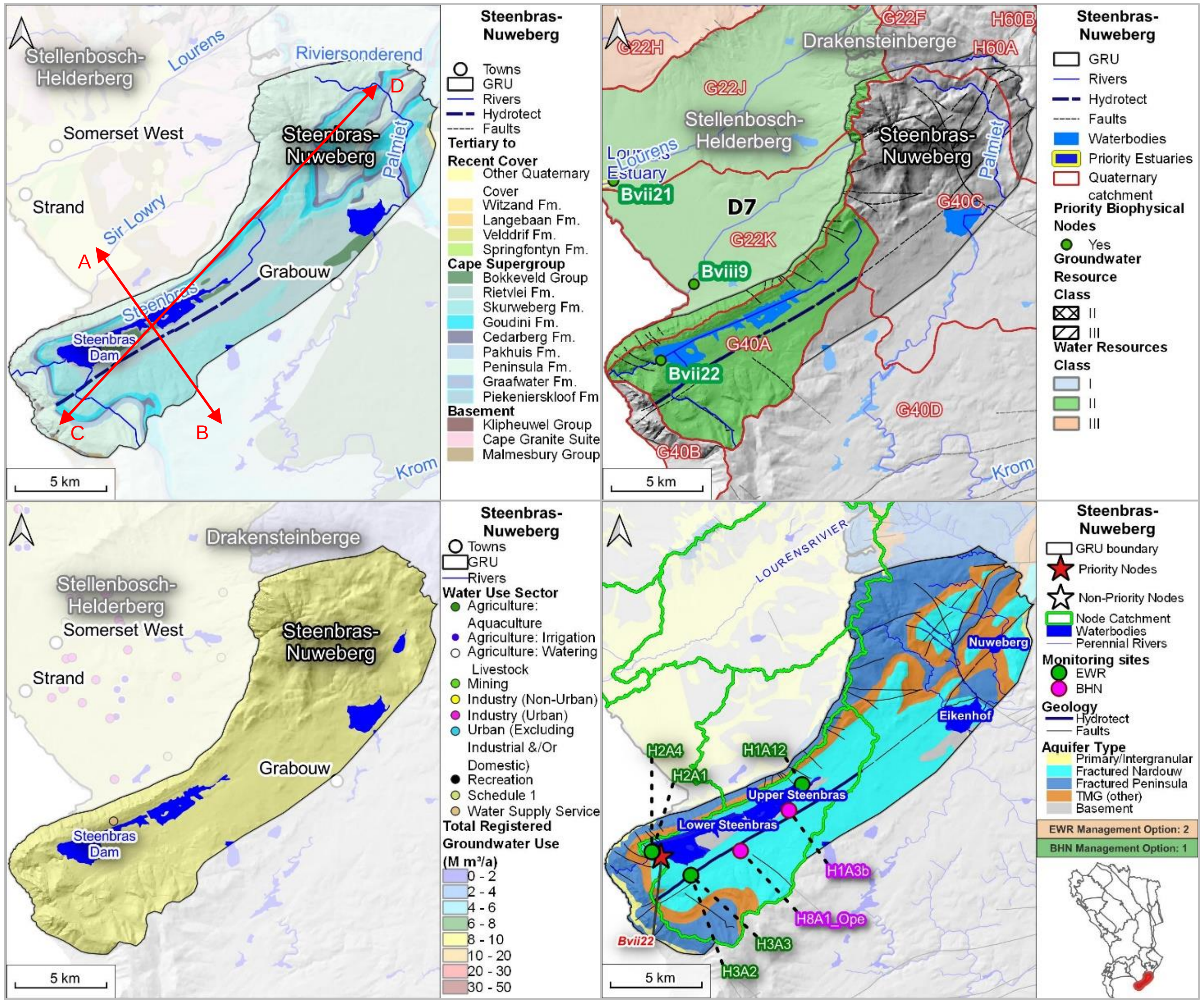


Figure 3-8 A series of maps for the Steenbras-Nuweberg GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.2.3. Drakensteinberge GRU

GRU	GRU Name: Drakensteinberge Main Towns: None Total Area (km^2): 164.95
GRU Boundary Description	The Drakensteinberge GRU is delimited by the TMG outcrop, primarily consisting of the Peninsula Fm. Portions of the Skurweberg, Goudini, Cedarberg, and Pakhuis Fm, along with the Lourens River in the southwest, contribute to the southern and southwestern boundaries of the GRU. The southern extent is specifically marked by the La Motte Fault, as indicated by the DWAF (2008a) and CoCT (2004) reports. Refer to **Figure 3-9** and DWS, 2022d and 2023a).
Quaternary Catchments	G10A, G10C, G22F, G22J, H60A and H60B (**Figure 3-9**)
Resource Unit	Fractured Table Mountain Group Aquifer
Description	The TMG Super aquifer in this area is composed of the larger Peninsula Aquifer, with an estimated thickness ranging from approximately 600 to 1000 meters, and the smaller Nardouw Aquifer, which includes its component sub-aquifers, measuring approximately 150 to 300 meters in thickness. Within this super aquifer system, the Peninsula Aquifer and the Skurweberg Sub-aquifer are recognized as the primary deep aquifer targets (refer to DWS, 2022d and 2023a). In the southeastern part of this GRU, the Goudini, Skuwerberg, and minor sections of the Rietvlei Fm, belonging to the Nardouw Sub-group, are present. This geological configuration is situated as the western limb of a syncline. The Nardouw Aquifer in this region is predominantly made up of the Skuwerberg Fm and may potentially include portions of the Rietvlei Fm. The thickness of the Nardouw Aquifer can vary between 150 to 300 meters (refer to DWS, 2022d and 2023a).
Surface Water System	Tributaries of the Berg River, specifically the Wolwekloof and Dwars rivers, have their origins in this GRU and constitute the primary surface water systems within this region. Additionally, the Berg River Dam, situated just east of the GRU, serves as the eastern boundary of the GRU (refer to (see **Figure 3-9** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	Only a portion of the GRU is located within the Eerste (D6) and Upper Berg (D8) IUAs, while the remaining part extends beyond the IUAs, as the GRU expands outside of the Berg catchment area, specifically the former Berg WMA (2004). The segments of the GRU within the D6 and D8 IUAs (catchments G10A and G22F) have a Water Resource Class of III and II, respectively. The part of the GRU within the D6 IUA (catchment G22F) is assigned a Groundwater Resource Class of III, and the portion within the D8 IUA (catchment G10A) has a Groundwater Resource Class of II. The GRU includes 1 priority biophysical site with a TEC of A (see **Figure 3-9** and the table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
D8 Upper Bergs	II	G10A	D8-R01	Berg	Bvii13	A	98

Recharge

An estimated recharge of 27.6 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 167.32 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	164.95	27.6	167.32

GRU	GRU Name: Drakensteinberge Main Towns: None Total Area (km^2): 164.95

Groundwater Use

In this GRU, there are 2 registered groundwater users within the Agricultural (Watering Livestock) sector, collectively utilizing 0.05 M m^3/a (see **Figure 3-9** and the table on the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured TMG Aquifer		
Agriculture: Watering Livestock	2	0.05
Total	2	0.05

Water Quality

No water quality data available

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'A', indicating an unstressed or slightly stressed aquifer, and the Groundwater Quality Present Status Category cannot be determined due to limited data availability (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
27.6	0.05	0.00	A	-

Groundwater Reserve

Quality Component

No water quality data available

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 (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
27.6	2.88	0.00	2.88	24.72	0.05	24.67

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 27.86 to 26.86 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 0.05 to 1.21 M m^3/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 0.00 to 0.01 M m^3/a, primarily attributed to population growth. Under these conditions, the Allocation Category does not change from a category B (refer to Section 2.5 and the table below).

Recharge (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
26.86	2.88	0.01	2.89	23.97	1.21	22.77

GRU	GRU Name: Drakensteinberge Main Towns: None Total Area (km^2): 164.95
Monitoring Programme	The Drakensteinberge GRU was assigned a Management Option 2 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 3 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Drakensteinberge GRU (see **Figure 3-9** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 2						
G1N0509	HYDSTRA	Bvii13	EWR	-33.95688	19.07258	Frequency: Quarterly 1) Groundwater level ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Bviii1: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN])); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen) Bvii13: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN])); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen)
G1N0316	HYDSTRA	Bviii1	EWR	-33.90105	19.0503	
G1N0499	HYDSTRA	Bviii1	EWR	-33.9371	19.0198	
BHN Management Option 1						
G1N0499	HYDSTRA	Bviii1	BHN	-33.9371	19.0198	Frequency: Quarterly or Biannual (Summer & Winter): 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms

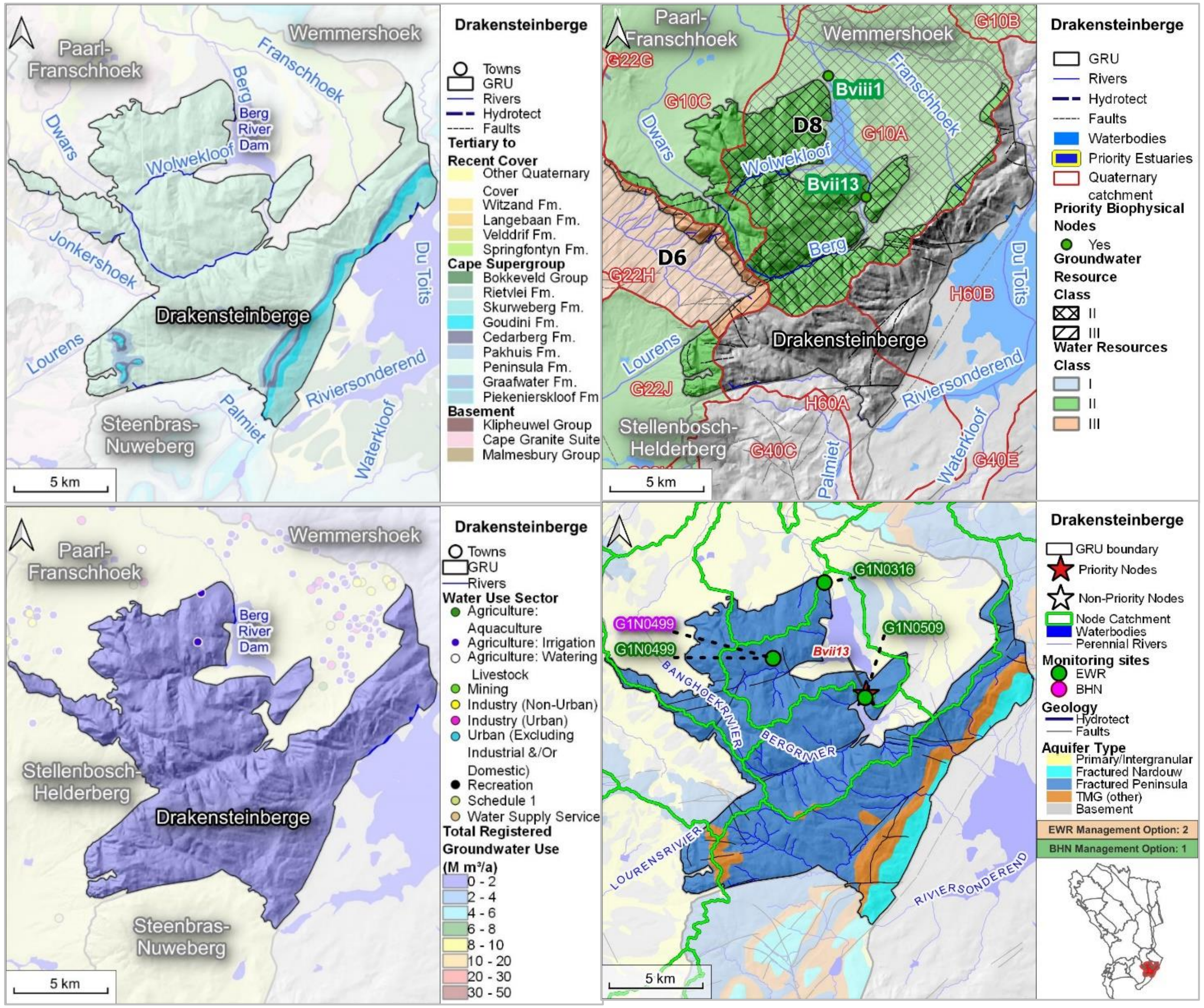


Figure 3-9 **A series of maps for the Drakensteinberge GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

3.2.4. Wemmershoek GRU

GRU	GRU Name: Wemmershoek Main Towns: None Total Area (km^2): 229.13
GRU Boundary Description	The Wemmershoek GRU is defined by the extent of the TMG and its contact with the basement lithologies, specifically the CGS and the Malmesbury Group, in the Franschhoek valley and along the Stettyns anticline to the east. To the north, the GRU is bounded by the Du Toits/Wellington fault, as indicated in the DWAF (2008a) report. The southern boundary is marked by the La Motte fault and the basement aquitard (refer to **Figure 3-10** and DWS, 2022d and 2023a).
Quaternary Catchments	G10B, G10A, G10C, H10J, H60B and H10K (**Figure 3-10**)
Resource Unit	Fractured Table Mountain Group Aquifer
Description	This GRU is predominantly defined by the Peninsula Fm, a thickly bedded quartzite with an average thickness ranging from approximately 600 to 1000 meters within the TMG. This formation functions as an unconfined aquifer, transitioning to a confined aquifer at greater depths. The Peninsula Fm overlays the Malmesbury Group and CGS basement, composed of granites and metasediments. The contact between the Peninsula Fm and the underlying basement is visible at the base of the mountain slopes and is exposed in the valley. Additionally, younger Cenozoic sediments extensively fill the valley, overlaying the basement geology (refer to **Figure 3-10** and DWS, 2022d and 2023a). In the surrounding Wemmershoek valley, the Goudini, Skuwerberg, and Rietvlei Formations, part of the Nardouw Sub-group, outcrop prominently. This geological feature is particularly evident in the south-western section of the GRU, extending into portions of the north-east. The thickness of these formations ranges from approximately 150 to 300 meters. Within the valley, the basement rocks of the Malmesbury Group and the CGS are exposed, alongside younger Cenozoic sediments that fill the valleys. This geological setting contributes to the diverse and complex hydrogeological characteristics of the Wemmershoek valley within the GRU (refer to DWS, 2022d and 2023a).
Surface Water System	Wemmershoek Dam, a component of the WCWSS, is situated within this GRU. This GRU features several rivers, including the Hugos, Elands, Holsloot, and Du Toits rivers. Moreover, the Drakenstein and Olifants rivers contribute to the flow into the Wemmershoek Dam (refer to **Figure 3-10** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	Only a portion of the GRU is located within the Upper Berg (D8) IUA, while the remaining part extends beyond the D8 IUA, as the GRU expands outside of the Berg WMA (2004). The segments of the RU within the D8 IUA (catchments G10A and G10B) have a Water Resource Class of II and a Groundwater Resource Class of II. The GRU does not include any EWR sites nor any priority biophysical nodes (**Figure 3-10**).
Recharge	An estimated recharge of 26.83 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 117.10 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	229.13	26.83	117.10

GRU	GRU Name: Wemmershoek Main Towns: None Total Area (km^2): 229.13

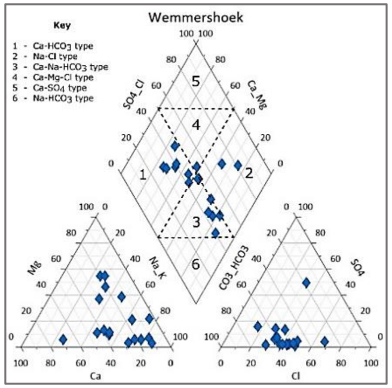
Groundwater Use

In the Peninsula Aquifer RU, there are 11 registered groundwater users collectively utilizing 0.73 M m^3/a of groundwater. The main sectors for groundwater use are Agriculture (Irrigation) and Agriculture (Aquaculture), contributing 58.9% and 41.1%, respectively, to the total annual groundwater use volume.

In the Nardouw Aquifer RU, there are 4 registered groundwater users collectively utilizing 0.09 M m^3/a of groundwater. The predominant sector for groundwater use is Agriculture (Irrigation), constituting 89% of the total annual groundwater use volume (see **Figure 3-10** and the table on the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured TMG Aquifer (Peninsula)		
Agriculture: Irrigation	10	0.43
Fractured TMG Aquifer (Nardouw)		
Agriculture: Irrigation	2	0.01
Industry (Non-Urban)	2	0.08
Primary / Intergranular Aquifers		
Agriculture: Aquaculture	1	0.30
Total	15	0.82

Water Quality



The primary water types in the Wemmershoek GRU are Ca-HCO_3 and Ca-Mg-Cl. Ca-HCO_3 type waters arise from the dissolution of carbonate minerals, while Ca-Mg-Cl type waters result from Na^+ cation exchange between Na-Cl type waters and Ca^{2+} and Mg^{2+} ions in the lithology.

Exceedances of baseline concentrations were observed for all parameters except dissolved arsenic, lead, manganese, and mercury. The adjusted water quality category is A, indicating that predominantly natural water quality conditions prevail. However, concerns persist regarding natural factors such as acidic pH and elevated iron in the water (refer to DWS, 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'A', indicating an unstressed or slightly stressed aquifer, and a Groundwater Quality Present Status Category of 'A' indicating unmodified, pristine conditions (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Adjusted Groundwater Quality Present Status Category
26.83	0.82	0.03	A	A

GRU	GRU Name: Wemmershoek Main Towns: None Total Area (km^2): 229.13

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured Table Mountain Group Aquifer (Peninsula)	Sulphate	mg/l	5	19	3.45	0.20	20.90	0.72	10.24	10.24	
	Electrical conductivity	mS/m		31	9.27	4.66	16.00	8.10	13.95	13.95	
	pH			31	8.26	6.40	10.01	7.30	9.60	9.60	
	Ammonia	mg/l		28	0.45	0.01	0.66	0.05	0.45	0.45	
	Nitrate + nitrite	mg/l		24	0.53	0.00	1.27	0.02	0.62	0.62	
	Fluoride	mg/l		4	0.16	0.05	0.39	0.11	0.36	0.36	
	Orthophosphate	mg/l		22	0.05	0.00	0.43	0.02	0.33	0.33	
	Calcium	mg/l		28	4.39	0.20	10.83	3.15	6.37	6.37	
	Magnesium	mg/l		28	0.46	0.20	7.00	0.60	6.63	6.63	
	Sodium	mg/l		26	10.44	2.20	11.00	5.75	9.23	10.44	
	Potassium	mg/l		20	8.20	0.10	8.43	0.75	8.39	8.39	
	Chloride	mg/l		28	13.77	6.00	17.62	8.05	12.67	13.77	

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 (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
26.83	3.59	0.00	3.59	23.24	0.82	22.43

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 26.83 to 25.60 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 0.81 to 1.56 M m^3/a due to sectoral growth and the implementation of groundwater development schemes in the area. Under these conditions, the Allocation Category did not change from category B (refer to Section 2.5 and the table below).

Recharge (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
25.60	3.59	0.00	3.59	22.01	1.56	20.45

GRU	GRU Name: Wemmershoek Main Towns: None Total Area (km²): 229.13
Monitoring Programme	The Wemmershoek GRU was assigned a Management Option 2 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 3 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Wemmershoek GRU (see **Figure 3-10** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 2						
Proposed BH		Biii2	EWR	-33.83659818	19.11174645	Frequency: Quarterly 1) Groundwater level: ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4
G1N0500	HYDSTRA	Biii2	EWR	-33.8466	19.0493	
G1N0501	HYDSTRA	Biii2	EWR	-33.81001	19.07955	
BHN Management Option 1						
W7D1	CoCT	GRU	BHN	-33.81629	19.06087	Frequency: Quarterly or Biannual (Summer & Winter): 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms

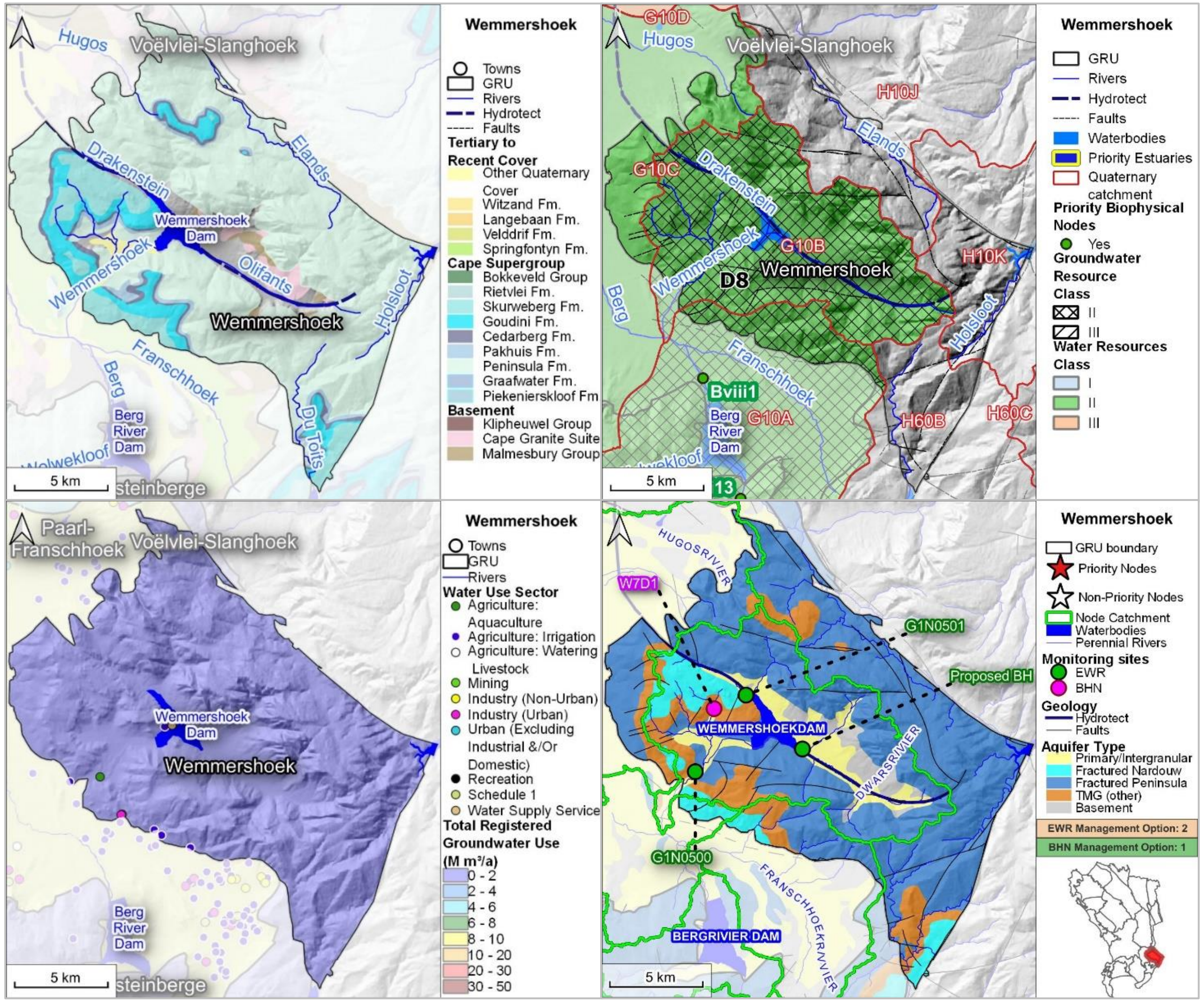


Figure 3-10 A series of maps for the Wemmershoek GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.2.5. Voëlvlei-Slanghoek GRU

GRU	GRU Name: Voëlvlei-Slanghoek Main Towns: None Total Area (km^2): 184.26
GRU Boundary Description	The Voëlvlei-Slanghoek GRU is constrained by the TMG extent and its contact with various basement lithologies, including the Klipheuwel Group, CGS, and Malmesbury Group, along both the western and eastern/north-eastern edges of the GRU. To the north, the GRU is separated from the Groot Winterhoek GRU by the Roodezandspas Fault. The eastern/south-eastern fringe is demarcated by the Stettyns and Koue Bokkeveld anticline, along with sections of the Du Toits/Wellington fault (refer to **Figure 3-11**; DWS, 2022d and 2023a).
Quaternary Catchments	G10E, G10J, G10D, G10F, H10E, H10F and H10J (**Figure 3-11**)
Resource Unit	Fractured Table Mountain Group Aquifer
Description	The TMG Super aquifer within this GRU is primarily composed of the larger Peninsula Aquifer, characterized by thickly bedded quartzite. This aquifer serves as the primary deep target within the GRU, with an average thickness ranging from approximately 600 to 1500 meters. The Peninsula Aquifer overlies the Malmesbury Group and CGS basement, and the contact between these formations is visible at the base of the mountain slopes. This contact is further exposed in the valley on the eastern edge of the GRU (**Figure 3-11**). The Goudini, Skuwerberg, and Rietvlei Formations, part of the Nardouw Sub-group, are also present along the slopes of this GRU. Within these formations, the aquifers include the Skuwerberg and Rietvlei Formations, with an average thickness of approximately 200 to 300 meters and 150 to 200 meters, respectively. These geological features contribute to the hydrogeological characteristics of the GRU, influencing groundwater dynamics and storage (refer to DWS, 2022d and 2023a).
Surface Water System	The GRU is located immediately to the west of the Voëlvlei Dam, which stands as the second-largest reservoir in the WCWSS. This area encompasses a canal designed to distribute water from the reservoir, sourced from a weir located in the Nuewkloof Pass on the Klein Berg River (refer to **Figure 3-11** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	Only a portion of the GRU is located within the Middle Berg (D9), the Berg tributaries (C5), and the Lower Berg (B4) IUAs, while the remaining part extends beyond the IUAs, as the GRU expands outside of the Berg catchment area, specifically the former Berg WMA (2004). The segments of the GRU within the D9 and B4 IUAs (catchments G10D and G10F) have a Water Resource Class of III, and the portions within the C5 IUA have a Water Resource Class of II, with a corresponding Groundwater Resource Class of II. The rest of the GRU lacks a Groundwater Resource Class designation. This site includes 1 priority biophysical site - the Klein Berg River node with a TEC of C (see **Figure 3-11** and the table below).
Recharge	An estimated recharge of 14.1 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 76.52 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
C5 Berg Tributaries	II	G10E	C5-R07	Klein Berg	Biii4	C	82

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	184.26	14.1	76.52

GRU

GRU Name: Voëlvlei-Slanghoek
Main Towns: None
Total Area (km^2): 184.26

Groundwater Use

In the Peninsula Aquifer RU, there are 3 registered groundwater users collectively utilizing 0.14 M m^3/a of groundwater (see **Figure 3-11** and the table on the right). The primary groundwater use sectors in this GRU are Agriculture (Watering Livestock) and Agriculture (Irrigation), contributing 73.1% and 26.9%, respectively, to the total annual groundwater use volume.

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured TMG Aquifer		
Agriculture: Irrigation	2	0.04
Agriculture: Watering Livestock	1	0.10
Total	3	0.14

Water Quality

No water quality data available

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'A', indicating an unstressed or slightly stressed aquifer, and the Groundwater Quality Present Status Category cannot be determined due to limited data availability (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
14.1	0.14	0.01	A	N/A

Groundwater Reserve

Quality Component

No water quality data available

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)
14.1	1.62	0.01	1.63	12.47	0.14	12.34

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 14.1 to 12.87 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 0.13 to 0.31 M m^3/a due to sectoral growth and the implementation of groundwater development schemes in the area. Under these conditions, the Allocation Category did not change from category B (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)
12.87	1.62	0.01	1.63	11.24	0.31	10.93

GRU	GRU Name: Voëlvlei-Slanghoek Main Towns: None Total Area (km^2): 184.26
Monitoring Programme	The Voëlvlei-Slanghoek GRU was assigned a Management Option 2 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 1 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Voëlvlei-Slanghoek GRU (see **Figure 3-11** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 2						
3319AC00039	NGA	Biii4	EWR	-33.31689	19.08263	Frequency: Quarterly 1) Groundwater level: ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO2, NO3, NH4 ○ Site specific additions as per RQO [19]: Biii4: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen); Toxins (Ammonia, Atrazine, Endusulfan)
BHN Management Option 1						
3319AC00040	NGA	Biv3	BHN	-33.28911	19.06541	Frequency: Quarterly or Biannual (Summer & Winter): 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms

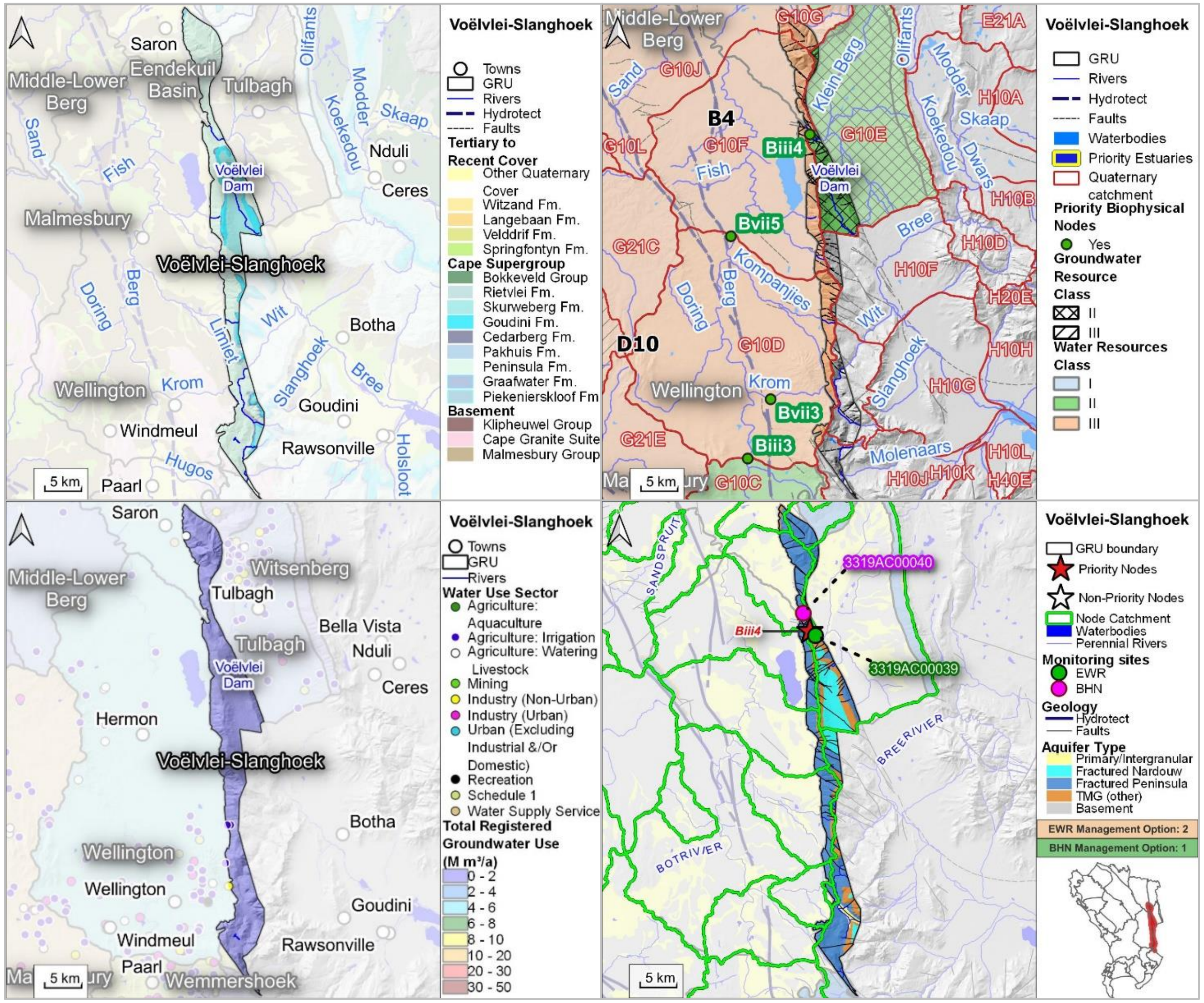


Figure 3-11 A series of maps for the Voëlvlei-Slanghoek GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.2.6. Witzenberg GRU

GRU	GRU Name: Witzenberg Main Towns: None Total Area (km²): 39.95
GRU Boundary Description	The Witzenberg GRU is defined by the western extent, which is delimited by the TMG rocks, predominantly the Peninsula Fm, and its contact with basement lithologies, specifically the Malmesbury Group. The eastern and southern boundaries are determined by the extent of the Berg WMA (2004), while the northern portion of the GRU is bounded by the G10G surface water quaternary catchment divide (refer to **Figure 3-12** and DWS, 2022d and 2023a).
Quaternary Catchments	G10E (**Figure 3-12**)
Resource Unit	Fractured Table Mountain Group Aquifer
Description	The Peninsula Fm, characterized by thickly bedded quartzites, stands as the predominant geological feature in the mountains of the GRU. Functioning as an unconfined aquifer, the thickness of the Peninsula Fm varies within the range of approximately 550 to 1500 meters. The properties of the Peninsula Fm play a pivotal role in shaping the hydrogeology and groundwater dynamics of the GRU (refer to **Figure 3-12** and DWS, 2022d and 2023a). Within this GRU, components of the Nardouw Sub-group, namely the Goudini, Skuwerberg, and Rietvlei Formations, are present. The aquifers within these formations include the Skuwerberg and Rietvlei Fm, with an average thickness of approximately 200 to 300 meters and 150 to 200 meters, respectively. These geological features contribute significantly to the hydrogeological characteristics of the GRU, impacting groundwater storage and flow dynamics (refer to DWS, 2022d and 2023a).
Surface Water System	There are no major surface water systems in this RU except for a tributary of the Klein-Berg River (refer to **Figure 3-12** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls entirely within the Berg Tributaries (C5) IUA and is assigned a Water Resource Class of II and a Groundwater Resource Class of II. There are no EWR sites nor any priority biophysical nodes (**Figure 3-12**).
Recharge	An estimated recharge of 2.78 M m³/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 69.59 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details. (see table below)
Groundwater Use	In this GRU, there are 3 registered groundwater users, collectively utilizing 0.08 M m³/a of groundwater. The primary groundwater use sectors are Agriculture (Watering) and Agriculture (Irrigation), constituting 100% of the total annual groundwater use volume (see **Figure 3-12** and the table on the right). (see table below)

Recharge:

Method	Area (km²)	Recharge Volume (M m³/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	39.95	2.78	69.59

Groundwater Use:

Water Use Sector	No. of Users	Total Volume (M m³/a)
Fractured TMG Aquifer		
Agriculture: Irrigation	3	0.08
Total	3	0.08

UMVOTO
EARTH | WATER | SCIENCE | LIFE

GRU	GRU Name: Witzenberg Main Towns: None Total Area (km^2): 39.95
Water Quality	*No water quality data available*
Aquifer Stress	The GRU is considered to have a Groundwater Availability Present Status Category of 'A', indicating an unstressed or slightly stressed aquifer, and the Groundwater Quality Present Status cannot be determined due to limited data availability (see table below).
Groundwater Reserve	Quality Component *No water quality data available* 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.
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 2.78 to 2.60 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 0.08 to 0.16 M m^3/a due to sectoral growth and the implementation of groundwater development schemes in the area. Under these conditions, the Allocation Category did not change from category B (refer to Section 2.5 and the table below).

Aquifer Stress:

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
2.78	0.08	0.03	A	N/A

Groundwater Reserve:

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)
2.78	0.18	0.00	0.18	2.60	0.08	2.52

Future Scenario 2050 (Scenario 7b):

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)
2.60	0.18	0.00	0.18	2.42	0.16	2.26

GRU	GRU Name: Witzenberg Main Towns: None Total Area (km^2): 39.95
Monitoring Programme	The Witzenberg GRU was assigned a Management Option 1 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 1 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Witzenberg GRU (see **Figure 3-12** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 1						
3319AC00012	NGA	Biii4	EWR	-33.358	19.24152	Frequency: Quarterly or Biannual (Summer & Winter) 1) Groundwater level: o Manual groundwater level measurements 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]: Biii4: Nutrients (Phosphate [PO4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen); Toxins (Atrazine and Endusulfan).
BHN Management Option 1						
3319AC00012	NGA	Biii4	BHN	-33.358	19.24152	Frequency: Quarterly or Biannual (Summer & Winter) 1) Groundwater level: o Manual groundwater level measurements 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 o Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms

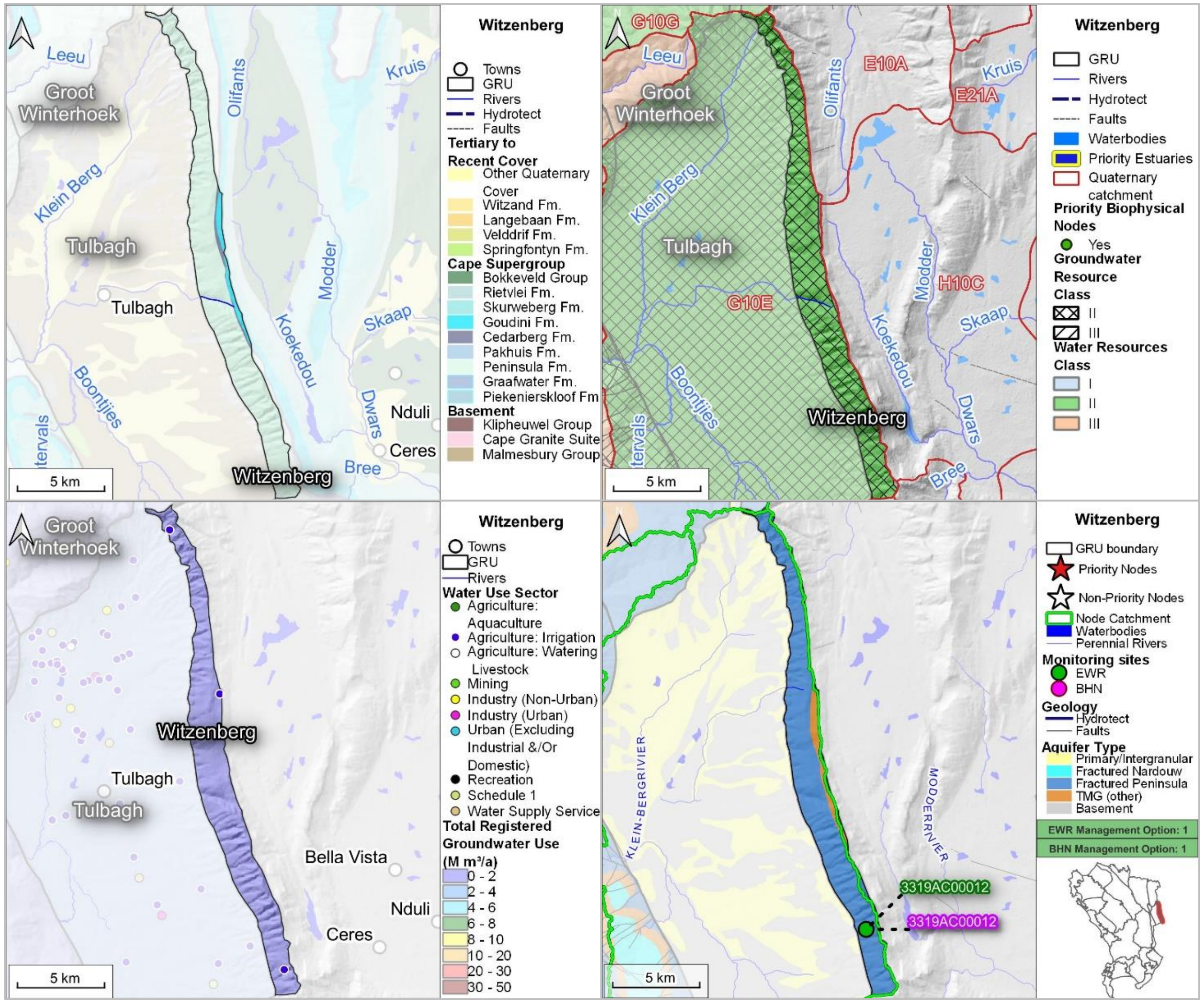


Figure 3-12 A series of maps for the Witzenberg GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.2.7. Groot Winterhoek GRU

GRU	GRU Name: Groot Winterhoek Main Towns: None Total Area (km²): 379.26
GRU Boundary Description	The Groot Winterhoek GRU is delineated by the extent of the TMG and its contact with basement lithologies, specifically the Malmesbury Group on its western flank. The southern boundary, and its demarcation from the Voëlvlei-Slanghoek and Witzenberg GRUs, is defined by the Roodezandspas Fault line, the contact with the Malmesbury Group basement, and segments of the G10G surface water quaternary catchment divide. The north-eastern edge of the GRU is marked by sections of the E10C surface water quaternary catchment divide and the extent of the Berg catchment (refer to **Figure 3-13** and DWS, 2022d and 2023a).
Quaternary Catchments	G10J, G10E, G10H, E10C and G10G (**Figure 3-13**)
Resource Unit	Fractured Table Mountain Group Aquifer
Description	In the Groot Winterhoek region, the TMG has undergone folding, creating a syncline. This geological process has resulted in the exposure of the Peninsula Fm, comprising thickly bedded, super-mature quartzite, and quartz sandstones. The Peninsula Fm is prominently visible in the steep limbs to the east and west of the GRU. Within this specific area, the thickness of the Peninsula Fm ranges from approximately 600 to 1000 meters. The syncline structure and the distinct characteristics of the Peninsula Fm play a significant role in shaping the hydrogeological features of the Groot Winterhoek GRU (refer to DWS, 2022d and 2023a). Centrally located within the syncline are the Goudini, Skuwerberg, and Rietvlei Formations, belonging to the Nardouw Sub-group and having a thickness ranging from 150 to 300 meters. The Groot-Kliphuis River closely follows the axis of the syncline. Within these formations, the aquifers include the Skuwerberg, characterized by thickly bedded quartzite, and the Rietvlei, composed of feldspathic sandstone with minor shales. The geological features within the syncline, especially these aquifer formations, play a crucial role in influencing the hydrogeology and groundwater dynamics in the area (refer to DWS, 2022d and 2023a).
Surface Water System	The Olifants River, originating from the northern extent of the Groot Winterhoek GRU, is composed of several tributaries such as the Klein Kliphuis River and the Vier-en-Twintig River. The principal surface water system in this GRU is the Olifants River itself, which flows directly through the northern and northeastern edges of the GRU. The course of most surface water features in the area follows the general topography of the Groot Drakenstein Mountains (refer to **Figure 3-13** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	Only a portion of the GRU is located within the Berg Tributaries (C5) and the Lower Berg (B4) IUAs, while the remaining part extends beyond the IUAs, as the GRU expands outside of the Berg catchment area, specifically the former Berg WMA (2004). The segments of the RU within the B4 IUA (catchments G10H and G10J) have a Water Resource Class of III, and the portions of the GRU within the C5 IUA (catchment G10G and G10E) have a Water Resource Class of II. The segments of the GRU within the B4 IUA (catchment G10H) have a Groundwater Resource Class of II, and the portions within the C5 IUA (catchment G10E) have a Groundwater Resource Class of II. This site includes 1 priority biophysical site – the Vier-en-twintig River node with a TEC of B/C (see **Figure 3-13** and the table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
C5 Berg Tributaries's	II	G10G	C5-R08	Vier-en-Twintig	Bi1	B/C	23

GRU	GRU Name: Groot Winterhoek Main Towns: None Total Area (km²): 379.26
Recharge	An estimated recharge of 22.5 M m³/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments (see table below). The average recharge rate is 59.33 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to DWS (2022e) for further details.
Groundwater Use	In the Peninsula Aquifer RU, there are 4 registered groundwater users, collectively utilizing 0.19 (M m³/a) of groundwater. In the Nardouw Aquifer RU, there are 7 registered groundwater users, with a combined groundwater use of 0.21 M m³/a. The primary groundwater use sector in this region is Agriculture (Irrigation). Refer to **Figure 3-13** and the table on the right.
Water Quality	*No water quality data available*
Aquifer Stress	The GRU is considered to have a Groundwater Availability Present Status Category of 'B', indicating an unstressed or slightly stressed aquifer, and the Groundwater Quality Present Status cannot be determined due to limited data availability (see table below).
Groundwater Reserve	Quality Component *No water quality data available* 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:

Method	Area (km²)	Recharge Volume (M m³/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	379.26	22.5	59.33

Groundwater Use:

Water Use Sector	No. of Users	Total Volume (M m³/a)
Fractured TMG Aquifer (Peninsula)		
Agriculture: Irrigation	3	0.18
Industry (Non-Urban)	1	0.01
Fractured TMG Aquifer (Nardouw)		
Agriculture: Irrigation	7	1.21
Total	11	1.39

Aquifer Stress:

Recharge Volume (M m³/a)	Groundwater Use (M m³/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
22.50	1.39	0.06	B	N/A

Groundwater Reserve:

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)
22.5	0.77	0.02	0.79	21.71	1.39	20.32

GRU	GRU Name: Groot Winterhoek Main Towns: None Total Area (km^2): 379.26
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 22.5 to 20.11 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 1.39 to 3.27 M m^3/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 0.02 to 0.03 M m^3/a, primarily attributed to population growth. Under these conditions, the Allocation Category did not change from category B (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)
20.11	0.77	0.03	0.80	19.31	3.27	16.04

Monitoring Programme

The Groot Winterhoek GRU was assigned a Management Option 1 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 2 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Groot Winterhoek GRU (see **Figure 3-13** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 1						
Proposed BH		Bi1	EWR	-33.13404333	19.06101774	Frequency: Quarterly or Biannual (Summer & Winter) 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Bi1: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen)
3219CC00015	NGA	Bi1	EWR	-32.98054	19.07122	
BHN Management Option 1						
3219CC00015	NGA	Bi1	BHN	-32.98054	19.07122	Frequency: Quarterly or Biannual (Summer & Winter): 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms

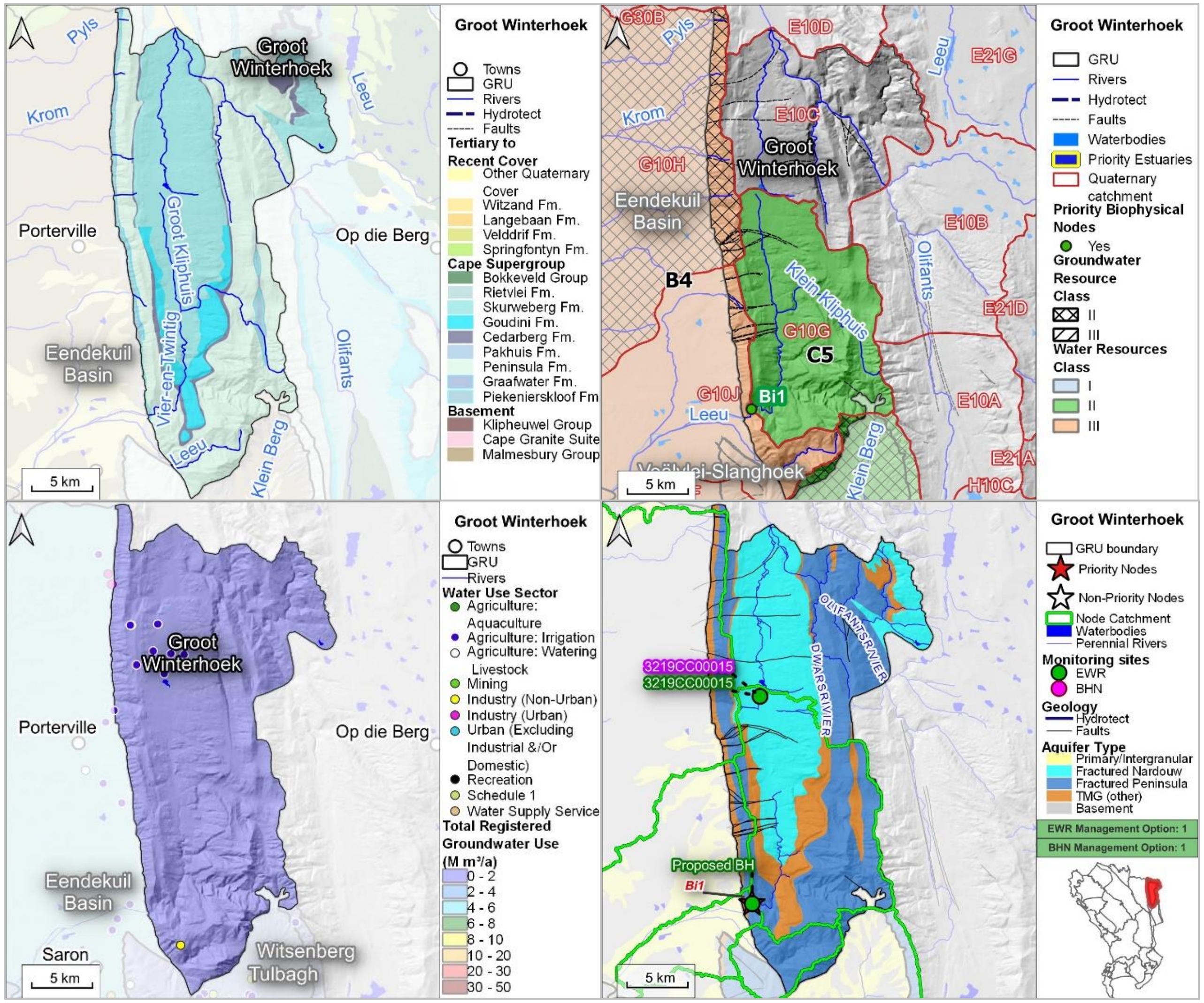


Figure 3-13 A series of maps for the Groot Winterhoek GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.2.8. Piketberg GRU

GRU	GRU Name: Piketberg Main Towns: Goedwerwacht Total Area (km^2): 298.29
GRU Boundary Description	The Piketberg GRU is entirely defined by the extent of the TMG outcrop, primarily composed of the Peninsula, Rietvlei, Cederberg, Graafwaters, and Piekenierskloof Fm. Its boundary is determined by the contact with the surrounding basement lithologies, specifically the Malmesbury Group. The south/south-western edge of the GRU is marked by portions of the Aurora-Piketberg fault zone (refer to **Figure 3-14** and DWS, 2022d and 2023a).
Quaternary Catchments	G10M, G30D, G10K, G30A and G10H (**Figure 3-14**)
Resource Unit	Fractured Table Mountain Group Aquifer
Description	In this mountainous region of the TMG, the aquifer-bearing Peninsula Fm, with a thickness ranging from approximately 600 to 1000 meters, is located in the limbs of a syncline, positioned above the Malmesbury Group basement. The basement itself is situated at the base of the mountain on the eastern side, outside the boundaries of this GRU. This basement acts as a no-flow boundary for groundwater on the southeast side of the Piketberg GRU, with only minor flow occurring into screes and weathered zones of the Malmesbury Group. Additionally, the Sandveld Group overlays flat areas and screes on the mountain slopes, covering the TMG and basement to the northwest of the GRU (refer to DWS, 2022d and 2023a). The mountainous area is primarily characterized by the Rietvlei Fm, part of the Nardouw Sub-group. This Fm, consisting of feldspathic sandstone with minor shales and approximately 150-200 meters thick, dominates the valley of the syncline. In addition to the Rietvlei Fm, flat areas and screes on the mountain slopes are overlain by the Sandveld Group. The Sandveld Group extends over the TMG and basement to the northwest of the GRU. These geological Fms contribute to the hydrogeological characteristics of the region (refer to DWS, 2022d and 2023a).
Surface Water System	The primary surface water systems in this area are the Boesmans and Platkloof Rivers. Surface-water flow is observed originating from the elevated Piketberg Mountains of the TMG outcrop (refer to **Figure 3-14** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	Only a portion of the GRU is situated within the Lower Berg (B4) and the Berg Estuary (A1) IUAs, while the remaining part extends beyond the IUAs, as the GRU expands outside of the Berg catchment area. The segments of the RU within the B4 IUA (catchments G10K and G10H) have a Water Resource Class of III, and the portions within the A1 IUA (catchment G10M) have a Water Resource Class of II. The segments of the GRU within the B4 IUA (catchment G10H) lack a Groundwater Resource Class (except for the small portion within catchment G10H, which has a Groundwater Resource Class of II), and the portions within catchment G10M have a Groundwater Resource Class of II. This GRU does not contain any EWR sites nor any priority biophysical nodes (**Figure 3-14**).
Recharge	An estimated recharge of 20.33 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 68.16 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	298.29	20.33	68.16

GRU	GRU Name: Piketberg Main Towns: Goedwerwacht Total Area (km²): 298.29

Groundwater Use

In the Peninsula Aquifer RU, there are 46 registered groundwater users collectively utilizing 5.14 M m^3/a of groundwater (**Figure 3-14**). The predominant groundwater use sector in this region is Agriculture (Irrigation), accounting for 97.5% of the total annual groundwater use volume. In the Nardouw RU, there are 6 registered groundwater users collectively utilizing 0.44 M m^3/a of groundwater (**Figure 3-14**). The primary groundwater use sector in this region is Agriculture (Irrigation), contributing 99.5% to the total annual groundwater use volume.

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured TMG Aquifer (Peninsula)		
Agriculture: Irrigation	41	5.02
Industry (Non-Urban)	2	0.056
Water Supply Service	3	0.07
Fractured TMG Aquifer (Nardouw)		
Agriculture: Irrigation	5	0.44
Primary / Intergranular Aquifers		
Agriculture: Irrigation	1	0.002
Total	46	5.58

Water Quality

No water quality data available

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'C', indicating a moderately stressed aquifer, and the Groundwater Quality Present Status cannot be determined due to limited data availability (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
20.33	5.58	0.27	C	N/A

Groundwater Reserve

Quality Component

No water quality data available

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 (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
20.33	2.07	0.04	2.11	18.22	5.58	12.64

GRU	GRU Name: Piketberg Main Towns: Goedwerwacht Total Area (km^2): 298.29
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 20.33 to 19.02 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 5.58 to 9.80 M m^3/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 0.04 to 0.06 M m^3/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).
Monitoring Programme	The Piketberg GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 3 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Piketberg GRU (see **Figure 3-14** 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)
19.02	2.07	0.06	2.13	16.89	9.80	7.09

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
G3N0547	HYDSTRA	Biv2	EWR	-32.73111111	18.52194444	Frequency: Monthly or Quarterly 1) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4
3218DC00011	NGA	Biv2	EWR	-32.80305	18.68729	
G1N0404	HYDSTRA	Biv2	EWR	-32.72257	18.5704	
BHN Management Option 1						
3218DA00006	NGA	GRU	BHN	-32.6961	18.53395	Frequency: Quarterly or Biannual (Summer & Winter) 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms

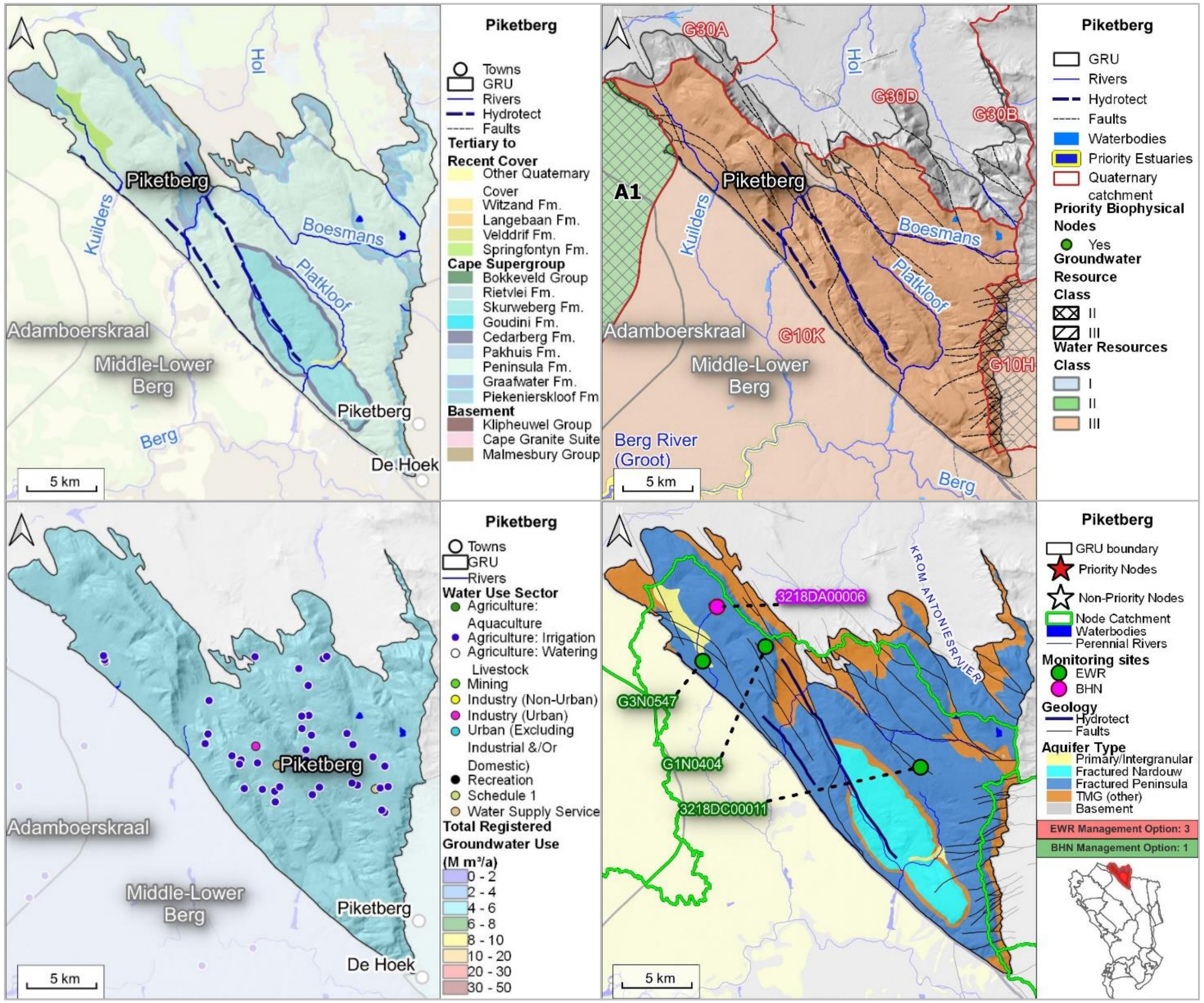
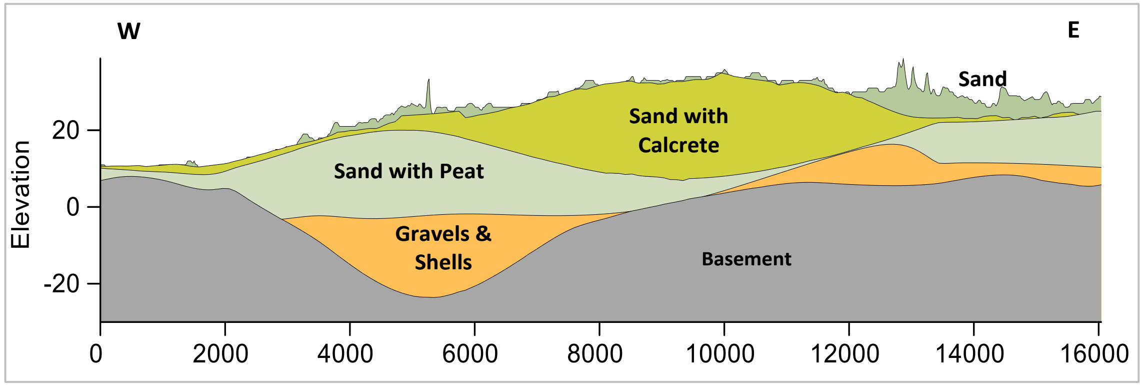


Figure 3-14 **A series of maps for the Piketberg GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

3.3. Fractured and Intergranular Basement GRUs

3.3.1. Cape Town Rim GRU

<table>
<tr><td rowspan="3">GRU</td><td>GRU Name: Cape Town Rim</td></tr>
<tr><td>Main Towns: Cape Town, Cape Flats and Brackenfell</td></tr>
<tr><td>Total Area (km²): 826.03</td></tr>
<tr><td>GRU Boundary Description</td><td>The northern and eastern edges of the Cape Town Rim GRU are defined by portions of the G21F, G21E, G22H, and G22G surface water quaternary catchment divides. The boundary between the Cape Town Rim GRU and the Cape Peninsula GRU is established by the extent of basement lithologies, namely the CGS and the Malmesbury Group, along with their contact with the Table TMG rocks. Quaternary catchments were utilized due to the tendency of groundwater flow to align with topography. The western/north-western fringe of the GRU is bordered by the Table Bay and False Bay coastlines (refer to Figure 3-15; DWS, 2022d and 2023a).</td></tr>
<tr><td>Quaternary Catchments</td><td>G22C, G22E, G22B and G22D (Figure 3-15)</td></tr>
<tr><td>Resource Unit</td><td>Fractured and Intergranular Basement Aquifer</td></tr>
<tr><td>Description</td><td>The Cape Town Rim's Basement underlies, as illustrated in the cross-section of the CFA, and surrounds the Cape Flats GRU. The basement geology is composed of Neoproterozoic rocks belonging to the Tygerberg Fm (Malmesbury Group), intruded by the late Neoproterozoic to early Cambrian CGS. The Tygerberg Fm constitutes a relatively uniform succession of deep-water, turbiditic meta-sediments and shale that has undergone Fm into simple folds, typically displaying high weathering characteristics (refer to Figure 3-15 and DWS, 2022d and 2023a).

</td></tr>
<tr><td>Surface Water System</td><td>The main rivers in the area include the Kuils, Lotus, Liesbeek, and Elsieskraal rivers. It's important to note that the majority of these rivers are situated on the CFA, which overlays the basement rocks in this area (refer to Figure 3-15 and DWS, 2022d and 2023a).</td></tr>
</table>

GRU	
GRU	GRU Name: Cape Town Rim Main Towns: Cape Town, Cape Flats and Brackenfell Total Area (km^2): 826.03

Water Resource Classes & RQOs

The GRU falls within the Peninsula (E1) and Cape Flats (E12) IUAs and has Water Resource Class II and III respectively. The portion of the GRU that fall within IUA E12 (catchments G22D and G22C) has a Groundwater Resource Class of II, and no Groundwater Resource Class for the portions that fall within IUA E11 (catchments G22A and G22B). There are no priority EWR sites within this IUA, although portions of 1 estuary node (Rietvlei/ Diep) with a TEC of C fall within the GRU (see table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
D10 Diep	III	G21F	D10-E03	Rietvlei/ Diep	Bxi7	C	78

Recharge

An estimated recharge of 18.6 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments (see table below). The average recharge rate is 22.83 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to DWS (2022e) for further details.

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	298.29	18.6	22.83

Groundwater Use

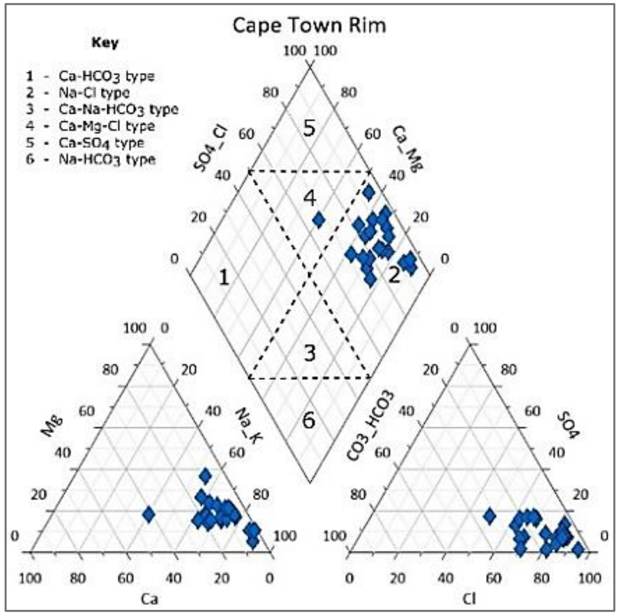
In this GRU, 169 registered groundwater users access various aquifers, including the Fractured and Intergranular Basement Aquifer, the Fractured TMG Aquifer (Peninsula), as well as the Primary/Intergranular Aquifer. Together, they utilize 6.11 M m^3/a of groundwater (see **Figure 3-15** and the table on the right). The leading groundwater use sectors in this region are Industry and Agriculture (Irrigation), contributing 43.5% and 39.0%, respectively, to the total annual groundwater use volume.

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured And Intergranular Basement Aquifer		
Agriculture: Irrigation	6	0.07
Industry (Non-Urban)	2	0.02
Industry (Urban)	9	0.26
Schedule 1	3	0.004
Urban (Excluding Industrial And/Or Domestic)	1	0.01
Water Supply Service	9	0.36
Fractured TMG Aquifer (Peninsula)		
Agriculture: Irrigation	12	0.49
Agriculture: Watering Livestock	1	0.03
Industry (Urban)	1	0.03
Water Supply Service	1	0.03
Primary / Intergranular Aquifers (At surface but abstracting from the underlying basement)		
Agriculture: Aquaculture	1	0.004
Agriculture: Irrigation	22	1.82
Agriculture: Watering Livestock	3	0.06
Industry (Urban)	9	0.20
Industry (Non-Urban)	70	2.37
Schedule 1	7	0.02
Urban (Excluding Industrial And/Or Domestic)	3	0.02
Water Supply Service	9	0.31
Total	169	6.11

GRU

GRU Name: Cape Town Rim
Main Towns: Cape Town, Cape Flats and Brackenfell
Total Area (km^2): 826.03

Water Quality



The main water type in the Cape Town Rim GRU is Na-Cl. The presence of Na-Cl waters is attributed to the saturation of Na and Cl ions due to increased groundwater residence time in the relatively low transmissivity, clay-rich shale, and siltstone basement aquifer.

Exceedances of baseline concentrations were observed for EC, pH, ammonia, nitrate + nitrite, and orthophosphate, with 50% of samples exceeding baselines for sulphate and fluoride. None of the 19 samples exceeded RQOs for this GRU. The adjusted water quality category is C, indicating the existence of moderate levels of localized contamination. Contaminating activities, including agriculture and industry, contribute to these concerns. However, it's important to note that naturally elevated concentrations of dissolved ions also play a role in exceeding baseline concentrations (refer to DWS, 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of ‘C’, indicating a moderately stressed aquifer, and a Groundwater Quality Present Status Category of ‘C’ indicating moderate levels of localised contamination, but little or no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
18.6	6.11	0.33	C	C

GRU	GRU Name: Cape Town Rim Main Towns: Cape Town, Cape Flats and Brackenfell Total Area (km^2): 826.03
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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (Tygerberg)	Sulphate	mg/l	21	21	8.50	5.50	350.00	34.10	169.40	169.40	
	Electrical conductivity	mS/m			105.10	21.00	659.00	92.00	470.00	470.00	
	pH				7.78	7.00	8.62	7.47	7.96	7.96	
	Ammonia	mg/l			0.02	0.02	0.75	0.02	0.05	0.05	
	Nitrate + nitrite	mg/l			0.28	0.02	6.57	0.13	4.31	4.31	
	Fluoride	mg/l			0.14	0.12	2.60	0.27	0.88	0.88	
	Orthophosphate	mg/l			0.01	0.00	0.13	0.01	0.06	0.06	
	Calcium	mg/l			45.50	2.30	259.80	15.80	81.10	81.10	
	Magnesium	mg/l			19.10	1.70	119.10	20.60	103.00	103.00	
	Sodium	mg/l			142.60	28.20	1048.00	128.40	957.70	957.70	
	Potassium	mg/l			3.05	0.87	13.20	3.02	7.90	7.90	
	Chloride	mg/l			240.60	44.00	2100.00	220.00	1636.70	1636.70	

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)
18.6	0.87	0.20	1.07	17.54	6.21	11.33

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 18.6 to 16.26 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 6.21 to 8.71 M m^3/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 0.20 to 0.36 M m^3/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)
16.26	0.87	0.36	1.23	15.03	8.71	6.32

GRU	GRU Name: Cape Town Rim Main Towns: Cape Town, Cape Flats and Brackenfell Total Area (km^2): 826.03
Monitoring Programme	The Cape Town Rim 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 8 monitoring sites for the EWR and 3 for the BHN were strategically selected within the Cape Town Rim GRU (see **Figure 3-15** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 2						
G2N0103	HYDSTRA	Biv9	EWR	-34.010081	18.709376	Frequency: Quarterly 1) Groundwater level: ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Bviii6: Nutrients (Phosphate [PO4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen). Bvii7: Nutrients (Phosphate [PO4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen).
96058	WMS	Bviii6	EWR	-34.016389	18.382222	
96060	WMS	Bvii7	EWR	-34.028056	18.417222	
96139	WMS	Bviii8	EWR	-33.855556	18.627222	
G2N0637	HYDSTRA	Biv9	EWR	-33.85839	18.66518	
G2N0604	HYDSTRA	Bviii8	EWR	-33.90177	18.64386	
3318DC00027	NGA	Biv9	EWR	-33.89189	18.73259	
G2N0112	HYDSTRA	GRU	EWR	-33.980081	18.479369	
BHN Management Option 3						
3318CD00036	NGA	GRU	BHN	-33.90301	18.41037	Frequency: Monthly or Quarterly 1) Groundwater level: ○ 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): ○ 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
3318DC00290	NGA	GRU	BHN	-33.88447	18.70283	
96211	WMS	GRU	BHN	-33.838611	18.607222	

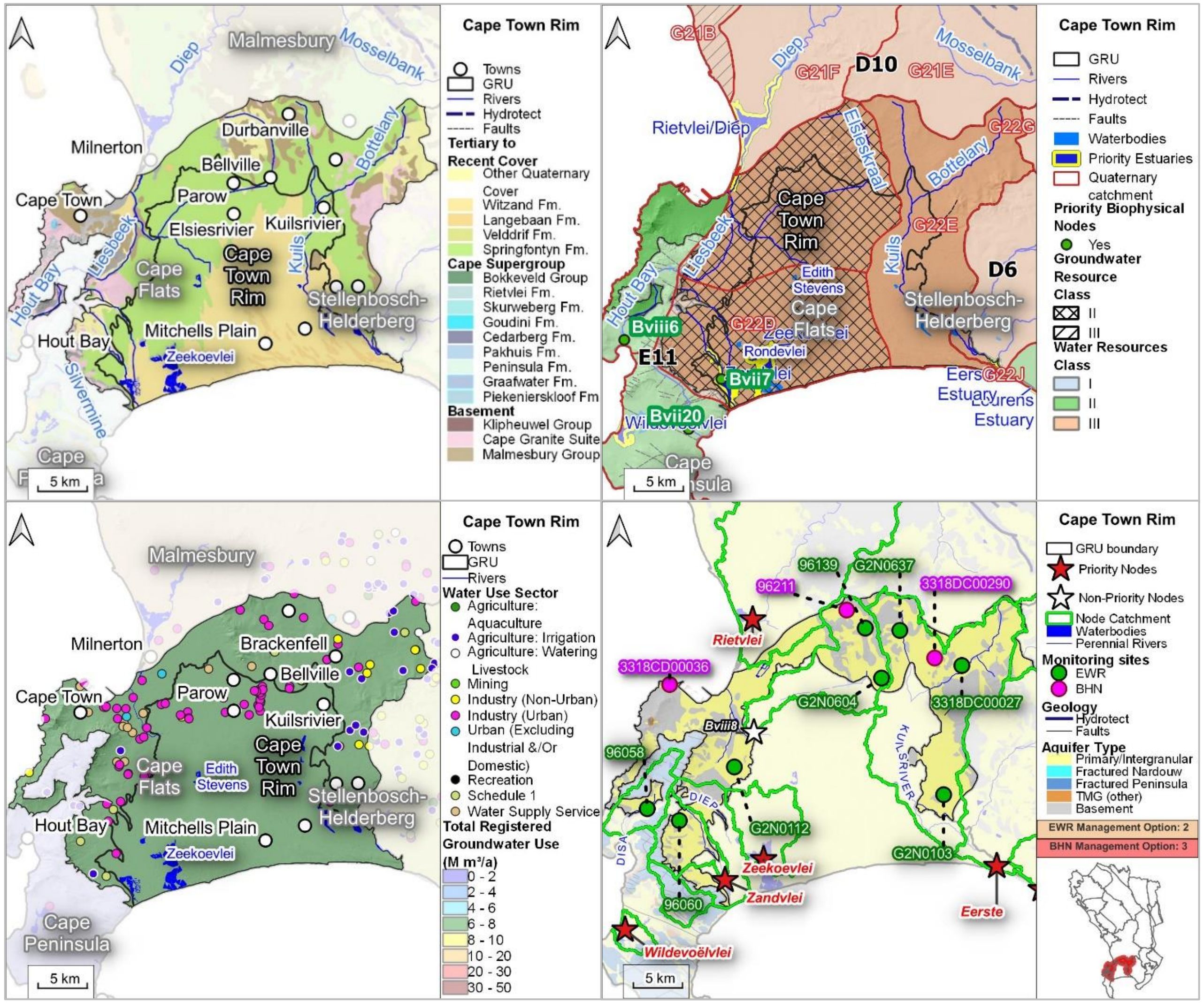


Figure 3-15 A series of maps for the Cape Town Rim GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.3.2. Stellenbosch-Helderberg GRU

GRU	GRU Name: Stellenbosch-Helderberg Main Towns: Stellenbosch and Somerset West Total Area (km^2): 570.58
GRU Boundary Description	The northern and western extents of the Stellenbosch-Helderberg GRU are delineated by portions of the G22E and G21E surface water quaternary catchment divides, as well as the aquifer model boundary outlined in the CoCT (2018) report (i.e., the Cape Flats GRU). The G10C surface water quaternary catchment divide, along with the contact between an interpolated extent of the basement lithology (the CGS and the Malmesbury Group) and the TMG, marks the southern and eastern/south-eastern boundaries of the GRU, respectively. The False Bay coastline defines the south-western edge, where the consideration of preferential groundwater flow direction towards the southwest played a role in defining the GRU boundary (refer to **Figure 3-16** and DWS, 2022d and 2023a).
Resource Unit	Fractured and Intergranular Basement Aquifer
Quaternary Catchments	G22G, G22H, G22F, G22J and G22K (**Figure 3-16**)
Description	The geological composition of this area is primarily characterized by the Malmesbury Group and CGS. The CGS gives rise to elevated rocky hills, in contrast to the generally weathered lower rolling hills predominantly formed by the Malmesbury Group (**Figure 3-16**). To the east, the Peninsula Fm outcrops, shaping the Stellenbosch and Jonkershoek mountains. In this GRU, the Peninsula Aquifer is unconfined, though it has the potential to function as a significant aquifer (refer to DWS, 2022d and 2023a).
Surface Water System	This GRU is characterized by numerous rivers, namely the Eerste, Lourens, Jonkershoek, and Sir Lowrys Pass rivers. The Eerste River is formed by the convergence of the Blouklip, Jonkershoek, and Klippies tributaries. These rivers consistently follow the topography, streaming from the elevated mountainous regions in the north to the coastal areas in the south (refer to **Figure 3-16** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls within the Eerste (D6) and Sir Lowry's (D7) IUAs, with Water Resource Class III and II, respectively. The segment of the GRU within IUA D6 (catchment G22F) is designated a Groundwater Resource Class of III, while the rest of the RU lacks a Groundwater Resource Class designation. There is 1 priority EWR site - the Eerste (Jonkershoek), and 3 priority biophysical river nodes. Additionally, the Eerste and Lourens estuaries are present in this GRU, both with a TEC of D (see **Figure 3-16** and the table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
D6 Eerste	III	G22F	D6-R16	Eerste (Jonkershoek)	Biii6	C	93
		G22G	D6-R17	Klippies	Biv8	D	77
		G22H	D6-E06	Eerste Estuary	Bxi3	D	90
D7 Sir Lower's	II	G22J	D7-R18	Lourens	Bvii21	D	114
		G22K	D7-R19	Sir Lowry's Pass*	Bviii9	C	84
		G22J	D7-E07	Lourens Estuary	Bxi4	D	85

Recharge

An estimated recharge of 41.52 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 72.77 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	570.58	41.52	72.77

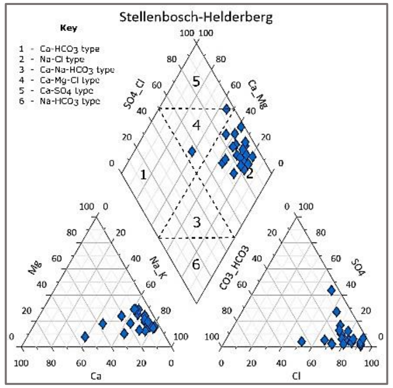
GRU	
GRU	GRU Name: Stellenbosch-Helderberg
	Main Towns: Stellenbosch and Somerset West
	Total Area (km^2): 570.58

Groundwater Use

In this GRU, there are 163 registered groundwater users utilizing a total of 8.79 M m^3/a, drawing from both the Fractured and Intergranular Basement Aquifer and the Primary/Intergranular Aquifer. The primary groundwater use sectors are Water Supply Services and Agriculture (Irrigation), accounting for 64.3% and 21.9%, respectively, of the total annual groundwater use volume (see **Figure 3-16** and the table on the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured And Intergranular Basement Aquifer		
Agriculture: Aquaculture	3	0.001
Agriculture: Irrigation	35	0.87
Industry (Non-Urban)	8	0.05
Industry (Urban)	11	0.27
Schedule 1	3	0.003
Water Supply Service	2	3.50
Primary / Intergranular Aquifer		
Agriculture: Irrigation	38	1.06
Agriculture: Watering Livestock	1	0.01
Industry (Non-Urban)	11	0.11
Industry (Urban)	41	0.71
Recreation	1	0.02
Schedule 1	4	0.03
Water Supply Service	5	2.16
Total	163	8.79

Water Quality



The primary water type in Stellenbosch-Helderberg GRU is Na-Cl. The presence of Na-Cl waters is attributed to the deposition of marine aerosols, recharge by coastal rainfall, and the dissolution and saturation of Na and Cl ions due to increased groundwater residence time in the relatively low transmissivity granitic and clay-rich shale and siltstone basement aquifer.

No RQOs have been established for the drainage regions in which this GRU falls. In boreholes targeting the Tygerberg Fm, at least 50% of samples exceeded baseline concentrations for sulphate, EC, ammonia, nitrate + nitrite, and orthophosphate. For this lithology, the adjusted water quality category is C, indicating the presence of some localized contamination that may impact the purpose for which groundwater is used. Anthropogenic impacts, likely from agriculture and industry, contribute to these concerns, but exceedances are also influenced by naturally elevated salinity, posing water quality concerns.

In boreholes targeting the CGS, at least 50% of samples exceeded baseline concentrations for pH, ammonia, nitrate + nitrite, and orthophosphate. For this lithology, the final water quality category is also C, indicating the presence of some localized contamination that may impact the purpose for which groundwater is used. (reefer to DWS 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of ‘C’, indicating a moderately stressed aquifer, and a Groundwater Quality Present Status Category of ‘C’ indicating moderate levels of localised contamination, but little or no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
41.52	8.79	0.21	C	C

GRU	GRU Name: Stellenbosch-Helderberg
	Main Towns: Stellenbosch and Somerset West
	Total Area (km^2): 570.58

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95^{th} Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (Tygerberg)	Sulphate	mg/l	15	15	10.20	7.70	338.40	73.05	282.60	282.60	
	Electrical conductivity	mS/m			197.00	32.70	885.00	203.00	734.75	734.75	
	pH				7.08	6.72	7.18	6.98	7.18	7.18	
	Ammonia	mg/l			0.04	0.02	0.09	0.05	0.08	0.08	
	Nitrate + nitrite	mg/l			0.02	0.02	5.61	0.21	4.55	4.55	
	Fluoride	mg/l			2.35	0.05	2.61	0.67	2.54	2.54	
	Orthophosphate	mg/l			0.01	0.01	0.06	0.01	0.05	0.05	
	Calcium	mg/l			54.5	4.30	200.80	43.40	165.05	165.05	
	Magnesium	mg/l			28.9	5.90	376.90	56.85	306.05	306.5	
	Sodium	mg/l			297.3	54.10	1510.20	307.85	1261.70	1261.70	
	Potassium	mg/l			6.38	2.98	8.80	3.78	7.60	7.60	
	Chloride	mg/l			610.6	86.50	3495.00	586.65	2878.03	2878.03	

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95^{th} Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (CGS)	Sulphate	mg/l	6	6	14.80	2.00	289.80	5.90	138.88	138.88	
	Electrical conductivity	mS/m			68.40	17.60	197.00	48.90	146.32	146.32	
	pH				7.00	6.41	7.48	7.00	7.34	7.34	
	Ammonia	mg/l			0.04	0.04	0.11	0.05	0.07	0.07	
	Nitrate + nitrite	mg/l			0.24	0.02	8.34	0.94	6.01	0.24	
	Fluoride	mg/l			1.25	0.16	2.46	0.41	2.38	2.38	
	Orthophosphate	mg/l			0.01	0.01	0.08	0.01	0.07	0.07	
	Calcium	mg/l			9.6	1.60	99.10	9.60	67.88	67.88	
	Magnesium	mg/l			13.8	2.90	35.80	9.00	30.97	30.97	
	Sodium	mg/l			95.6	22.40	297.30	66.70	194.33	194.33	
	Potassium	mg/l			7.07	0.96	7.07	3.15	6.59	7.07	
	Chloride	mg/l			167.2	34.50	610.60	115.90	373.93	373.93	

GRU	GRU Name: Stellenbosch-Helderberg Main Towns: Stellenbosch and Somerset West Total Area (km²): 570.58
	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.
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 41.52 to 38.49 M m³/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 8.81 to 11.30 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 0.24 to 0.46 M m³/a, primarily attributed to population growth. In light of these changes, the Allocation Category shifted from. Under these conditions, the Allocation Category did not change from a category C (refer to Section 2.5 and the table below).

Current:

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)
41.52	2.34	0.24	2.58	38.94	8.79	30.13

Future Scenario 2050 (Scenario 7b):

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)
38.49	2.34	0.46	2.80	35.69	11.30	24.39

GRU	
GRU	GRU Name: Stellenbosch-Helderberg Main Towns: Stellenbosch and Somerset West Total Area (km^2): 570.58
Monitoring Programme	The Stellenbosch-Helderberg 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 4 for the BHN were strategically selected within the Stellenbosch-Helderberg GRU (see **Figure 3-16** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 2						
3418BB00038	NGA	Bviii9	EWR	-34.14602	18.87707	Frequency: Quarterly 1) Groundwater level: ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Bviii9: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen), Toxins (Ammonia, Atrazine, Endosulfan) Biv8: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen), Toxins (Ammonia, Atrazine, Endosulfan) Bxi3 (Eerste): Nutrients (Dissolved Inorganic Nutrients [DIN] and Dissolved Inorganic Phosphate [DIP]); Salts; Pathogens (Enterococci & Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen). Biii6: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen), Toxins (Ammonia, Atrazine, Endosulfan) Bvii21: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen), Toxins (Ammonia, Atrazine, Endosulfan)
3418BB00071	NGA	Bviii9	EWR	-34.11769	18.92707	
G2N0672	HYDSTRA	Biv8	EWR	-33.83622	18.84286	
G2N0674	HYDSTRA	Eerste	EWR	-33.99185	18.80492	
G2N0684	HYDSTRA	Biii6	EWR	-33.93032	18.87903	
G2N0690	HYDSTRA	Biii6	EWR	-33.96561	18.92327	
3418BB00016	NGA	Bvii21	EWR	-34.08269	18.86485	
3418BB00052	NGA	Bvii21	EWR	-34.06964	18.90762	
BG00479	NGA	Biv8	EWR	-33.93513	18.8528	
BHN Management Option 3						
96032	WMS	GRU	BHN	-34.052778	18.785556	Frequency: Monthly or Quarterly 2) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 3) Groundwater Quality (Background water quality and BHN): ○ 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
96036	WMS	GRU	BHN	-34.053333	18.840278	
BG00364	NGA	GRU	BHN	-33.92159	18.85123	
96033	WMS	GRU	BHN	-34.029444	18.806389	

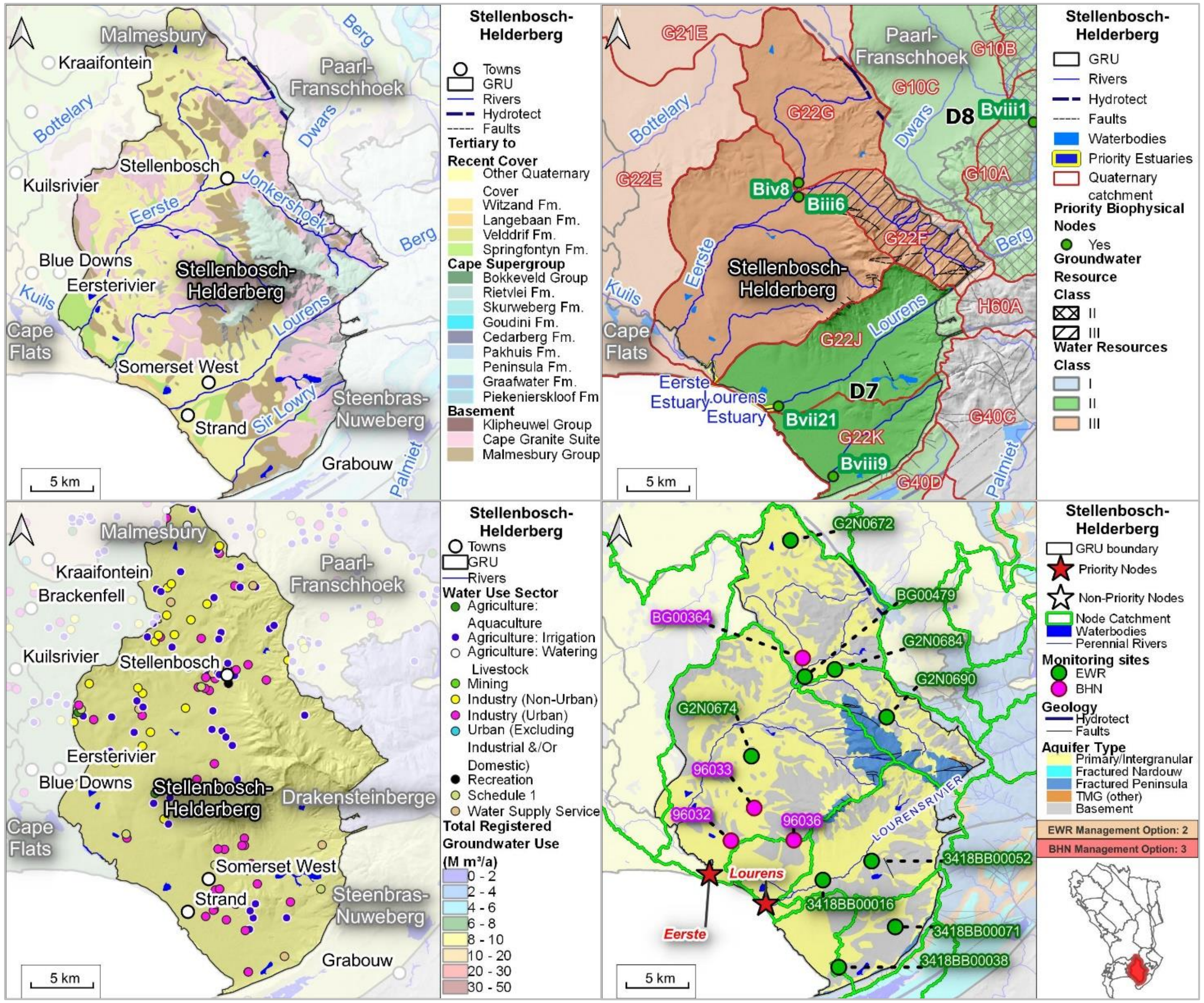


Figure 3-16 A series of maps for the Stellenbosch-Helderberg GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.3.3. Paarl-Franschhoek GRU

GRU	GRU Name: Paarl-Franschhoek Main Towns: Paarl, Franschhoek Total Area (km2): 368.50
GRU Boundary Description	The Paarl-Franschhoek GRU is enclosed by the extent of basement lithologies, specifically the CGS and the Malmesbury Group, and their contact with the TMG along the eastern and southern edges. The northern and western boundaries of the GRU are defined by portions of the G10D, G21E, and G21D surface water quaternary catchment divides (refer to **Figure 3-17** and DWS, 2022d and 2023a).
Quaternary Catchments	G10C, G10A and G10B (**Figure 3-17**)
Resource Unit	Fractured and Intergranular Basement Aquifer
Description	The GRU consists of sequences of basement rocks, primarily belonging to the Malmesbury Group and the CGS. These rocks dominate the outcrop in the undulating northern and western regions of the area. The Peninsula Fm of the TMG is observed in the mountainous southeast and along the eastern boundary. Additionally, Quaternary cover, including Fms such as the Springfontyn Fm and other younger Quaternary sediments, extensively fill valleys, especially along the Berg River (refer to DWS, 2022d and 2023a).
Surface Water System	The primary surface water system in the area is the Berg River, which includes the Dwars and Franschhoek tributaries. This river flows in a northward direction from the Berg River Dam to St Helena Bay (refer to **Figure 3-17** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls entirely within the Upper Berg (D8) and is assigned a Water Resource Class II. The segment of the GRU within catchments G10A and G10B has a Groundwater Resource Class of II. There are no priority EWR sites within this IUA; however, there are 2 priority biophysical river nodes with a TEC of C and D (refer to the TEC table below and to **Figure 3-17**).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
D8 Upper Berg	II	G10A	D8-R02	Berg	Bviii1	C	27
		G10C	D8-R03	Berg	Biii3	D	53

Recharge

An estimated recharge of 26.61 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 72.21 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	368.50	26.61	72.21

UMVOTO

EARTH | WATER | SCIENCE | LIFE

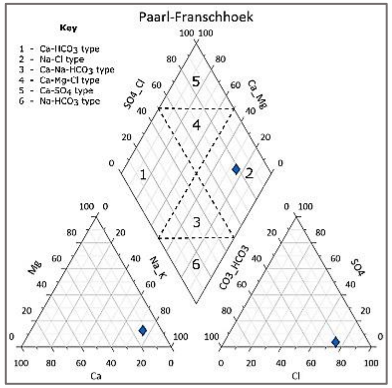
GRU	GRU Name: Paarl-Franschhoek Main Towns: Paarl, Franschhoek Total Area (km2): 368.50

Groundwater Use

In this GRU, there are 268 registered groundwater users utilizing a combined groundwater volume of 9.84 M m^3/a, drawing from the Fractured and Intergranular Basement Aquifer, the Primary/Intergranular Aquifer, and the Fractured TMG Aquifer (Peninsula). The major groundwater use sectors include Agriculture (Irrigation), Industry (Urban), and Water Supply Services, contributing 61.1%, 15.1%, and 14.7%, respectively, to the total annual groundwater use volume (see **Figure 3-17** and the table on the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured and Intergranular Basement Aquifer		
Agriculture: Aquaculture	1	0.22
Agriculture: Irrigation	33	0.90
Agriculture: Watering livestock	3	0.10
Industry (Non-urban)	16	0.32
Industry (Urban)	7	0.17
Schedule 1	1	0.01
Primary / Intergranular Aquifer		
Water Supply service	1	0.004
Agriculture: Irrigation	1	0.07
Fractured TMG Aquifer (Peninsula)		
Agriculture: Irrigation	140	5.04
Agriculture: Watering Livestock	7	0.08
Industry (Non-urban)	5	0.11
Industry (Urban)	34	1.31
Schedule 1	9	0.06
Urban (Excluding industrial and/or domestic)	1	0.01
Water Supply service	9	1.44
Total	268	9.84

Water Quality



The primary water type in Paarl-Franschhoek GRU is Na-Cl. The presence of Na-Cl waters is attributed to the saturation of Na and Cl ions, resulting from increased groundwater residence time in the relatively low transmissivity of the granite and clay-rich shale and siltstone basement aquifer.

Only 1 sample exists for this GRU. While this sample can establish a baseline, no other data exists for comparison, and consequently, no water quality category has been established. Despite agriculture being prevalent within the GRU, the low parameter concentrations indicate that pristine water quality conditions are likely. However, a more conclusive present status would require additional monitoring data (refer to DWS, 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'C', indicating a moderately stressed aquifer, and the Groundwater Quality Present Status cannot be determined due to limited data availability (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
26.61	9.84	0.37	C	N/A

GRU	GRU Name: Paarl-Franschhoek Main Towns: Paarl, Franschhoek Total Area (km2): 368.50

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (CGS)	Sulphate	mg/l	1	1	2.00	2.00	2.00	2.00	2.00	2.00	
	Electrical conductivity	mS/m			14.40	14.40	14.40	14.40	14.40	14.40	
	pH				7.04	7.04	7.04	7.04	7.04	7.04	
	Ammonia	mg/l			0.06	0.06	0.06	0.06	0.06	0.06	
	Nitrate + nitrite	mg/l			0.76	0.76	0.76	0.76	0.76	0.76	
	Fluoride	mg/l			0.25	0.25	0.25	0.25	0.25	0.25	
	Orthophosphate	mg/l			0.10	0.10	0.10	0.10	0.10	0.10	
	Calcium	mg/l			2.80	2.80	2.80	2.80	2.80	2.80	
	Magnesium	mg/l			1.70	1.70	1.70	1.70	1.70	1.70	
	Sodium	mg/l			18.20	18.20	18.20	18.20	18.20	18.20	
	Potassium	mg/l			1.75	1.75	1.75	1.75	1.75	1.75	
	Chloride	mg/l			27.50	27.50	27.50	27.50	27.50	27.50	

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)
26.61	3.01	0.13	3.14	23.47	9.84	13.65

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 26.61 to 24.60 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 9.82 to 15.50 M m^3/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 0.13 to 0.21 M m^3/a, primarily attributed to population growth. In light of these changes, the Allocation Category shifted from C to E (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)
24.60	3.01	0.21	3.22	21.38	15.50	5.88

GRU	GRU Name: Paarl-Franschhoek Main Towns: Paarl, Franschhoek Total Area (km2): 368.50
Monitoring Programme	The Paarl-Franschhoek GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 2 for monitoring the groundwater contribution to the BHN. A total of 2 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Paarl-Franschhoek GRU (see **Figure 3-17** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
G1N0439	HYDSTRA	Bvii2	EWR	-33.89888889	18.99027778	Frequency: Monthly or Quarterly 1) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Biii3: Nutrients (Phosphate [PO4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen), Toxins (Ammonia, Atrazine, Endusulfan)
G1N0440	HYDSTRA	Biv5	EWR	-33.92332	19.11257	
G1N0502	HYDSTRA	Biii3	EWR	-33.76862	19.01813	
G1N0320	HYDSTRA	Biv5	EWR	-33.88316	19.04709	
G1N0322	HYDSTRA	Bvii2	EWR	-33.87951	19.03125	
3319CC00104	NGA	Biii2	EWR	-33.85883	19.0303	
G1N0428	HYDSTRA	Biv5	EWR	-33.92333333	19.08166667	
G1N0446	HYDSTRA	Biii3	EWR	-33.82835	18.94113	
BG00450	NGA	Bvii14	EWR	-33.91134	18.94703	
3318DD00243	NGA	Bvii2	EWR	-33.86135	18.99509	
3318DD00235	NGA	Bvii2	EWR	-33.84467	18.99092	
BHN Management Option 2						
96019	WMS	GRU	BHN	-33.915556	18.920833	Frequency: Quarterly 1) Groundwater level: ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality (Background water quality and BHN): ○ 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
3318DD00221	NGA	GRU	BHN	-33.82247	18.96593	
3318DB00090	NGA	GRU	BHN	-33.7197	18.99509	

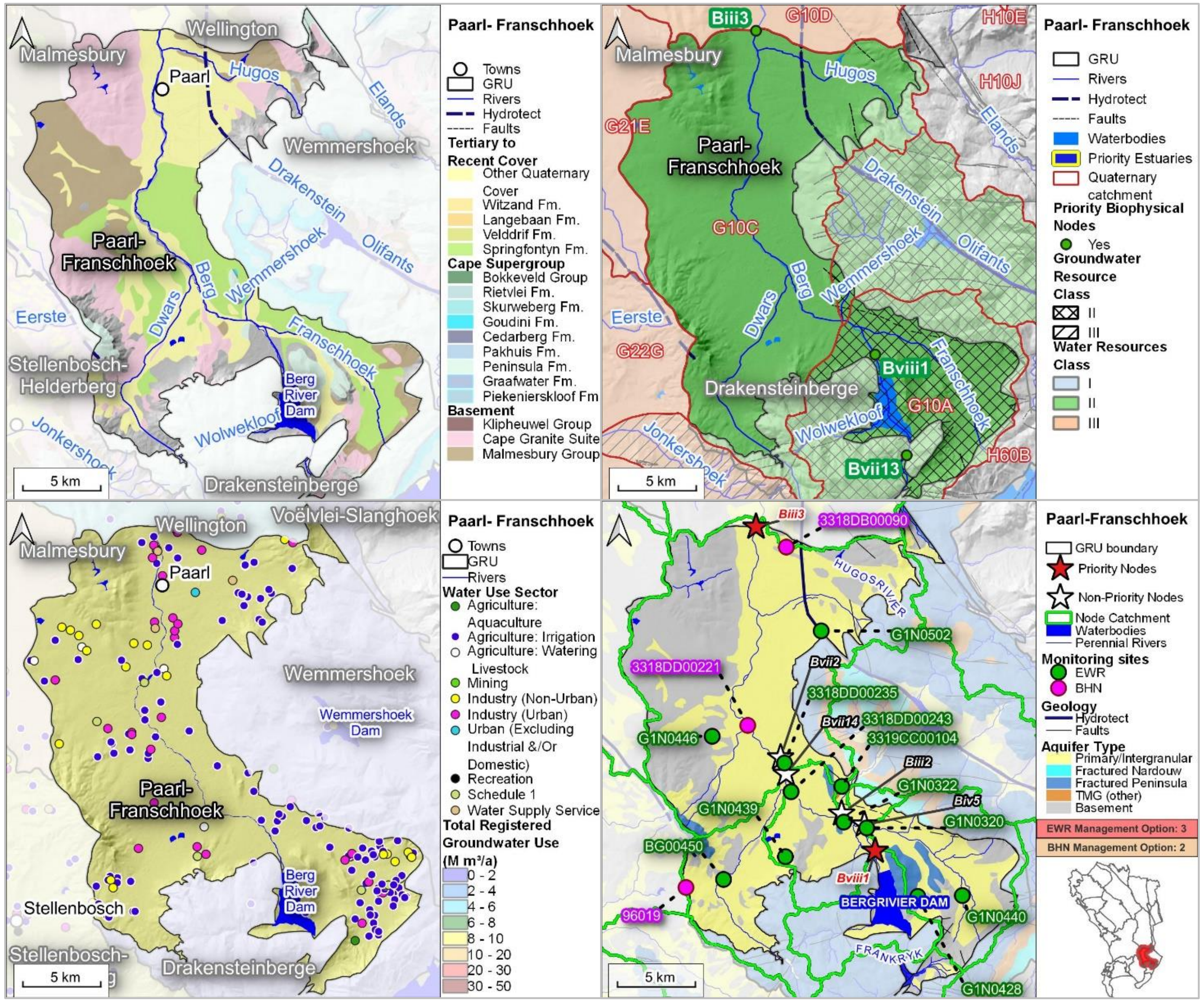


Figure 3-17 A series of maps for the Paarl-Franschoek GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.3.4. Malmesbury GRU

<table>
<tr><td rowspan="3">GRU</td><td>GRU Name: Malmesbury</td></tr>
<tr><td>Main Towns: Malmesbury and Melkbosstrand</td></tr>
<tr><td>Total Area (km2): 1600.36</td></tr>
<tr><td>GRU Boundary Description</td><td>The Malmesbury GRU is defined by a combination of an interpolated basement geology extent, encompassing the Klipheuwel Group, CGS, and Malmesbury Group, along with the G22G, G10D, G22C, G22E, G10C, G10J, G10L, G10F, and G21A surface water quaternary catchment divides on its northern, eastern, and southern edges. The western extent of the GRU is marked by portions of the CoCT (2020) aquifer model boundary (Atlantis GRU) and the Table Bay coastline (refer to Figure 3-18 and DWS, 2022d and 2023a).</td></tr>
<tr><td>Quaternary Catchments</td><td>G201E, G21C, G21D, G21F and G21B (Figure 3-18)</td></tr>
<tr><td>Resource Unit</td><td>Fractured and Intergranular Basement Aquifer</td></tr>
<tr><td>Description</td><td>The GRU is primarily underlain by the Malmesbury Group, intruded by CGS plutons. The CGS plutons give rise to elevated rocky hills, in contrast to the generally weathered lower rolling hills associated with the Malmesbury Group. Groundwater flow is predominantly restricted to weathered zones or granite scree slopes on the flanks of the plutons, and little regional flow can be anticipated (refer to DWS, 2022d and 2023a).</td></tr>
<tr><td>Surface Water System</td><td>The major surface water systems in the area consist of the Diep, Sout, and Mosselbank rivers (refer to Figure 3-18 and DWS, 2022d and 2023a).</td></tr>
<tr><td>Water Resource Classes & RQOs</td><td>The GRU falls within the West Coast (A3) and Diep (D10) IUAs, both of which have a Water Resource Class III. The segment of the GRU within IUA D10 (catchment G21D) and the segment within A3 (catchment G21B) both have a Groundwater Resource Class of II, while the rest of the GRU has no Groundwater Resource Class assigned. There are no EWR sites within this IUA; however, there are 3 priority biophysical nodes: 1 estuary node (Rietvlei/Diep) with a TEC of C and 2 river nodes (refer to the TEC table and Figure 3-18 below).
<table>
<tr><th>IUA</th><th>Water Resource Class</th><th>Quaternary Catchment</th><th>RU</th><th>Resource Name</th><th>Biophysical Node</th><th>TEC</th><th>nMAR</th></tr>
<tr><td rowspan="3">D10 Diep</td><td rowspan="3">III</td><td>G21D</td><td>D10-R11</td><td>Diep</td><td>Bv1</td><td>D</td><td>66</td></tr>
<tr><td>G21D</td><td>D10-R12</td><td>Diep</td><td>Biv6</td><td>D</td><td>68</td></tr>
<tr><td>G21F</td><td>D10-E03</td><td>Rietvlei/ Diep</td><td>Bxi7</td><td>C</td><td>78</td></tr>
</table></td></tr>
<tr><td>Recharge</td><td>An estimated recharge of 52.65 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 32.90 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to DWS (2022e) for further details.
<table>
<tr><th>Method</th><th>Area (km^2)</th><th>Recharge Volume (M m^3/a)</th><th>Average Recharge Rate (mm/a)</th></tr>
<tr><td>Map Centric Simulation Method</td><td>1600.36</td><td>52.65</td><td>32.90</td></tr>
</table></td></tr>
</table>

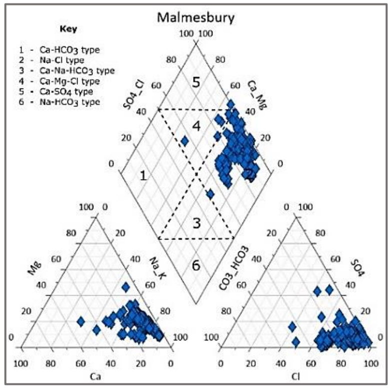
GRU	GRU Name: Malmesbury Main Towns: Malmesbury and Melkbosstrand Total Area (km2): 1600.36

Groundwater Use

In this GRU, there are 245 registered groundwater users collectively utilizing 14.8 M m^3/a of groundwater. The primary groundwater use sectors are Agriculture (Irrigation), Agriculture (Watering Livestock), and Industry (Urban), contributing 67.5%, 17.0%, and 12.4%, respectively, to the total annual groundwater use volume (see **Figure 3-18** and the table on the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured And Intergranular Basement		
Agriculture: Irrigation	78	5.44
Agriculture: Watering Livestock	18	0.67
Industry (Non-Urban)	2	0.002
Industry (Urban)	19	1.44
Mining	1	0.003
Schedule 1	4	0.01
Primary / Intergranular Aquifers		
Water Supply Service	1	0.01
Agriculture: Aquaculture	63	4.51
Agriculture: Irrigation	28	1.84
Agriculture: Watering Livestock	2	0.13
Industry (Non-Urban)	20	0.39
Industry (Urban)	1	0.02
Urban (Excluding Industrial And/Or Domestic)	6	0.27
Water Supply Service	1	0.01
Total	245	14.75

Water Quality



The primary water type in Malmesbury GRU is Na-Cl. The presence of Na-Cl waters is attributed to the saturation of Na and Cl ions, resulting from increased groundwater residence time in the relatively low transmissivity clay-rich shale and siltstone basement aquifer.

Exceedances of baseline concentrations were observed for all parameters except dissolved mercury, with 50% of samples exceeding the baseline for pH. Out of the 149 samples collected, 5 samples exceeded the RQO for EC, 1 for pH, and 34 for nitrate + nitrite. These exceedances are attributed to contamination from agriculture and industry, as well as naturally elevated concentrations of dissolved ions. The adjusted water quality category is B, indicating that low levels of contamination exist, but largely natural conditions prevail (see DWS 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of ‘C’, indicating a moderately stressed aquifer, and a Groundwater Quality Present Status of ‘B’, indicating localised, low levels of contamination, but no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
52.65	14.75	0.28	C	B

UMVOTO
EARTH | WATER | SCIENCE | LIFE

GRU	GRU Name: Malmesbury Main Towns: Malmesbury and Melkbosstrand Total Area (km2): 1600.36
Groundwater Reserve	(see below)
Future Scenario 2050 (Scenario 7b)	(see below)

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (Tygerberg)	Sulphate	mg/l	66	196	172.57	1.50	360.70	33.30	228.53	228.53	
	Electrical conductivity	mS/m		197	1549.90	29.66	2110.00	107.90	752.40	1549.90	
	pH			197	7.15	1.00	8.60	7.64	8.17	8.17	
	Ammonia	mg/l		195	0.10	0.00	1.27	0.03	0.14	0.14	
	Nitrate + nitrite	mg/l		194	503.08	0.02	589.68	0.56	17.24	503.08	
	Fluoride	mg/l		191	0.26	0.03	2.94	0.38	1.10	1.10	
	Orthophosphate	mg/l		195	0.10	0.00	14.00	0.02	0.16	0.16	
	Calcium	mg/l		194	178.18	3.50	219.30	16.98	106.08	178.18	
	Magnesium	mg/l		193	66.07	4.30	205.00	18.68	135.78	135.78	
	Sodium	mg/l		191	282.03	25.00	1726.90	156.40	931.90	931.90	
	Potassium	mg/l		192	18.77	1.10	50.31	3.67	17.06	18.77	
	Chloride	mg/l		197	655.78	50.00	2879.60	257.01	1678.57	1678.57	

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)
52.65	1.18	0.34	1.52	51.13	14.75	36.38

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 52.65 to 44.42 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 14.75 to 25.12 M m^3/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 0.34 to 0.64 M m^3/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)
44.42	1.18	0.64	1.82	42.61	25.12	17.49

GRU	GRU Name: Malmesbury Main Towns: Malmesbury and Melkbosstrand Total Area (km2): 1600.36
Monitoring Programme	The Malmesbury 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 14 monitoring sites for the EWR and 4 for the BHN were strategically selected within the Malmesbury GRU (see **Figure 3-18** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
G1N0439	HYDSTRA	Bvii2	EWR	-33.89888889	18.99027778	Frequency: Monthly or Quarterly 3) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 4) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Biii3: Nutrients (Phosphate [PO4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen), Toxins (Ammonia, Atrazine, Endusulfan)
G1N0440	HYDSTRA	Biv5	EWR	-33.92332	19.11257	
G1N0502	HYDSTRA	Biii3	EWR	-33.76862	19.01813	
G1N0320	HYDSTRA	Biv5	EWR	-33.88316	19.04709	
G1N0322	HYDSTRA	Bvii2	EWR	-33.87951	19.03125	
3319CC00104	NGA	Biii2	EWR	-33.85883	19.0303	
G1N0428	HYDSTRA	Biv5	EWR	-33.92333333	19.08166667	
G1N0446	HYDSTRA	Biii3	EWR	-33.82835	18.94113	
BG00450	NGA	Bvii14	EWR	-33.91134	18.94703	
3318DD00243	NGA	Bvii2	EWR	-33.86135	18.99509	
3318DD00235	NGA	Bvii2	EWR	-33.84467	18.99092	
BHN Management Option 2						
96019	WMS	GRU	BHN	-33.915556	18.920833	Frequency: Quarterly 3) Groundwater level: ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 4) Groundwater Quality (Background water quality and BHN): ○ 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
3318DD00221	NGA	GRU	BHN	-33.82247	18.96593	
3318DB00090	NGA	GRU	BHN	-33.7197	18.99509	

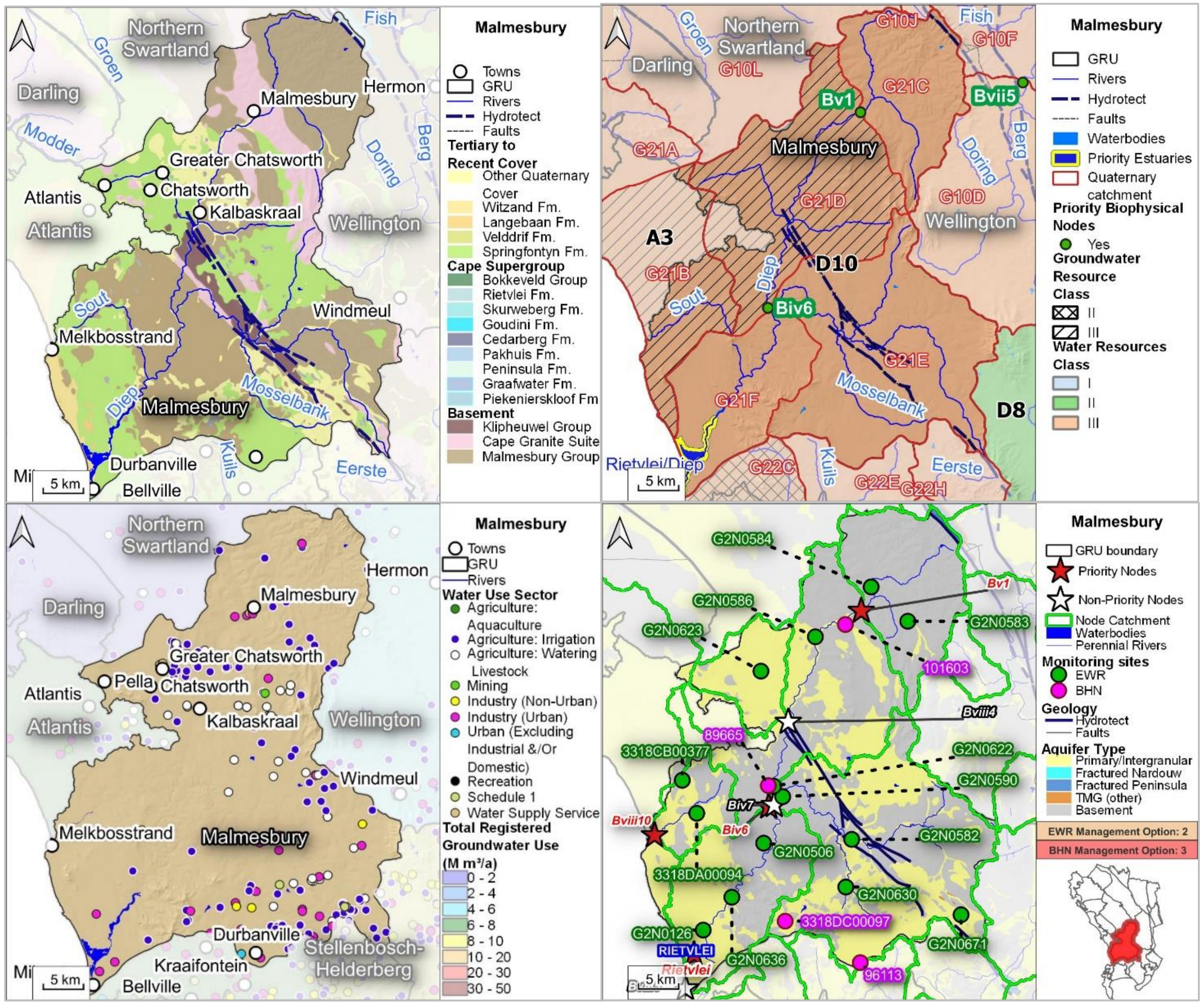


Figure 3-18 A series of maps for the Malmesbury GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.3.5. Wellington GRU

GRU	GRU Name: Wellington Main Towns: Wellington Total Area (km^2): 1068.81
GRU Boundary Description	The Wellington GRU is delineated by a combination of an interpolated basement geology extent, specifically the CGS and Malmesbury Group. On its western and southern edge, the GRU is bounded by the G21E, G21C, G10C, and G10J surface water quaternary catchment divides, incorporating sections of the Berg River. The eastern edge is defined by the contact between the TMG and the basement lithologies, as well as portions of the G10D surface water quaternary catchment divide (refer to **Figure 3-19** and DWS, 2022d and 2023a).
Quaternary Catchments	G10D and G10F (**Figure 3-19**)
Resource Unit	Fractured and Intergranular Basement Aquifer
Description	The GRU is primarily composed of the Malmesbury Group, intruded by CGS plutons. These plutons form higher rocky hills, in contrast to the generally weathered lower rolling hills associated with the Malmesbury Group. Groundwater flow is mainly restricted to weathered zones, deeper structures, or granite scree slopes on the pluton flanks, with little regional flow expected. Within the GRU, relatively thin and laterally discontinuous outcrops of the Sandveld Group are scattered. Groundwater primarily discharges to streamflow along various streams and perennial rivers. The dominant land use in the area is agriculture (refer to DWS, 2022d and 2023a).
Surface Water System	The primary surface water system in this GRU is the Berg River, which encompasses various tributaries such as the Fish, Kompanjies, Limiet, Doring, and Krom rivers. Additionally, the GRU is home to the second-largest reservoir of the WCWSS, the Voëlvlei Dam. Several smaller dams, including the Kersfontien Dam, are also located within this GRU (refer to **Figure 3-19** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls within the Lower Berg (B1) and Middle Berg (D9) IUAs, both of which have a Water Resource Class III. The GRU does not have a Groundwater Resource Class designation. There are no priority EWR sites within this IUA; however, there are 2 priority biophysical nodes (refer to the **Figure 3-19** and the TECs in the table below).

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
D9 Middle Berg	III	G10D	D9-R05	Kromme	Bvii3	D	89
		G10D	D9-R06	Berg	Bvii5	D	49

Recharge

An estimated recharge of 39.49 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 36.95 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to DWS (2022e) for further details.

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	1068.81	39.49	36.95

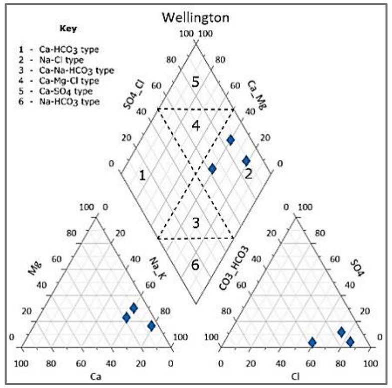
GRU	GRU Name: Wellington Main Towns: Wellington Total Area (km^2): 1068.81

Groundwater Use

In this GRU, there are 117 registered groundwater users, collectively utilizing 4.48 M m^3/a of groundwater. The primary groundwater use sectors are Agriculture (Irrigation) and Agriculture (Livestock Watering), contributing a combined 89.8% to the total annual groundwater use volume (see **Figure 3-19** and the table to the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured And Intergranular Basement Aquifer		
Agriculture: Aquaculture	1	0.16
Agriculture: Irrigation	70	3.08
Agriculture: Watering Livestock	5	0.26
Industry (Non-Urban)	2	0.00
Industry (Urban)	11	0.12
Recreation	1	0.00
Schedule 1	6	0.01
Water Supply Service	3	0.04
Primary Intergranular Aquifers		
Agriculture: Watering Livestock	14	0.63
Industry (Non-Urban)	1	0.06
Industry (Urban)	3	0.12
Total	117	4.48

Water Quality



The primary water type in Wellington GRU is Na-Cl. The presence of Na-Cl waters is attributed to the saturation of Na and Cl ions, resulting from increased groundwater residence time in the relatively low transmissivity clay-rich shale and siltstone basement aquifer.

Exceedances of baseline concentrations were observed for ammonia and orthophosphate. No RQOs have been established for this GRU. The nutrient exceedances are attributed to contamination from agriculture. The adjusted water quality category is B, indicating that low levels of contamination exist, but largely natural conditions prevail (refer to DWS, 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of ‘B’, indicating an unstressed or slightly stressed aquifer, and a Groundwater Quality Present Status of ‘B’, indicating localised, low levels of contamination, but no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
39.49	4.48	0.11	B	B

UMVOTO
EARTH | WATER | SCIENCE | LIFE

GRU	GRU Name: Wellington Main Towns: Wellington Total Area (km²): 1068.81
Groundwater Reserve	(see below)
Future Scenario 2050 (Scenario 7b)	(see below)

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (Tygerberg)	Sulphate	mg/l	3	3	118.00	4.30	118.00	4.30	106.63	118.00	
	Electrical conductivity	mS/m			202.00	25.60	202.00	29.70	184.77	202.00	
	pH				7.56	7.03	7.56	7.40	7.54	7.56	
	Ammonia	mg/l			0.14	0.05	0.21	0.14	0.20	0.20	
	Nitrate + nitrite	mg/l			1.39	1.26	1.39	1.28	1.38	1.39	
	Fluoride	mg/l			1.09	0.22	1.09	0.26	1.01	1.09	
	Orthophosphate	mg/l			0.01	0.01	0.14	0.01	0.12	0.12	
	Calcium	mg/l			42.30	1.90	42.30	9.70	39.04	42.30	
	Magnesium	mg/l			78.10	4.20	78.10	7.30	71.02	78.10	
	Sodium	mg/l			290.80	33.90	290.80	36.50	265.37	290.80	
	Potassium	mg/l			4.09	1.39	4.09	2.68	3.95	4.09	
	Chloride	mg/l			551.60	51.90	551.60	64.50	502.89	551.60	

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)
39.49	6.75	0.24	6.99	32.51	4.48	28.03

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 39.49 to 33.07 M m³/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 4.48 to 8.79 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 0.24 to 0.39 M m³/a, primarily attributed to population growth. Under these conditions, the Allocation Category did not change from a category C (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)
33.07	6.75	0.39	7.14	25.92	8.79	17.13

GRU	GRU Name: Wellington Main Towns: Wellington Total Area (km^2): 1068.81
Monitoring Programme	The Wellington GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 2 for monitoring the groundwater contribution to the BHN. A total of 17 monitoring sites for the EWR and 4 for the BHN were strategically selected within the Wellington GRU (see **Figure 3-19** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
3319CA00018	NGA	Bvii10	EWR	-33.69466	19.00487	Frequency: Monthly or Quarterly 1) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO2, NO3, NH4 ○ Site specific additions as per RQO [19]: Bvii3: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen), Toxins (Ammonia, Atrazine and Endusulfan). Bvii5: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen), Toxins (Ammonia, Atrazine and Endusulfan).
3319CA00056	NGA	Bvii3	EWR	-33.62661	19.02652	
Proposed BH		Bvii4	EWR	-33.49244285	19.08339959	
G1N0432	HYDSTRA	Bvii4	EWR	-33.5285	19.04005	
G1N0434	HYDSTRA	Bvii5	EWR	-33.44024	18.93324	
G1N0429	HYDSTRA	Bvii11	EWR	-33.37518	18.88481	
G1N0447	HYDSTRA	Bvii11	EWR	-33.39082	18.99627	
G1N0448	HYDSTRA	Bvii15	EWR	-33.52897	18.85041	
G1N0453	HYDSTRA	Bvii5	EWR	-33.59839	18.97863	
G1N0454	HYDSTRA	Bvii10	EWR	-33.6605	18.95209	
3318BD00196	NGA	Biv1	EWR	-33.28495	18.9912	
3318BD00182	NGA	Bvii4	EWR	-33.49301	18.9837	
3318BD00185	NGA	Bvii5	EWR	-33.46384	18.92232	
Proposed BH		Bviii11	EWR	-33.62228308	19.08690413	
3318DB00329	NGA	Bvii10	EWR	-33.63912	18.99648	
3318DB00328	NGA	Bvii10	EWR	-33.6369	18.96593	
G1N0551	HYDSTRA	Biv1	EWR	-33.29367	18.87805	
BHN Management Option 2						
3318DB00358	NGA	GRU	BHN	-33.67853	18.95396	Frequency: Quarterly 1) Groundwater level: a. Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality (Background water quality and BHN): ○ 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
3318DB00083	NGA	GRU	BHN	-33.68082	18.99092	
3318BD00169	NGA	GRU	BHN	-33.34884	18.87482	
96016	WMS	GRU	BHN	-33.691944	18.901667	

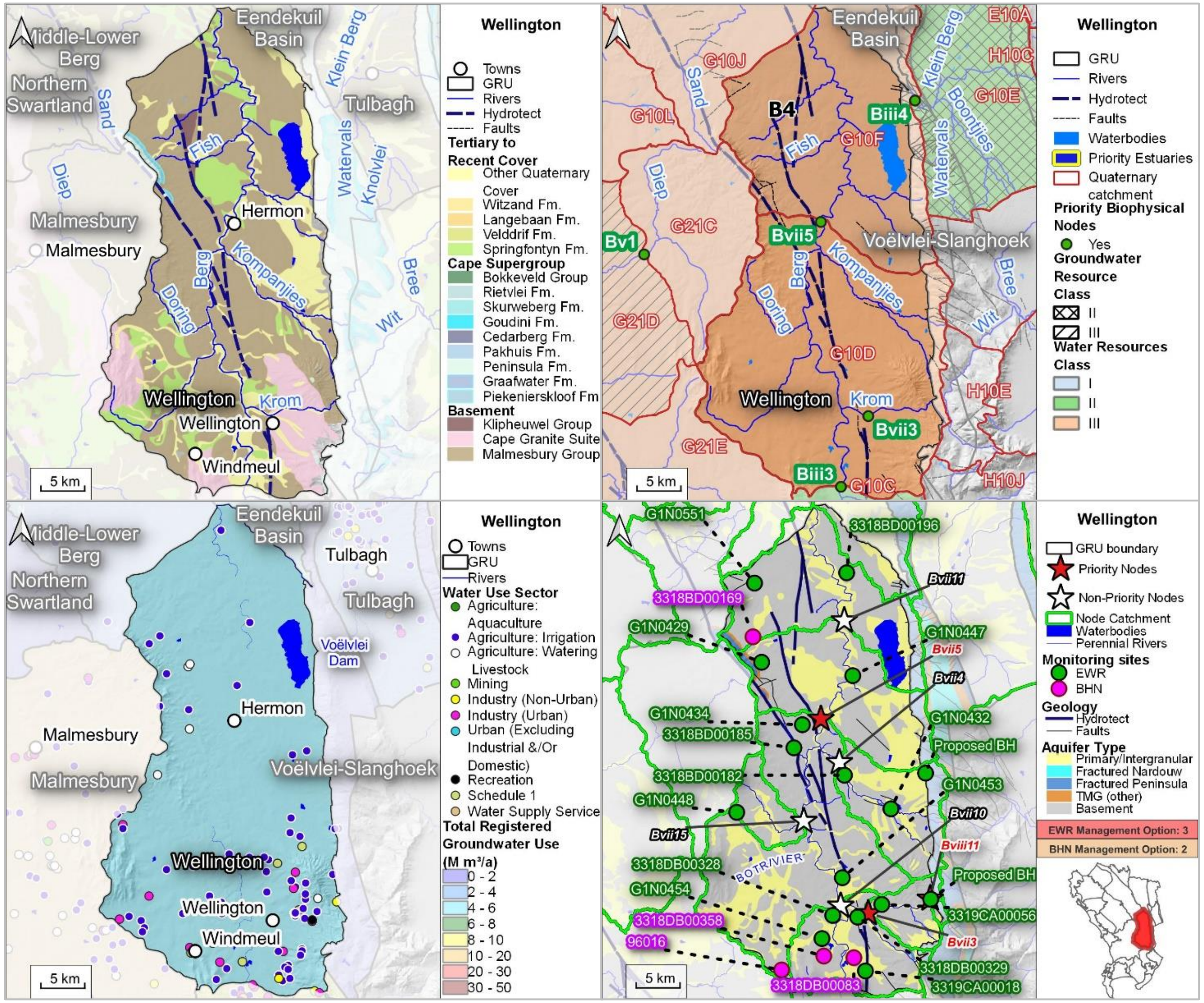


Figure 3-19 A series of maps for the Wellington GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.3.6. Tulbagh GRU

<table>
<tr><th rowspan="3">GRU</th><th>GRU Name: Tulbagh</th></tr>
<tr><th>Main Towns: Tulbagh</th></tr>
<tr><th>Total Area (km^2): 291.38</th></tr>
<tr><td>GRU Boundary Description</td><td>The Tulbagh GRU is confined by the extent of the basement lithology, specifically the Malmesbury Group, and its contact with the TMG on its northern, eastern, and western edges. The southern boundary is defined by the Berg catchment, specifically the H10F surface water quaternary catchment divide (refer to Figure 3-20 and DWS, 2022d and 2023a).</td></tr>
<tr><td>Quaternary Catchments</td><td>G10E and G10G (Figure 3-20)</td></tr>
<tr><td>Resource Unit</td><td>Fractured and Intergranular Basement Aquifer</td></tr>
<tr><td>Description</td><td>The Tulbagh GRU is primarily underlain by the Malmesbury Group, with thin and discontinuous Cenozoic cover in only a few places, such as gravel terraces from the paleo Breede River in the Klein Berg catchment. In the east of the GRU, the Tulbagh Valley is bounded on the east, west, and north by slopes of the TMG, predominantly the Peninsula Fm. The western boundary of the Tulbagh Valley, represented by the Waterval Mountains Nature Reserve, comprises a syncline of the TMG, exposing the Nardouw Sub-group in the centre (refer to DWS, 2022d and 2023a).</td></tr>
<tr><td>Surface Water System</td><td>The primary surface water system in this GRU is the Klein-Berg River, which is complemented by its tributaries including the Boontjies, Waterval, Brakkloof, and Knolvlei rivers (refer to Figure 3-20 and DWS, 2022d and 2023a).</td></tr>
<tr><td>Water Resource Classes & RQOs</td><td>The GRU falls entirely within the Berg Tributaries (C5) IUA and is assigned a Water Resource Class II. The segments of the GRU within catchment G10E have a Groundwater Resource Class of II, while the remainder of the GRU has no Groundwater Resource Class assigned. There are no EWR sites or priority biophysical nodes in this GRU (see Figure 3-20).</td></tr>
<tr><td>Recharge</td><td>An estimated recharge of 10.87 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method, and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 37.31 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.
<table>
<tr><th>Method</th><th>Area (km^2)</th><th>Recharge Volume (M m^3/a)</th><th>Average Recharge Rate (mm/a)</th></tr>
<tr><td>Map Centric Simulation Method</td><td>291.38</td><td>10.87</td><td>37.31</td></tr>
</table></td></tr>
<tr><td>Groundwater Use</td><td>In this GRU, there are 81 registered groundwater users, collectively utilizing 3.78 M m^3/a of groundwater. The dominant groundwater use sector in this region is Agriculture (Irrigation), accounting for 97.6% of the total annual groundwater use volume (see Figure 3-20 and the table on the right).
<table>
<tr><th>Water Use Sector</th><th>No. of Users</th><th>Total Volume (M m^3/a)</th></tr>
<tr><td colspan="3">Fractured and Intergranular Basement Aquifer</td></tr>
<tr><td>Agriculture: Irrigation</td><td>30</td><td>2.00</td></tr>
<tr><td>Industry (Non-urban)</td><td>1</td><td>0.0004</td></tr>
<tr><td>Schedule 1</td><td>1</td><td>0.001</td></tr>
<tr><td>Water Supply service</td><td>2</td><td>0.01</td></tr>
<tr><td colspan="3">Primary / Intergranular Aquifers</td></tr>
<tr><td>Agriculture: Irrigation</td><td>38</td><td>1.69</td></tr>
<tr><td>Agriculture: Watering Livestock</td><td>2</td><td>0.01</td></tr>
<tr><td>Industry (Non-urban)</td><td>3</td><td>0.01</td></tr>
<tr><td>Industry (Urban)</td><td>2</td><td>0.04</td></tr>
<tr><td>Schedule 1</td><td>1</td><td>0.001</td></tr>
<tr><td>Water Supply service</td><td>1</td><td>0.01</td></tr>
<tr><td>Total</td><td>81</td><td>3.78</td></tr>
</table></td></tr>
</table>

GRU	GRU Name: Tulbagh Main Towns: Tulbagh Total Area (km^2): 291.38
Water Quality	*No water quality data*
Aquifer Stress	The GRU is considered to have a Groundwater Availability Present Status Category of 'C', indicating a moderately stressed aquifer, and the Groundwater Quality Present Status could not be determined due to limited data availability (see table below).
Groundwater Reserve	Groundwater Quality Component *No water quality data* 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.
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 10.87 to 9.34 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 3.78 to 6.66 M m^3/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 0.02 to 0.05 M m^3/a, primarily attributed to population growth. In light of these changes, the Allocation Category shifted from C to F (refer to Section 2.5 and the table below).

Aquifer Stress:

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
10.87	3.78	0.35	C	N/A

Groundwater Reserve:

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)
10.87	1.28	0.02	1.30	9.57	3.78	5.79

Future Scenario 2050 (Scenario 7b):

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)
9.34	1.28	0.05	1.33	8.01	6.66	1.35

GRU	GRU Name: Tulbagh Main Towns: Tulbagh Total Area (km^2): 291.38
Monitoring Programme	The Tulbagh GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 5 monitoring sites for the EWR and 2 for the BHN were strategically selected within the Tulbagh GRU (see **Figure 3-20** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
3319AA00001	NGA	Biii4	EWR	-33.23078	19.13263	Frequency: Monthly or Quarterly 1) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Biii4: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen); Toxins (Ammonia, Atrazine, Endusulfan)
3319AC00001	NGA	Biii4	EWR	-33.38355	19.21597	
3319AC00043	NGA	Biii4	EWR	-33.32106	19.11874	
3319AA00005	NGA	Biii4	EWR	-33.24188	19.15487	
3319AA00009	NGA	Biii4	EWR	-33.23356	19.10763	
BHN Management Option 1						
3319AC00028	NGA	GRU	BHN	-33.28355	19.14096	Frequency: Quarterly or Biannual (Summer & Winter): 1) Groundwater level: ○ Manual groundwater level measurements 2) Groundwater Quality (Background water quality and BHN): ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms
89812	WMS	GRU	BNH	-33.376667	19.168889	

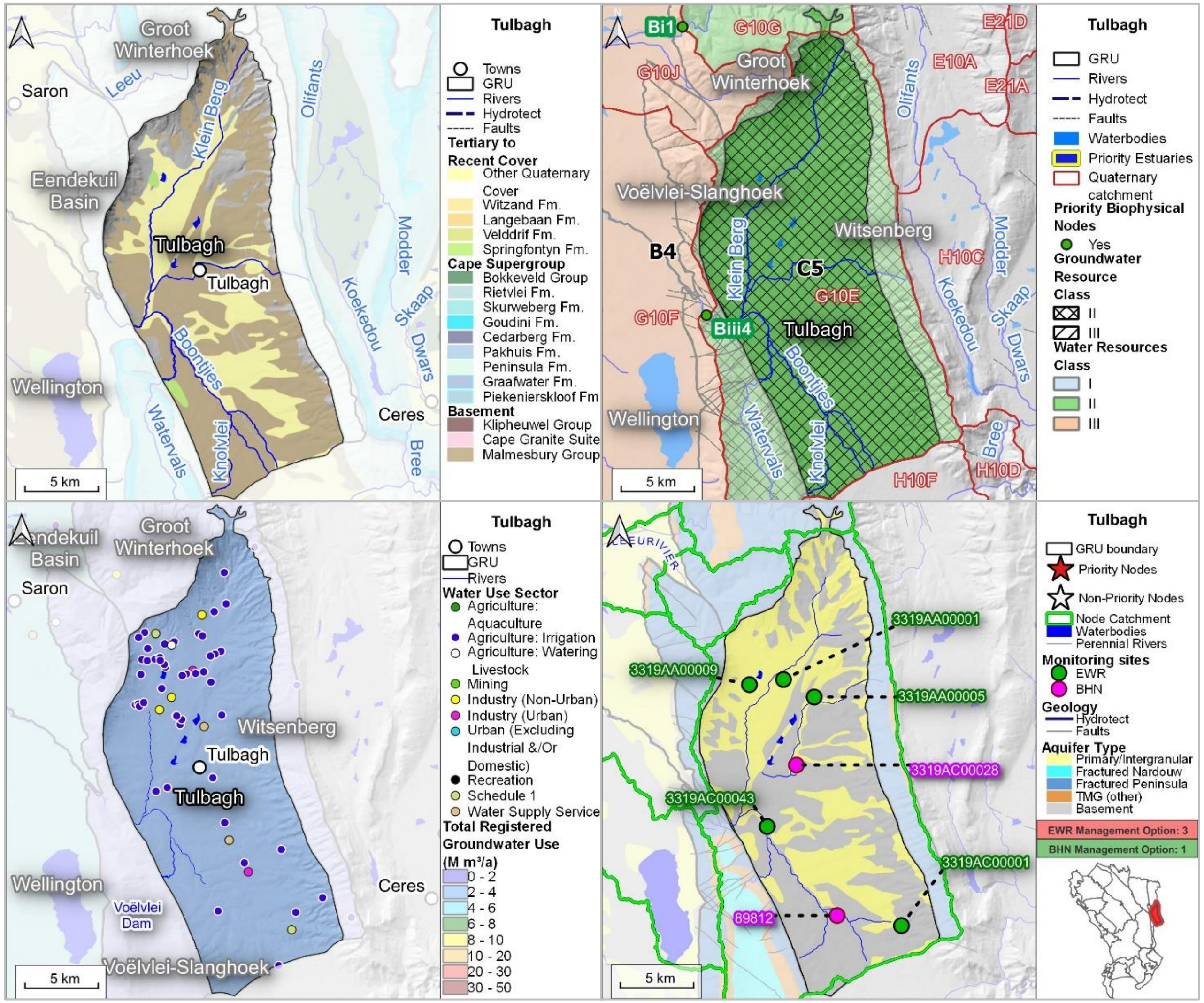


Figure 3-20 **A series of maps for the Tulbagh GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

3.3.7. Eendekuil Basin GRU

GRU	GRU Name: Eendekuil Basin Main Towns: Porterville and Piketberg Total Area (km^2): 939.94
GRU Boundary Description	The Eendekuil Basin GRU is defined by the extent of the basement lithologies, specifically the Malmesbury Group, and its contact with the TMG outcrop on the eastern flank of the GRU. In the north, portions of the Aurora-Piketberg fault zone contribute to the boundary. The Berg and Klein Berg rivers serve as the south/south-western boundaries. The definition of the GRU also takes into account the preferential groundwater flow direction and inferred discharge directions toward both the north and south (refer to **Figure 3-21** and DWS, 2022d and 2023a).
Quaternary Catchments	G10H, G10J, G10F and G10K (**Figure 3-21**)
Resource Unit	Fractured and Intergranular Basement Aquifer
Description	The Eendekuil Basin GRU is primarily composed of the Malmesbury Group, with some outcrops of the Klipheuwel Group making up the basement lithology. Additionally, there are Quaternary-recent sediment deposits resulting from the weathering of the TMG mountains to the east of the GRU, which are transported by the Vier-en-Twintig River and overlay the basement in certain areas (refer to DWS, 2022d and 2023a).
Surface Water System	The western boundary of the GRU is defined by the Berg River, serving as the primary surface water system in this region. Additional surface water systems encompass the Misverstand Dam, supplied by several rivers originating from the mountainous areas of the Groot Winterhoek, including the Krom, Pyls, Assegaaibosspruit, Jakkalskloof, Bothmankloof, and Vier-en-Twintig rivers (refer to **Figure 3-21** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls entirely within the Lower Berg (B4) and is assigned a Water Resource Class III. For the portions of the GRU within catchment G10H, it has a Groundwater Resource Class of III, while the rest of the GRU has no Groundwater Resource Class designated. There are no EWR sites within this IUA, nor are there any priority biophysical nodes (**Figure 3-21**).
Recharge	An estimated recharge of 21.88 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was selected as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 23.35 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.
Groundwater Use	In this GRU, there are 33 registered groundwater users, collectively utilizing 4.85 M m^3/a of groundwater. The primary groundwater use sectors are Water Supply Services and Agriculture (Irrigation), contributing 61.9% and 36.7%, respectively, to the total annual groundwater use volume (see **Figure 3-21** and the table on the right).

Recharge:

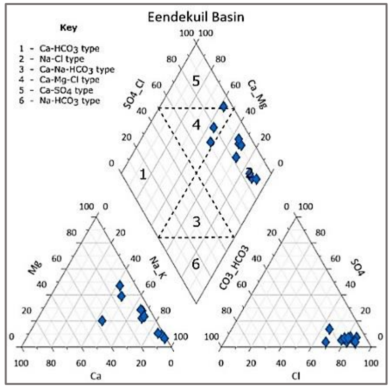
Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	936.94	21.88	23.35

Groundwater Use:

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured And Intergranular Basement		
Agriculture: Irrigation	19	1.52
Agriculture: Watering Livestock	3	0.06
Industry (Urban)	3	0.01
Primary / Intergranular Aquifers		
Agriculture: Irrigation	7	0.26
Water Supply Service	1	3.00
Total	33	4.85

GRU	GRU Name: Eendekuil Basin Main Towns: Porterville and Piketberg Total Area (km^2): 939.94

Water Quality



The primary water type in Eendekuil Basin GRU is Na-Cl. The presence of Na-Cl waters is attributed to the saturation of Na and Cl ions, resulting from increased groundwater residence time in the relatively low transmissivity clay-rich shale and siltstone basement aquifer.

Exceedances of baseline concentrations were observed for multiple parameters, with more than 50% of samples exceeding baselines for sulphate, EC, nitrate + nitrite, and fluoride. Two of the four samples collected exceed the RQO for pH. The adjusted water quality category is C, indicating that moderate levels of contamination exist in the Eendekuil Basin GRU (see DWS, 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'C', indicating a moderately stressed aquifer, and a Groundwater Quality Present Status of 'C', indicating moderate levels of localised contamination, but little or no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
21.88	4.85	0.22	C	C

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (Tygerberg)	Sulphate	mg/l	10	10	52.60	7.30	219.00	79.55	187.05	187.05	
	Electrical conductivity	mS/m			205.00	42.10	583.00	233.00	524.05	524.05	
	pH				8.20	7.86	8.45	8.14	8.42	8.42	
	Ammonia	mg/l			0.02	0.02	0.05	0.02	0.04	0.04	
	Nitrate + nitrite	mg/l			0.84	0.04	5.39	0.85	4.68	4.68	
	Fluoride	mg/l			0.94	0.20	1.87	1.01	1.55	1.55	
	Orthophosphate	mg/l			0.01	0.01	0.02	0.01	0.02	0.02	
	Calcium	mg/l			25.50	10.60	151.00	20.85	140.25	140.25	
	Magnesium	mg/l			58.20	18.40	342.00	55.05	249.39	249.39	
	Sodium	mg/l			323.20	41.70	967.10	444.10	877.24	877.24	
	Potassium	mg/l			11.27	1.28	44.80	4.22	36.74	36.74	
	Chloride	mg/l			543.60	92.80	1873.40	664.90	1702.27	1702.27	

GRU	GRU Name: Eendekuil Basin Main Towns: Porterville and Piketberg Total Area (km^2): 939.94
	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 (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
21.88	6.95	0.09	7.04	14.84	4.85	9.99

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 21.88 to 17.31 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 4.85 to 6.57 M m^3/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 0.09 to 0.016 M m^3/a, primarily attributed to population growth. In light of these changes, the Allocation Category shifted from D to E (refer to Section 2.5 and the table below).

Recharge (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
17.31	6.95	0.16	7.11	10.21	6.57	3.64

Monitoring Programme

The Eendekuil Basin GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 2 for monitoring the groundwater contribution to the BHN. A total of 9 monitoring sites for the EWR and 3 for the BHN were strategically selected within the Eendekuil Basin GRU (see **Figure 3-21** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
G1N0193	HYDSTRA	Biii5	EWR	-32.960132	18.999392	Frequency: Monthly or Quarterly 1) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4 ○ Site specific additions as per RQO [19]: Bvii6: Nutrients (Phosphate [PO_4-P] and Total Inorganic Nitrogen [TIN]); Salts (Electrical Conductivity [EC]); Pathogens (Escherichia Coli); System Variables (Temperature, pH, Dissolved Oxygen); Toxins (Atrazine and Endusulfan).
Proposed BH		Biv3	EWR	-33.21410414	18.95370508	
G1N0059	HYDSTRA	Biii5	EWR	-32.99013	18.849388	
3318BB00057	NGA	Biv4	EWR	-33.18023	18.95732	
3318BB00038	NGA	Bvii16	EWR	-33.1444	18.92009	
3319AA00063	NGA	Bvii16	EWR	-33.05716	19.01653	
3318BB00066	NGA	Bvii8	EWR	-33.10245	18.88343	
3319AA00013	NGA	Biv3	EWR	-33.1905	19.0243	
3319AC00042	NGA	Biv3	EWR	-33.28355	19.05208	
BHN Management Option 2						
3218DD00046	NGA	GRU	BHN	-32.88721	18.75511	Frequency: Quarterly 1) Groundwater level: ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality (Background water quality and BHN): ○ 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
3318BB00044	NGA	GRU	BHN	-33.00858	18.98259	
96167	WMS	GRU	BHN	-33.058333	18.884167	

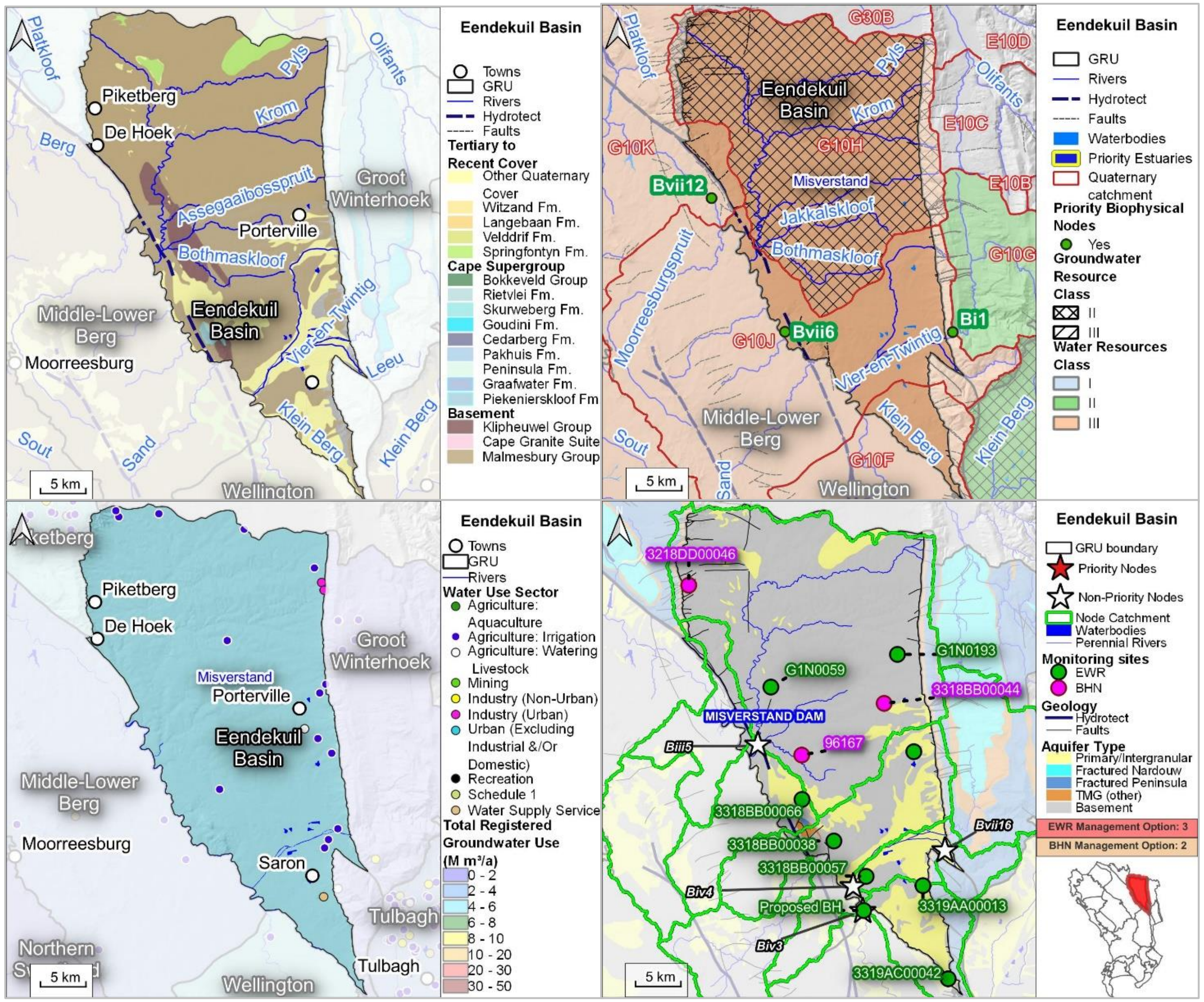


Figure 3-21 **A series of maps for the Eendekuil Basin GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

3.3.8. Middle-Lower Berg GRU

<table>
<tr><td>GRU</td><td>GRU Name: Middle-Lower Berg
Main Towns: Moorreesburg and Aurora
Total Area (km²): 1485.40</td></tr>
<tr><td>GRU Boundary Description</td><td>The Middle-Lower Berg GRU is enclosed by portions of the G21C, G10L, and G10F surface water quaternary catchment divides on its south-western to south-eastern edge. The eastern edge is defined by portions of the Aurora-Piketberg fault zone and the Berg and Klein Berg rivers. On the north-eastern border, the GRU is separated from the Piketberg GRU by the contact between the TMG and interpolated basement lithologies of the Malmesbury Group, as well as portions of the Berg catchment boundary. The north/north-western boundary is formed by the Adamboerskraal aquifer model boundary (SRK, 2004) and the St Helena Bay coastline (refer to Figure 3-22 and DWS, 2022d and 2023a).</td></tr>
<tr><td>Quaternary Catchments</td><td>G10J, G30A, G10K and G10M (Figure 3-22)</td></tr>
<tr><td>Resource Unit</td><td>Fractured and Intergranular Basement Aquifer</td></tr>
<tr><td>Description</td><td>The Middle-Lower Berg GRU is primarily composed of the Malmesbury Group, which serves as the basement lithology. Additionally, there are Quaternary-recent sediment deposits in the area. Towards the north-west, the GRU is dominated by laterally continuous Sandveld Group sediments (refer to DWS, 2022d and 2023a).</td></tr>
<tr><td>Surface Water System</td><td>The Berg Estuary initiates from the north-western corner of this GRU and constitutes a significant surface water system. Contributing to the Berg River are the Kuilders, Boesmans, and Platkloof rivers, originating from the mountainous Piketberg area. Additionally, the Soutkloof and Sand rivers are part of the water systems in this region (refer to Figure 3-22 and DWS, 2022d and 2023a).</td></tr>
<tr><td>Water Resource Classes & RQOs</td><td>The GRU falls within the Lower Berg (B4) and Berg Estuary (A1) IUAs, with Water Resource Class III and II, respectively. Only portions of the A1 IUA that fall within catchment G10M have a Groundwater Resource Class of II, while the rest of the GRU has no Groundwater Resource Class designated. There are no priority EWR sites within this IUA; however, there are two priority biophysical nodes, both with a TEC of D, as well as portions of the Berg (Groot) priority estuary (see Figure 3-22 and the table below).
<table>
<tr><th>IUA</th><th>Water Resource Class</th><th>Quaternary Catchment</th><th>RU</th><th>Resource Name</th><th>Biophysical Node</th><th>TEC</th><th>nMAR</th></tr>
<tr><td rowspan="2">B4 Lower Berg</td><td rowspan="2">III</td><td>G10J</td><td>B4-R09</td><td>Berg</td><td>Bvii6</td><td>D</td><td>52</td></tr>
<tr><td>G10K</td><td>B4-R10</td><td>Berg</td><td>Bvii12</td><td>D</td><td>51</td></tr>
<tr><td>A1 Berg Estuary</td><td>II</td><td>G10M</td><td>A1-E01</td><td>Berg (Groot)</td><td>Bxi1</td><td>C</td><td>52</td></tr>
</table></td></tr>
<tr><td>Recharge</td><td>An estimated recharge of 42.49 M m³/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 28.61 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.
<table>
<tr><th>Method</th><th>Area (km²)</th><th>Recharge Volume (M m³/a)</th><th>Average Recharge Rate (mm/a)</th></tr>
<tr><td>Map Centric Simulation Method</td><td>1485.40</td><td>42.49</td><td>28.61</td></tr>
</table></td></tr>
</table>

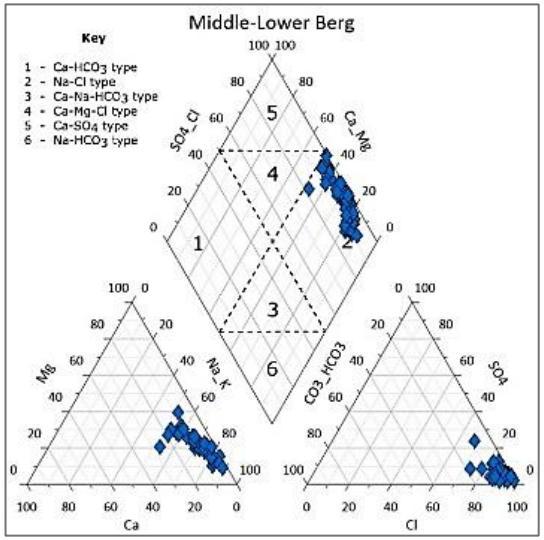
GRU	GRU Name: Middle-Lower Berg Main Towns: Moorreesburg and Aurora Total Area (km^2): 1485.40

Groundwater Use

In this GRU, there are 32 registered groundwater users collectively utilizing 2.23 M m^3/a of groundwater. The primary groundwater use sector in this region is Agriculture (Irrigation), constituting 97.5% of the total annual groundwater use volume (see **Figure 3-22** and the table on the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured And Intergranular Basement Aquifer		
Agriculture: Irrigation	5	0.09
Industry (Urban)	1	0.0003
Water Supply Service	1	0.06
Primary / Intergranular Aquifers		
Agriculture: Irrigation	25	2.08
Total	32.00	2.23

Water Quality



The primary water type in the Middle-Lower Berg GRU is Na-Cl. The presence of Na-Cl waters is attributed to the saturation of Na and Cl ions, resulting from increased groundwater residence time in the relatively low transmissivity clay-rich shale and siltstone basement aquifer.

Exceedances of baseline concentrations were observed for multiple parameters, with 50% of samples exceeding the baseline for pH, ammonia, fluoride, and orthophosphate. Out of the 46 samples collected, 4 samples exceeded the RQO for EC, 12 for pH, and 3 for nitrate + nitrite. These exceedances are attributed to contamination from agriculture, along with naturally elevated concentrations of dissolved ions. The adjusted water quality category is C, indicating that moderate levels of contamination exist in the Middle-Lower Berg GRU (see DWS, 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of ‘B’, indicating an unstressed or slightly stressed aquifer, and a Groundwater Quality Present Status of ‘C’, indicating moderate levels of localised contamination, but little or no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
42.49	2.23	0.05	B	C

GRU	GRU Name: Middle-Lower Berg Main Towns: Moorreesburg and Aurora Total Area (km²): 1485.40
Groundwater Reserve	Groundwater Quality Component (see below)
Future Scenario 2050 (Scenario 7b)	(see below)

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (Tygerberg)	Sulphate	mg/l	46	58	342.80	3.52	799.60	196.90	431.35	431.35	
	Electrical conductivity	mS/m		60	841.00	20.68	1212.00	636.00	1073.75	1073.75	
	pH			60	7.63	3.11	8.71	7.70	8.35	8.35	
	Ammonia	mg/l		58	0.02	0.02	1.37	0.04	0.33	0.33	
	Nitrate + nitrite	mg/l		58	6.16	0.02	24.96	1.24	18.00	18.00	
	Fluoride	mg/l		58	0.57	0.17	2.22	0.67	1.59	1.59	
	Orthophosphate	mg/l		58	0.01	0.00	0.13	0.01	0.08	0.08	
	Calcium	mg/l		58	166.30	4.70	218.40	63.36	181.85	181.85	
	Magnesium	mg/l		58	204.00	2.85	353.00	135.16	329.04	329.04	
	Sodium	mg/l		57	1345.50	75.00	2376.10	930.60	1897.00	1897.00	
	Potassium	mg/l		57	22.53	1.73	79.19	24.37	48.81	48.81	
	Chloride	mg/l		58	2627.50	25.52	4393.30	1972.70	3375.43	3375.43	

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)
42.49	11.15	0.09	11.24	31.26	2.23	29.03

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 42.49 to 36.88 M m³/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 2.23 to 5.09 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 0.09 to 0.16 M m³/a, primarily attributed to population growth. Under these conditions, the Allocation Category did not change from category C (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)
36.88	11.15	0.16	11.31	25.57	5.09	20.48

GRU	GRU Name: Middle-Lower Berg Main Towns: Moorreesburg and Aurora Total Area (km^2): 1485.40
Monitoring Programme	The Middle-Lower Berg GRU was assigned a Management Option 3 for monitoring the groundwater contribution to the EWR and a Management Option 2 for monitoring the groundwater contribution to the BHN. A total of 11 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Middle-Lower Berg GRU (see **Figure 3-22** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 3						
G1N0203	HYDSTRA	Biv2	EWR	-32.97013	18.569379	Frequency: Monthly or Quarterly 1) Groundwater level: ○ Manual water level measurements and continuous hourly readings from automatically recorded level loggers. Possible need for telemetry systems. 2) Groundwater Quality: ○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 ○ Site specific additions for EWR: NO_2, NO_3, NH_4
BG00369	NGA	Bvii8	EWR	-33.09141	18.8334	
96095	WMS	GRU	EWR	-33.0925	18.710833	
96152	WMS	Bvii8	EWR	-33.138889	18.805556	
G3N0546	HYDSTRA	Biv2	EWR	-32.79555556	18.51277778	
G1N0548	HYDSTRA	Bvii17	EWR	-33.18139	18.87706	
G1N0531	HYDSTRA	Bvii17	EWR	-33.34023	18.80592	
3318BA00042	NGA	Bvii18	EWR	-33.14467	18.70759	
3218CB00140	NGA	GRU	EWR	-32.68957	18.45493	
G1N0195	HYDSTRA	Biv2	EWR	-32.96013	18.499377	
G1N0534	HYDSTRA	Bvii17	EWR	-33.25757	18.80806	
BHN Management Option 2						
3318BA00046	NGA	GRU	BHN	-33.13496	18.66871	Frequency: Quarterly 1) Groundwater level: ○ Manual groundwater level measurements, as well as average daily reading from automatically recorded level logger. 2) Groundwater Quality (Background water quality and BHN): ○ 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

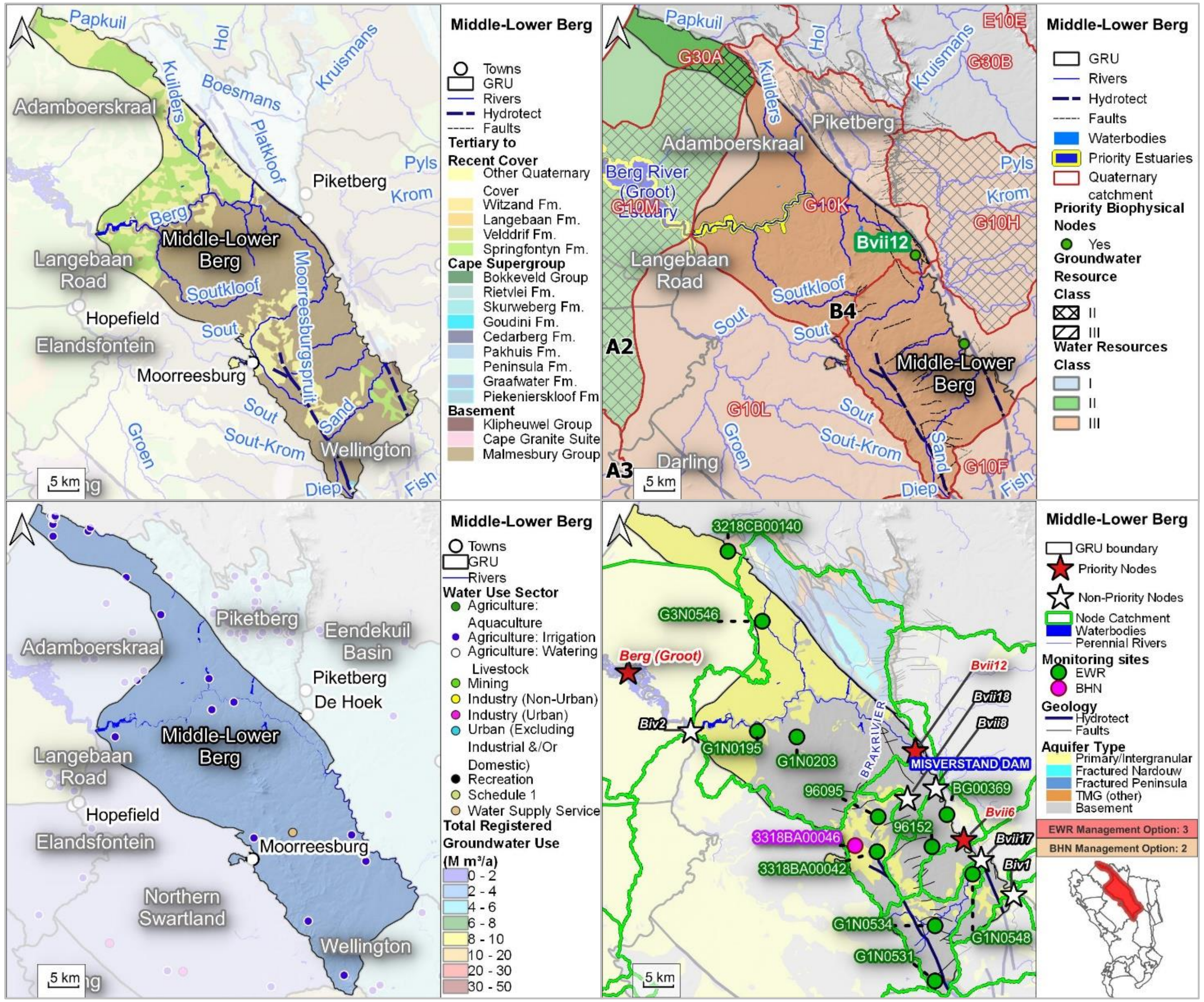


Figure 3-22 A series of maps for the Middle-Lower Berg GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.3.9. Northern Swartland GRU

GRU	GRU Name: Northern Swartland Main Towns: None Total Area (km^2): 1262.65
GRU Boundary Description	The Northern Swartland GRU is defined by a combination of an interpolated basement lithology extent, including the CGS and the Malmesbury Group, and portions of the G21C, G21D, G10J, and G10K surface water quaternary catchment divides on its northern, eastern, and southern borders. Along the western edge of the GRU, the boundary is characterized by the Colenso Fault, portions of the Modder River, and the contact between the Springfontyn Fm and the basement lithologies, creating the south-western/western edge. The western/north-western border is marked by the Sout River (refer to **Figure 3-23** and DWS, 2022d and 2023a).
Quaternary Catchments	G10L (**Figure 3-23**)
Resource Unit	Fractured and Intergranular Basement Aquifer
Description	This GRU is formed by a combination of basement Malmesbury Group and various plutons of the CGS. Additionally, laterally continuous Sandveld Group sediments, as well as fluvial sediments from ephemeral streams, are predominant in this GRU (refer to DWS, 2022d and 2023a).
Surface Water System	The predominant surface water flow direction in this area is from the south-east to north-west. Multiple tributaries, including the Sout, Sout-Krom, and Groen rivers, converge into the Sout River, ultimately contributing to the Berg River (refer to **Figure 3-23** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls almost entirely within the Lower Berg (B4) IUA, with a Water Resource Class of III. For most of the GRU, there is no Groundwater Class, except for the small portions within the G21D catchment, which has a Groundwater Resource Class of III. There are no priority EWR sites within this IUA; however, it contains portions of the priority Berg (Groot) estuary with a TEC of C (see **Figure 3-23** and the table below).
Recharge	An estimated recharge of 31.85 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method, and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 25.33 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.

IUA	Water Resource Class	Quaternary Catchment	RU	Resource Name	Biophysical Node	TEC	nMAR
A1 Berg Estuary	II	G10M	A1-E01	Berg (Groot)	Bxi1	C	

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	1257.65	31.85	25.33

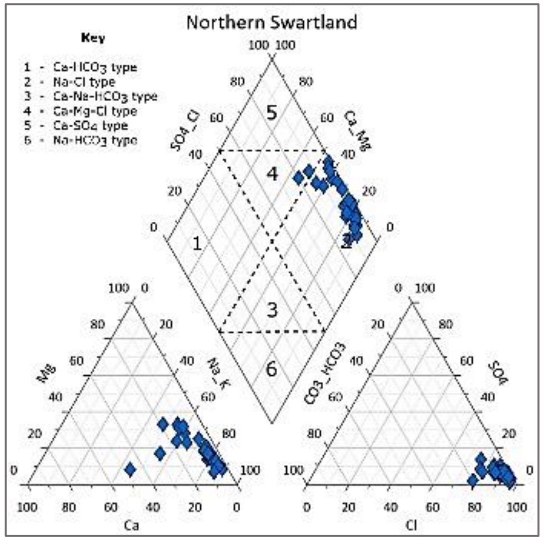
GRU	GRU Name: Northern Swartland Main Towns: None Total Area (km^2): 1262.65

Groundwater Use

In this GRU, there are 19 registered groundwater users, collectively utilizing 1.8 M m^3/a of groundwater. The primary groundwater use sectors are Agriculture (Irrigation) and Industry (Urban), contributing 72.3% and 19%, respectively, to the total annual groundwater use volume (see **Figure 3-23** and the table on the right).

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured And Intergranular Basement Aquifer		
Agriculture: Irrigation	3	0.65
Primary / Intergranular Aquifer		
Agriculture: Irrigation	6	0.65
Agriculture: Watering Livestock	5	0.16
Industry (Urban)	5	0.34
Total	19	1.80

Water Quality



The primary water type in Northern Swartland GRU is Na-Cl. The presence of Na-Cl waters is attributed to the saturation of Na and Cl ions, resulting from increased groundwater residence time in the relatively low transmissivity clay-rich shale and siltstone basement aquifer.

Exceedances of baseline concentrations were observed for multiple parameters, with 50% of samples exceeding the baseline for pH and nitrate + nitrite. Out of the 31 samples collected, 5 samples exceeded the RQO for EC, 1 for pH, and 3 for nitrate + nitrite. These exceedances are attributed to contamination from agriculture, coupled with naturally elevated concentrations of dissolved ions. The adjusted water quality category is C, indicating that moderate levels of contamination exist in the Northern Swartland GRU (refer to DWS, 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'B', indicating an unstressed or slightly stressed aquifer, and a Groundwater Quality Present Status of 'C', indicating moderate levels of localised contamination, but little or no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
31.85	1.8	0.06	B	C

GRU	GRU Name: Northern Swartland Main Towns: None Total Area (km^2): 1262.65

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95^{th} Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (Tygerberg)	Sulphate	mg/l	31	31	114.70	7.90	484.70	114.70	363.70	363.70	
	Electrical conductivity	mS/m			532.00	49.70	1175.50	400.00	1094.00	1094.00	
	pH				7.59	5.55	8.13	7.70	8.01	8.01	
	Ammonia	mg/l			0.02	0.02	0.52	0.02	0.33	0.33	
	Nitrate + nitrite	mg/l			0.87	0.02	21.53	0.96	16.56	16.56	
	Fluoride	mg/l			0.72	0.15	1.25	0.70	1.05	1.05	
	Orthophosphate	mg/l			0.01	0.00	0.11	0.01	0.06	0.06	
	Calcium	mg/l			35.70	3.80	286.50	52.40	213.55	213.55	
	Magnesium	mg/l			81.00	9.90	437.30	76.50	350.25	350.25	
	Sodium	mg/l			984.70	65.50	2133.50	614.00	1840.80	1840.80	
	Potassium	mg/l			23.46	1.48	116.34	14.00	58.54	58.54	
	Chloride	mg/l			1643.10	135.10	4123.90	1121.80	3976.25	3976.25	

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 (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
31.85	0.20	0.05	0.25	31.60	1.79	29.81

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 31.85 to 26.11 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 1.79 to 2.29 M m^3/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 0.05 to 0.09 M m^3/a, primarily attributed to population growth. Under these conditions, the Allocation Category did not change from category B (refer to Section 2.5 and the table below).

Recharge (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
26.11	0.20	0.09	0.29	25.82	2.92	22.90

<table>
<tr><td rowspan="3">GRU</td><td>GRU Name: Northern Swartland</td></tr>
<tr><td>Main Towns: None</td></tr>
<tr><td>Total Area (km²): 1262.65</td></tr>
<tr><td>Monitoring Programme</td><td>
The Northern Swartland GRU was assigned a Management Option 1 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 2 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Northern Swartland GRU (see Figure 3-23 and the table below).
<table>
<tr><th>Site Name</th><th>Data Source</th><th>Monitoring Area</th><th>Monitoring Objective</th><th>Latitude</th><th>Longitude</th><th>Monitoring Description</th></tr>
<tr><td colspan="7">EWR Management Option 1</td></tr>
<tr><td>G2N0587</td><td>HYDSTRA</td><td>Bii1</td><td>EWR</td><td>-33.35619</td><td>18.64199</td><td rowspan="2">Frequency: Quarterly or Biannual (Summer & Winter)
1) Groundwater level:
○ Manual groundwater level measurements
2) Groundwater Quality:
○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4
○ Site specific additions for EWR: NO_2, NO_3, NH_4</td></tr>
<tr><td>G1N0376</td><td>HYDSTRA</td><td>Bii1</td><td>EWR</td><td>-33.21675</td><td>18.39426</td></tr>
<tr><td colspan="7">BHN Management Option 1</td></tr>
<tr><td>96144</td><td>WMS</td><td>GRU</td><td>BHN</td><td>-33.245556</td><td>18.635556</td><td>Frequency: Quarterly or Biannual (Summer & Winter)
1) Groundwater level:
○ Manual groundwater level measurements
2) Groundwater Quality (Background water quality and BHN):
○ Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4
○ Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms</td></tr>
</table>
</td></tr>
</table>

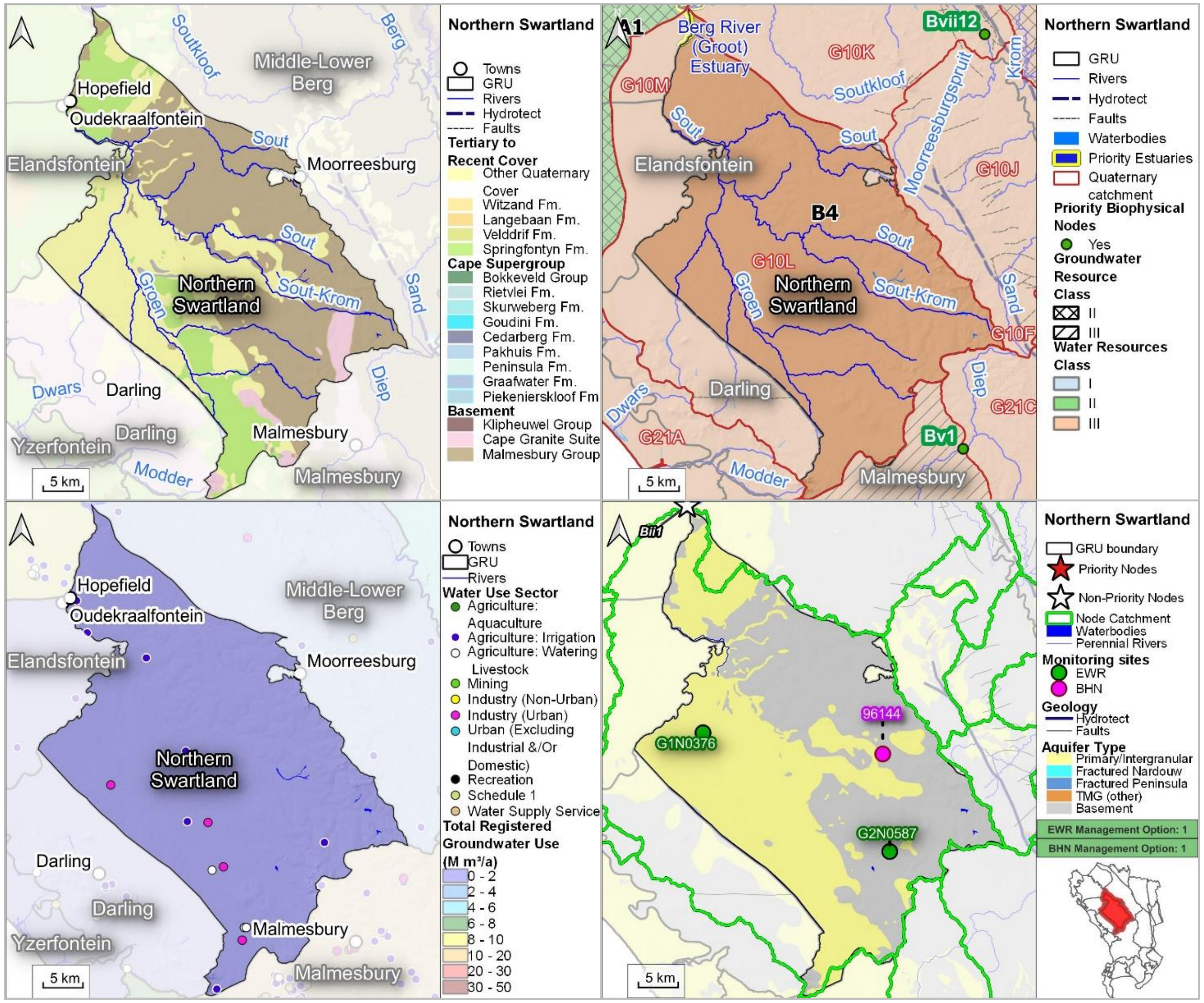


Figure 3-23 A series of maps for the Northern Swartland GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

UMVOTO
EARTH | WATER | SCIENCE | LIFE

3.3.10. Darling GRU

GRU	GRU Name: Darling Main Towns: Darling and Mamre Total Area (km^2): 408.82
GRU Boundary Description	The eastern flank of the Darling GRU is delimited by the Colenso Fault, Modder River, and Groen River, representing the extent of the Northern Swartland GRU. The boundary between the Elandsfontein and Yzerfontein GRUs is defined by the extent of the Springfontyn Fm and its contact with the CGS. In the south, the Darling GRU is demarcated by portions of the G21B surface water quaternary catchment divide and the CoCT (2020) aquifer model boundary for the Atlantis GRU (refer to **Figure 3-24** and DWS, 2022d and 2023a).
Quaternary Catchments	G10L and G21A (**Figure 3-24**)
Resource Unit	Fractured and Intergranular Basement Aquifer
Description	This GRU is dominantly composed of the CGS plutons that have intruded the Malmesbury Group shales. Several ephemeral streams emanate from the granite hills after heavy rain, depositing fluvial sediments to the north-east of the GRU (refer to DWS, 2022d and 2023a).
Surface Water System	The surface water systems in this area exhibit dual flow directions, with some tributaries flowing northward and others southward. The Modder and Dwars tributaries direct their flow towards the coast, while the tributaries in the northern part of the GRU flow towards the Groen River in the Northern Swartland GRU (refer to **Figure 3-24** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls within the Lower Berg (B4) and West Coast (A3) IUAs, both with a Water Resource Class of III and no Groundwater Class designated. There are no EWR sites within this IUA, nor are there any priority biophysical nodes (refer to **Figure 3-24** and DWS, 2022d and 2023a).
Recharge	An estimated recharge of 9.95 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 24.34 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below ands DWS (2022e) for further details. (see table below)
Groundwater Use	In this GRU, there are 9 registered groundwater users collectively utilizing 0.77 M m^3/a of groundwater. The predominant groundwater use sector in this region is Agriculture (Irrigation), accounting for 93.0% of the total annual groundwater use volume (see **Figure 3-24** and the table on the right). (see table below)

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	408.82	9.95	24.34

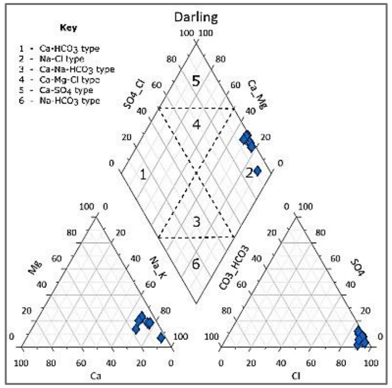
Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured And Intergranular Basement Aquifer		
Agriculture: Irrigation	5	0.71
Agriculture: Watering Livestock	3	0.05
Industry (Urban)	1	0.01
Total	9	0.77

UMVOTO

EARTH | WATER | SCIENCE | LIFE

GRU	GRU Name: Darling Main Towns: Darling and Mamre Total Area (km^2): 408.82

Water Quality



The primary water type in Darling GRU is Na-Cl. The presence of Na-Cl waters is attributed to the saturation of Na and Cl ions, resulting from increased groundwater residence time in the relatively low transmissivity granitic basement aquifer.

Exceedances of baseline concentrations were observed for multiple parameters, with 50% of samples exceeding the baseline for EC, pH, and fluoride. Out of the 9 samples collected, 1 sample exceeded the RQO for EC. These exceedances are attributed to contamination from agriculture, along with naturally elevated concentrations of dissolved ions. The adjusted water quality category is C, indicating that moderate levels of contamination exist in Darling (refer to DWS, 2022d, 2022e and 2023a for detail).

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of ‘B’, indicating an unstressed or slightly stressed aquifer, and a Groundwater Quality Present Status of ‘C’, indicating moderate levels of localised contamination, but little or no negative impacts apparent (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Availability Present Status Category	Groundwater Quality Present Status Category
9.95	0.77	0.08	B	C

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 (to be confirmed).

Aquifer Unit	Parameter	Unit	No. BHs	No. Samples	Baseline Conc.	Min Conc.	Max Conc.	Median Conc.	95th Percentile Conc.	Groundwater Quality Reserve	Groundwater Quality BHN Reserve
Fractured and Intergranular Basement Aquifer (CGS))	Sulphate	mg/l	9	9	96.10	10.70	542.20	96.10	440.76	440.76	
	Electrical conductivity	mS/m			192.00	108.60	1100.00	281.60	987.36	987.36	
	pH				6.80	6.70	7.86	7.20	7.80	7.80	
	Ammonia	mg/l			0.02	0.02	0.08	0.02	0.06	0.06	
	Nitrate + nitrite	mg/l			0.83	0.02	4.16	0.83	3.60	3.60	
	Fluoride	mg/l			0.15	0.10	1.50	0.56	1.29	1.29	
	Orthophosphate	mg/l			0.01	0.00	0.02	0.00	0.01	0.01	
	Calcium	mg/l			16.90	9.30	251.00	46.60	202.92	202.92	
	Magnesium	mg/l			38.80	11.50	236.10	57.60	230.62	230.62	
	Sodium	mg/l			299.20	151.90	1907.00	416.30	1635.36	1635.36	
	Potassium	mg/l			8.06	7.01	43.63	11.42	35.15	35.15	
	Chloride	mg/l			499.10	332.70	3413.80	766.10	3067.00	3067.00	

<table>
<tr><td>GRU</td><td>GRU Name: Darling
Main Towns: Darling and Mamre
Total Area (km²): 408.82</td></tr>
<tr><td></td><td>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.

<table>
<tr><th>Recharge (Mm³/a)</th><th>EWR Reserve (Mm³/a)</th><th>BHN Reserve (Mm³/a)</th><th>GW Reserve (Mm³/a)</th><th>Total Allocable Volume (Mm³/a)</th><th>Water Use (Mm³/a)</th><th>Still Allocable (Mm³/a)</th></tr>
<tr><td>9.95</td><td>0.03</td><td>0.02</td><td>0.05</td><td>9.91</td><td>0.76[23]</td><td>9.15</td></tr>
</table></td></tr>
<tr><td>Future Scenario 2050 (Scenario 7b)</td><td>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 9.95 to 8.02 M m³/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 0.76 to 1.40 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 0.02 to 0.03 M m³/a, primarily attributed to population growth. Under these conditions, the Allocation Category did not change from category B (refer to Section 2.5 and the table below).

<table>
<tr><th>Recharge (Mm³/a)</th><th>EWR Reserve (Mm³/a)</th><th>BHN Reserve (Mm³/a)</th><th>GW Reserve (Mm³/a)</th><th>Total Allocable Volume (Mm³/a)</th><th>Water Use (Mm³/a)</th><th>Still Allocable (Mm³/a)</th></tr>
<tr><td>8.02</td><td>0.03</td><td>0.03</td><td>0.06</td><td>7.97</td><td>1.40</td><td>6.56</td></tr>
</table></td></tr>
<tr><td>Monitoring Programme</td><td>The Darling GRU was assigned a Management Option 1 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 1 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Darling GRU (see Figure 3-24 and the table below).

<table>
<tr><th>Site Name</th><th>Data Source</th><th>Monitoring Area</th><th>Monitoring Objective</th><th>Latitude</th><th>Longitude</th><th>Monitoring Description</th></tr>
<tr><td colspan="7">EWR Management Option 1</td></tr>
<tr><td>G1N0555</td><td>HYDSTRA</td><td>Bii1</td><td>EWR</td><td>-33.393056</td><td>18.463889</td><td>Frequency: Quarterly or Biannual (Summer & Winter)

2) Groundwater level:
o Manual groundwater level measurements
3) 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</td></tr>
<tr><td colspan="7">BHN Management Option 1</td></tr>
<tr><td>94570</td><td>WMS</td><td>GRU</td><td>BHN</td><td>-33.4259</td><td>18.4212</td><td>Frequency: Quarterly or Biannual (Summer & Winter):

1) Groundwater level:
o Manual groundwater level measurements
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
o Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms</td></tr>
</table></td></tr>
</table>

[23] *The WARMS dataset places Yzerfontein's municipal abstraction of 0.26 Mm³/a in the Darling GRU. It has been updated to reflect for the Yzerfontein GRU.*

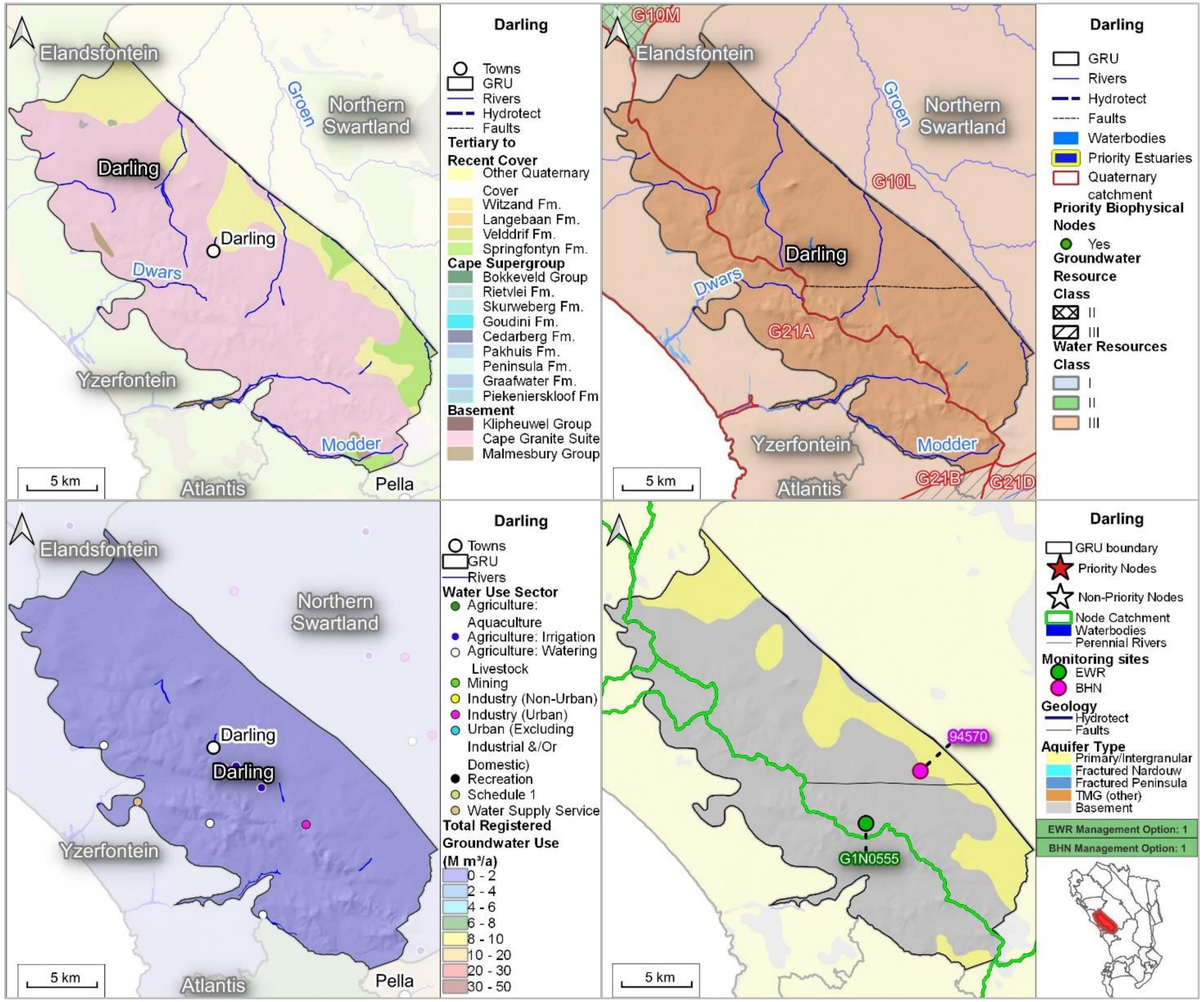


Figure 3-24 A series of maps for the Darling GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.

3.3.11. Vredenburg GRU

GRU	GRU Name: Vredenburg Main Towns: Vredenburg, Paternoster and Saldanha Total Area (km^2): 376.18
GRU Boundary Description	The Vredenburg GRU is defined by the CGS outcrop and its contact with the Springfontyn Fm on its eastern edge. The south-eastern border is established by a combination of an interpolated extent of CGS outcrops and the Bok River. The northern, western, and southern extents of the GRU are delineated by the Atlantic coastline, Saldanha Bay, and St Helena Bay coastlines, respectively (refer to **Figure 3-25** and DWS, 2022d and 2023a).
Quaternary Catchments	G10M (**Figure 3-25**)
Resource Unit	Fractured and Intergranular Basement Aquifer
Description	The West Coast region is formed by basement Malmesbury Group and various plutons of the CGS, overlain by the Sandveld Group, which is laterally continuous over large areas and also reaches significant thicknesses (refer to DWS, 2022d and 2023a).
Surface Water System	Following heavy rain, numerous ephemeral streams originate from the hills of the CGS. The flow of these rivers adheres to the topography, moving from the elevated regions in the east towards the coastal areas in the west (refer to **Figure 3-25** and DWS, 2022d and 2023a).
Water Resource Classes & RQOs	The GRU falls within the Langebaan (A2) and Berg Estuary (A1) IUAs, both of which have a Water Resource Class of II and Groundwater Class II. There are no EWR sites within this IUA, nor are there any priority biophysical nodes (refer to **Figure 3-25** and DWS, 2022d and 2023a).
Recharge	An estimated recharge of 7.43 M m^3/a was determined from first-order recharge calculations using the Map-Centric Simulation method and was chosen as the estimated recharge value for the Aquifer Stress assessments. The average recharge rate is 19.75 mm/a based on the total GRU area. Additional recharge estimations are available in the literature. Refer to the table below and DWS (2022e) for further details.
Groundwater Use	In this GRU, there are 6 registered groundwater users, collectively utilizing 1.16 M m^3/a of groundwater. The primary groundwater use sectors are Urban (excluding Industrial or Domestic volume), Agriculture (Irrigation), and Industry (Urban), contributing 65.4%, 21.8%, and 12.8%, respectively, to the total annual groundwater use volume (see **Figure 3-25** and the table on the right).

Method	Area (km^2)	Recharge Volume (M m^3/a)	Average Recharge Rate (mm/a)
Map Centric Simulation Method	376.18	7.43	19.75

Water Use Sector	No. of Users	Total Volume (M m^3/a)
Fractured And Intergranular Basement Aquifer		
Industry (Urban)	1	0.15
Primary / Intergranular Aquifers		
Agriculture: Irrigation	1	0.25
Schedule 1	1	0.0002
Urban (Excluding Industrial And/Or Domestic)	3	0.76
Total	6	1.16

GRU

GRU Name: Vredenburg
Main Towns: Vredenburg, Paternoster and Saldanha
Total Area (km^2): 376.18

Water Quality

No water quality data

Aquifer Stress

The GRU is considered to have a Groundwater Availability Present Status Category of 'B', indicating an unstressed or slightly stressed aquifer, and the Groundwater Quality Present Status is unknown due to limited data availability (see table below).

Recharge Volume (M m^3/a)	Groundwater Use (M m^3/a)	Stress Index	Groundwater Present Status Category (after WRC, 2007)	Final Groundwater Quality Present Status Category
7.43	1.16	0.16	B	N/A

Groundwater Reserve

Quality Component

No water quality data

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 (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
7.43	0.00	0.01	0.01	7.42	1.16	6.26

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 7.43 to 6.63 M m^3/a, influenced by both climate change and the elimination of IAPs. Additionally, groundwater use increased from 1.16 to 1.97 M m^3/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 0.01 to 0.02 M m^3/a, primarily attributed to population growth. In light of these changes, the Allocation Category shifted from B to C (refer to Section 2.5 and the table below).

Recharge (Mm^3/a)	EWR Reserve (Mm^3/a)	BHN Reserve (Mm^3/a)	GW Reserve (Mm^3/a)	Total Allocable Volume (Mm^3/a)	Water Use (Mm^3/a)	Still Allocable (Mm^3/a)
6.63	0.00	0.02	0.02	6.61	1.97	4.64

GRU	GRU Name: Vredenburg Main Towns: Vredenburg, Paternoster and Saldanha Total Area (km^2): 376.18
Monitoring Programme	The Vredenburg GRU was assigned a Management Option 1 for monitoring the groundwater contribution to the EWR and a Management Option 1 for monitoring the groundwater contribution to the BHN. A total of 2 monitoring sites for the EWR and 1 for the BHN were strategically selected within the Vredenburg GRU (see **Figure 3-25** and the table below).

Site Name	Data Source	Monitoring Area	Monitoring Objective	Latitude	Longitude	Monitoring Description
EWR Management Option 1						
3217DD00034	NGA	GRU	EWR	-32.76058	17.95753	Frequency: Quarterly or Biannual (Summer & Winter) 1) Groundwater level: o Manual groundwater level measurements 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
G1N0024	HYDSTRA	GRU	EWR	-32.950127	17.91936	
BHN Management Option 1						
46113	NGA	GRU	BHN	-32.98103	17.96632	Frequency: Quarterly or Biannual (Summer & Winter): 2) Groundwater level: o Manual groundwater level measurements 3) Groundwater Quality: o Standard Parameters: pH, EC, Ca, Mg, Na, K, Palk, MAlk, F, Cl, PO_4, SO_4 o Site specific additions for BHN (microbiological): E coli, Total Coliforms, Faecal Coliforms

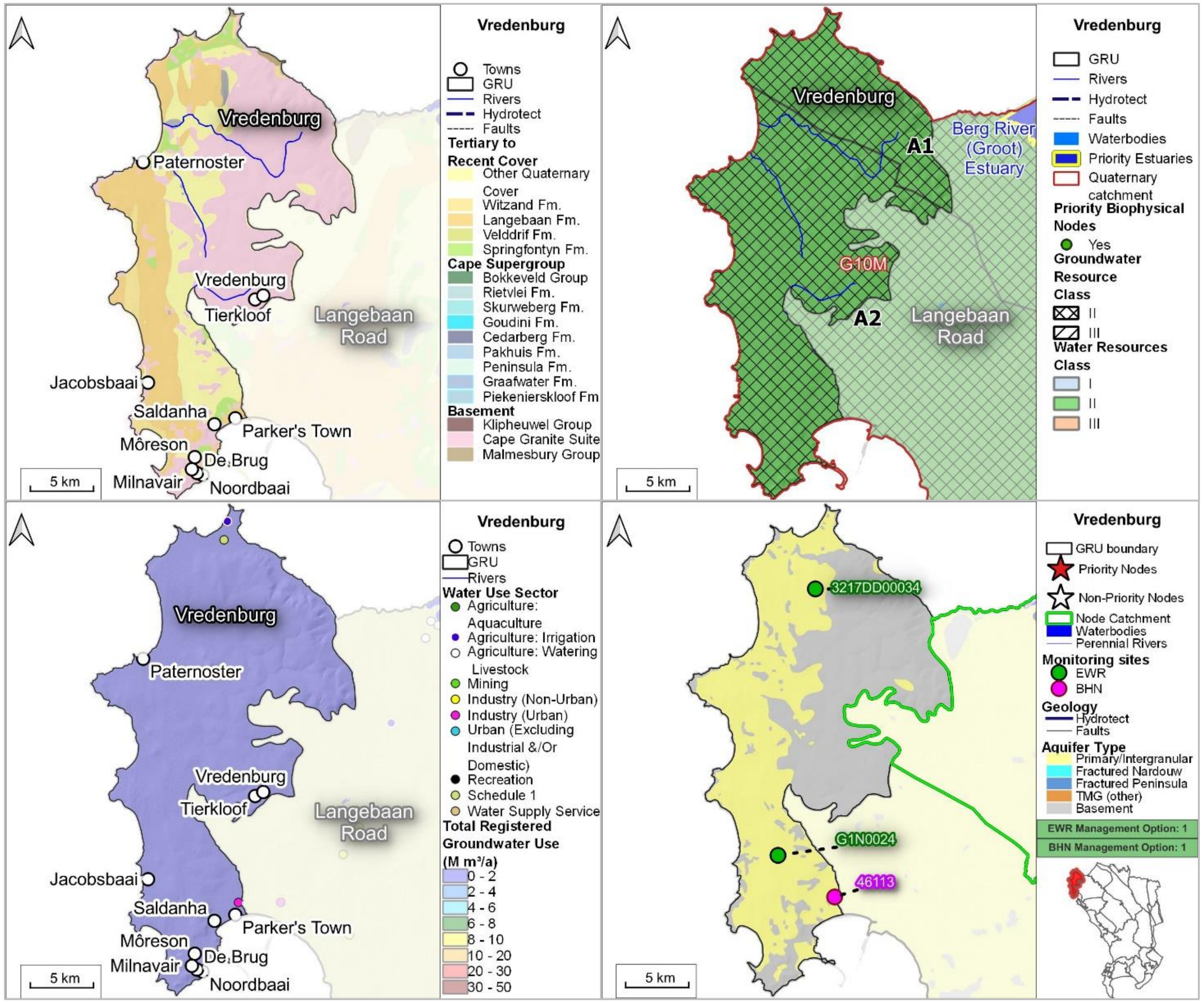


Figure 3-25 **A series of maps for the Vredenberg GRU: Top-left displays the GRU extent with geology and structural features; Top-right displays IUAs, WRCs, and Groundwater Classes; Bottom-left indicates total registered groundwater use with boreholes and water use sectors; Bottom-right depicts EWR and BHN monitoring sites per GRU based on Management Options.**

4. REFERENCES

City of Cape Town (CoCT). (2018). Numerical Groundwater Model of the Cape Flats Aquifer - Progress Report, Water Resilience Plan: Cape Flats Aquifer. (Report No. 896/7.1/01/2018, 59 pp). Prepared by R. Hugman, J. F. Atkins, J. Weitz, E. Wise, T. Flugel, C. J.H. Hartnady of Umvoto Africa Pty (Ltd.) on behalf of the City of Cape Town.

City of Cape Town (CoCT). (2020). Numerical Groundwater Model of the Atlantis Aquifer, New Water Programme: Atlantis Water Resource Management Scheme. (Report No. 897/7.2b/12/2020, 103 pp). Prepared by J. Weitz, R. Hugman, E. Wise, T. Flügel, E. Van Den Berg and L. Towers of Umvoto Africa Pty (Ltd.) on behalf of the City of Cape Town - Bulk Water Department.

City of Cape Town (CoCT). (2022a). Cape Flats Aquifer Management Scheme Water Use License Application - Section 21(a) and (e) Hydrogeological Technical Report. Prepared by Kevin de Bruin, Keanan Woolf, E Wise and David McGibbon of Umvoto South Africa Pty (Ltd.) for Zutari on behalf of City of Cape Town. Version 1 / Final Draft; Report No. 994/7.1/6/2022, pg.163 excluding Appendices.

City of Cape Town. (2022b). City of Cape Town New Water Programme: Table Mountain Group Aquifer. Steenbras Wellfield Integrated Water Use Licence Application: Section 21(a) Hydrogeological Report. Prepared by K. Riemann, D. Blake, Z. Rademan, K. Prinsloo, J. Weitz, M. Mokhethi, K. De Bruin, K. Gibson and G. Bluff of Umvoto South Africa (Pty) Ltd on behalf of the City of Cape Town. Version 1 / Draft, Report No.: 995/WP032/5/1/2022.

Department of Water Affairs (DWA) (2012). Pre-feasibility and feasibility studies for the augmentation of the Western Cape water supply system by means of further surface water developments. Report 1: Ecological Water Requirements assessments. Volume No. 1: main report. Report by Southern Waters Ecological Research and Consulting on behalf of the Western Cape Water Consultants Joint Venture to the Department of Water Affairs. DWA report No. P WMA P WMA 19/G10/00/2413/1.

Department of Water Affairs and Forestry (DWAF). (2007a). Berg River Baseline Monitoring Programme. Final Report – Volume 1. Introduction to the Berg River catchment; groundwater and hydrology. Report by Freshwater Consulting Group and Anchor Environmental Consultants to the Department of Water Affairs and Forestry. DWAF report No. PWMA/19/G10/00/1707.

Department of Water Affairs and Forestry (DWAF). (2007b). Berg River Baseline Monitoring Programme. Final Report – Volume 2. River baseline monitoring programme and statement of baseline conditions. Report by Freshwater Consulting Group and Anchor Environmental Consultants to the Department of Water Affairs and Forestry. DWAF report No. PWMA/19/G10/00/1807.

Department of Water Affairs and Forestry (DWAF). (2008). The Assessment of Water Availability in the Berg Catchment (WMA 19) by means of Water Resource Related Models. Groundwater Model Report Vol. 6 Langebaan Road and Elandsfontein Aquifer System Model. (Report no. P WMA 19/000/00/0408).

Department of Water Affairs and Forestry (DWAF). (2008a). The Assessment of Water Availability in the Berg Catchment (WMA 19) by Means of Water Resource Related Models: Groundwater Model Report Volume 4 – Regional Water Balance Model.

Department of Water Affairs and Forestry (DWAF). (2008b). The Assessment of Water Availability in the Berg Catchment (WMA 19) by Means of Water Resource Related Models: Groundwater Model Report Volume 7 – TMG Aquifer, Piketberg Model.

Department of Water Affairs and Forestry (DWAF). (2008c). The Assessment of Water Availability in the Berg Catchment (WMA 19) by Means of Water Resource Related Models: Groundwater Model Report Volume 8 – TMG Aquifer, Witzenberg-Nuy Model.

Department of Water Affairs and Forestry (DWAF). (2008d). The Assessment of Water Availability in the Berg Catchment (WMA 19) by Means of Water Resource Related Models: Groundwater Model Report Volume 5 – Cape Flats Aquifer Model.

Department of Water Affairs and Forestry (DWAF). (2008e). The Assessment of Water Availability in the Berg Catchment (WMA 19) by Means of Water Resource Related Models: Groundwater Model Report Volume 6 – Langebaan Road and Elandsfontein Aquifer System Model.

Department of Water Affairs and Forestry (DWAF). (2008f). The Assessment of Water Availability in the Berg Catchment (WMA 19) by Means of Water Resource Related Models: Groundwater Model Report Volume 9 – Breede River Alluvium Aquifer Model.

Department of Water and Sanitation (DWS) (2015). Support to the Continuation of the Water Reconciliation Strategy for the Western Cape Water Supply System: Status Report October 2015. Prepared by Umvoto Africa (Pty) Ltd in association with WorleyParsons RSA on behalf of the Directorate: National Water Resource Planning. DWS Report No.

Department of Water and Sanitation (DWS). (2016). Determination of Water Resource Classifications and Resource Quality Objectives in the Berg Catchment Study. Project Number WP10987.

Department of Water and Sanitation (DWS). (2016a). Determination of Water Resource Classifications and Resource Quality Objectives in the Berg Catchment: Inception Report. Project Number WP10987. DWS Report No: RDM/WMA9/00/CON/CLA/0116.

Department of Water and Sanitation (DWS). (2016b). Determination of Water Resource Classifications and Resource Quality Objectives in the Berg Catchment: Stakeholder Identification and Mapping Report. (Report No: RDM/WMA9/00/CON/CLA/0216).

Department of Water and Sanitation (DWS). (2016c). Determination of Water Resource Classes and Resource Quality Objectives in the Berg Catchment: Water Resources Information Gap Analysis and Models. (Report No: RDM/WMA9/00/CON/WRC/0316).

Department of Water and Sanitation (DWS). (2016d). Determination of Water Resources Classes and Associated Resource Quality Objectives in the Berg Catchment: Resource Units and Integrated Units of Analysis Delineation. Project Number WP10987. DWS Report No: RDM/WMA9/00/CON/CLA/0416.

Department of Water and Sanitation (DWS). (2016e). Determination of Water Resource Classes and Associated Resource Quality Objectives in the Berg Catchment: Linking the Value and Condition of the Water Resource. Project Number WP10987. (DWS Report No: RDM/WMA9/00/CON/CLA/0117).

Department of Water and Sanitation (DWS). (2016F). Reconciliation Strategy for the Western Cape Water Supply System (WCWSS).

Department of Water and Sanitation (DWS). (2017a). Determination of Water Resources Classes and Associated Resource Quality Objectives in the Berg Catchment: Status Quo Report. Project Number WP10987. (DWS Report No: RDM/WMA9/00/CON/CLA/0516).

Department of Water and Sanitation (DWS). (2017b). Determination of Water Resource Classes and Associated Resource Quality Objectives in the Berg Catchment: Quantification of the Ecological Water Requirements and Changes in Ecosystem Goods, Services and Attributes. Project Number WP 10987. (DWS Report No: RDM/WMA9/00/CON/CLA/0217).

Department of Water and Sanitation (DWS). (2017c). Determination of Water Resource Classes and Associated Resource Quality Objectives in the Berg Catchment: Ecological base configuration scenarios Report. Project Number WP10987. (DWS Report No: RDM/WMA9/00/CON/CLA/0317).

Department of Water and Sanitation (DWS). (2017d). Determination of Water Resources Classes and Resource Quality Objectives in the Berg Catchment: Evaluation of Scenarios Report. (Report No: RDM/WMA9/00/CON/CLA/0417).

Department of Water and Sanitation (DWS). (2018a). Determination of Water Resource Classes and Associated Resource Quality Objectives in the Berg Catchment: Resource Units Prioritisation Report. Project Number WP10987. (DWS Report No: RDM/WMA9/00/CON/CLA/0517).

Department of Water and Sanitation (DWS). (2018b). Determination of Water Resource Classes and Associated Resource Quality Objectives in the Berg Catchment: Evaluation of Resource Units Report. Project Number WP10987. (DWS Report No: RDM/WMA9/00/CON/CLA/0118

Department of Water and Sanitation (DWS). (2018c). Determination of Water Resources Classes and associated Resource Quality Objectives in Berg Catchment: Outline of Resource Quality Objectives Report. Project Number WP10987. (DWS Report No: RDM/WMA9/00/CON/CLA/0218).

Department of Water and Sanitation (DWS). (2018d). Determination of Water Resources Classes and associated Resource Quality Objectives in Berg Catchment: Monitoring programme to support Resource Quality Objectives Implementation Report Project Number WP10987. (DWS Report No: RDM/WMA9/00/CON/CLA/0318).

Department of Water and Sanitation (DWS). (2018e). Determination of Water Resources Classes and associated Resource Quality Objectives in Berg Catchment: Confidence of Resource Quality Objectives Report. Project Number WP10987. (DWS Report No: RDM/WMA9/00/CON/CLA/0318).

Department of Water and Sanitation (DWS). (2019a). Determination of Water Resources Classes and associated Resource Quality Objectives in Berg Catchment: Final Project Close Out Report. (Report No: RDM/WMA9/00/CON/CLA/0718).

Department of Water and Sanitation (DWS). (2019b: 121). National Water Act, 1998 (Act no. 36 of 1998): Proposed classes of water resource and resource quality objectives for the Berg catchment. (Notice 655) Government Gazette, 42451.

Department of Water and Sanitation (DWS). (2022a). High Confidence Groundwater Reserve Determination Study in the Berg Catchment – Inception Report. Version 1 / Final Report No. RDM/WMA19/02/CON/COMP/0122, 28. Prepared by L. Goslin, M. Misrole and D. McGibbon of Umvoto South Africa Pty (Ltd.) on behalf of DWS.

Department of Water and Sanitation (DWS). (2022b). High Confidence Groundwater Reserve Determination Study in the Berg Catchment – Gap Analysis Report. (Version 1 / Draft Report No. RDM/WMA19/02/CON/COMP/0222), 25. Prepared by M. Misrole, L. Goslin and D. McGibbon of Umvoto South Africa Pty (Ltd.) on behalf of DWS.

Department of Water and Sanitation (DWS). (2022c). High Confidence Groundwater Reserve Determination Study in the Berg Catchment – Inventory of Water Resource Models Report. (Version 1). Prepared by J. Weitz of Umvoto South Africa Pty (Ltd.) on behalf of DWS.

Department of Water and Sanitation (DWS). (2022d). High Confidence Groundwater Reserve Determination Study in the Berg Catchment – Delineation of GRUs Report. Version 1 / Final; Report No. 1001/1/4/2022, 37. Prepared by M. Misrole, T. Flugel and D. McGibbon of Umvoto South Africa Pty (Ltd.) on behalf of DWS.

Department of Water and Sanitation (DWS). (2022e). High Confidence Groundwater Reserve Determination Study in the Berg Catchment – Ecological Reference Conditions Report. Prepared by M. Misrole, A. Vicente, E. Wise and M. Mokhethi of Umvoto South Africa Pty (Ltd.) on behalf of DWS.

Department of Water and Sanitation (DWS). (2023a). High Confidence Groundwater Reserve Determination Study in the Berg Catchment – BHN and EWR Requirement Report. Prepared by M. Misrole, A. Vicente, E. Wise, and S. Adams of Umvoto South Africa Pty (Ltd.) on behalf of DWS.

Department of Water and Sanitation (DWS). (2023b). National Water Resource Strategy. Third Edition. Department of Water Affairs. South Africa.

Department of Water and Sanitation (DWS). (2023c). High Confidence Groundwater Reserve Determination Study in the Berg Catchment – Operational Scenarios & Socio-Economic and Ecological Consequences Report. Prepared by M. Misrole, A. Vicente and E. Wise of Umvoto South Africa Pty (Ltd.) on behalf of DWS. Version 1 / Final; Report No. 1001/1/2/2023, pg. 61 excluding appendices.

Department of Water and Sanitation (DWS). (2023d). High Confidence Groundwater Reserve Determination Study in the Berg Catchment – Stakeholder Engagement of Operational Scenarios Report. Prepared by M. Misrole, A. Vicente and E. Wise of Umvoto South Africa Pty (Ltd.) on behalf of DWS. Version 1 / Final; Report No. 1001/1/3/2023, pg. 71 excluding appendices.

Department of Water and Sanitation (DWS). (2023e). High Confidence Groundwater Reserve Determination Study in the Berg Catchment – Monitoring Programme Report. Prepared by M. Misrole, and E. Wise of Umvoto South Africa Pty (Ltd.) on behalf of DWS. Version 1 / Final; Report No. 1001/1/4/2023, pg. 78 excluding appendices

Water Research Commission (WRC). (2007). Groundwater Resource Directed Measures Manual, Setting Resource Directed Measures (RDM) for Groundwater: A pilot study. (Report No. TT 299/07). Prepared by Parsons, R. and Wentzel, J. for the Department of Water Affairs and Forestry.

Water Research Commission (WRC). (2012). Water Resources of South Africa, 2012 (WR2012). Bailey, A. and Pitman, W. WRC Project No. K5/2143/1.

Water Research Commission (WRC). (2013). Groundwater Resources Directed Measures. (WRC Report No TT 506/12). Dennis, I.; Witthüsser, K.; Vivier, K.; Dennis, R.; Mavurayi, A.

Water Research Commission (WRC). (2018). Strategic Water Source Areas: Management Framework and Implementation Guidelines for Planners and Managers (Report No. TT 754/2/18). Prepared by Le Maitre, D.C., Walsdorff, A., Cape, L., Seyler, H., Audouin, M, Smith-Adao, L., Nel, J.A., Holland, M.and Witthüser. K.