High Confidence Groundwater Reserve Determination Study for the Berg Catchment

PROJECT STEERING COMMITTEE MEETING

Presented by: Umvoto
Date: 11 July 2023

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water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP

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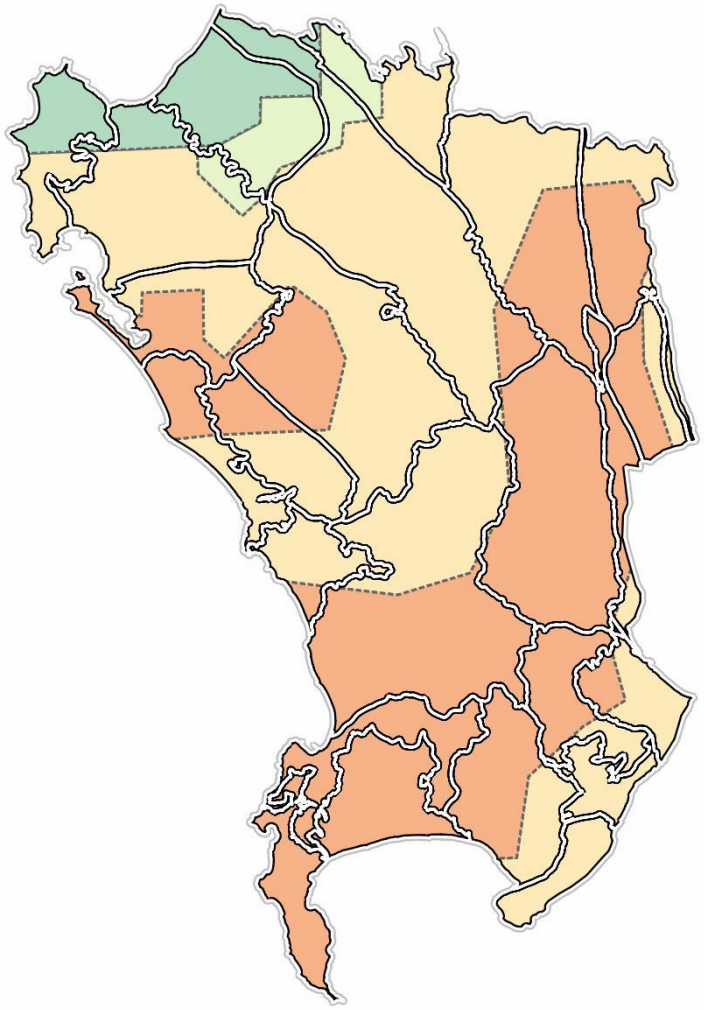
PRESENTATION OUTLINE

1. **Operational Scenarios and Socio-Economic and Ecological Consequences Report**
    - Methodology for Assessing Impacts of Predictive Operational Scenarios
    - Groundwater Allocation Stress Index
    - Description of Scenarios
    - Scenario Integration
2. **Capacity Building Programme**
3. **Programme of Upcoming Activities**
4. **Discussion**



SUMMARY OF PROJECT PHASES, TASKS AND DELIVERABLES

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

STEP 5 GRDM OBJECTIVES

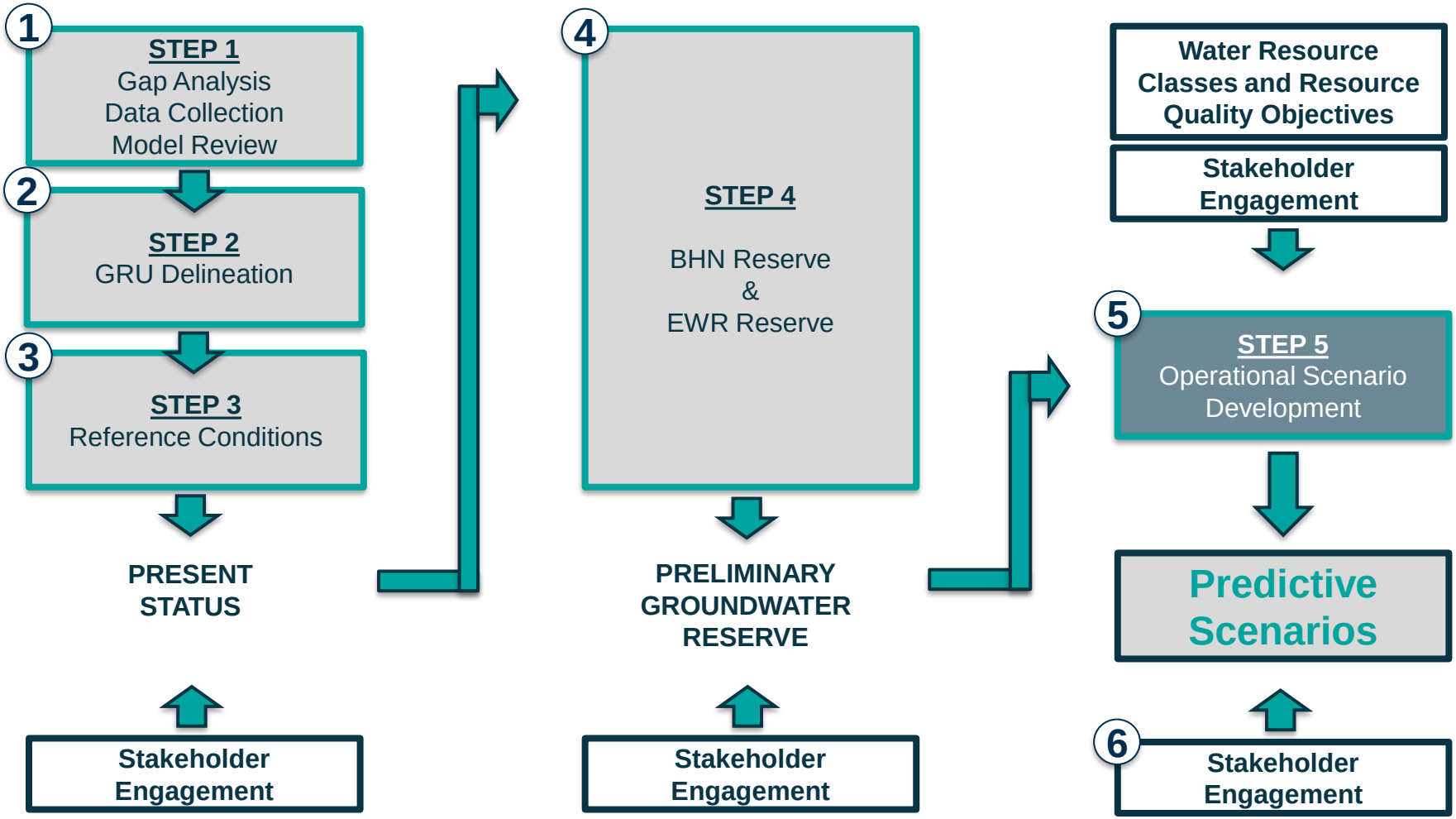
1. Review the "future" catchment scenarios that were developed to determine the Ecologically Sustainable Base Configuration (ESBC) as part of the Berg catchment Water Resource Classes (WRCs) and Resource Quality Objectives (RQOs) study (DWS, 2016).

2. Collate the results from the Step 3: Present Status (PS) and Step 4: Preliminary Groundwater Reserve per Groundwater Resource Unit (GRU) (DWS, 2022).

3. Develop operational scenarios and determine their socio-economic and ecological impacts per GRU.

Operational Scenarios and Socio-Economic and Ecological Consequences Report

APPROACH


1
STEP 1
Gap Analysis
Data Collection
Model Review
2
STEP 2
GRU Delineation
3
STEP 3
Reference Conditions
PRESENT STATUS
Stakeholder Engagement
4
STEP 4
BHN Reserve
&
EWR Reserve
PRELIMINARY GROUNDWATER RESERVE
Stakeholder Engagement
Water Resource Classes and Resource Quality Objectives
Stakeholder Engagement
5
STEP 5
Operational Scenario Development
Predictive Scenarios
6
Stakeholder Engagement

GROUNDWATER ALLOCATION STRESS INDEX

To assess the potential impact of operational scenarios on GRUs, an **ALLOCATION STRESS INDEX** was developed.

This index represents the **ratio** of the groundwater that is '**still allocable**' volume (after considering the GW Reserve and future groundwater use) to the **total recharge** for the GRU. The stress index is divided into 6 allocation categories, reflecting a spectrum from unstressed to potentially critically stressed conditions.

Allocation Stress Index = Still Allocable Volume / Recharge Volume

As this ratio approaches zero, the level of stress potentially increases, indicating minimal remaining 'still allocable' volumes and a potential threat to the GW Reserve.

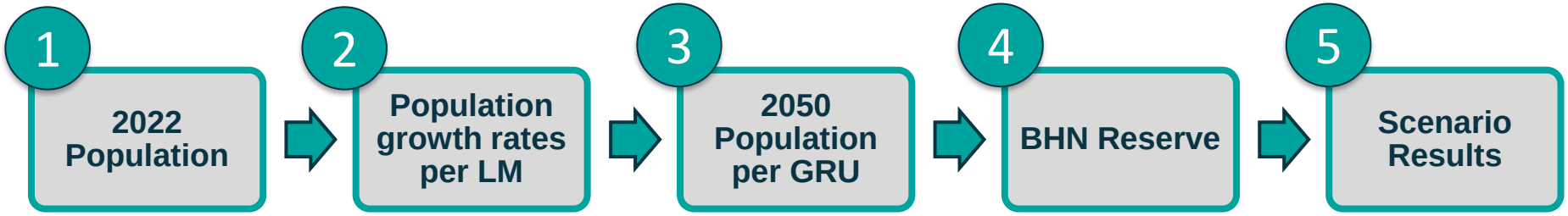
Allocation Category	Description	Allocation Stress Index
A	Unstressed or slightly stressed	>0.95
B		0.75 - 0.95
C	Moderately stressed	0.5 - 0.75
D		0.35 - 0.50
E	Potentially highly stressed	0.15 - 0.35
F	Potentially critically stressed	<0.15

DESCRIPTION OF SCENARIOS CONSIDERED

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	Sectoral Water Demand	Explore historical trends in groundwater demand per sector, focusing on agriculture, industry, and other sectors, to understand future water use.
Sc 3	Groundwater Developments	Evaluate scheduled groundwater developments and strategies for the Berg catchment, calculating their impact on the Reserve and allocable volumes.
Sc 4	Climate Change	Investigate the impact of climate change, particularly under warmer conditions, on groundwater recharge rates and its effects on the Reserve.
Sc 5	Alien and Invasive Species	Examine the impacts of Invasive Alien Plants (IAPs) on groundwater recharge and evaluate their effects on the Reserve and allocable volumes.
Sc 6a	Combination Scenario	Integrate population growth, sectoral growth, groundwater developments, climate change, and absence of clearing alien vegetation for impact assessment.
Sc 6b	Combination Scenario	Integrate population growth, groundwater developments, climate change, and clearing alien vegetation for impact assessment.

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.

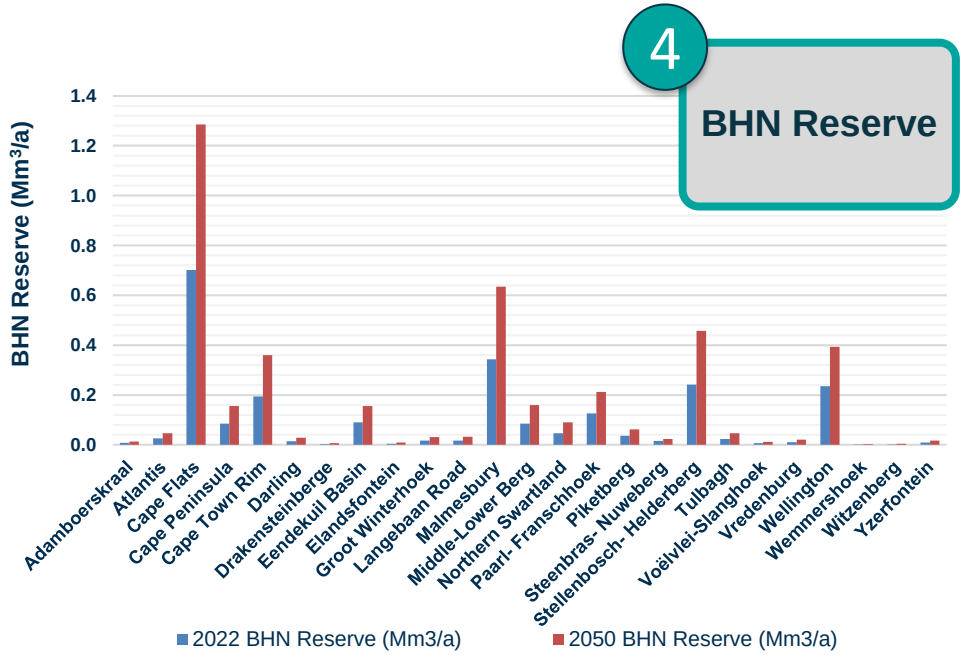


1. 2022 Qualifying Population from the PS Report (DWS, 2022).
2. Population Growth rates per local district municipality (LM) based on the difference between Census (2011) and Census (2022) data.
3. Population Growth rates were applied to the Qualifying Population (2022) to predict Qualifying Population (2050) per GRU.
4. 25 l/c/d was allocated to Qualifying Population (2050) to quantify the BHN Reserve (2050).
5. Assess the potential impacts on the Reserve and GRUs using an Allocation Stress Index.

Sc 1: POPULATION GROWTH

The BHN Reserve for 2050 is projected to be **4.27 Mm³/a for 2050**, compared to **2.35 Mm³/a for 2022.**

Cape Flats, Malmesbury, Stellenbosch-Helderberg, Wellington, and Cape Town Rim GRUs have the greatest BHN reserve volumes.



GRU	2022		2050	
	Qualifying population	BHN Reserve (Mm³/a)	Qualifying population	BHN Reserve (Mm³/a)
Adamboerskraal	889	0.008	1528	0.014
Atlantis	2801	0.026	5137	0.047
Cape Flats	76862	0.701	140858	1.285
Cape Peninsula	9346	0.085	17127	0.156
Cape Town Rim	21348	0.195	39423	0.360
Darling	1640	0.015	3155	0.029
Drakensteinberge	372	0.003	719	0.007
Eendekuil Basin	9968	0.091	17071	0.156
Elandsfontein	545	0.005	1047	0.010
Groot Winterhoek	1861	0.017	3498	0.032
Langebaan Road	1891	0.017	3612	0.033
Malmesbury	37580	0.343	69593	0.635
Middle-Lower Berg	9355	0.085	17561	0.160
Northern Swartland	5149	0.047	9934	0.091
Paarl- Franschhoek	13875	0.127	23208	0.212
Piketberg	3965	0.036	6817	0.062
Steenbras-Nuweberg	1709	0.016	2559	0.023
Stellenbosch-Helderberg	26508	0.242	50113	0.457
Tulbagh	2568	0.023	5168	0.047
Voëlvlei-Slanghoek	739	0.007	1347	0.012
Vredenburg	1227	0.011	2348	0.021
Wellington	25733	0.235	43151	0.394
Wemmershoek	187	0.002	340	0.003
Witzenberg	243	0.002	490	0.004
Yzerfontein	970	0.009	1872	0.017
TOTAL	257331	2.348	467677	4.268

5 Scenario Results

Sc 1: POPULATION GROWTH

GRU	PS (2022)		Sc 1 (2050)		Sc 1 vs PS 2022 Still Allocable Volume Difference (Mm^3/a)
	Still Allocable (Mm^3/a)	Allocable Stress Index	Still Allocable (Mm^3/a)	Allocable Stress Index	
Adamboerskraal	13.47	0.62	13.47	0.62	0.00
Atlantis	18.79	0.83	18.77	0.83	0.00
Cape Flats	28.04	0.68	27.45	0.67	-0.01
Cape Peninsula	5.41	0.49	5.33	0.49	-0.01
Cape Town Rim	11.33	0.61	11.16	0.60	-0.01
Darling	9.15	0.92	9.13	0.92	0.00
Drakensteinberge	24.67	0.89	24.66	0.89	0.00
Eendekuil Basin	9.99	0.46	9.92	0.45	0.00
Elandsfontein	7.99	0.52	7.98	0.52	0.00
Groot Winterhoek	20.32	0.90	20.31	0.90	0.00
Langebaan Road	9.15	0.39	9.14	0.39	0.00
Malmesbury	36.38	0.69	36.08	0.69	-0.01
Middle-Lower Berg	29.03	0.68	28.95	0.68	0.00
Northern Swartland	29.81	0.94	29.77	0.93	0.00
Paarl-Franschhoek	13.65	0.51	13.57	0.51	0.00
Piketberg	12.64	0.62	12.62	0.62	0.00
Steenbras-Nuweberg	49.58	0.84	49.58	0.84	0.00
Stellenbosch-Helderberg	30.13	0.73	29.91	0.72	-0.01
Tulbagh	5.79	0.53	5.76	0.53	0.00
Voëlvlei-Slanghoek	12.34	0.88	12.34	0.88	0.00
Vredenburg	6.26	0.84	6.25	0.84	0.00
Wellington	28.03	0.71	27.87	0.71	0.00
Wemmershoek	22.43	0.84	22.43	0.84	0.00
Witzenberg	2.52	0.91	2.52	0.90	0.00
Yzerfontein	8.91	0.97	8.90	0.97	0.00
TOTAL	445.79	-	443.87	-	-1.92

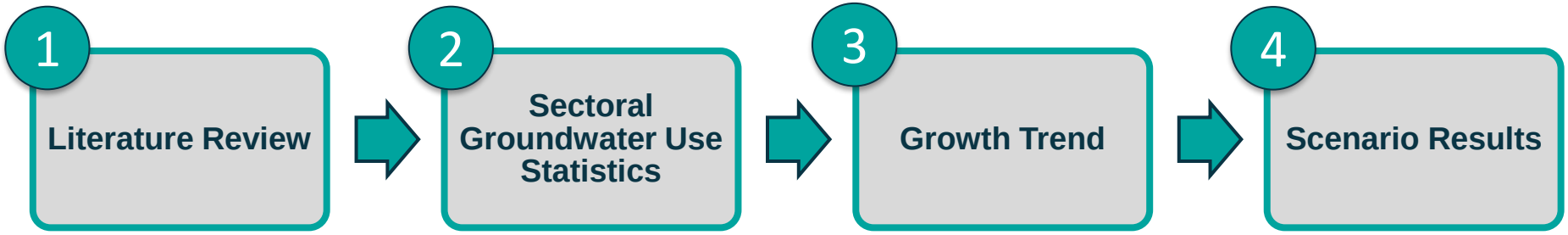
NOTES

Forecasted BHN Reserve had a **minimal effect on the total allocable volumes**, resulting in a minor overall **reduction of only 1.92 Mm^3/a.**

Given that the changes in BHN Reserve volumes are relatively insignificant, the **Allocation Stress largely remained consistent between the two periods**.

Sc 2: SECTORAL WATER DEMAND

Explore historical trends in groundwater demand per sector, focusing on agriculture, industry, and other sectors, to understand future water use.

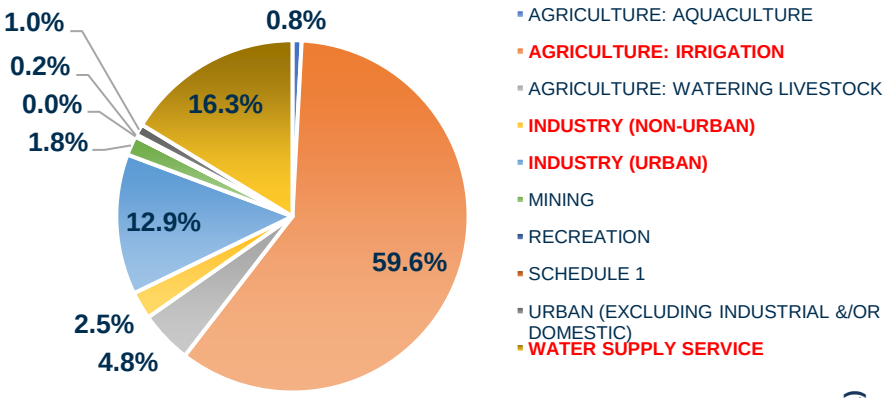


1 LITERATURE REVIEW

1. **Step 3 of the GRDM: Ecological Reference Conditions (DWS, 2022)**
2. **WRCs and RQO Study (DWS, 2016)**
3. **WARMS (2022)**
4. All Town Reconciliation Strategies for the Southern Planning Region (DWA, 2016)
5. National Water Resource Strategy (DWA, 2013)

2 Sectoral Groundwater Use Statistics

Percentage of Total Registered Volume (%) per Sector

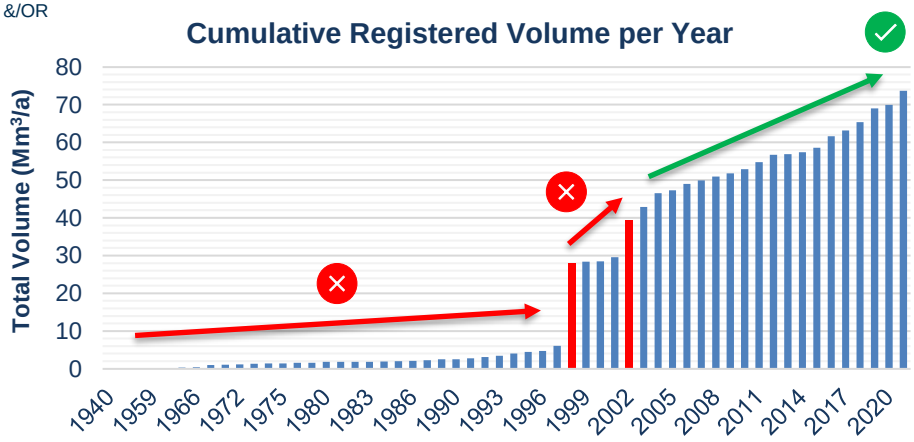


2. The **relative growth trend** was calculated from **2004 – 2022** as the registrations showed sharp increases in 1998 and 2002 due to legislative changes.

1. A **"least squares method"** trend analysis was applied to calculate a trend line equation for each sector, which was then **used to predict the total volume of groundwater use in 2050 per GRU.**

3 Growth Trend

Cumulative Registered Volume per Year



4 Scenario Results

Sc 2: SECTORAL WATER DEMAND

GRU	PS (2022)		Sc 2 (2050)		Sc 2 vs PS 2022 Still Allocable Volume Difference (Mm^3/a)
	Still Allocable (Mm^3/a)	Allocable Stress Index	Still Allocable (Mm^3/a)	Allocable Stress Index	
Adamboerskraal	13.47	0.62	11.92	0.55	-1.56
Atlantis	18.79	0.83	19.66	0.86	0.86
Cape Flats	28.04	0.68	30.72	0.74	2.68
Cape Peninsula	5.41	0.49	5.33	0.48	-0.08
Cape Town Rim	11.33	0.61	8.82	0.47	-2.50
Darling	9.15	0.92	8.50	0.85	-0.64
Drakensteinberge	24.67	0.89	23.51	0.85	-1.16
Eendekuil Basin	9.99	0.46	8.27	0.38	-1.72
Elandsfontein	7.99	0.52	6.37	0.41	-1.61
Groot Winterhoek	20.32	0.90	18.44	0.82	-1.88
Langebaan Road	9.15	0.39	13.79	0.59	4.63
Malmesbury	36.38	0.69	26.01	0.49	-10.37
Middle-Lower Berg	29.03	0.68	26.17	0.62	-2.86
Northern Swartland	29.81	0.94	28.69	0.90	-1.13
Paarl-Franschhoek	13.65	0.51	7.97	0.30	-5.68
Piketberg	12.64	0.62	8.42	0.41	-4.22
Steenbras- Nuweberg	49.58	0.84	57.56	0.98	7.98
Stellenbosch-Helderberg	30.13	0.73	27.64	0.67	-2.49
Tulbagh	5.79	0.53	2.91	0.27	-2.88
Voëlvlei-Slanghoek	12.34	0.88	12.16	0.86	-0.18
Vredenburg	6.26	0.84	5.45	0.73	-0.81
Wellington	28.03	0.71	24.34	0.62	-3.68
Wemmershoek	22.43	0.84	21.68	0.81	-0.75
Witzenberg	2.52	0.91	2.44	0.88	-0.08
Yzerfontein	8.91	0.97	9.17	1.00	0.26
TOTAL	**445.79**	**-**	**415.94**	**-**	**-29.85**

NOTES

for GRUs **where future groundwater development was known**, **the water supply sector was excluded** from the scenario analysis. This exclusion occurred prior to applying the sectoral growth rate, as the water supply sector was **addressed separately in Sc 3**.

The purpose of separating the water supply sector was to ensure that there was **no double counting** in terms of future water use.

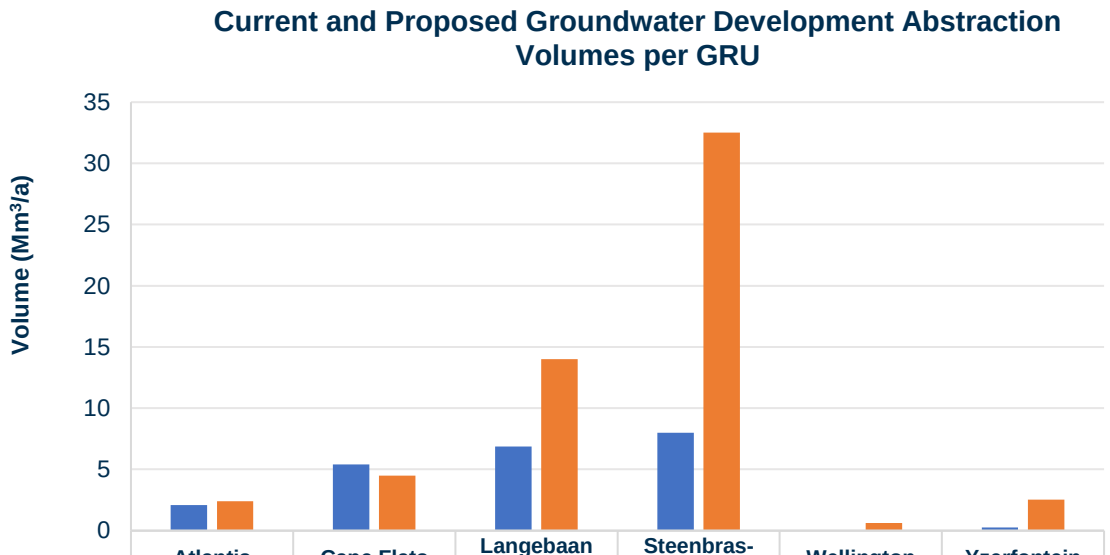
Sc 3: GROUNDWATER DEVELOPMENTS

Evaluate scheduled groundwater developments and strategies for the Berg catchment, calculating their impact on the Reserve and allocable volumes.

Notes:

Groundwater development net yields were analysed using abstraction and injection/infiltration (MAR) data from:

- Department of Water and Sanitation
- City of Cape Town
- Local Municipalities Agricultural Organizations
- Irrigation Boards



	Atlantis	Cape Flats	Langebaan Road	Steenbras-Nuweberg	Wellington	Yzerfontein
2022 Volumes	2.08	5.40	6.87	8.00	0.00	0.26
2050 Volumes	2.41	4.50	14.00	32.50	0.63	2.52

Projections for 2050 suggest the highest net yields are from Steenbras-Nuweberg wellfield (32.50 Mm³/a), followed by Langebaan Road (14 Mm³/a), and Cape Flats (4.50 Mm³/a).

Sc 3: GROUNDWATER DEVELOPMENTS

The sum of all proposed groundwater developments net yield for **2050** equates to a volume of **56.56 Mm³/a**, which is approximately double that of the **2022** at **22.61 Mm³/a**.

GRU	2022 Volumes (Mm³/a)				2050 Volumes (Mm³/a)			
	Abstraction	Injection	Net Yield	Comment	Abstraction	Injection	Net Yield	Comment
Atlantis	5.00	2.92	2.08	PS*	12.25	9.84	2.41	AWRMS expansion
Cape Flats	20.00	14.60	5.40	CFA Phase 1 (PS)	28.00	23.50	4.50	CFA Phase 2
Langebaan Road	6.87	0.00	6.87	PS	14.00	0.00	14.00	LRAS
Steenbras-Nuweberg	8.00	0.00	8.00	TMG Phase 1 (PS)	32.50	0.00	32.50	TMG Phase 3
Wellington	0.00	0.00	0.00	PS*	0.63	0.00	0.63	Paarl & Wellington wellfields
Yzerfontein	0.26	0.00	0.26	PS & re-furbishment	2.52	0.00	2.52	Grootwater Aquifer
Total	**40.13**	**17.52**	**22.61**		**89.90**	**33.34**	**56.56**	

**PS stands for Present Status and is an indication of current groundwater use included in the PS calculation. This was often found to be a partial "phase 1" volume (see Ecological Reference Conditions Report (DWS, 2022e) for detail.*

Sc 3: GROUNDWATER DEVELOPMENTS

RESULTS:

Langebaan Road GRU is categorized as potentially '**pot. critically stressed**' (assuming a 14 Mm³/a abstraction rate).

The **Cape Flats** GRU is classed as '**pot. highly stressed**', with abstractions reducing allocable volumes from 28 Mm³/a to roughly 14 Mm³/a, a decrease of ~50%

Steenbras-Nuweberg GRU is classified as '**moderately stressed**', attributable to high abstraction volumes from the TMGA.

GRU	PS (2022)		Sc 3 (2050)		Sc 3 vs PS 2022 Still Allocable Volume Difference (Mm³/a)
	Still Allocable (Mm³/a)	Allocable Stress Index	Still Allocable (Mm³/a)	Allocable Stress Index	
Adamboerskraal	13.47	0.62	13.47	0.62	0.00
Atlantis	18.79	0.83	18.46	0.81	-0.33
Cape Flats	28.04	0.68	14.34*	0.35	-13.70
Cape Peninsula	5.41	0.49	5.41	0.49	0.00
Cape Town Rim	11.33	0.61	11.33	0.61	0.00
Darling	9.15	0.92	9.15	0.92	0.00
Drakensteinberge	24.67	0.89	24.67	0.89	0.00
Eendekuil Basin	9.99	0.46	9.99	0.46	0.00
Elandsfontein	7.99	0.52	7.99	0.52	0.00
Groot Winterhoek	20.32	0.90	20.32	0.90	0.00
Langebaan Road	9.15	0.39	2.02	0.09	-7.13
Malmesbury	36.38	0.69	36.38	0.69	0.00
Middle-Lower Berg	29.03	0.68	29.03	0.68	0.00
Northern Swartland	29.81	0.94	29.81	0.94	0.00
Paarl-Franschhoek	13.65	0.51	13.65	0.51	0.00
Piketberg	12.64	0.62	12.64	0.62	0.00
Steenbras- Nuweberg	49.58	0.84	25.08	0.43	-24.50
Stellenbosch-Helderberg	30.13	0.73	30.13	0.73	0.00
Tulbagh	5.79	0.53	5.79	0.53	0.00
Voëlvlei-Slanghoek	12.34	0.88	12.34	0.88	0.00
Vredenburg	6.26	0.84	6.26	0.84	0.00
Wellington	28.03	0.71	27.40	0.69	-0.63
Wemmershoek	22.43	0.84	22.43	0.84	0.00
Witzenberg	2.52	0.91	2.52	0.91	0.00
Yzerfontein	8.91	0.97	6.65	0.72	-2.26
TOTAL	**445.79**	**18.00**	**397.24**	**16.67**	**-48.55**

**Includes the PHA Abstraction rate.*

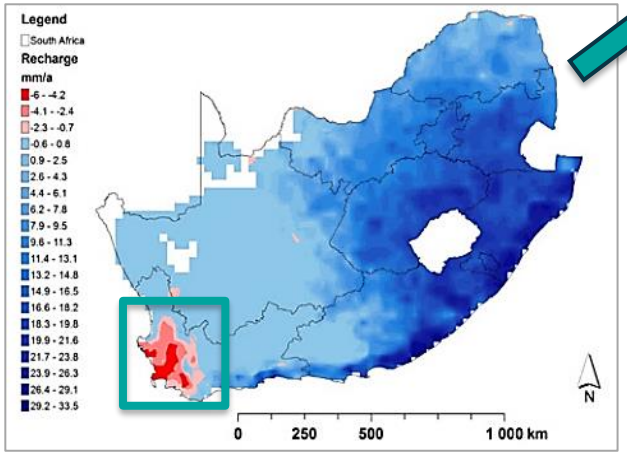
Sc 4: CLIMATE CHANGE

Investigate the impact of climate change, particularly under warmer conditions, on groundwater recharge rates and its effects on the Reserve.

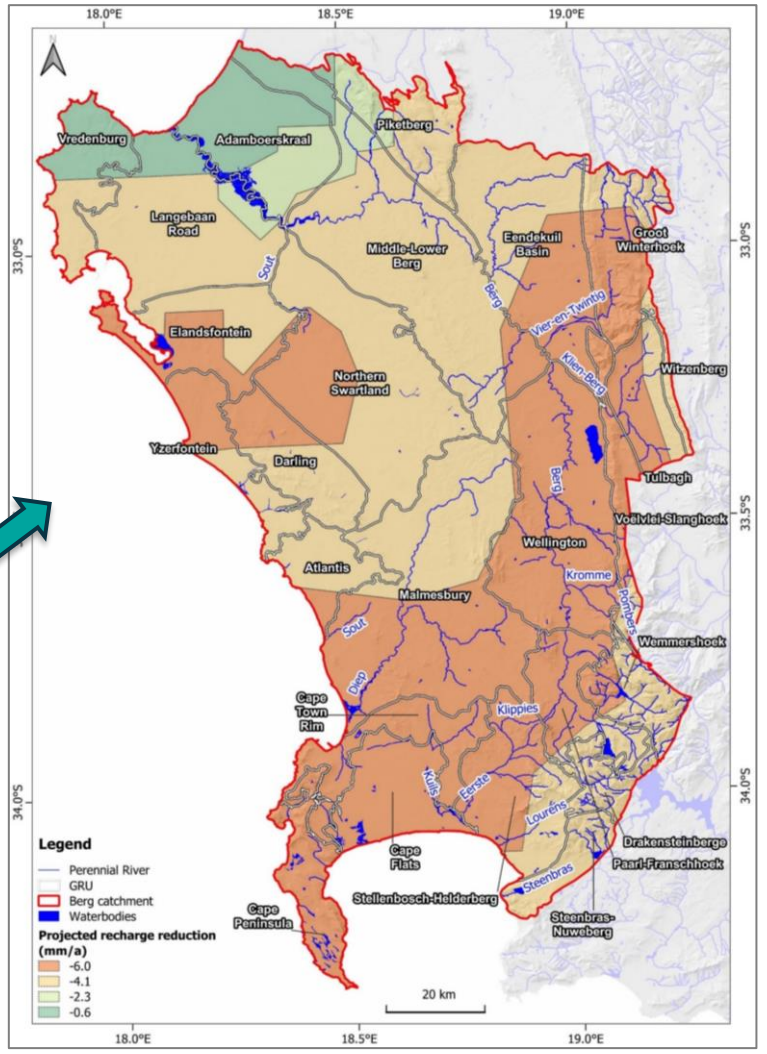
1. **Recharge reduction map**
2. **Recharge rates per GRU**
3. **Reduced recharge rates applied to PS Recharge**
4. **Scenario Results**

Dennis et al., 2012 calculated **reduced recharge rates** using a function considering both **recharge-rainfall** relationship and **slope**.

Majority of the study area experiences a reduced recharge rate ranging from **4.1 to 6 mm/a.**



Projected recharge rates by Dennis et. al (2012)



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Scenario Results

Sc 4: CLIMATE CHANGE

Climate change significantly affects allocable volumes through less recharge, causing a **~64 Mm³/a reduction in still allocable volumes**, from **~446 Mm³/a in 2022** to **~382 Mm³/a in 2050**.

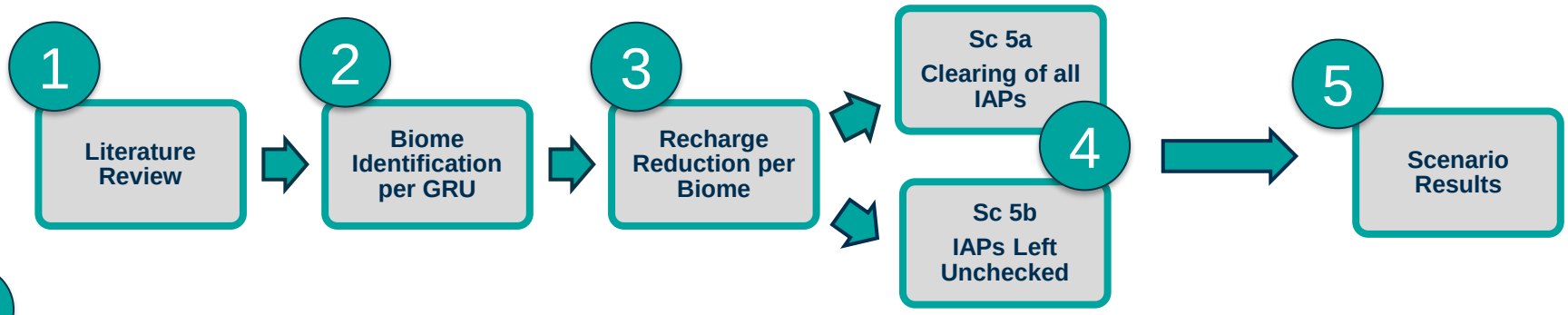
While none are classified as 'potentially critically stressed', the Langebaan Road and Eendekuil Basin are classified as 'potentially highly stressed'.

The Malmesbury, Wellington, Northern Swartland, Middle-Lower Berg, Eendekuil, Langebaan Road, and Stellenbosch-Helderberg GRUs obtained the greatest reductions in recharge.

GRU	PS (2022)		Sc 4 (2050)		Sc 4 vs PS 2022 Still Allocable Volume Difference (Mm³/a)
	Still Allocable (Mm³/a)	Allocable Stress Index	Still Allocable (Mm³/a)	Allocable Stress Index	
Adamboerskraal	13.47	0.62	12.66	0.61	-0.81
Atlantis	18.79	0.83	17.67	0.82	-1.12
Cape Flats	28.04	0.68	25.47	0.66	-2.57
Cape Peninsula	5.41	0.49	3.58	0.39	-1.82
Cape Town Rim	11.33	0.61	8.97	0.55	-2.36
Darling	9.15	0.92	7.19	0.90	-1.95
Drakensteinberge	24.67	0.89	23.92	0.89	-0.75
Eendekuil Basin	9.99	0.46	5.36	0.31	-4.62
Elandsfontein	7.99	0.52	5.67	0.43	-2.32
Groot Winterhoek	20.32	0.90	17.91	0.89	-2.42
Langebaan Road	9.15	0.39	6.04	0.30	-3.11
Malmesbury	36.38	0.69	28.05	0.63	-8.32
Middle-Lower Berg	29.03	0.68	23.32	0.63	-5.70
Northern Swartland	29.81	0.94	23.99	0.92	-5.82
Paarl-Franschhoek	13.65	0.51	11.62	0.47	-2.03
Piketberg	12.64	0.62	11.31	0.60	-1.33
Steenbras-Nuweberg	49.58	0.84	48.78	0.84	-0.80
Stellenbosch-Helderberg	30.13	0.73	27.06	0.70	-3.07
Tulbagh	5.79	0.53	4.24	0.45	-1.55
Voëlvlei-Slanghoek	12.34	0.88	11.10	0.86	-1.24
Vredenburg	6.26	0.84	5.46	0.82	-0.80
Wellington	28.03	0.71	21.53	0.65	-6.49
Wemmershoek	22.43	0.84	21.18	0.83	-1.24
Witzenberg	2.52	0.91	2.34	0.90	-0.18
Yzerfontein	8.91	0.97	7.30	0.96	-1.61
TOTAL	**445.79**	**-**	**381.75**	**-**	**-64.04**

Sc 5: ALIEN AND INVASIVE SPECIES

Examine the impacts of Invasive Alien Plants (IAPs) on groundwater recharge and evaluate their effects on the Reserve and allocable volumes.



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NOTES

Current and future reduction volumes (modified after Van Wilgen, 2008).

Biomes in the Berg catchment

1. Fynbos Biome
2. Thicket Biome
3. Succulent Karoo Biome

Biomes	Total area (km^2)	Current reduction volume in groundwater recharge (Mm^3/a)	Future reduction volume in groundwater recharge (Mm^3/a)	Current reduction rate per unit area ($Mm^3/km^2/a$)	Future reduction rate per unit area ($Mm^3/km^2/a$)
Fynbos	71340	4.40	36.10	61.68	506.03
Grassland	349190	0.00	6.40	0.00	18.33
Succulent Karoo	83100	0.20	3.20	2.41	38.51
Nama Karoo	360110	0.00	7.90	0.01	21.94
Thicket	402870	0.03	5.40	0.07	13.40

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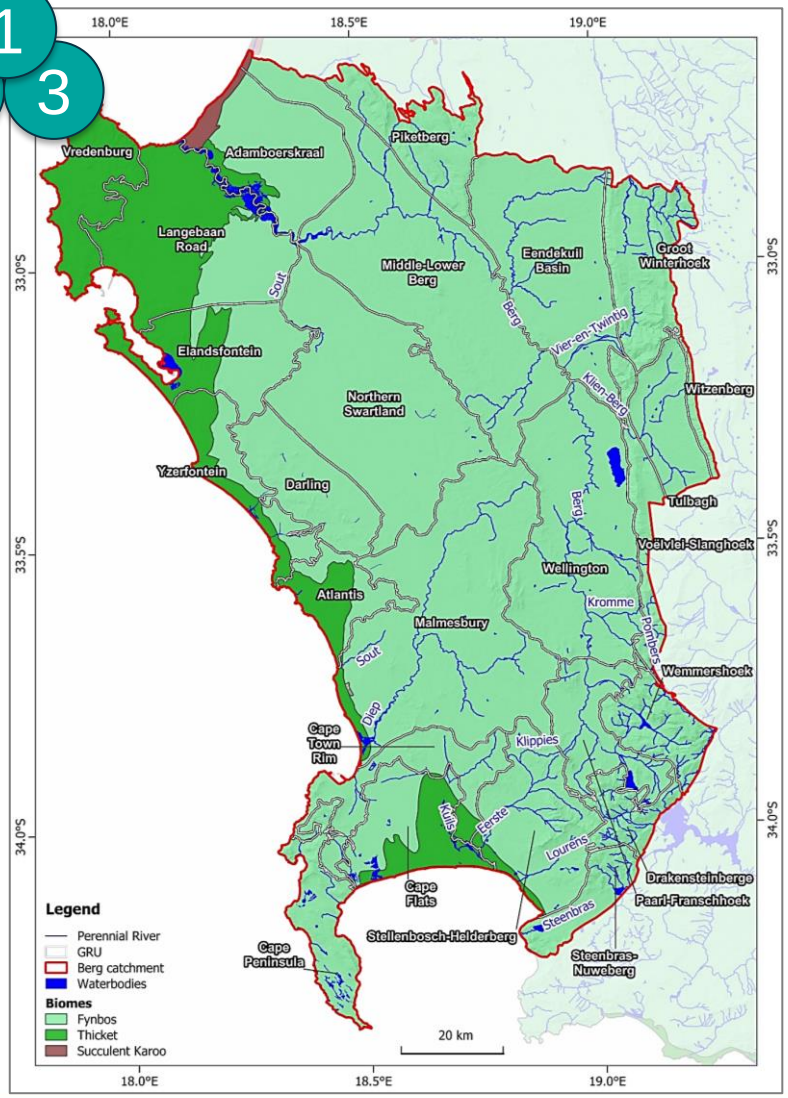


Sc 5: ALIEN AND INVASIVE SPECIES

4

Sc 5a
Clearing of all IAPs

NOTES

It was assumed that **clearing** all IAPs would restore groundwater **recharge rates to their pre-invasion levels**.

4

Sc 5b
IAPs Left Unchecked

NOTES

If left **unchecked**, IAPs would **lead to a reduction in future recharge**, which was **subtracted** from the **current recharge** volume.

Sc 5: ALIEN AND INVASIVE SPECIES

GRU	PS (2022)		5a Clearing of all IAPs			5b IAPs Left Unchecked		
			Sc 5a (2050)		Sc 5a vs PS 2022	Sc 5b (2050)		Sc 5b vs PS 2022
	Still Allocable (Mm^3/a)	Allocable Stress Index	Still Allocable (Mm^3/a)	Allocable Stress Index	Still Allocable Volume Difference (Mm^3/a)	Still Allocable (Mm^3/a)	Allocable Stress Index	Still Allocable Volume Difference (Mm^3/a)
Adamboerskraal	13.47	0.62	13.50	0.62	0.03	13.22	0.62	-0.26
Atlantis	18.79	0.83	18.80	0.83	0.01	18.73	0.83	-0.06
Cape Flats	28.04	0.68	28.05	0.68	0.01	27.92	0.68	-0.12
Cape Peninsula	5.41	0.49	5.42	0.49	0.02	5.25	0.48	-0.15
Cape Town Rim	11.33	0.61	11.35	0.61	0.02	11.14	0.60	-0.18
Darling	9.15	0.92	9.17	0.92	0.03	8.94	0.92	-0.21
Drakensteinberge	24.67	0.89	24.68	0.89	0.01	24.57	0.89	-0.09
Eendekuil Basin	9.99	0.46	10.05	0.46	0.06	9.51	0.44	-0.48
Elandsfontein	7.99	0.52	8.00	0.52	0.02	7.83	0.51	-0.16
Groot Winterhoek	20.32	0.90	20.35	0.90	0.03	20.09	0.90	-0.23
Langebaan Road	9.15	0.39	9.17	0.39	0.02	9.00	0.39	-0.15
Malmesbury	36.38	0.69	36.47	0.69	0.10	35.59	0.69	-0.79
Middle-Lower Berg	29.03	0.68	29.12	0.68	0.09	28.28	0.68	-0.75
Northern Swartland	29.81	0.94	29.89	0.94	0.08	29.18	0.93	-0.64
Paarl-Franschhoek	13.65	0.51	13.68	0.51	0.02	13.47	0.51	-0.19
Piketberg	12.64	0.62	12.67	0.62	0.02	12.45	0.62	-0.20
Steenbras- Nuweberg	49.58	0.84	49.60	0.84	0.01	49.49	0.84	-0.10
Stellenbosch-Helderberg	30.13	0.73	30.16	0.73	0.03	29.86	0.72	-0.27
Tulbagh	5.79	0.53	5.80	0.53	0.02	5.64	0.53	-0.15
Voëlvlei-Slanghoek	12.34	0.88	12.36	0.88	0.01	12.23	0.87	-0.11
Vredenburg	6.26	0.84	6.26	0.84	0.00	6.25	0.84	-0.01
Wellington	28.03	0.71	28.09	0.71	0.07	27.47	0.71	-0.55
Wemmershoek	22.43	0.84	22.44	0.84	0.02	22.29	0.84	-0.14
Witzenberg	2.52	0.91	2.52	0.91	0.00	2.50	0.91	-0.02
Yzerfontein	8.91	0.97	8.92	0.97	0.01	8.83	0.97	-0.08
TOTAL	**445.79**	**-**	**446.53**	**-**	**0.74**	**439.72**	**-**	**-6.07**

SCENARIO INTEGRATION AND COMBINATION

Comprehensively assessing multiple factors including population and sectoral growth, groundwater developments, climate change, and not cleared or cleared alien vegetation to understand the combined influence on total allocable volumes.

1. Collate scenario results projected volumes.
2. Assign scenario results (i.e., projected volumes) to relevant Reserve and Allocation parameters, namely: GW Reserve (BHN and EWR), Recharge and Water Use.
3. Create a combined scenario by merging multiple Reserve and Allocation parameters.
4. Assess the potential impacts using an Allocation Stress Index.

SCENARIO INTEGRATION AND COMBINATION SCENARIOS

2 3

Scenario 6a – Worst Case

Scenario No.	Scenario Name	Parameter	Influence / Impacts	Total Volume Change (Mm^3/a)
Sc 1	Population Growth	BHN Reserve	Increase ↑	-1.92
Sc 2	Sectoral Water Demand	Groundwater Use	Increase ↑	-28.85
Sc 3	Groundwater Developments	Groundwater Use	Increase ↑	-48.55
Sc 4	Climate Change	Recharge	Decrease ↓	-64.04
Sc 5b (unchecked)	Alien and Invasive Species	Recharge	Decrease ↓	-6.07
Total				**-149.43**

2 3

Scenario 6b – Most-likely

Scenario No.	Scenario Name	Parameter	Influence / Impacts	Total Volume Change
Sc 1	Population Growth	BHN Reserve	Increase ↑	-1.92
Sc 2	Sectoral Water Demand	Groundwater Use	Increase ↑	-28.85
Sc 3	Groundwater Developments	Groundwater Use	Increase ↑	-48.55
Sc 4	Climate Change	Recharge	Decrease ↓	-64.04
Sc 5a (cleared)	Alien and Invasive Species	Recharge	Increase ↑	+0.74
Total				**-142.62**

Scenario 6a – Worst Case

- The difference in allocable volumes between 2022 and 2050 is **a decrease of 150.43 Mm³/a**, reflecting a ~34% reduction.
- The Cape Flats, Malmesbury, and Steenbras-Nuweberg, GRUs exhibited the most substantial differences in their Still Allocable Volumes compared to the PS volumes, with respective decreases of 14.29 Mm³/a, 19.77 Mm³/a and 17.43 Mm³/a.
- Tulbagh is 'Potentially Critically Stressed', while Eendekuil, Elandsfontein, Langebaan Road, and Paarl-Franshoek GRUs are 'Potentially Highly Stressed'.

GRU	PS (2022)		Sc 6a (2050)		Sc 6a vs PS 2022 Still Allocable Volume Difference (Mm³/a)
	Still Allocable (Mm³/a)	Allocable Stress Index	Still Allocable (Mm³/a)	Allocable Stress Index	
Adamboerskraal	13.47	0.62	10.84	0.53	-2.63
Atlantis	18.79	0.83	18.12	0.84	-0.67
Cape Flats	28.04	0.68	13.75	0.36	-14.29
Cape Peninsula	5.41	0.49	3.28	0.36	-2.12
Cape Town Rim	11.33	0.61	6.12	0.38	-5.21
Darling	9.15	0.92	6.33	0.81	-2.81
Drakensteinberge	24.67	0.89	22.67	0.85	-2.00
Eendekuil Basin	9.99	0.46	3.11	0.19	-6.88
Elandsfontein	7.99	0.52	3.89	0.30	-4.09
Groot Winterhoek	20.32	0.90	15.78	0.79	-4.55
Langebaan Road	9.15	0.39	3.38	0.17	-5.77
Malmesbury	36.38	0.69	16.61	0.38	-19.77
Middle-Lower Berg	29.03	0.68	19.64	0.54	-9.39
Northern Swartland	29.81	0.94	22.19	0.87	-7.63
Paarl-Franschhoek	13.65	0.51	5.67	0.23	-7.98
Piketberg	12.64	0.62	6.87	0.37	-5.78
Steenbras- Nuweberg	49.58	0.84	32.15	0.56	-17.43
Stellenbosch-Helderberg	30.13	0.73	24.09	0.63	-6.04
Tulbagh	5.79	0.53	1.19	0.13	-4.60
Voëlvlei-Slanghoek	12.34	0.88	10.80	0.85	-1.54
Vredenburg	6.26	0.84	4.64	0.70	-1.62
Wellington	28.03	0.71	16.52	0.51	-11.51
Wemmershoek	22.43	0.84	20.30	0.80	-2.13
Witzenberg	2.52	0.91	2.23	0.87	-0.28
Yzerfontein	8.91	0.97	5.21	0.69	-3.70
TOTAL	**445.79**	**-**	**295.36**	**-**	**-150.43**

Scenario 6b – Most-likely

- The difference in allocable volumes between 2022 and 2050 is a **decrease of 143.63 Mm³/a**, reflecting a ~32% reduction.
- The Cape Flats, Malmesbury, and Steenbras-Nuweberg, GRUs exhibited the most substantial differences in their Still Allocable Volumes compared to the PS volumes, with respective decreases of 14.16 Mm³/a, 18.88 Mm³/a and 17.32 Mm³/a.
- Tulbagh is 'Potentially Critically Stressed', while Eendekuil, Elandsfontein, Langebaan Road, and Paarl-Franshoek GRUs are 'Potentially Highly Stressed'.

GRU	PS (2022)		Sc 6b (2050)		Sc 6b vs PS 2022 Still Allocable Volume Difference (Mm³/a)
	Still Allocable (Mm³/a)	Allocable Stress Index	Still Allocable (Mm³/a)	Allocable Stress Index	
Adamboerskraal	13.47	0.62	11.13	0.53	-2.34
Atlantis	18.79	0.83	18.19	0.84	-0.60
Cape Flats	28.04	0.68	13.88	0.36	-14.16
Cape Peninsula	5.41	0.49	3.45	0.38	-1.95
Cape Town Rim	11.33	0.61	6.32	0.39	-5.00
Darling	9.15	0.92	6.56	0.82	-2.58
Drakensteinberge	24.67	0.89	22.77	0.85	-1.90
Eendekuil Basin	9.99	0.46	3.64	0.21	-6.35
Elandsfontein	7.99	0.52	4.07	0.31	-3.92
Groot Winterhoek	20.32	0.90	16.04	0.80	-4.29
Langebaan Road	9.15	0.39	3.55	0.18	-5.61
Malmesbury	36.38	0.69	17.49	0.39	-18.88
Middle-Lower Berg	29.03	0.68	20.48	0.56	-8.54
Northern Swartland	29.81	0.94	22.90	0.88	-6.91
Paarl-Franschhoek	13.65	0.51	5.88	0.24	-7.77
Piketberg	12.64	0.62	7.09	0.37	-5.56
Steenbras- Nuweberg	49.58	0.84	32.26	0.56	-17.32
Stellenbosch-Helderberg	30.13	0.73	24.39	0.63	-5.73
Tulbagh	5.79	0.53	1.35	0.14	-4.43
Voëlvlei-Slanghoek	12.34	0.88	10.93	0.85	-1.42
Vredenburg	6.26	0.84	4.64	0.70	-1.62
Wellington	28.03	0.71	17.13	0.52	-10.89
Wemmershoek	22.43	0.84	20.45	0.80	-1.98
Witzenberg	2.52	0.91	2.26	0.87	-0.26
Yzerfontein	8.91	0.97	5.30	0.70	-3.61
TOTAL	**445.79**	**-**	**302.16**	**-**	**-143.63**

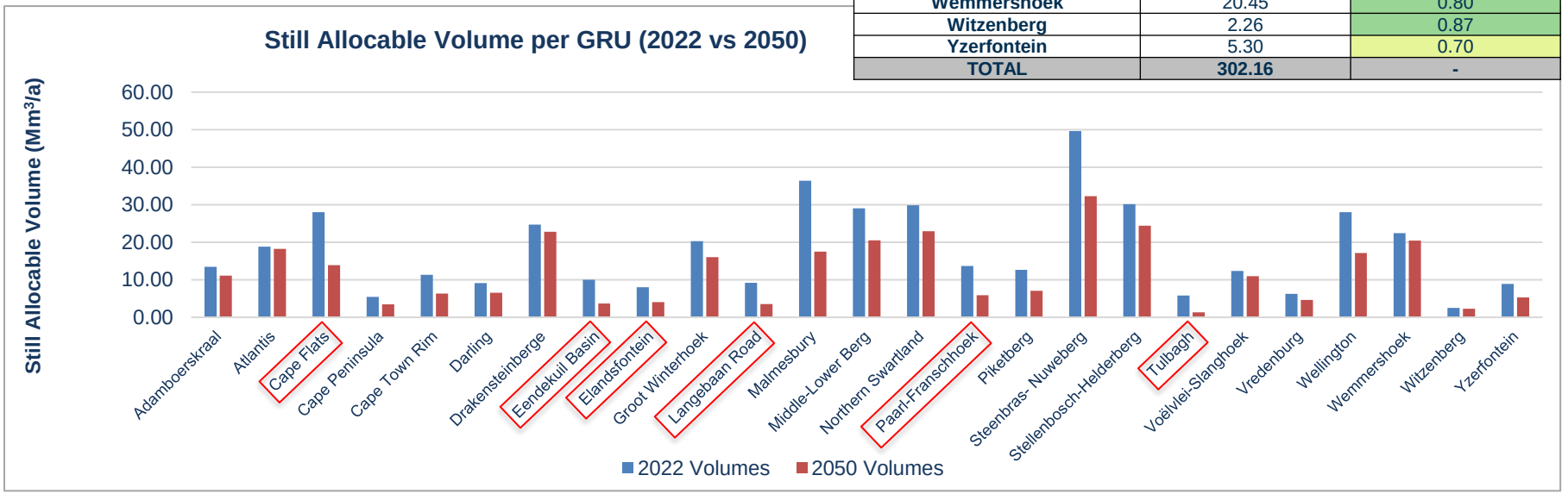
Operational Scenarios & Socio-Economic and Ecological Consequences

Scenario 6b – Most-likely

- Combination Scenarios 6a and 6b yield similar trends with a minor difference of **6.80 Mm³/a** in Total Allocable Volumes.
- Climate Change and Sectoral Demand exert the most substantial influence.

Tulbagh is 'Potentially Critically Stressed', while **Eendekuil, Elandsfontein, Langebaan Road**, and **Paarl-Franshoek** GRUs are **'Potentially Highly Stressed',** necessitating careful management to protect the Groundwater Reserve.

GRU	Sc 6b (2050)	
	Still Allocable (Mm³/a)	Allocable Stress Index
Adamboerskraal	11.13	0.53
Atlantis	18.19	0.84
Cape Flats	13.88	0.36
Cape Peninsula	3.45	0.38
Cape Town Rim	6.32	0.39
Darling	6.56	0.82
Drakensteinberge	22.77	0.85
Eendekuil Basin	3.64	0.21
Elandsfontein	4.07	0.31
Groot Winterhoek	16.04	0.80
Langebaan Road	3.55	0.18
Malmesbury	17.49	0.39
Middle-Lower Berg	20.48	0.56
Northern Swartland	22.90	0.88
Paarl-Franschhoek	5.88	0.24
Piketberg	7.09	0.37
Steenbras- Nuweberg	32.26	0.56
Stellenbosch-Helderberg	24.39	0.63
Tulbagh	1.35	0.14
Voëlvlei-Slanghoek	10.93	0.85
Vredenburg	4.64	0.70
Wellington	17.13	0.52
Wemmershoek	20.45	0.80
Witzenberg	2.26	0.87
Yzerfontein	5.30	0.70
TOTAL	302.16	-



CAPACITY BUILDING PROGRAMME

CAPACITY BUILDING PROGRAMME

Task	Description	Period
2.1	Gap Analysis and Water Resource Model Inventory: data collection, review, and analysis	Jun-22
3.1	GRU delineation	Aug-22
3.4	Water Resource Modelling: 1 week groundwater modelling training.	Jan-23
3.8	**Reserve Determination: Attend Final Reserve Determination stakeholder engagement workshop to observe how it is determined and update the reserve reporting based on stakeholder input.**	**Jan-24**

CAPACITY BUILDING PROGRAMME

Task	Description	Period
2.1	Gap Analysis and Water Resource Model Inventory: data collection, review, and analysis	June 2022
3.1	GRU delineation	August 2022
3.4	Water Resource Modelling: 1 week groundwater modelling training.	January 2023
3.6	**Operational Scenarios: Attend workshop to select and analysis scenarios after stakeholder input from PSC4.**	**August 2023**

PROGRAMME OF UPCOMING EVENTS

PROGREAMME OF UPCOMING EVENTS

June 2023

- **Management:**
    1. Project Management Committee Meeting (PMC 05) held on 09 June 2023
- **Tasks:**
    1. Task 3.6: Stakeholder engagement of operation scenarios
- **Deliverable:**
    1. Operational Scenarios & Socio-Economic and Ecological Consequences Final Draft Report

July 2023

- **Management:**
    1. Project Steering Committee Meeting (PSC 04) held on 11th July 2023
- **Deliverable:**
    1. Operational Scenarios & Socio-Economic and Ecological Consequences Final Report

August 2023

- **Management:**
    1. Project Management Committee Meeting (PMC 05). Date TBC
    2. Capacity building workshop on scenarios
- **Deliverable:** Stakeholder Engagement of Operational Scenarios Draft Report

STEP 6 DISCUSSION: EVALUATION OF OPERATIONAL SCENARIOS WITH STAKEHOLDERS

DISCUSSION

Additional Scenarios ?
Possible Scenario Integration ?
Data / Literature Sources ?

REVIEW OF SCENARIOS CONSIDERED

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	Sectoral Water Demand	Explore historical trends in groundwater demand per sector, focusing on agriculture, industry, and other sectors, to understand future water use.
Sc 3	Groundwater Developments	Evaluate scheduled groundwater developments and strategies for the Berg catchment, calculating their impact on the Reserve and allocable volumes.
Sc 4	Climate Change	Investigate the impact of climate change, particularly under warmer conditions, on groundwater recharge rates and its effects on the Reserve.
Sc 5	Alien and Invasive Species	Examine the impacts of Invasive Alien Plants (IAPs) on groundwater recharge and evaluate their effects on the Reserve and allocable volumes.
Sc 6a	Combination Scenario	Integrate population growth, sectoral growth, groundwater developments, climate change, and absence of clearing alien vegetation for impact assessment.
Sc 6b	Combination Scenario	Integrate population growth, groundwater developments, climate change, and clearing alien vegetation for impact assessment.

THANK YOU