water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP
NATIONAL DEVELOPMENT PLAN
Our Future - make it work

HIGH CONFIDENCE GROUNDWATER RESERVE DETERMINATION STUDY IN THE BERG CATCHMENT

PROJECT STEERING COMMITTEE MEETING

Presented by: Umvoto
Date: 16 March 2023



HIGH CONFIDENCE GROUNDWATER RESERVE DETERMINATION STUDY IN THE BERG CATCHMENT

UMVOTO

EARTH | WATER | SCIENCE | LIFE

PRESENTATION OUTLINE

1. **Overview of study, phases and tasks**
2. **BHN and EWR Requirements Report**
    - Summary of previous BHN
    - Updated BHN approach
    - BHN Reserve
    - Summary of previous EWR
    - Updated EWR approach
    - EWR Reserve
    - Groundwater Reserve
3. **Operation Scenarios and Socio-Economic and Ecological Consequences**
4. **Capacity Building Programme**
5. **Programme of Upcoming Activities**

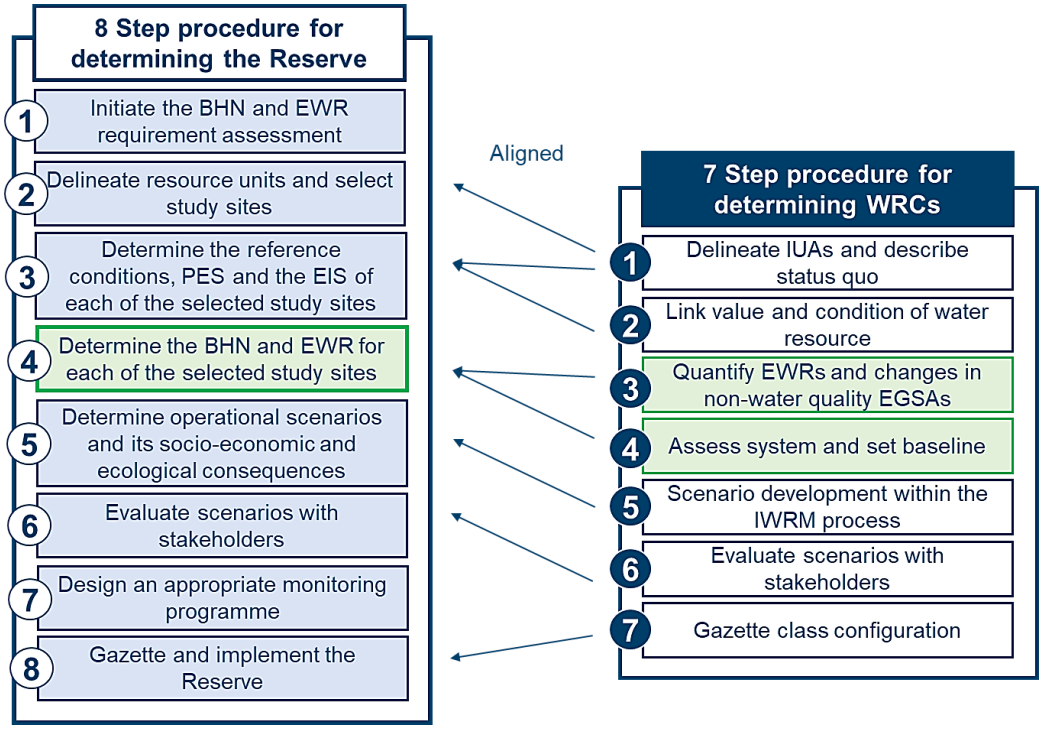
OVERVIEW OF STUDY, PHASES AND TASKS

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	Present Status of GRU	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

GROUNDWATER RESERVE DETERMINATION: STEP 4 OBJECTIVES

The BHN and EWR Requirements Report is **Deliverable 3.3** of Phase 3 of this study and is **Step 4 of eight-step groundwater Reserve determination procedure**. See summary of project phases, tasks and associated deliverables (Inception Report - DWS, 2022).



BHN AND EWR REQUIREMENTS

GROUNDWATER RESERVE DETERMINATION: STEP 4 OBJECTIVES

OBJECTIVES

1. Quantify the groundwater component of the BHN and EWR Reserve for the aquifer-specific Groundwater Resource Units (GRUs).
2. Outline the approach and methodology used to quantify the groundwater BHN and EWR Reserves.
3. Assess groundwaters contribution to the EWR Reserve at selected study sites and compare against existing EWRs.

SUMMARY OF PREVIOUS BHN

PREVIOUS BHN INFORMATION

Various databases and literature were used to inform the study:

- DWS (2016) Status Quo Report (DWS, 2017a)
- Case Study: BHN report for the Lower Orange WMA
- **Stats SA (Census 2001, 2011, and Preliminary Census 2022)**
- **Stats SA Community Survey (CS, 2007 and 2016)**

Status Quo Report

- Quantified surface water BHN Reserve based on Census 2011
  - Estimated ~ 4 819 households (~ 4 people per household) were reliant on surface water as their main source of domestic water.
  - Minimum daily flow to meet BHN requirements is 493 m^3/d or 180 000 m^3/a.

Limitations

- BHN Reserve included no GW component
- Presented per Socio Economic Zone per IUA

PREVIOUS BHN INFORMATION

Databases:

- Stats SA: CS, 2007 and 2016
- Stats SA: Census 2001, 2011, preliminary 2022

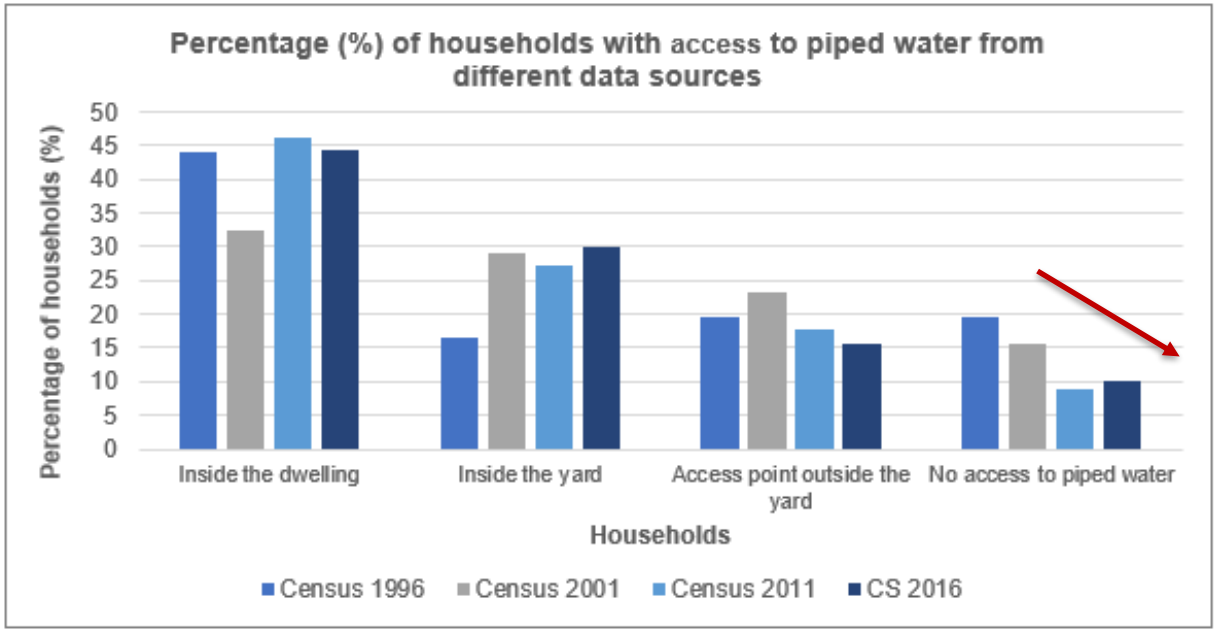


Figure 2-1 **Percentage (%) of households with access to piped water[1] from different data sources (after CS, 2016)**

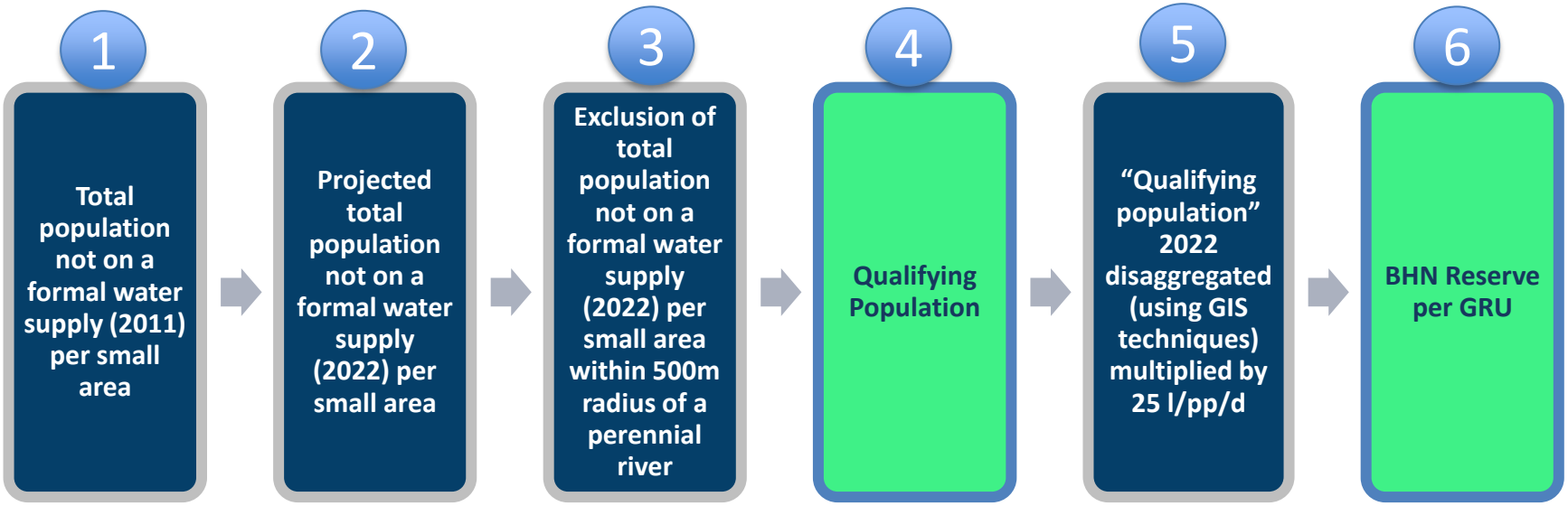
In 1996, ~19.7% of the population had no access to piped water (i.e., formal water supply), which decreased to ~10.1% in 2016.

UPDATED BHN RESERVE APPROACH

UPDATED BHN APPROACH

The BHN Reserve is based on the current population, of those either living within the catchment and directly dependent on the catchment or, more critically, not being supplied with water from a formal water supply scheme.

APPROACH



UPDATED BHN APPROACH

Population not on a formal water supply scheme (Census 2011)

Total Population (2011) – Population on Formal Supply (2011) = Population not on Formal Supply (2011)

LM Name	LM Code	2011 Total Population	2011 Population on a formal water supply	2011 Population NOT on a formal water supply
City of Cape Town	CPT	3739000	3620094	118906
Cederberg	WC012	789	789	0
Bergrivier	WC013	53147	36429	16718
Saldanha Bay	WC014	98899	95826	3073
Swartland	WC015	113712	82218	31494
Witzenberg	WC022	19835	15783	4052
Drakenstein	WC023	251197	214425	36772
Stellenbosch	WC024	155640	130386	25254
Breede Valley	WC025	185	99	86
Theewaterskloof	WC031	26739	25179	1560
TOTAL	**-**	**4 459 143**	**4 221 228**	**237 915**

1 **Total population not on a formal water supply (2011) per small area**

~95% of the population in 2011 were on a formal water supply scheme, while the remaining ~5% were not on a formal water supply scheme.

UPDATED BHN APPROACH

Population not on a formal water supply scheme 2022
(Projected from Census 2011)

Population not on a formal water supply (2022) = Population not on a formal water supply scheme (2011) x Population growth rate

LM Name	LM Code	2011 Population not on a formal water supply scheme	Relative growth rate (%)	2022 Population not a formal water supply scheme
City of Cape Town	CPT	118906	25.41%	149116
Cederberg	WC012	0	21.97%	0
Bergrivier	WC013	16718	23.45%	20638
Saldanha Bay	WC014	3073	28.05%	3934
Swartland	WC015	31494	28.70%	40532
Witzenberg	WC022	4052	31.16%	5314
Drakenstein	WC023	36772	20.07%	44152
Stellenbosch	WC024	25254	27.50%	32198
Breede Valley	WC025	86	16.12%	100
Theewaterskloof	WC031	1560	16.89%	1824
TOTAL	**-**	**237 915**	**-**	**297 809**

2 **Projected total population not on a formal water supply (2022) per small area**

3 **Exclusion of total population not on a formal water supply (2022) per small area within 500m radius of a perennial river**

- Average increase of ~24% in population over the past 11 years, exhibiting an average **growth rate of 1.6%**
- The extrapolation of population (2022) not a formal water supply scheme, did not account for urban migration, urban sprawl and developing infrastructure not taken into account.

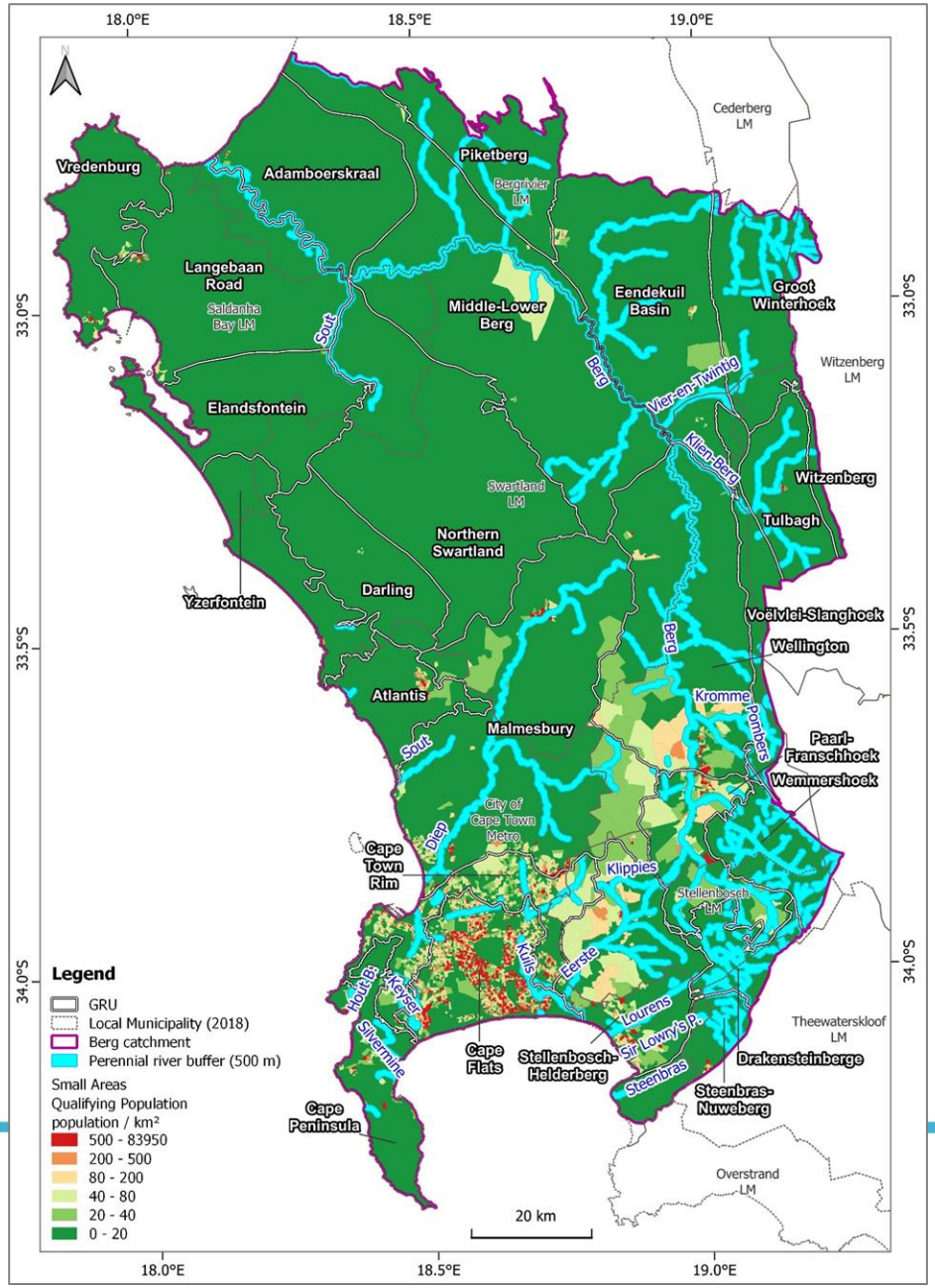
UPDATED BHN APPROACH

4 Qualifying Population (2022)

Qualifying population (2022) = Population not on a formal water supply – Population within 500m SW buffer

Spatially distributed population not on a formal water supply (2022) per “small area” and remove the population within 500m from a perennial rivers. The assumption is that anyone within 500m of a perennial river is reliant on surface water sources for their BHN.

LM Name	2022 Population not on a formal water supply	Population within 500m from river	Qualifying Population
City of Cape Town	149116	14422	134694
Cederberg	0	0	0
Bergrivier	20638	3207	17432
Saldanha Bay	3934	63	3872
Swartland	40532	3829	36703
Witzenberg	5314	1055	4259
Drakenstein	44152	7942	36210
Stellenbosch	32198	9616	22582
Breede Valley	100	21	79
Theewaterskloof	1824	324	1500
TOTAL	**297 809**	**40 478**	**257 331**

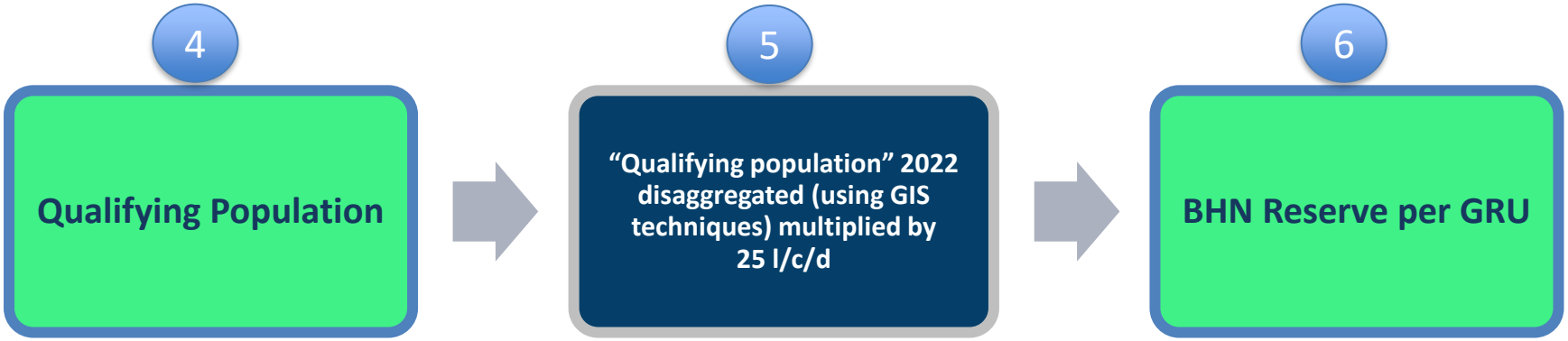


BHN RESERVE

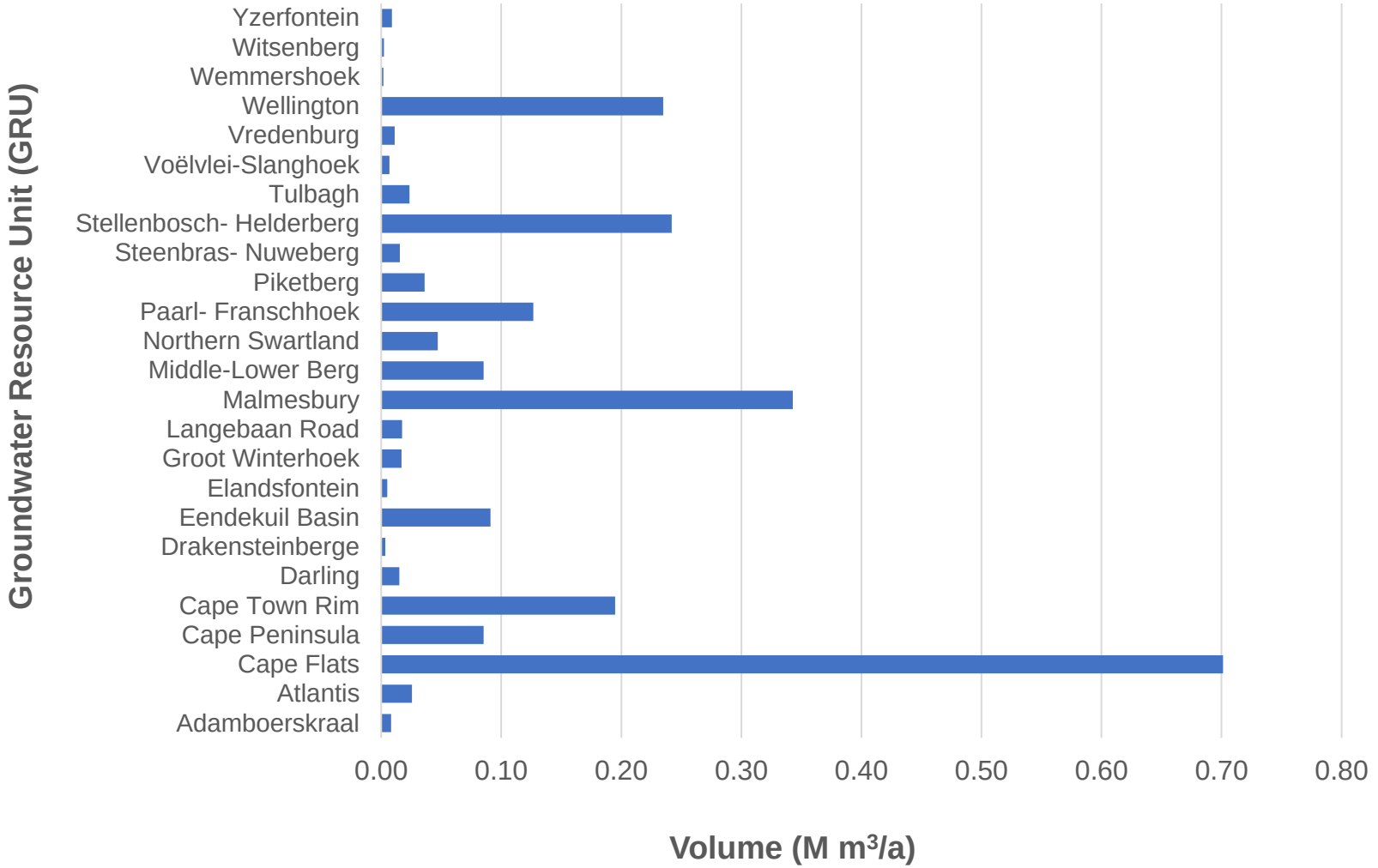
BHN RESERVE

BHN Reserve (2022) = Qualifying Population (2022) X 25 l/c/d

Local District Municipality	Qualifying Population	BHN Reserve M m^3/a
City of Cape Town	134694	1.23
Cederberg	0	0.00
Bergrivier	17432	0.16
Saldanha Bay	3872	0.04
Swartland	36703	0.33
Witzenberg	4259	0.04
Drakenstein	36210	0.33
Stellenbosch	22582	0.21
Breede Valley	79	0.00
Theewaterskloof	1500	0.01
TOTAL	**257 331**	**2.35**

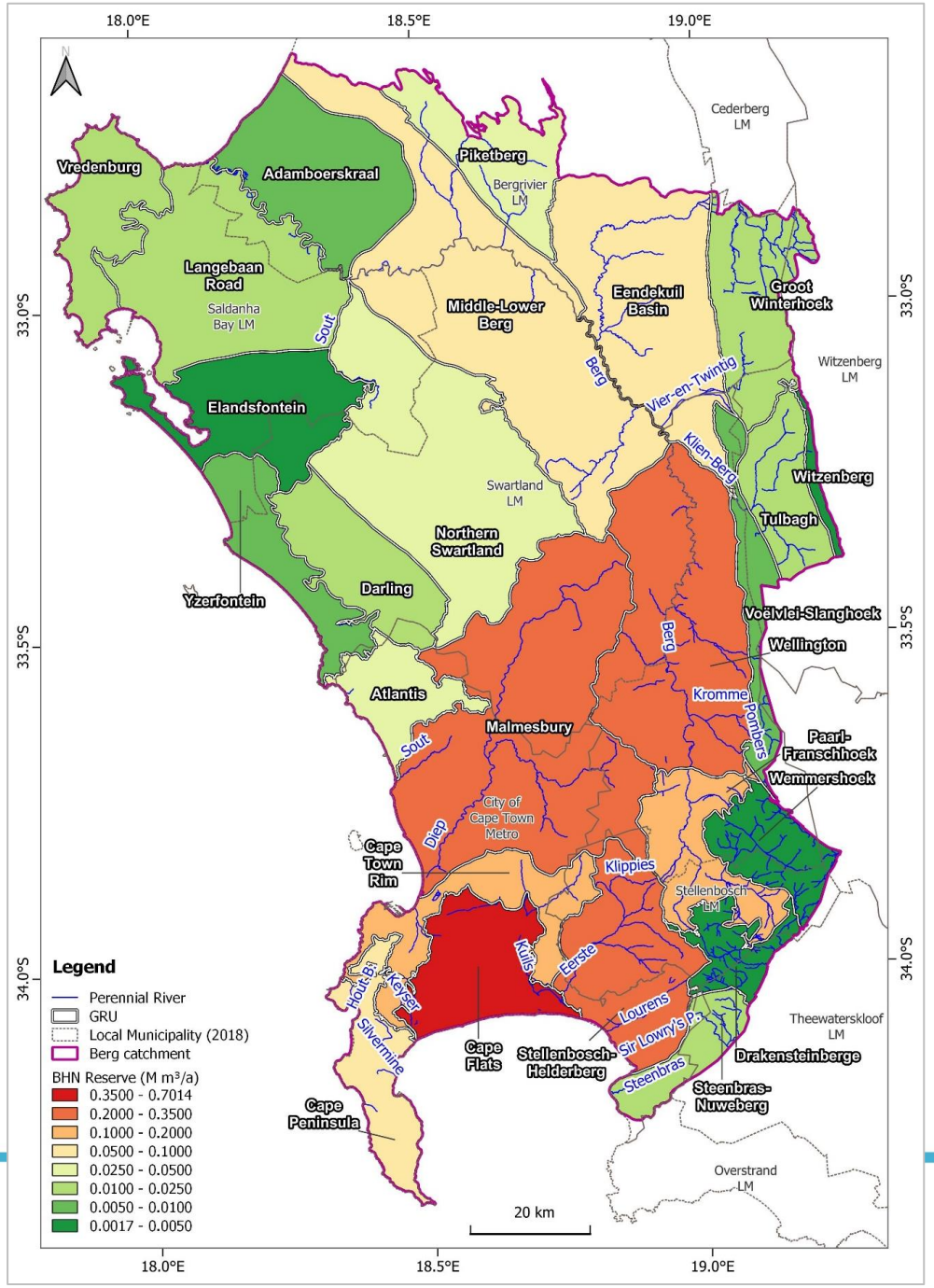


BHN RESERVE


Groundwater Resource Unit (GRU)
Yzerfontein
Witsenberg
Wemmershoek
Wellington
Vredenburg
Voëlvlei-Slanghoek
Tulbagh
Stellenbosch- Helderberg
Steenbras- Nuweberg
Piketberg
Paarl- Franschhoek
Northern Swartland
Middle-Lower Berg
Malmesbury
Langebaan Road
Groot Winterhoek
Elandsfontein
Eendekuil Basin
Drakensteinberge
Darling
Cape Town Rim
Cape Peninsula
Cape Flats
Atlantis
Adamboerskraal
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
Volume (M m³/a)

BHN RESERVE

GRU	Qualifying Population	BHN Reserve (M m³/a)
Adamboerskraal	889	0.008
Atlantis	2801	0.026
Cape Flats	76862	0.701
Cape Peninsula	9346	0.085
Cape Town Rim	21348	0.195
Darling	1640	0.015
Drakensteinberge	372	0.003
Eendekuil Basin	9968	0.091
Elandsfontein	545	0.005
Groot Winterhoek	1861	0.017
Langebaan Road	1891	0.017
Malmesbury	37580	0.343
Middle-Lower Berg	9355	0.085
Northern Swartland	5149	0.047
Paarl- Franschhoek	13875	0.127
Piketberg	3965	0.036
Steenbras- Nuweberg	1709	0.016
Stellenbosch-Helderberg	26508	0.242
Tulbagh	2568	0.023
Voëlvlei-Slanghoek	739	0.007
Vredenburg	1227	0.011
Wellington	25733	0.235
Wemmershoek	187	0.002
Witzenberg	243	0.002
Yzerfontein	970	0.009
TOTAL	**257331**	**2.348**



SUMMARY OF PREVIOUS EWR

PREVIOUS EWR INFORMATION

The role of groundwater in Classification, Reserve, and RQO studies and the related methodology have evolved over time and differ between studies.

Informing study: DWS (2016) and resultant EWRs and RQOs

Underlying theories:

1. Groundwater contributes to WRCs' low flows and EWRs (no separate WRCs for groundwater as WRCs are based on TECs and biophysical nodes)
2. The PS of groundwater is linked to its natural state and the level of use, which affects its contribution to baseflow.
3. Groundwater TECs can be established based on
   a) TECs and WRCs
   b) On conservation-driven scenarios (i.e., guidelines for groundwater abstraction).

PREVIOUS EWR INFORMATION

Example of groundwater balance, stress (Use/Recharge) and present status (PS) per quaternary catchment (after DWS, 2017b).

Quaternary	Recharge (Mm^3/a)	Use (Mm^3/a)	GWBF (Mm^3/a)	Balance (Mm^3/a)	Use/Recharge (%)	Present Status
G10A	21.09	3.90	7.25	9.93	19%	I
G10B	12.27	0.36	5.34	6.57	3%	I
G10C	22.88	2.64	2.26	17.98	12%	I

Example of groundwater contribution to baseflow (GWBF) for all biophysical and river node, in the Berg catchment which are compared to Ecological Water Requirements (EWR) and Natural Mean Annual Runoff (nMAR) (after DWS, 2017b).

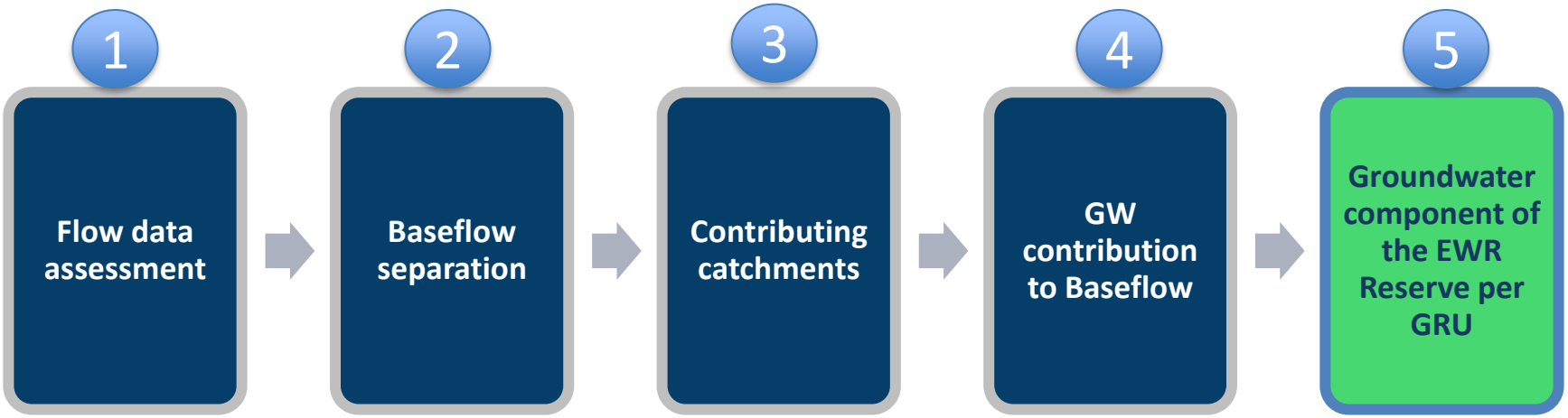
Node Name	Quaternary	EWR (Mm^3/a)	EWR-MLF (Mm^3/a)	nMAR (Mm^3/a)	GWBF (Mm^3/a)	GWBF/ EWR	GWBF / EWR-MLF	GWBF/ nMAR
Bvii13	G10A	84.5		84.5	3.4	4%		4%
Bviii1	G10A	44.0	27.4	141.7	2.4	5%	9%	2%
Biv5	G10A	5.3	2.9	34.9	1.5	27%	51%	4%
Biii2	G10B	12.5	6.0	85.6	5.3	43%	89%	6%

UPDATED EWR RESERVE APPROACH

UPDATED EWR APPROACH

The EWR Reserve is calculated using desktop derived flow data (no floods) that has been calibrated to the TEC/REC requirement.

A variety of baseflow separation techniques were applied to determine the total GWBF. To accurately assess the contribution of groundwater to the EWR per GRU, a detailed **GIS-based sub-catchment analysis** was done to re-evaluate the extent of each sub-catchment based on the local topography and flow direction. A **recharge ratio** was then applied to the total GWBF per contributing catchment, where the results will describe groundwaters contribution to the EWR Reserve per GRU and associated RUs.



UPDATED EWR APPROACH – RIVERS

1

Flow data assessment

Flow data assessment:

DWS 2016 included:

1. **Desktop derived flows (exclude large annual floods)**
2. **Total flows** that were used in the analysis of scenarios **which include large floods**

Both datasets were calibrated to the TEC/REC

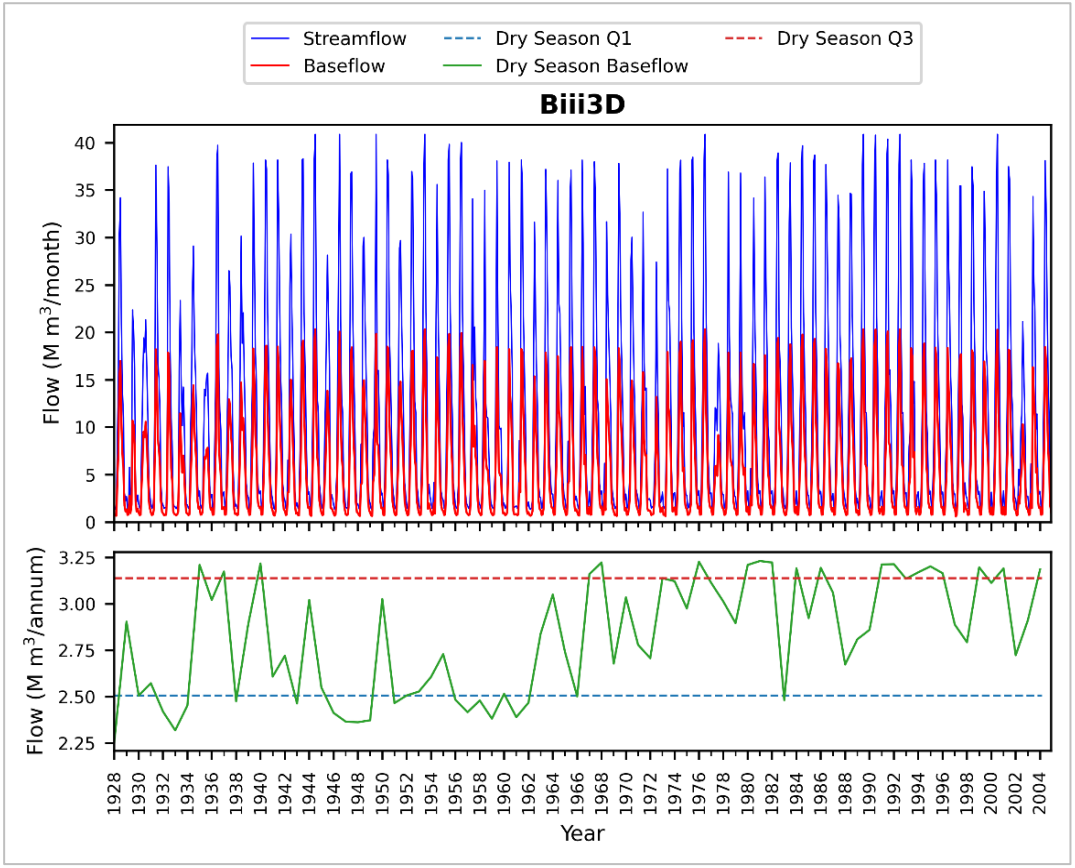
UPDATED EWR APPROACH – RIVERS

2

Baseflow separation

Baseflow Separation Methods

1. Graphical Filter Methods:
2. Recursive Digital Filter Methods:
   - Lynne & Hollick
   - Chapman
   - Eckhardt
   - Boughton
   - **Chapman & Maxwell**



UPDATED EWR APPROACH – RIVERS

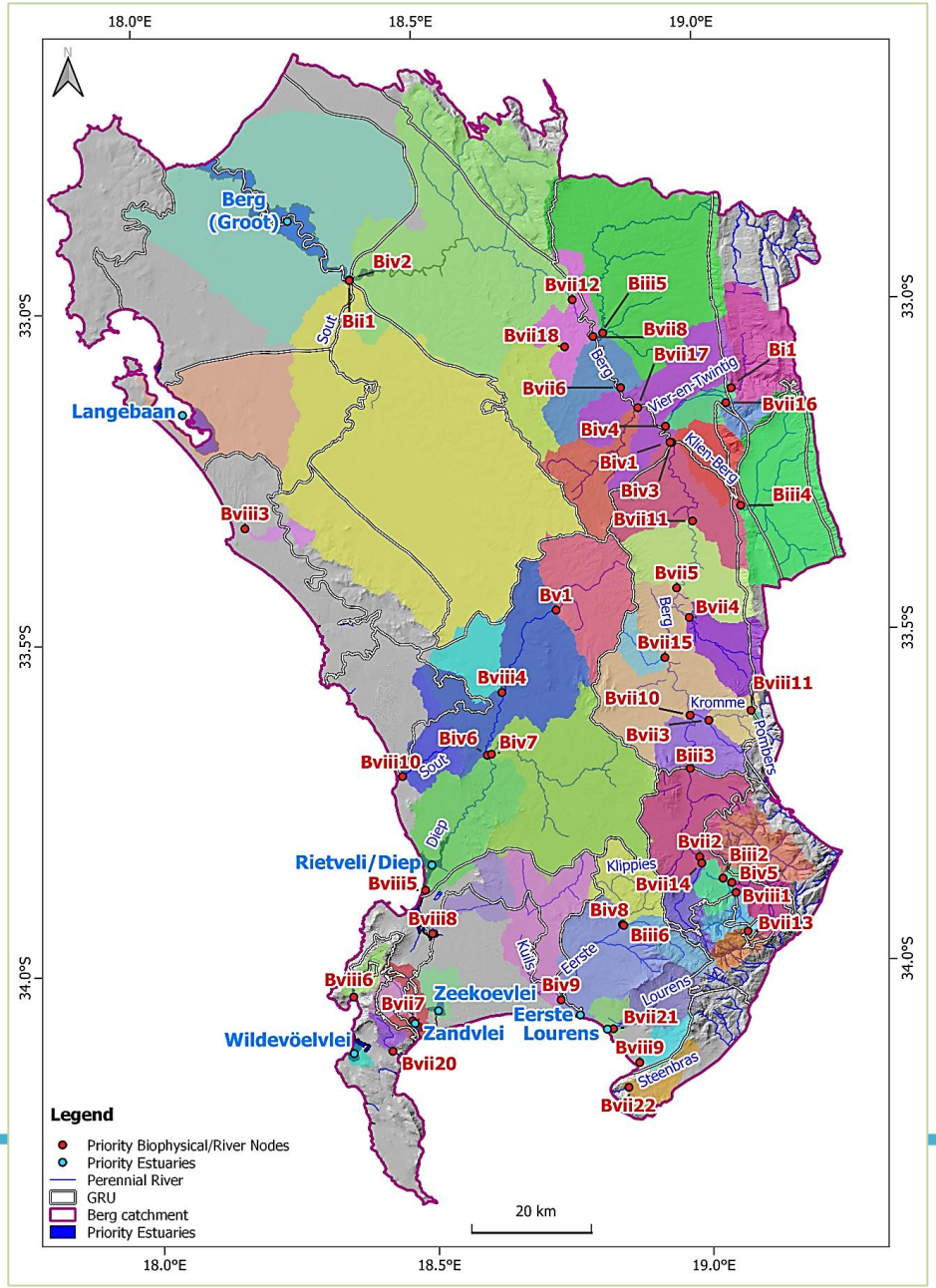
3

Contributing Catchments

Contributing Catchments:

Sub-catchments were generated using a GIS-based watershed analysis technique. Redefined based on local topography and flow direction.

- Advanced Land Observing Satellite (ALOS) 30m Digital Elevation Model (DEM)



Groundwater Contribution to EWR Reserve

Node Name	TEC	GWBF (M m^3/a)	Fractured and Intergranular	Nardouw Aquifer	Peninsula Aquifer	Primary/ Intergranular	TMG Other
Biii3	D	2.82	0.41	0.11	0.92	1.24	0.15
Biii4	C	0.56	0.19	0.04	0.12	0.19	0.03
Biii6	C	0.26	0.06	0	0.11	0.09	0
Biv6	D	0.1	0.05	0	0	0.05	0
Biv8	D	0.17	0.06	0	0	0.11	0
Bv1	D	0.04	0.04	0	0	0	0
Bvii12	D	7.82	6.25	0.02	0.35	1	0.21
Bvii21	D	0.3	0.1	0	0.04	0.15	0
Bvii22	BC	0.22	0.01	0.15	0.03	0	0.02
Bvii3	D	0.04	0.02	0	0.01	0.01	0
Bvii5	D	4.41	2.56	0	0.33	1.47	0.05
Bvii6	D	6.17	3.37	0	0.98	1.7	0.11
Bvii7	D	0.02	0	0	0	0.01	0
Bviii1	C	1.07	0.03	0	0.76	0.28	0
Bviii10	D	0.09	0.04	0	0	0.05	0
Bviii11	C	0.01	0	0	0.01	0	0
Bviii6	D	0.07	0.01	0	0	0.06	0
Bviii9	C	0.4	0.2	0	0.05	0.13	0.01

UPDATED EWR APPROACH – ESTUARIES

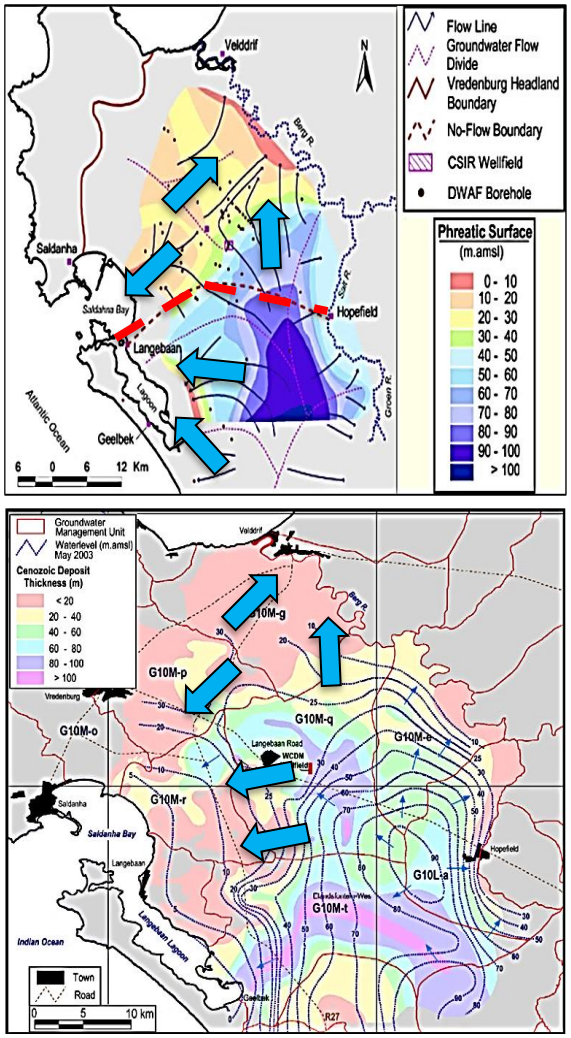
3

Contributing Catchments

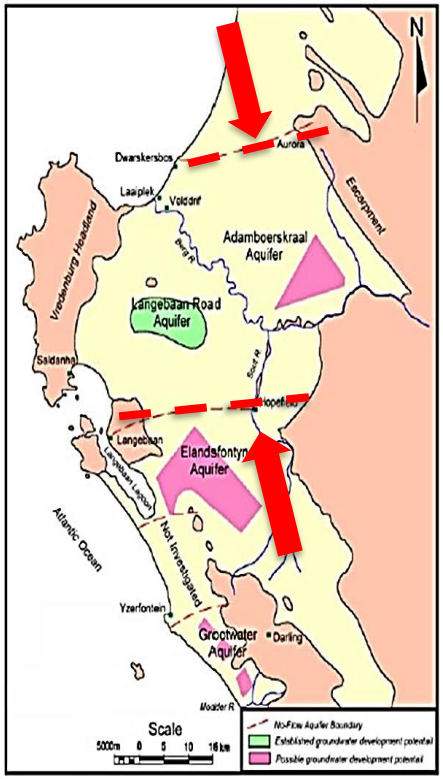
Contributing Catchments:

Groundwater catchments for estuaries downgradient of last river node were generated based on geology. Redefined based on local knowledge and flow direction.

Flow Direction



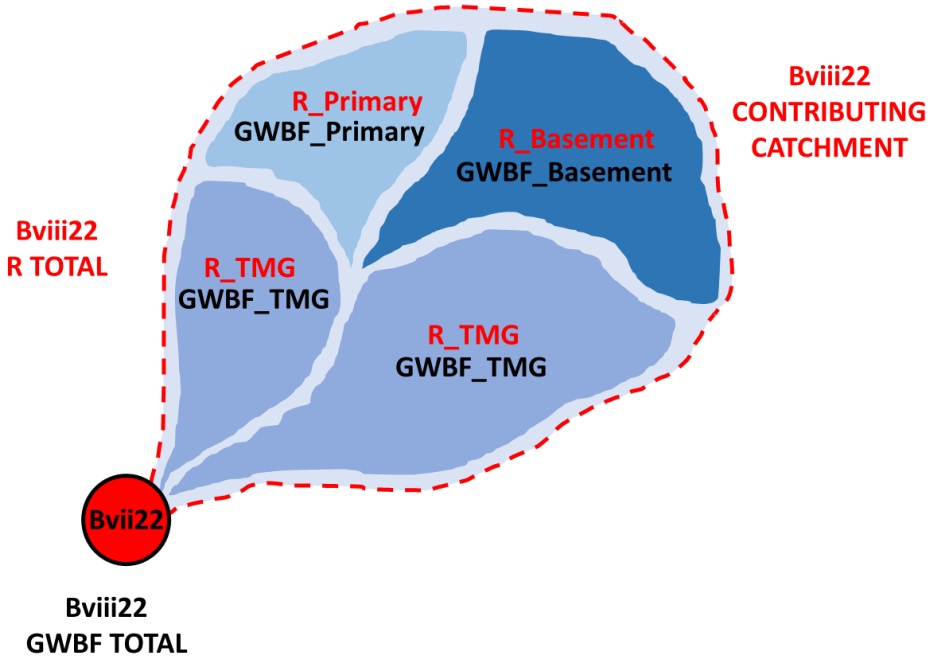
No Flow



UPDATED EWR APPROACH – GRU

4

Groundwater Contribution to Baseflow



GW contribution to baseflow

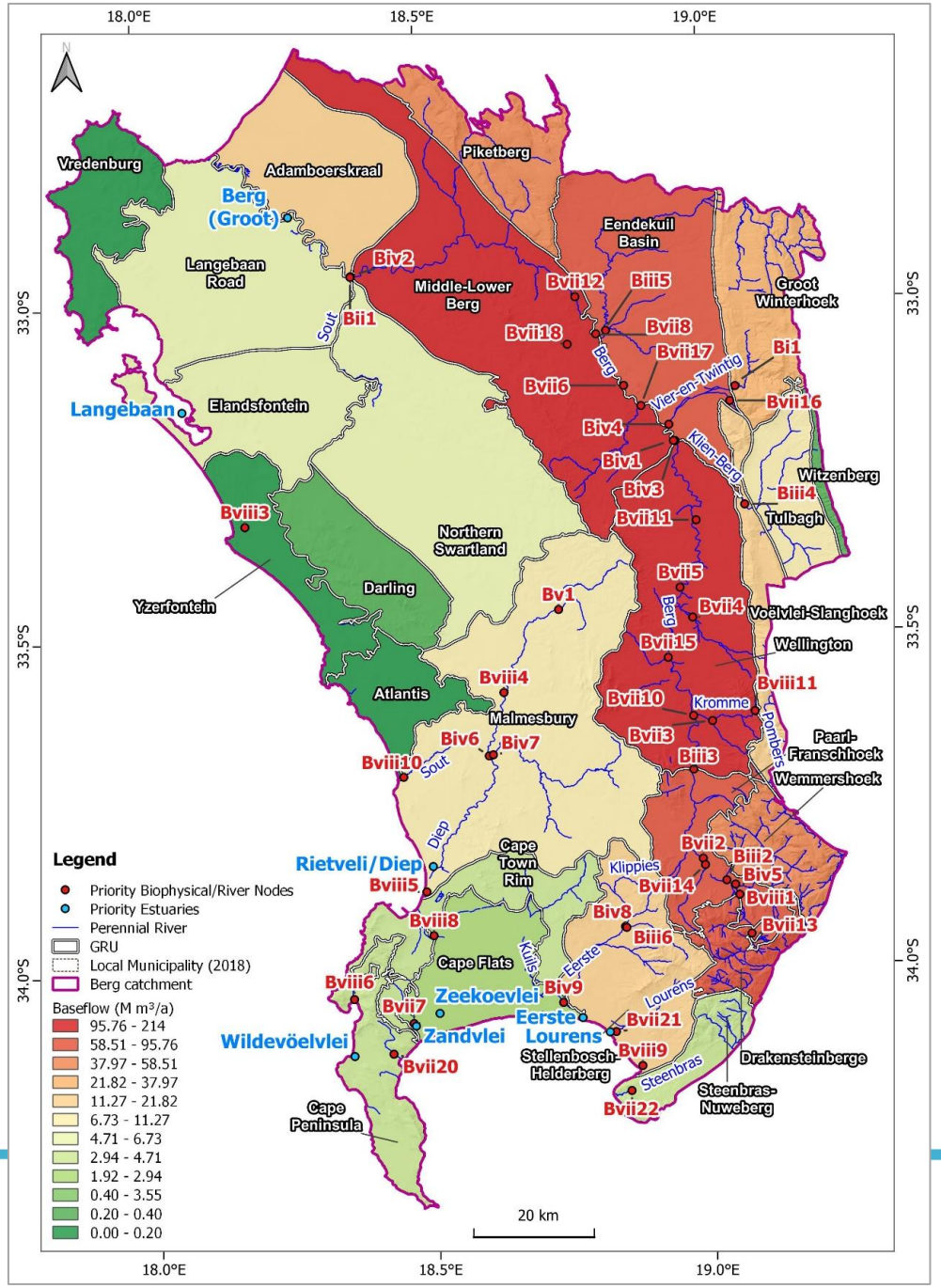
Datasets used for calculations:

- Flow data
- Recharge per GRU
- Total GWBF per contributing catchment

Factor based on the **ratio of the recharge volume of each RU and the total recharge of the contributing catchment** was applied to apportion the total groundwater baseflow (GWBF) to each RU (i.e., outputs from the baseflow separation).

EWR RESERVE

GRU	Groundwaters Contribution to Baseflow
Adamboerskraal	12.50
Atlantis	0.25
Cape Flats	2.29
Cape Peninsula	3.05
Cape Town Rim	4.23
Darling	0.40
Drakensteinberge	59.99
Eendekuil Basin	64.68
Elandsfontein	6.55
Groot Winterhoek	23.07
Langebaan Road	5.58
Malmesbury	7.11
Middle-Lower Berg	189.79
Northern Swartland	5.99
Paarl-Franschhoek	89.32
Piketberg	55.75
Steenbras-Nuweberg	3.55
Stellenbosch-Helderberg	17.54
Tulbagh	7.84
Voëlvlei-Slanghoek	18.81
Vredenburg	0.00
Wellington	109.48
Wemmershoek	48.34
Witzenberg	1.11
Yzerfontein	0.12
TOTAL	**737.31**



GROUNDWATER CONTRIBUTION TO EWR RESERVE

THE GROUDNWATER RESERVE

The aim of this report was to determine the groundwater component of the BHN and EWR Reserve (i.e., Step 4 of the eight-step GRDM: Reserve determination procedure) for the aquifer-specific GRUs.

BHN RESERVE

BHN requirements for the current population 2022 (accounting for population growth trends), who is reliant upon taking water from the groundwater resource for their essential needs of drinking water, food preparation and personal hygiene.

The BHN Reserve is based on the current population, of those either living within the catchment and directly dependent on the catchment or, more critically, not being supplied with water from a formal supply scheme.

+

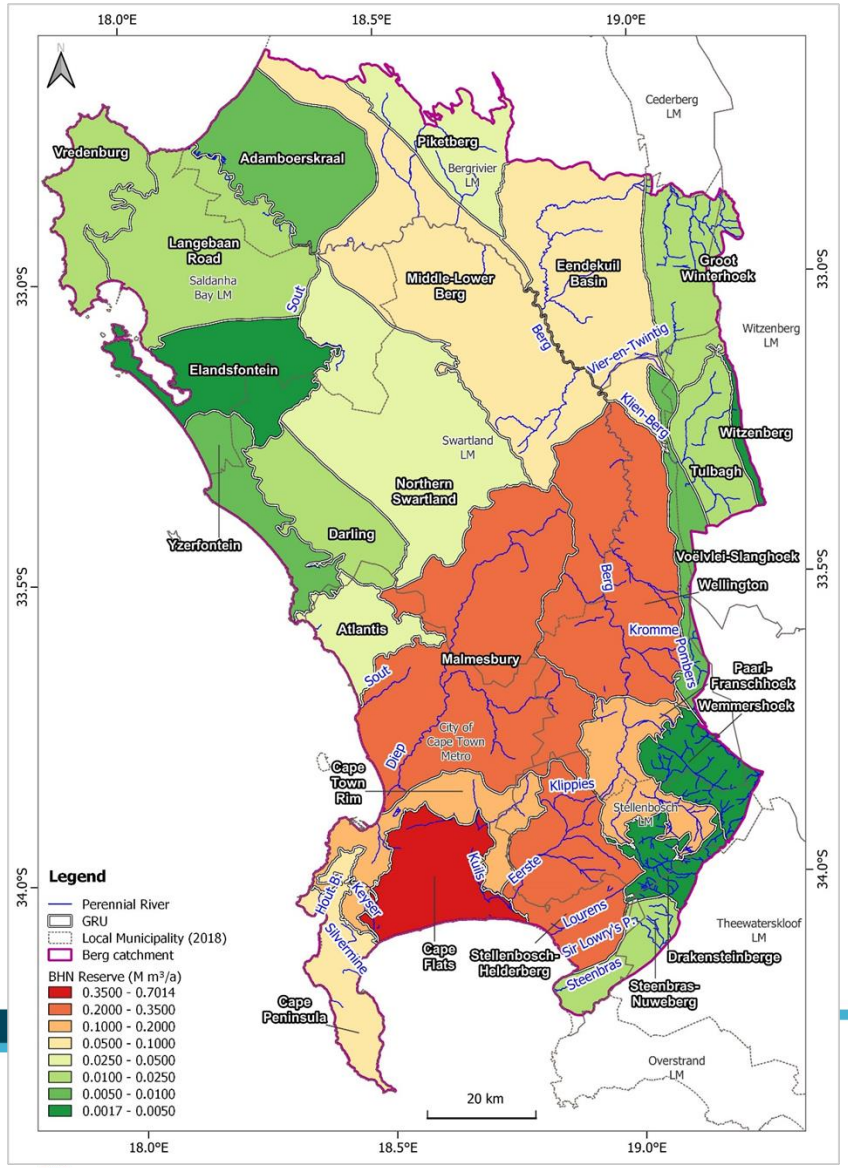
EWR RESERVE

Groundwater's contribution to the EWR is compared to all draft (i.e, scenario based, see DWS, 2016) & gazette EWRs (DWS, 2019: 121) for all biophysical/river nodes and priority estuaries in the study area. Where sufficient data is available, this determination was supported by analytical and existing numerical groundwater flow models.

The EWR Reserve is based on the volume of water required to maintain the EWR flow requirements.

THE GROUNDWATER RESERVE

BHN RESERVE



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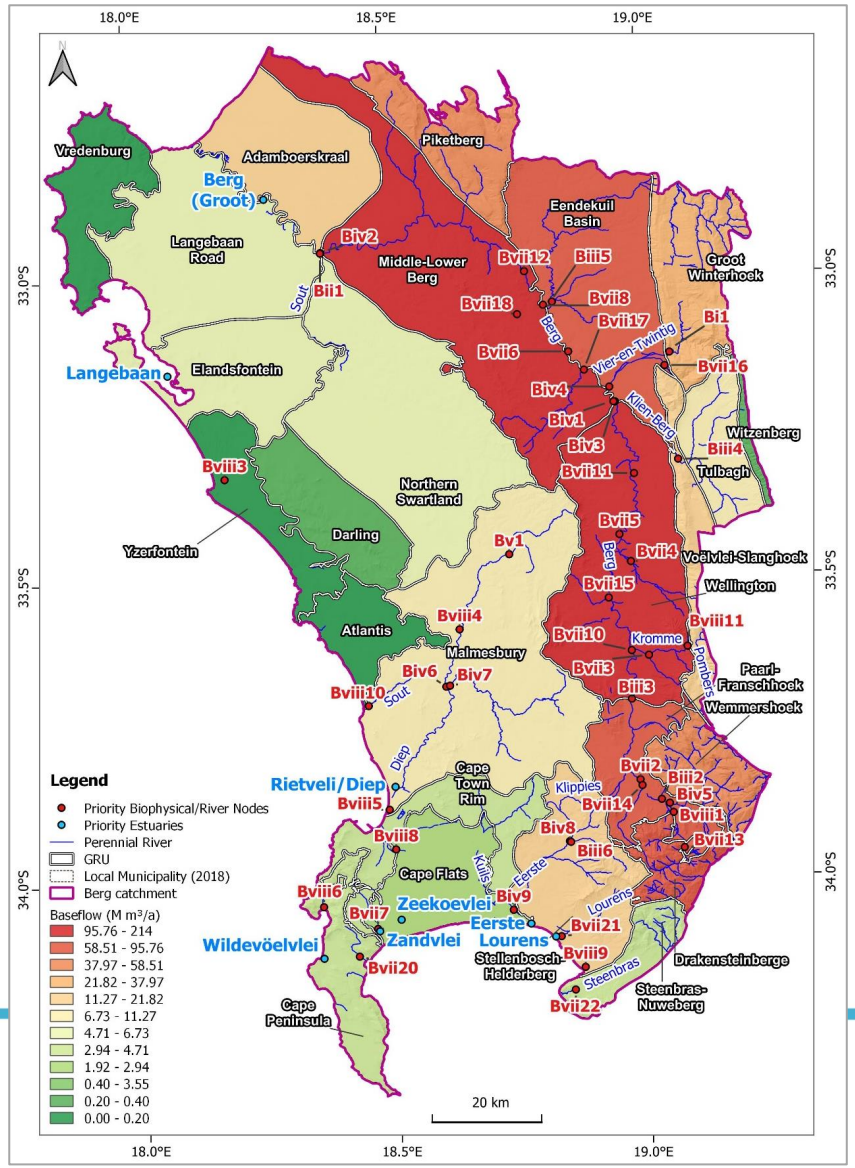
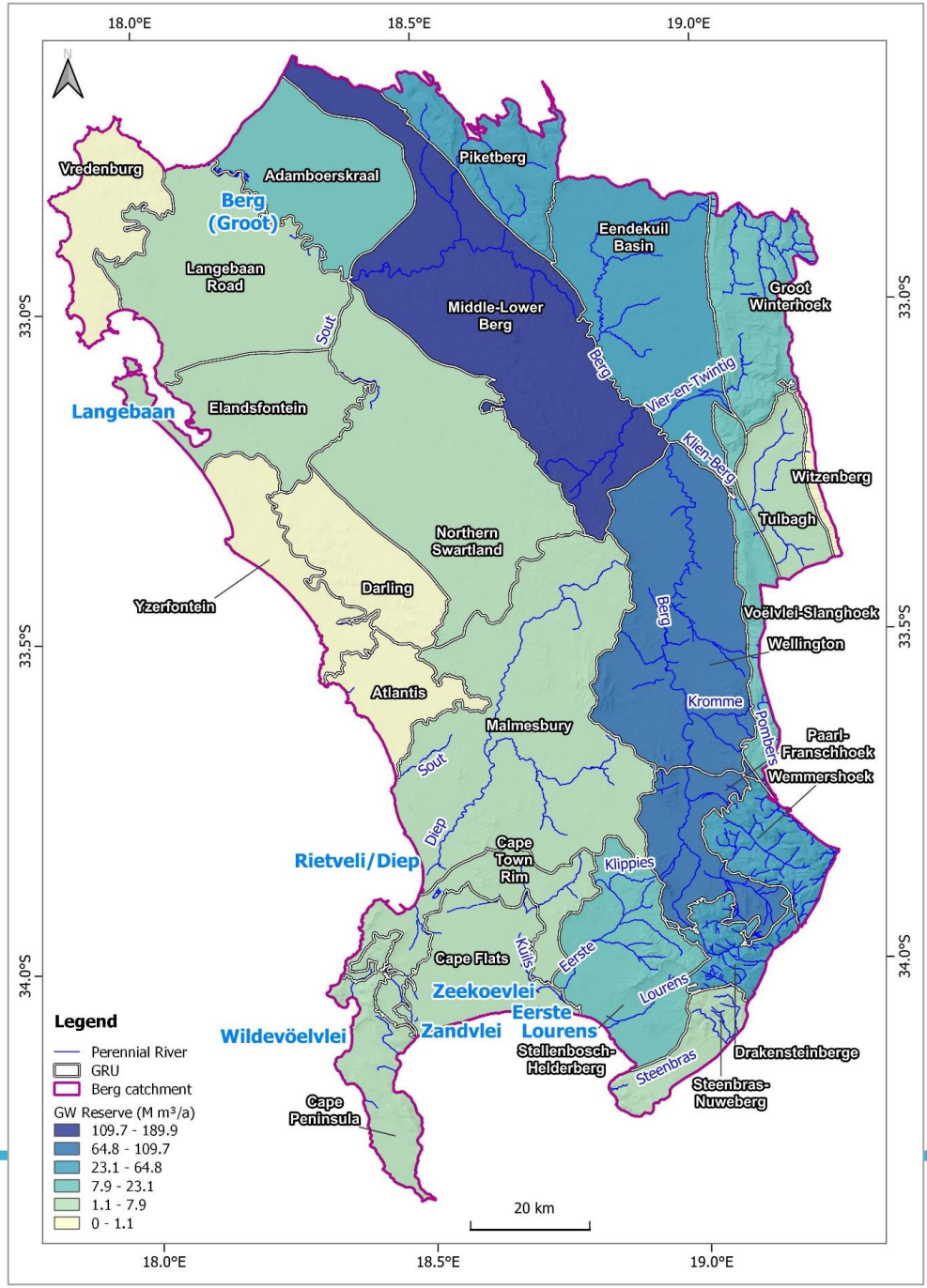
EWR RESERVE



GW RESERVE

GRU	EWR Reserve (M m3/a)	BHN Reserve (M m3/a)	GW Reserve (M m3/a)
Adamboerskraal	12.5	0.01	12.51
Atlantis	0.25	0.03	0.28
Cape Flats	2.29	0.7	2.99
Cape Peninsula	3.05	0.09	3.14
Cape Town Rim	4.23	0.2	4.43
Darling	0.4	0.02	0.42
Drakensteinberge	59.99	0	59.99
Eendekuil Basin	64.68	0.09	64.77
Elandsfontein	6.55	0.01	6.56
Groot Winterhoek	23.07	0.02	23.09
Langebaan Road	5.58	0.02	5.6
Malmesbury	7.11	0.34	7.45
Middle-Lower Berg	189.79	0.09	189.88
Northern Swartland	5.99	0.05	6.04
Paarl-Franschhoek	89.32	0.13	89.45
Piketberg	55.75	0.04	55.79
Steenbras-Nuweberg	3.55	0.02	3.57
Stellenbosch-Helderberg	17.54	0.24	17.78
Tulbagh	7.84	0.02	7.86
Voëlvlei-Slanghoek	18.81	0.01	18.82
Vredenburg	0	0.01	0.01
Wellington	109.48	0.24	109.72
Wemmershoek	48.34	0	48.34
Witzenberg	1.11	0	1.11
Yzerfontein	0.12	0.01	0.13
TOTAL	**737.31**	**2.35**	**739.73**



OPERATION SCENARIOS AND SOCIO-ECONOMIC AND ECOLOGICAL CONSEQUENCES

Scenario Analysis

Scenario Analysis

Scenario Analysis

Upcoming Programme

PROJECT PROGRESS STATUS

2022										2023											2024	
Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Step 1: Initiate the BHN and EWR requirement assessment																							
Step 2: Groundwater resource unit delineation report					X																		
Step 3: Ecological status & reference conditions per RU report							X																
Step 4: Determine BHN & EWR report											X												
Step 5: Operational scenarios & socio-economic and ecological consequences report														X									
Step 6: Evaluate scenarios with stakeholder's report																	X						
Step 7: Monitoring programme report																				X			
Step 8: Gazette & implement reserve - groundwater reserve determination report																							X
Database																							X
Gazette template																							X
General project management, capacity building and stakeholder engagement																							

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.** **Day 1 - Field trip to CFA and TMG – all DWS staff** **Day 2 - Introduction to Groundwater Modelling and Data Collation – in person training** **Day 3 - Conceptualization and Groundwater Model Set Up – in person training** **Day 4 - Model set up and Model Calibration – in person training** **Day 5 - Scenario Analysis and Results – in person training**	**23 – 27 January 2023**
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.	January 2024

CAPACITY BUILDING PROGRAMME

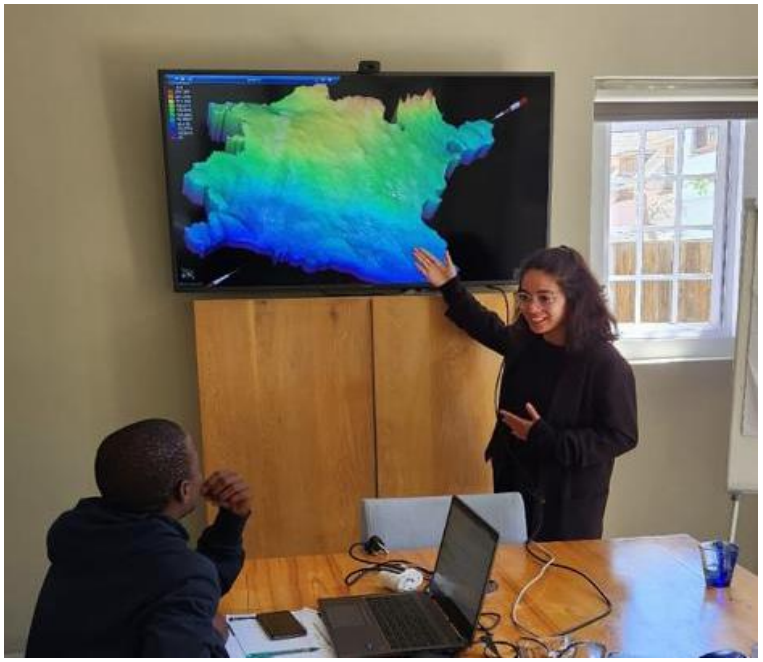
Field trip to CFA GRU

CAPACITY BUILDING PROGRAMME

Field trip to TMGA GRU

CAPACITY BUILDING PROGRAMME

Groundwater Modelling Workshop



Testimonial

★★★★★

"This training was very interesting, at first it was a bit challenging. But overall, it was very informative and I think I want to become a modeller because of this well organized course"

Philani Khoza
Department of Water and Sanitation

UMVOTO
EARTH | WATER | SCIENCE | LIFE

- Intro to modelling presentation
- Model conceptualization
- Model construction

- Calibration
- Predictive Scenarios
- Results Interpretation

PROGRAMME OF UPCOMING ACTIVITIES

March 2023

- **Management:**
    1. Project Stakeholder Committee (PSC) Meeting held on 16 March 2023
- **Tasks:**
    1. Task 3.5: Operational Scenarios
- **Deliverable:**
    1. Progress Report
    2. Deliverable 3.3 Updated BHN and EWR Report

April 2023

- **Tasks:**
    1. Task 3.5: Operational Scenarios
- **Deliverable:**
    1. Progress Report

May 2023

- **Management:**
    1. Project Management Committee (MPC) Meeting (date TBC)
- **Deliverable:**
    1. Deliverable 3.4 Operational Scenarios & Socio-economic and Ecological Consequences Report

THANK YOU