water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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CLASSIFICATION OF SIGNIFICANT WATER RESOURCES AND DETERMINATION OF RESOURCE QUALITY OBJECTIVES FOR WATER RESOURCES IN THE USUTU TO MHLATHUZE CATCHMENTS (WP11387)

RQO Workshop, Mbombela, 24 August 2023

GROUNDWATER RESOURCE QUALITY OBJECTIVES



Groundwater Resource Quality Objectives

Karim Sami

GW CONTRIBUTION TO THE RESERVE AND (RQOs)

GW component of the Reserve for each GRU is calculated by:

Reserve = (EWRgw + BHNgw), where:

- **BHNgw = basic human needs derived from groundwater**
- **EWRgw = groundwater contribution to EWR**

Groundwater contributions for the EWR include:

- **Baseflow to rivers and springs, including high lying springs fed by interflow.**
- **Seepage to wetlands and groundwater dependent ecosystems.**

The allocable groundwater is the difference between recharge and the groundwater component of the Reserve; and should not exceed 65% to ensure sustainability.

HOW DOES WATER USE AFFECT GW

- **Abstraction: Reduction of groundwater baseflow by interception of GW or by drawdown and gradient reversal near rivers.**

- **Alien Invasive Plants (AIPs): increased evaporation of shallow groundwater or reduce interflow from high lying areas.**

AIMS OF GW RQOS

1) Maintain the required groundwater contribution to the EWR
2) Protect groundwater resources for the direct and indirect users

- RQOs may stipulate:
  - the volume of abstraction that would cause an undesirable reduction in baseflow or undue stress on aquifer
  - specific distances from a river
  - flow at gauging stations and maximum baseflow reduction
  - GW levels with caution
  - water quality conditions (linked to potable use)
  - Why not Water levels? Because near rivers or in leaky aquifers abstraction may have large impact but water level remains stable

CRITERIA FOR SETTING RQOS

- **Abstraction: Harvest Potential, Allocable Groundwater, Stress Index, impact on baseflow**

- **Baseflow: Distance of abstraction from river, low flows at gauging stations (i.e <30% reduction from natural, duration curves)**

- **Water level: trends. Problematic: water levels vary by borehole location in terms of topography, pumping rates and aquifer hydraulic parameters. Hence, water level below surface is a site-specific variable which cannot be stipulated for an entire catchment**
- within 50 m of a river to ensure water levels do not drop more than 0.5 m", requires having a dense network of *regularly monitored* boreholes within 50 m of a river
- **Water quality: monitoring where poor quality is an issue**

DATA REQUIREMENTS

Stress Index

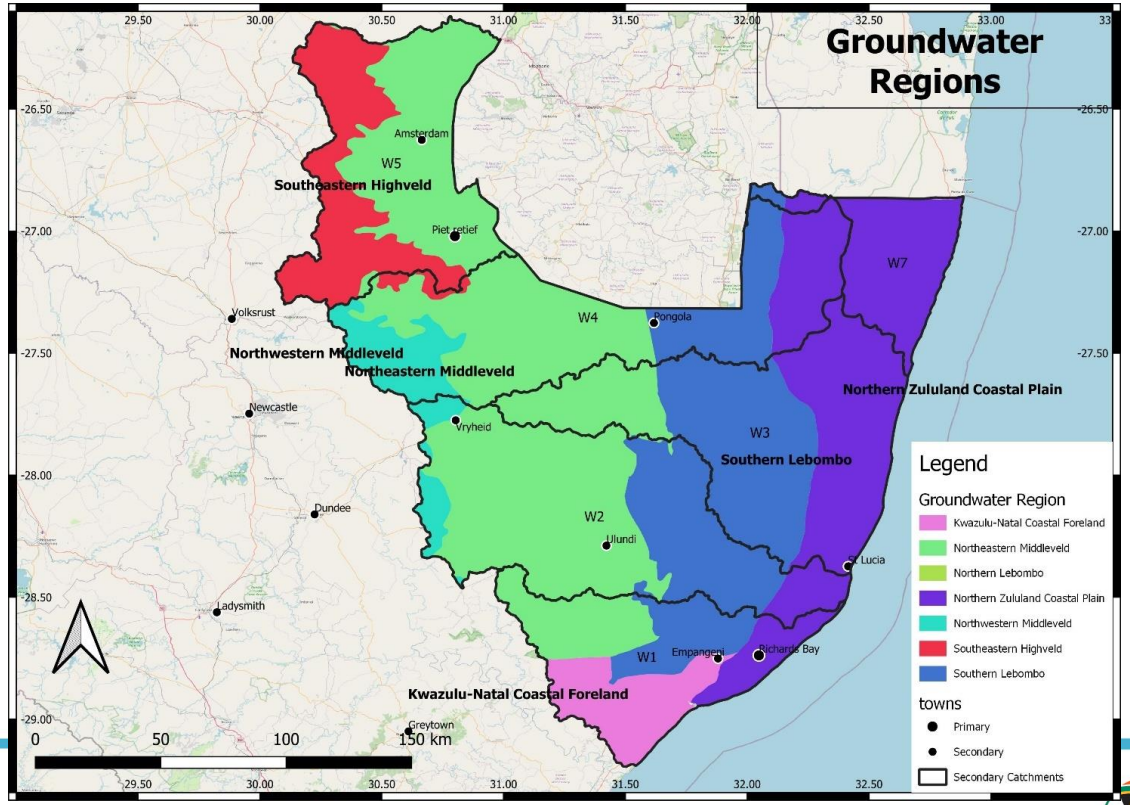
- **Lawful water use incl. Schedule 1 (StatsSA household survey), WARMS, V&V, All Towns etc**
- **Aquifer recharge (Not total Recharge)**

Baseflow

- **Monthly Baseflow**
- **Groundwater baseflow**
- **Groundwater use**
- **Baseflow reduction**

SETTING GRUS –GW REGIONS

Groundwater Region	Description
Northern Zululand Coastal Plain	Primary aquifers of the Maputoland
Southern Lebombo	Karoo SuperGroup, and Natal Group sandstone.
Northwestern Middleveld	Ecca Group to Drakensberg basalt.
Kwazulu-Natal Coastal Foreland	A structural province of NMP, Natal Group sandstone overlain by Dwyka tillite.
Southeastern Highveld	Karoo and Ecca shales, sandstones, mudstones, dolerite.
Northeastern Middleveld	Swazian volcanics and sedimentary, metamorphics, Swazian granites and gneisses, Randian gabbro, granite, quartzite, shale, Natal Group sandstone Dwyka tillite and Ecca shale.



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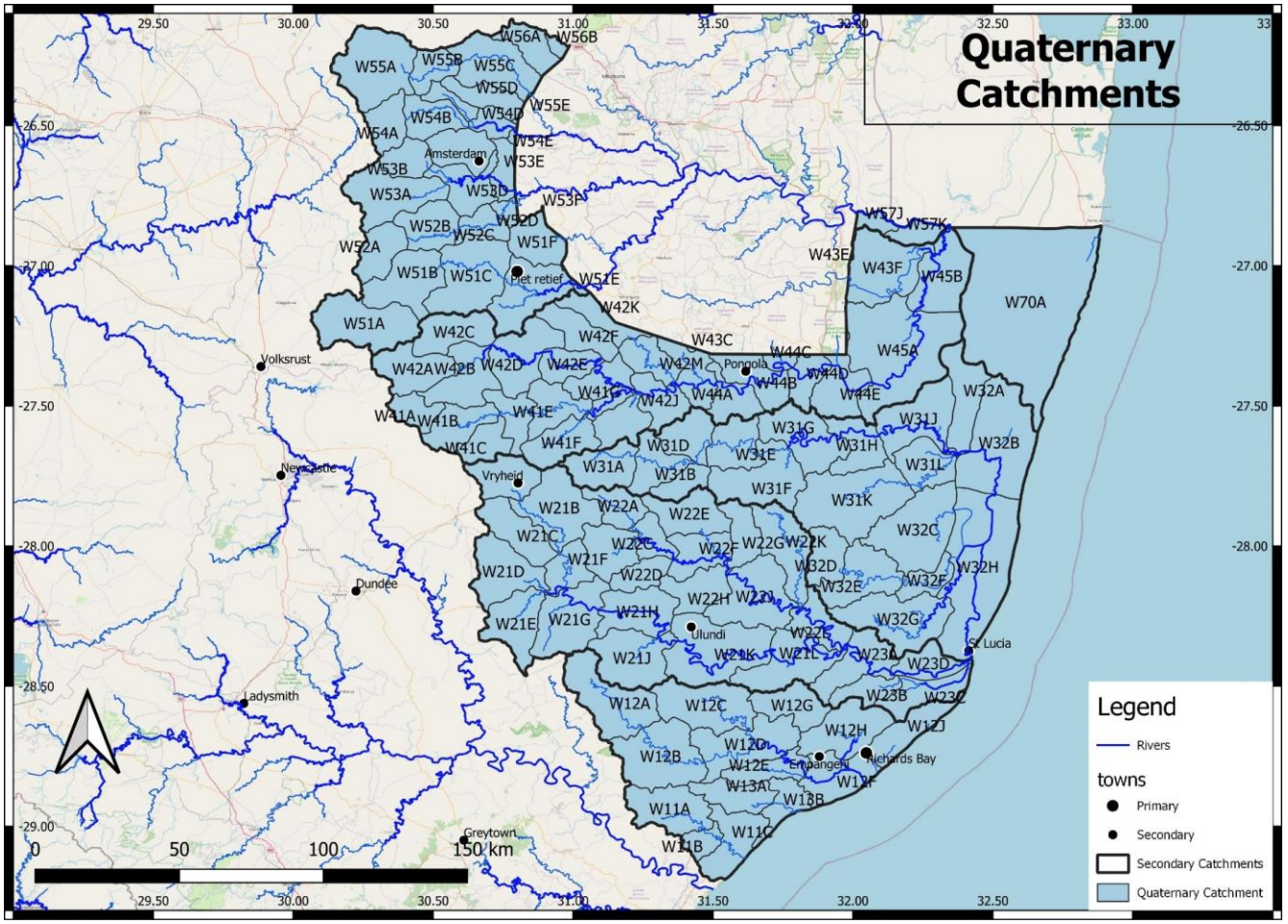
SETTING GRUS

- First step is quaternary catchments.

Grouping by :

- Geology.
- Climate.
- Topography and geomorphology.
- Borehole yield.
- Recharge.
- Groundwater quality.
- Groundwater use (and stress).
- Groundwater-surface water interactions.

SETTING GRUS –QUATERNARIES

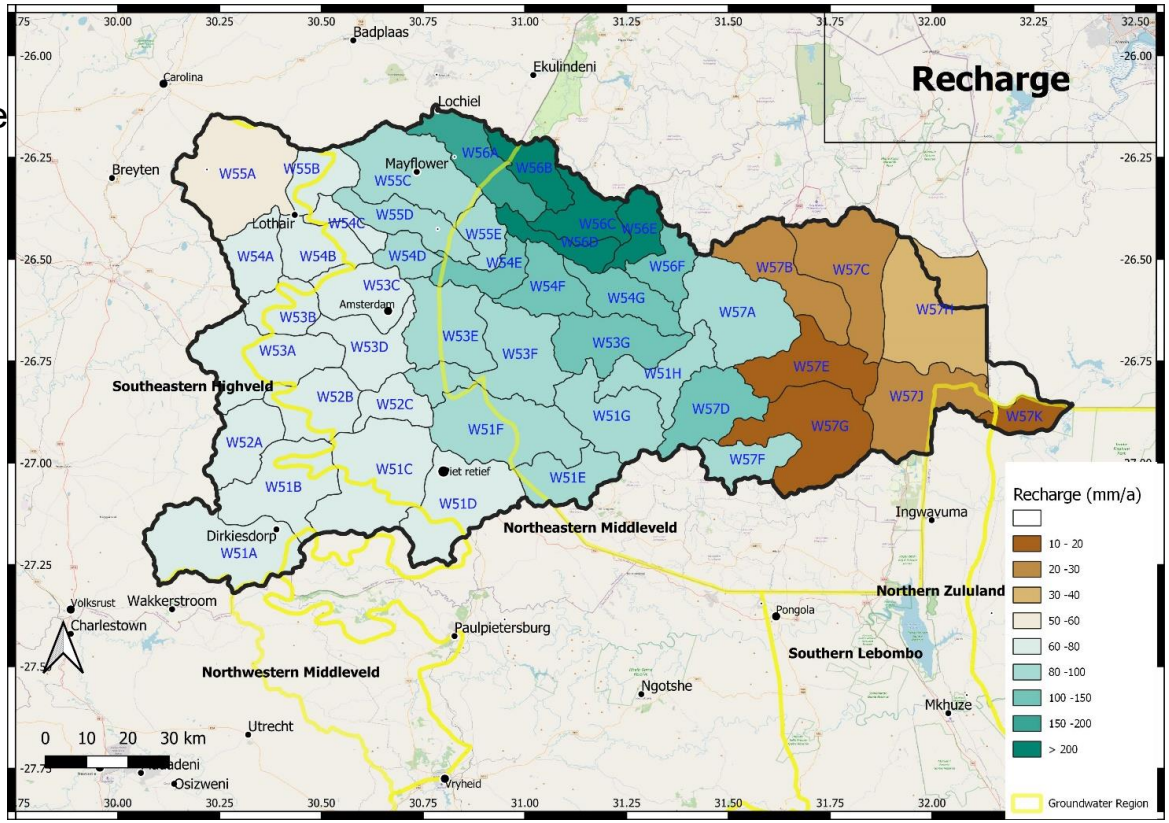


SETTING GRUS – RECHARGE

In catchments with high rainfall, significant relief and geological heterogeneities, a large part of recharge never enters the regional aquifer. Not all recharge is a groundwater resource

Recharge which does not flow through the regional aquifer is not available to borehole

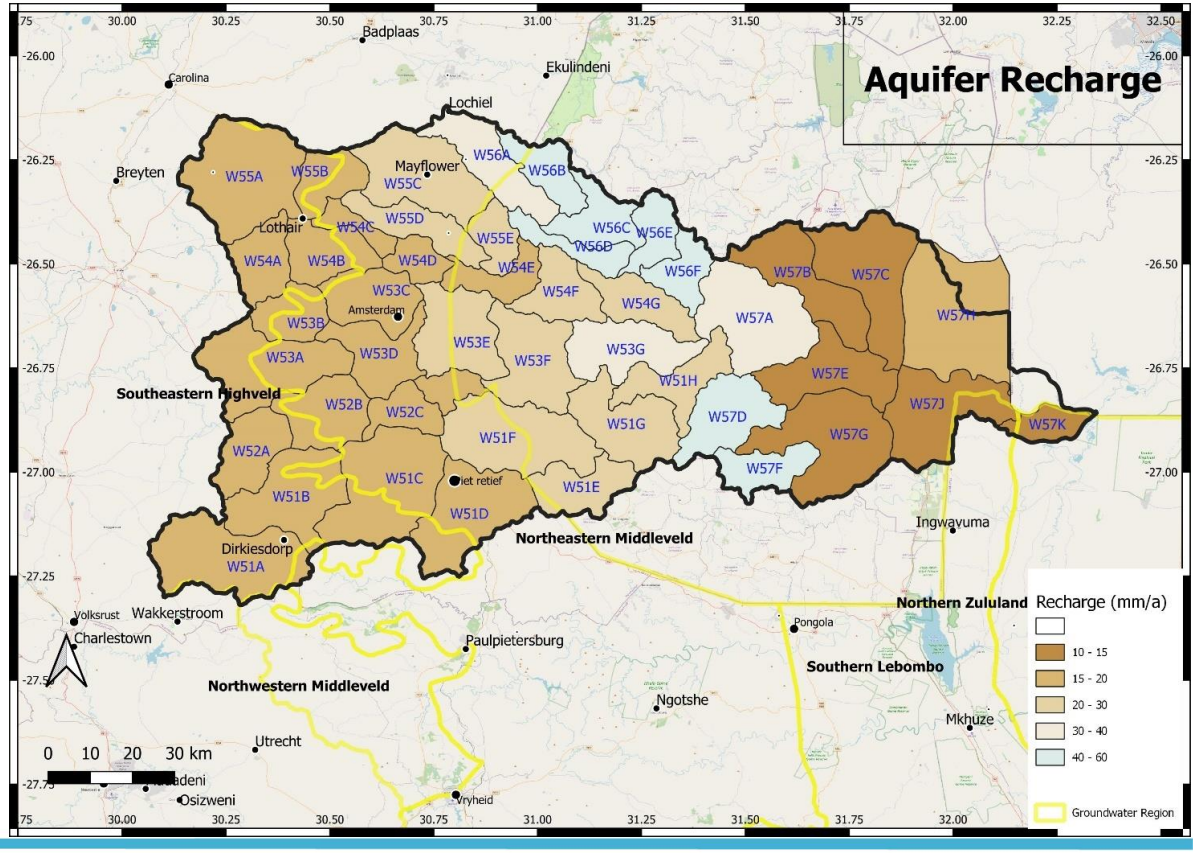
Some catchments with high recharge may have limited groundwater resources



SETTING GRUS – AQUIFER RECHARGE

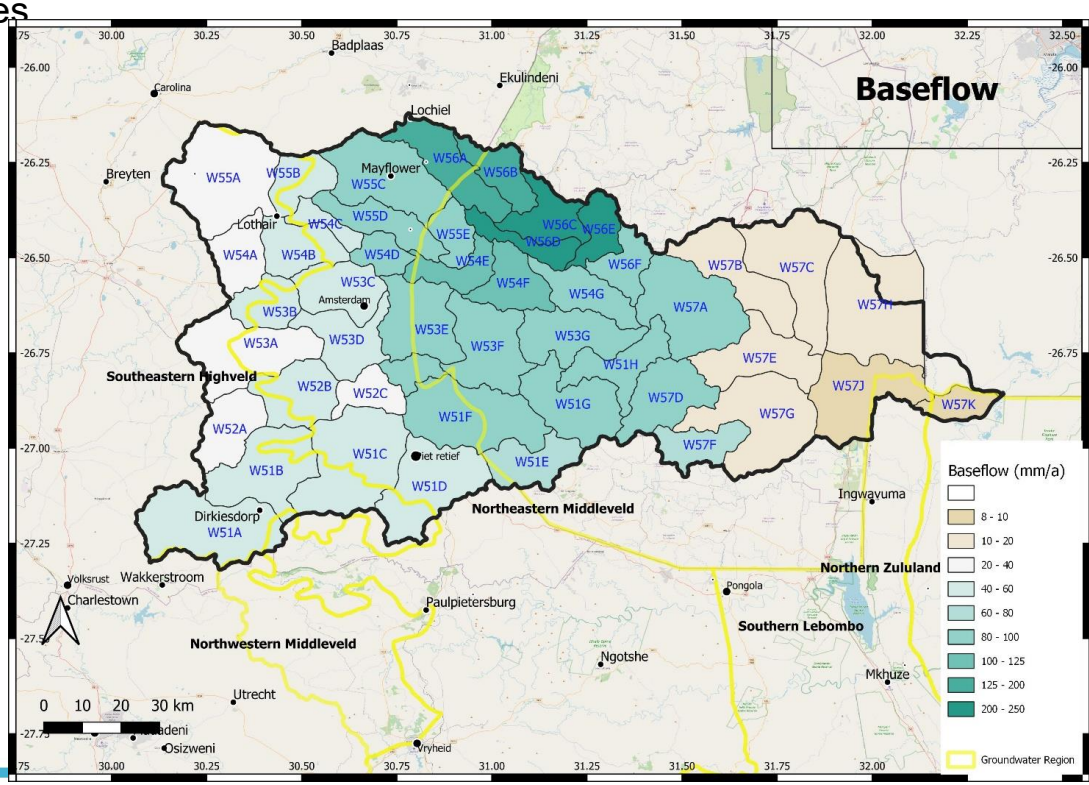
Aquifer recharge: recharge entering the regional aquifer (aquifer recharge) after losses to interflow. Some catchments with high recharge may have limited groundwater resources

Recharge entering the subsurface zone.



SETTING GRUS – BASEFLOW

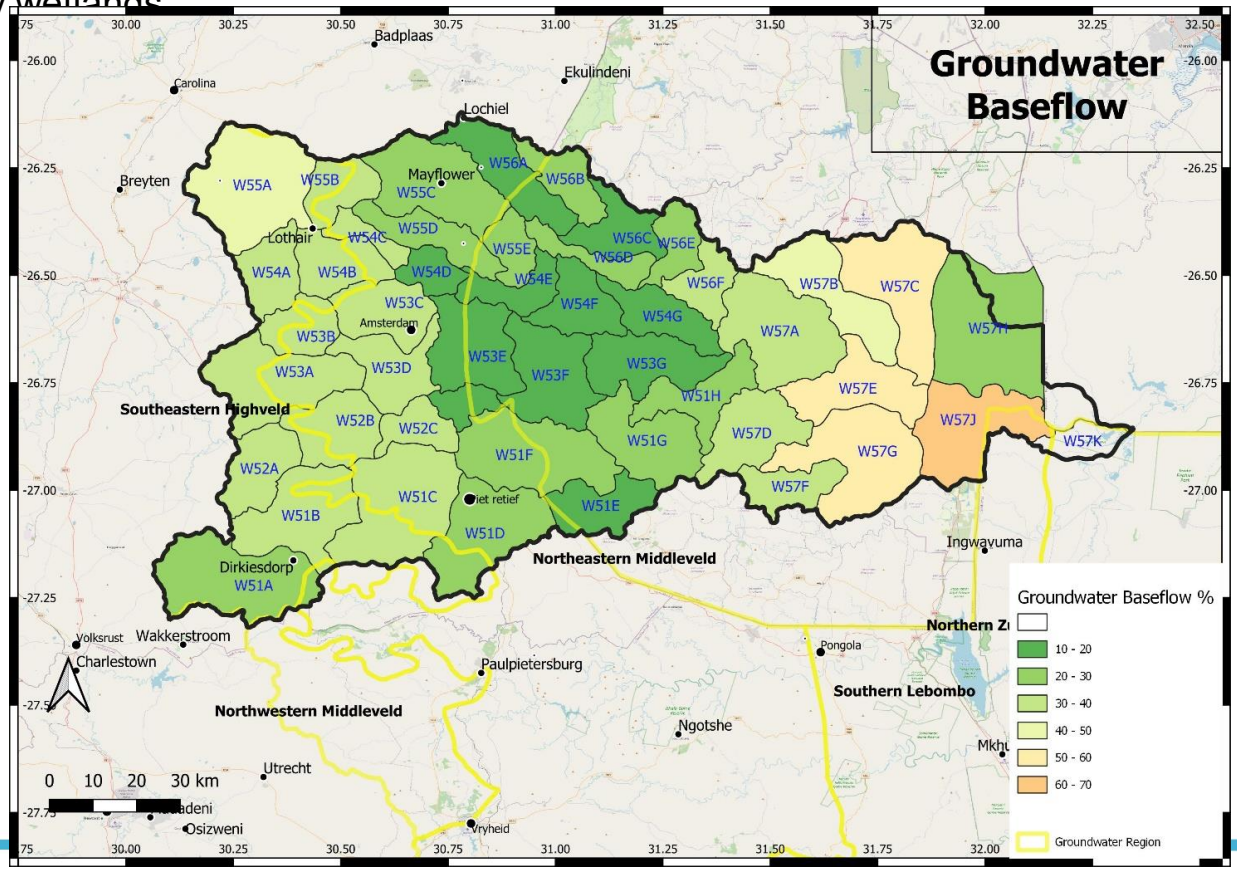
Baseflow: Streamflow originating from subsurface pathways. No differentiation.
not all these pathways incur passage through the regional aquifer.
Subsurface water which does not flow through the regional aquifer (interflow) is not available to boreholes and cannot be impacted by boreholes



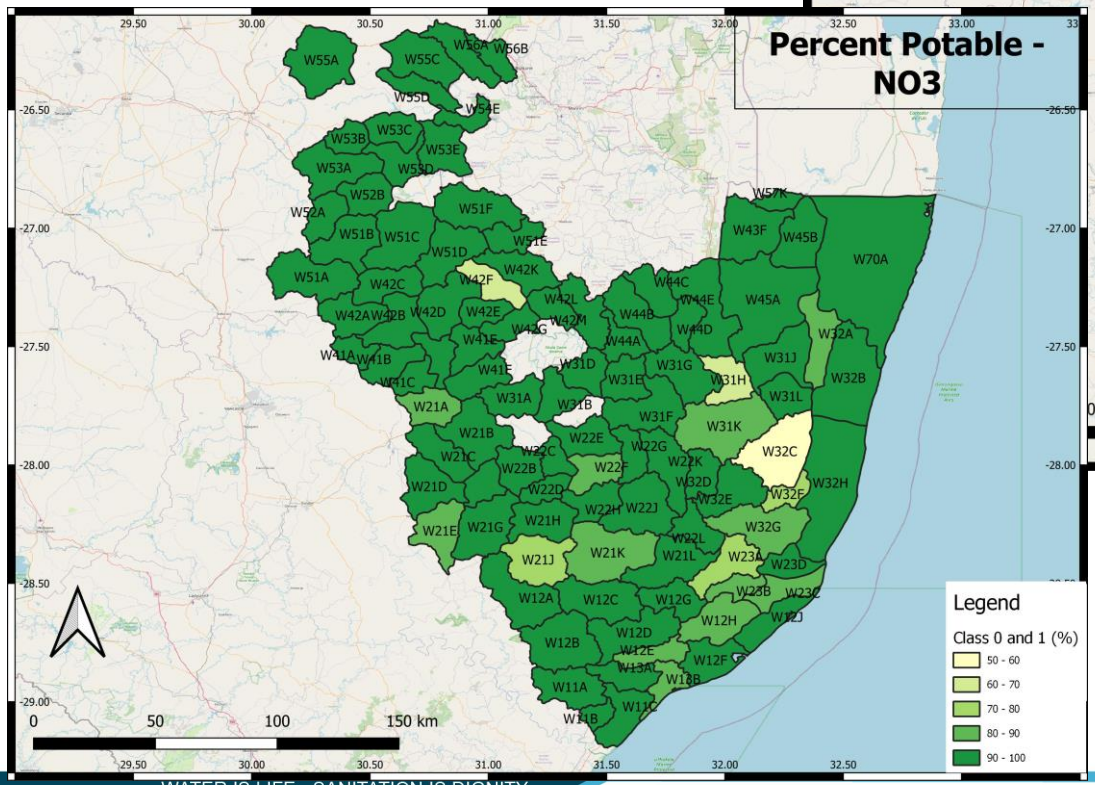
SETTING GRUS – INTERACTION TYPE

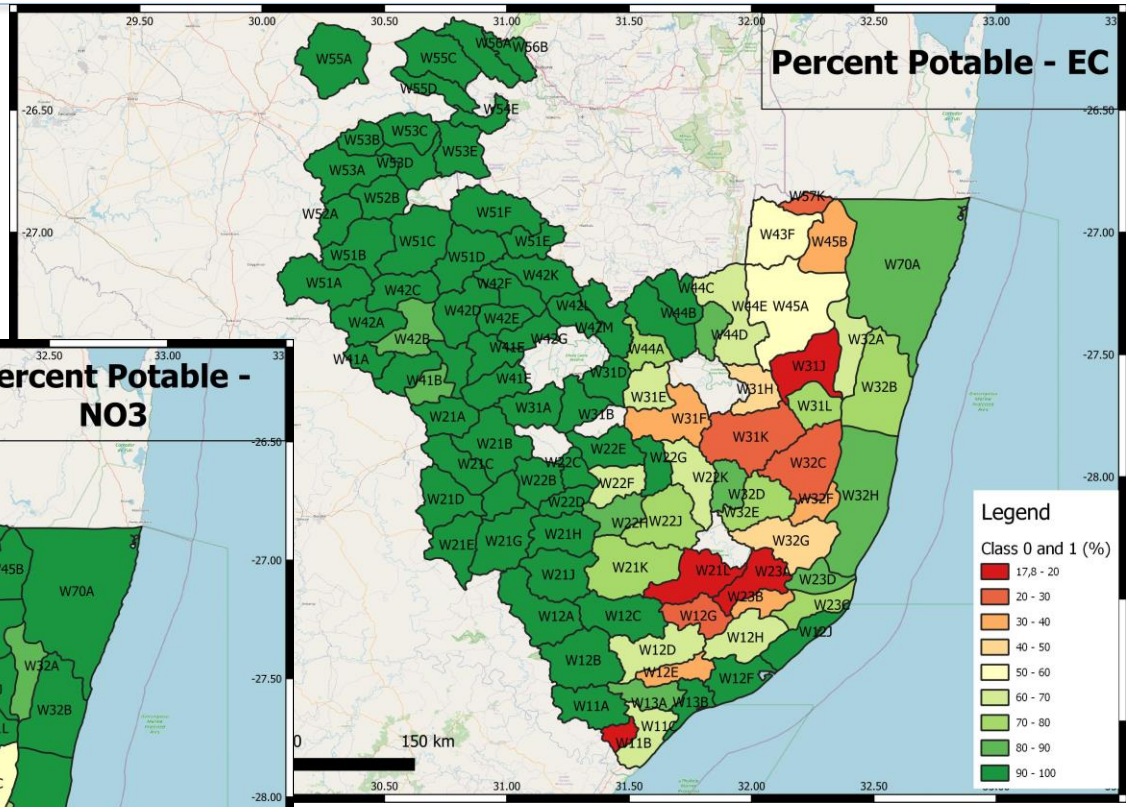
Groundwater baseflow

- Discharge from the regional aquifer to surface water as baseflow to river channels, either to perennial effluent or intermittent streams.
- seepage to permanent or temporary wetlands
- Seepage to reservoirs and lakes

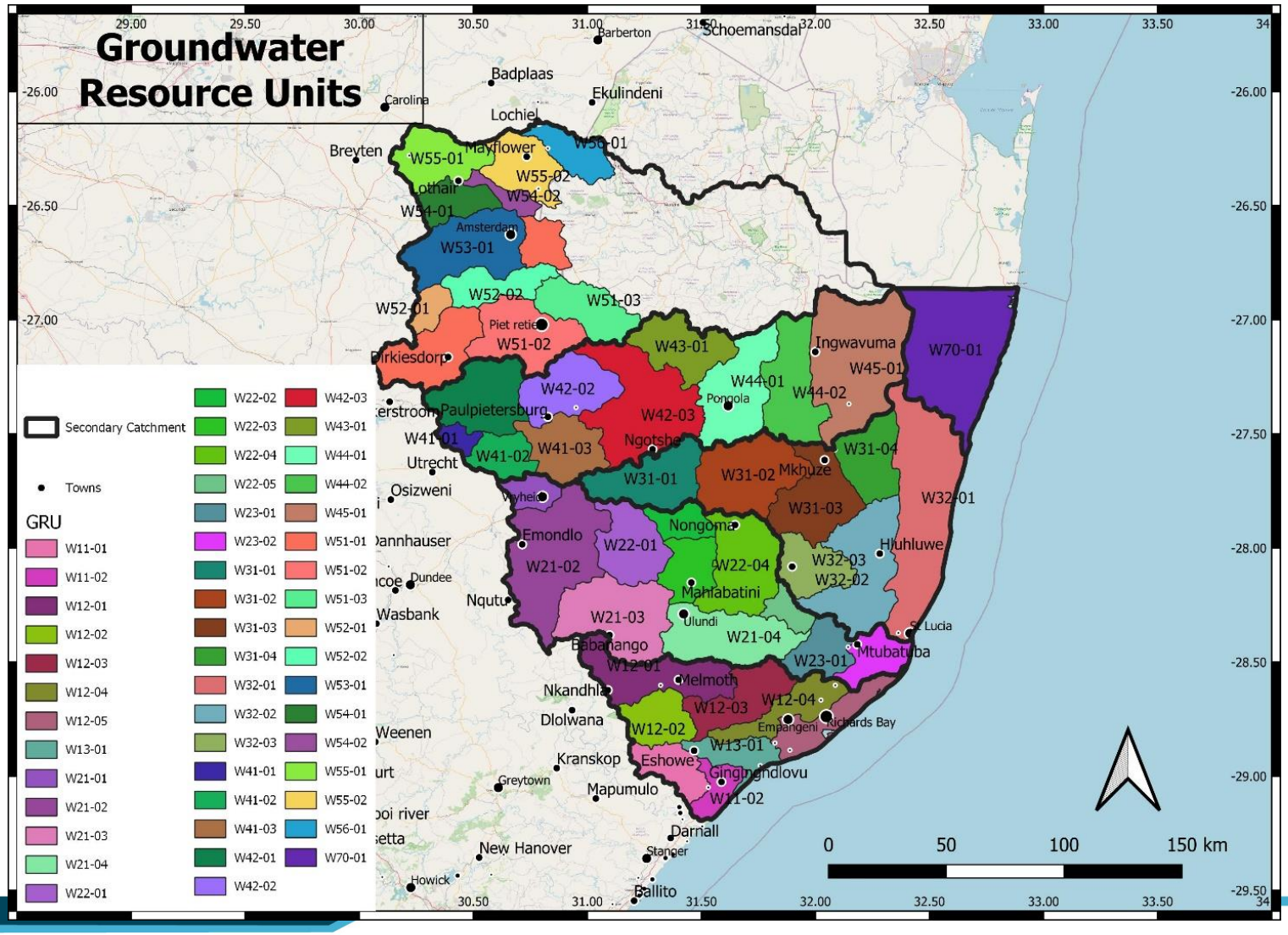


SETTING GRUS- WATER QUALITY

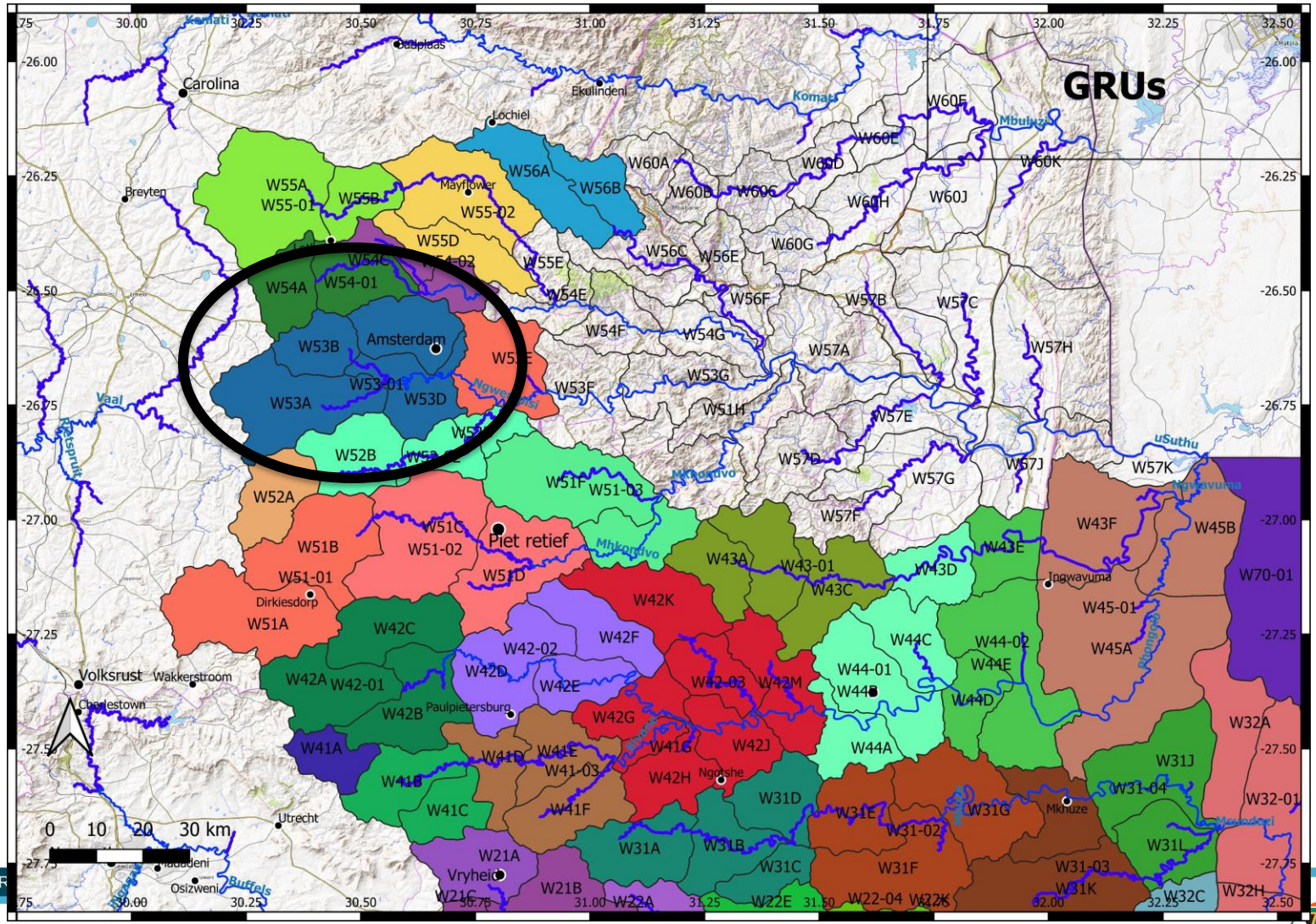




SETTING GRUS – DELINEATION



SETTING GRUS – DELINEATION



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STRESS INDEX - USE

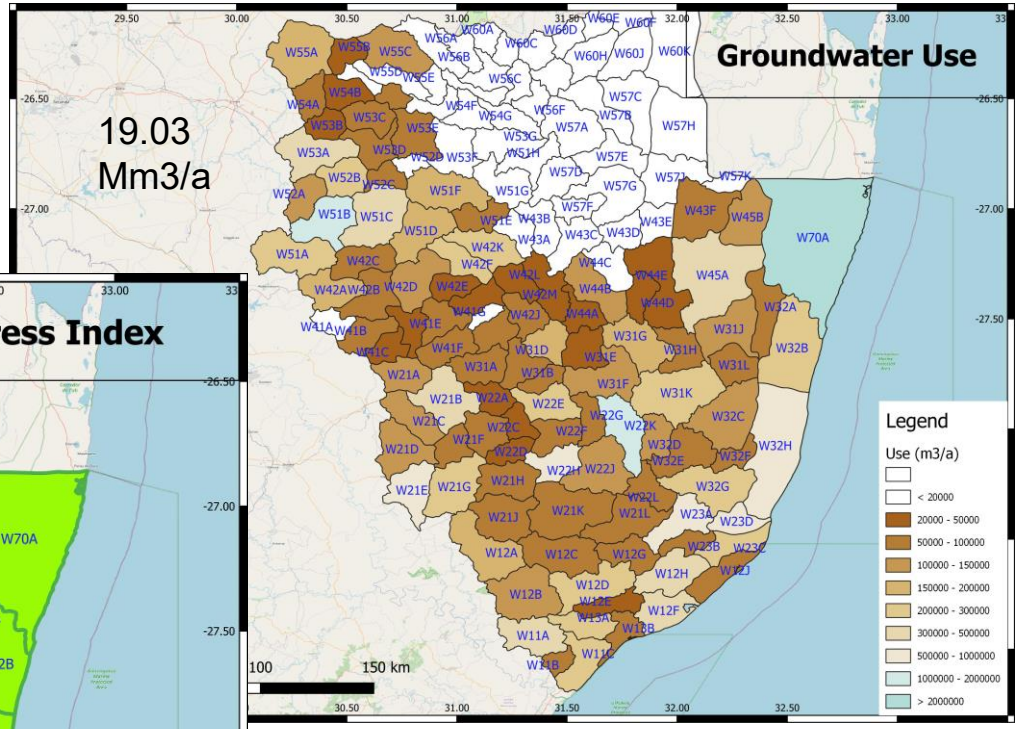
Quat	Irrigation (Mm3)	Industrial (Mm3)	Mining (Mm3)	Water Supply (Mm3)	Livestock (Mm3)	Schedule 1 (Mm3)	Total
W51A					0.0720	0.1523	0.2243
W51B	0.0000	0.0000	0.8534	0.0668	0.0735	0.1205	1.1142
W51C	0.2470	0.0000	0.0317	0.0000	0.1148	0.0762	0.4697
W51D	0.0300	0.0004	0.0000	0.0000	0.0893	0.0438	0.1635
W51E	0.0774	0.0000	0.0000	0.0000	0.0032	0.0037	0.0842
W51F	0.0014	0.0756	0.0000	0.0065	0.0518	0.0330	0.1683
W52A	0.0000	0.0249	0.0016	0.0000	0.0433	0.0539	0.1237
W52B	0.0000	0.1242	0.0000	0.0055	0.0570	0.0210	0.2076
W52C	0.0240	0.0000	0.0000	0.0000	0.0301	0.0116	0.0657
W52D					0.0122	0.0026	0.0148
W53A	0.3212	0.0380	0.0000	0.0000	0.0613	0.0310	0.4515
W53B	0.0000	0.0000	0.0000	0.0000	0.0199	0.0000	0.0199
W53C	0.0000	0.0265	0.0000	0.0000	0.0516	0.0105	0.0886
W53D	0.0000	0.0017	0.0000	0.0000	0.0493	0.0049	0.0559
W53E	0.0000	0.0000	0.0000	0.0000	0.0300	0.0168	0.0468
W53F					0.0002	0.0000	0.0002

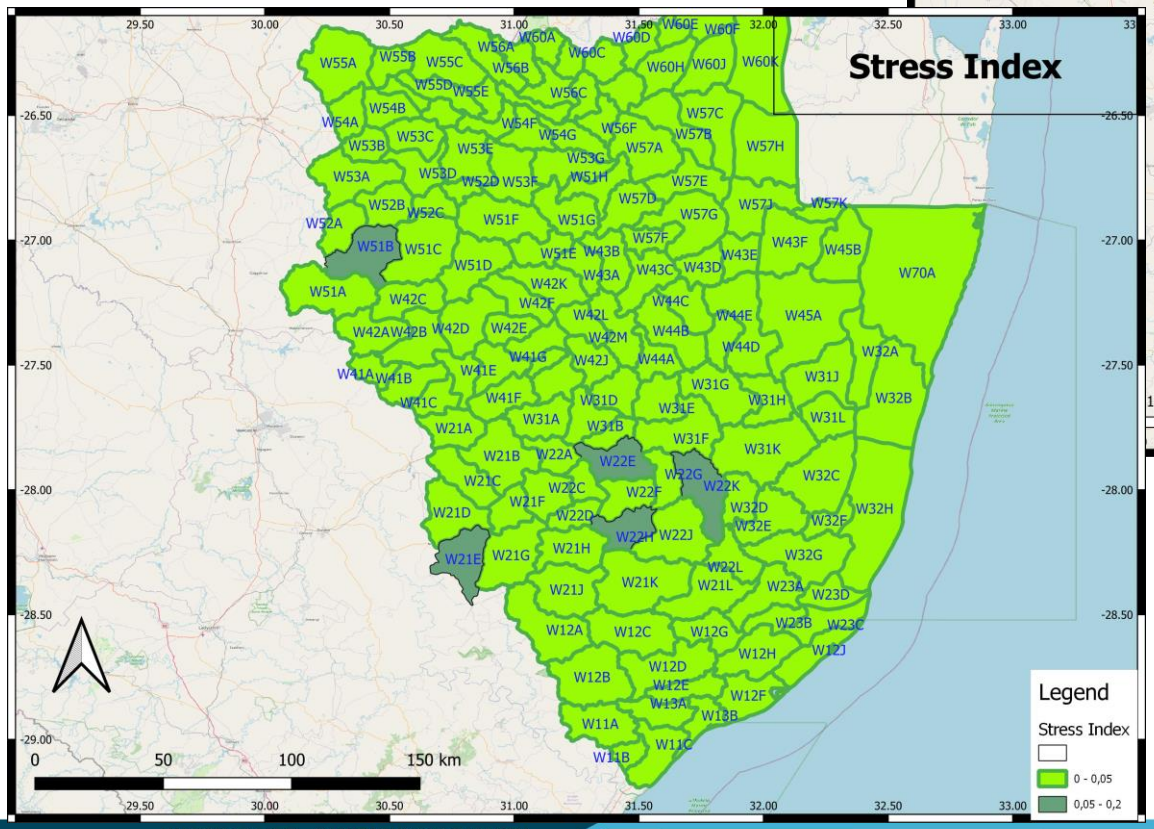
STRESS INDEX - RESOURCE

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exp. Pot (Mm^3/a)	GRAII Exp. Pot. (Mm^3/a)	Harvest Pot. (Mm^3/a)	Use (Mm^3/a)
W51A	624.64	41.11	10.39	6.81	15.25	13.53	0.2243
W51B	496.45	31.29	8.50	6.91	12.11	10.63	1.1142
W51C	677.71	47.70	12.53	9.38	18.11	22.89	0.4697
W51D	527.43	36.12	8.89	6.67	13.86	8.31	0.1635
W51E	274.28	21.47	6.11	1.66	0.67	3.07	0.0842
W51F	589.36	49.10	12.65	2.64	9.59	18.23	0.1683
W52A	289.44	17.79	5.03	3.80	5.81	6.03	0.1237
W52B	336.19	20.60	6.27	4.16	7.20	12.53	0.2076
W52C	177.84	10.71	3.35	2.33	3.86	6.71	0.0657
W52D	119.29	9.37	2.38	0.59	2.32	1.34	0.0148
W53A	547.48	34.42	10.25	7.87	11.47	17.25	0.4515
W53B	218.54	15.48	4.09	3.51	5.26	5.67	0.0199
W53C	315.62	24.97	5.82	5.09	8.91	7.55	0.0886
W53D	314.71	21.45	5.86	4.54	7.83	6.38	0.0559
W53E	421.87	36.96	8.96	2.39	5.53	9.29	0.0468
W53F	447.34	39.19	10.48	2.76	0.03	11.18	0.0002

USE

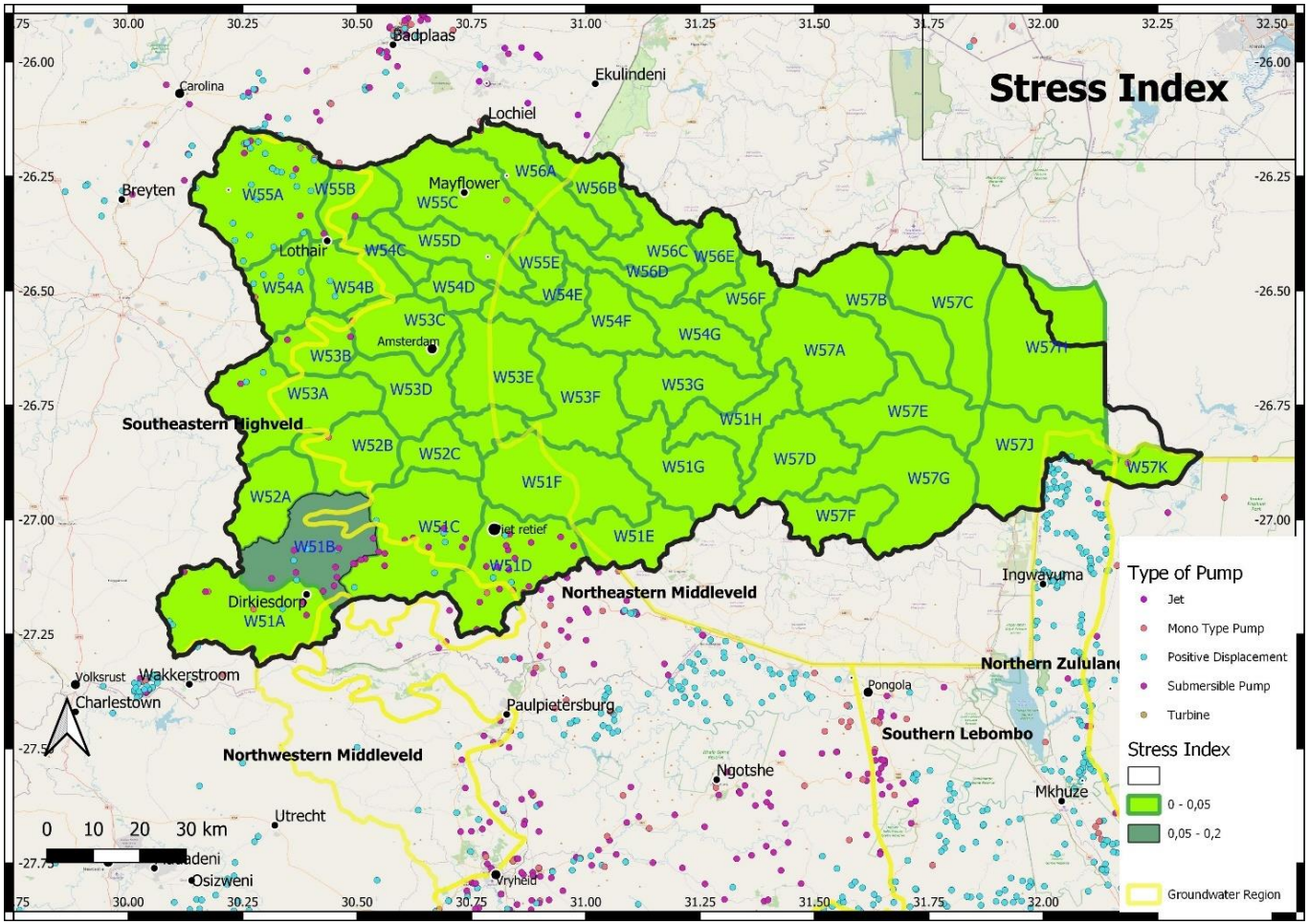
SI = Use/aquifer recharge





Based on WARMS + Schedule 1 Use + Livestock use)

STRESS INDEX



SETTING RQOs – NARRATIVE

- **Hydrogeology: Blah Blah to justify GRU, describe landscape, GW Region, type of baseflow, yield, aquifer type, Quats included, land use, stress index**

- **W53-01: Northestern Middelveld, 1150-1600 mamsl, fractured and weathered aquifers, W53A-D, >60% > 0.1 l/s, 30-40% exceed 2 l/s, MAP 700-1000 mm/a, MAE 1300-1400 mm/a, No Strategic water source area, Vryheid Formation, Granitoids, Dwyka tillite, Amsterdam Fm volcanics, unimproved grassland, SI <0.05**

Quat	Average (l/s)	Median (l/s)	% > 0.5 l/s	% > 2 l/s	% > 5 l/s
W51A	1.45	0.57	64.6	21.8	0
W51B	0.62	0.48	47	0	0
W51C	1.27	0.75	62.3	13.8	3.3
W51D	1.40	0.96	77.4	15.4	3.8
W51E	0.40	0.40	0	0	0
W51F	1.45	0.72	62.9	21.8	4.7
W52A	1.67	1.67	0	0	0
W52B	0.77	0.84	61.2	0	0
W52C	1.39	1.20	77.2	34.8	0
W53A	1.43	1.00	76.1	19.9	1.6
W53B	1.11	0.62	76.5	15	0
W53C	1.64	0.95	77.3	25.4	4.1
W53D	1.54	1.16	93	29.7	0
W53E	1.01	1.10	79.9	0	0

SETTING RQOs – RESOURCES AND USE

- **Groundwater Use and Resources: Recharge, Aquifer Recharge., HP, Use and SI by Quat**

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exp. Pot (Mm^3/a)	GRAII Exp. Pot. (Mm^3/a)	Harvest Pot. (Mm^3/a)	Use (Mm^3/a)
W51A	624.64	41.11	10.39	6.81	15.25	13.53	0.2243
W51B	496.45	31.29	8.50	6.91	12.11	10.63	1.1142
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W51F	589.36	49.10	12.65	2.64	9.59	18.23	0.1683
W52A	289.44	17.79	5.03	3.80	5.81	6.03	0.1237
W52B	336.19	20.60	6.27	4.16	7.20	12.53	0.2076
W52C	177.84	10.71	3.35	2.33	3.86	6.71	0.0657
W52D	119.29	9.37	2.38	0.59	2.32	1.34	0.0148
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W53E	421.87	36.96	8.96	2.39	5.53	9.29	0.0468
W53F	447.34	39.19	10.48	2.76	0.03	11.18	0.0002

SETTING RQOs – QUALITY

- **Groundwater Quality Distribution: description and problems**

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W51A	22.86	25.62	28.38	31.14	33.9	1
W51B	38.6	48.2	56.54	63.62	70.7	1
W51C	14.3	14.6	17.2	24.1	30.3	1
W51D	10.54	14.78	17.6	22.76	27.6	1
W51E	10.6	10.6	10.6	10.6	10.6	1
W51F	14.96	18.52	21.14	22.82	24.5	1
W52A	9.68	13.26	16.84	20.42	24	1
W52B	9.96	13.28	15.32	16.36	16.9	1
W53A	9.1	15.3	16.7	17.3	18.7	1
W53B	9.92	10.04	10.16	10.28	10.4	1

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W51A	2	0	0	0	0	I
W51B	2	1	0	0	0	I
W51C	6	0	0	0	0	I
W51D	7	0	0	0	0	I
W51E	1	0	0	0	0	I
W51F	3	0	0	0	0	I
W52A	2	0	0	0	0	I
W52B	4	0	0	0	0	I
W53A	6	0	0	0	0	I
W53B	2	0	0	0	0	I
W53C	6	0	1	0	0	II
W53D	1	0	0	0	0	I
W53E	1	0	0	0	0	I

SETTING RQOs – GW CONTRIBUTION TO BASEFLOW

- **Baseflow: type, description impact of abstraction, present day baseflow and % baseflow reduction**

Quaternary	Aquifer Recharge	Baseflow	Groundwater baseflow	GWEWR	GW % of Baseflow
W51A	10.39	32.14	8.27	4.09	25.72
W51B	8.50	20.92	6.59	3.24	31.50
W51C	12.53	33.05	9.99	6.36	30.24
W51D	8.89	25.65	7.00	4.44	27.30
W51E	6.11	21.47	4.20	1.56	19.56
W51F	12.65	49.24	10.16	3.96	20.64
W52A	5.03	11.32	3.85	2.16	33.98
W52B	6.27	14.17	4.92	2.80	34.75
W52C	3.35	7.04	2.59	1.45	36.83
W52D	2.38	9.55	1.80	0.52	18.87
W53A	10.25	20.70	7.95	3.84	38.40
W53B	4.09	9.11	3.20	1.35	35.10
W53C	5.82	15.47	4.66	2.25	30.09
W53D	5.86	13.51	4.61	2.17	34.16
W53E	8.96	37.03	7.20	2.87	19.44
W53F	10.48	39.12	7.64	3.11	19.51

SETTING RQOs – CLASSIFICATION AND ALLOCABLE GROUNDWATER

Allocable; description of current state, the Reserve and allocable groundwater as a basis for RQO

Quaternary	Aquifer Recharge	GWEWR	BHN	Use	Stress Index	PSC	Class	Reserve	Allocable
W51A	10.387	4.086	0.040	0.224	0.022	A	I	4.126	2.401
W51B	8.504	3.236	0.046	1.114	0.131	B	I	3.282	1.132
W51C	12.529	6.358	0.076	0.470	0.037	A	I	6.434	1.241
W51D	8.892	4.444	0.059	0.164	0.018	A	I	4.503	1.113
W51E	6.108	1.564	0.002	0.084	0.014	A	I	1.566	2.320
W51F	12.649	3.961	0.034	0.168	0.013	A	I	3.995	4.059
W52A	5.025	2.155	0.027	0.124	0.025	A	I	2.182	0.960
W52B	6.268	2.798	0.038	0.208	0.033	A	I	2.836	1.030
W52C	3.347	1.453	0.020	0.066	0.020	A	I	1.473	0.637
W52D	2.375	0.521	0.008	0.015	0.006	A	I	0.529	1.000
W53A	10.249	3.841	0.044	0.452	0.044	A	I	3.885	2.326
W53B	4.091	1.346	0.015	0.020	0.005	A	I	1.361	1.278
W53C	5.821	2.254	0.035	0.089	0.015	A	I	2.289	1.406
W53D	5.865	2.165	0.033	0.056	0.010	A	I	2.198	1.558
W53E	8.964	2.874	0.020	0.047	0.005	A	I	2.894	2.885
W53F	10.477	3.109	0.000	0.000	0.000	A	I	3.109	3.700

SETTING RQOs – IDENTIFY CRITICAL CONDITIONS

Justify which RQOs are set

GRU	Quat	Catchment	Baseflow	Quality	Groundwater level	Abstraction
W53-01	W53A-D	Ngwempisi	x	x		x

SETTING RQOs – NARRATIVE and NUMERICAL RQO

Quaternaries	Groundwater narrative RQO				Groundwater numerical RQO
	Abstraction	Baseflow	Water Level	Water Quality	
W53A-D	All users to comply with existing allocation schedules, including GA* and Schedule 1, and individual licence conditions within Allocable groundwater.	Due to the low groundwater use, monitoring not required.	Due to the low groundwater use and low aquifer contribution to baseflow, monitoring not required.	Some boreholes have elevated nitrate and fluoride levels, so nitrate and fluoride need to be tested for domestic boreholes.	The remaining Allocable groundwater is 6.6 Mm^3/a. Note allocable = 65% of aquifer recharge – Reserve AND current use.