water and sanitation

Department:
Water and Sanitation
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Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments

GROUNDWATER COMPONENT OF THE RESERVE REPORT

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Department of Water and Sanitation

Chief Directorate: Water Ecosystems Management

PROJECT NUMBER**:** WP 11387

Groundwater Report

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

SEPTEMBER 2022

REFERENCE

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REPORT SCHEDULE

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1	WEM/WMA3/4/00/CON/CLA/0122	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Inception Report including Gap Analysis chapter**
2	WEM/WMA3/4/00/CON/CLA/0222	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Status Quo and Delineation of Integrated Units of Analysis and Resource Unit Report**
3	WEM/WMA3/4/00/CON/CLA/0322	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Units Delineation and Prioritisation Report**
4	WEM/WMA3/4/00/CON/CLA/0422	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Hydrology Systems Analysis Report**
5	WEM/WMA3/4/00/CON/CLA/0522	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **River EWR estimates for Desktop Biophysical Nodes Report**
6	WEM/WMA3/4/00/CON/CLA/0622	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **River Survey Report**
7	WEM/WMA3/4/00/CON/CLA/0722	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Basic Human Needs Report**
8	WEM/WMA3/4/00/CON/CLA/0822	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Groundwater Report**
9	WEM/WMA3/4/00/CON/CLA/0922	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **River specialist meeting Report**
10	WEM/WMA3/4/00/CON/CLA/1022	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Estuary Survey Report**
11	WEM/WMA3/4/00/CON/CLA/1122	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Wetland Report**
12	WEM/WMA3/4/00/CON/CLA/1222	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Water Requirements Report**
13	WEM/WMA3/4/00/CON/CLA/1322	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Scenario Description Report**
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	volume 1	Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Consequences Report, Volume 1: Rivers**
	WEM/WMA3/4/00/CON/CLA/0123, volume 2	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecological Consequences Report, Volume 2: Estuaries**
15	WEM/WMA3/4/00/CON/CLA/0323	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Ecosystem Services Consequences Report**
16	WEM/WMA3/4/00/CON/CLA/0423	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Economic & User water quality Consequences Report**
17	WEM/WMA3/4/00/CON/CLA/0523	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Water Resource Classes Report**
18	WEM/WMA3/4/00/CON/CLA/0623, volume 1	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Quality Objectives Report, Volume 1: Rivers**
	WEM/WMA3/4/00/CON/CLA/0623, volume 2	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Quality Objectives Report, Volume 2: Estuaries**
	WEM/WMA3/4/00/CON/CLA/0623, volume 3	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Resource Quality Objectives Report, Volume 3: Wetlands and Groundwater**
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20	WEM/WMA3/4/00/CON/CLA/0124	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Main Report**
21	WEM/WMA3/4/00/CON/CLA/0224	Classification of Significant Water Resources and Determination of Resource Quality Objectives for Water Resources in the Usutu to Mhlathuze Catchments: **Issues and Responses Report**
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APPROVAL

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Maps were prepared by Paul de Sousa of WRP *Consulting Engineers*

EXECUTIVE SUMMARY

BACKGROUND

Chapter 3 of the National Water Act, 1998 (NWA) (Act 36 of 1998), deals with the protection of water resources. Section 12 of the NWA requires the Minister to develop a system to classify water resources. In response to this, the Water Resource Classification System (WRCS) was gazetted on 17 September 2010 and published in the Government Gazette no. 33541 as Regulation 810. The WRCS is a step-wise process, whereby water resources are categorised according to specific classes that represent a management vision of a particular catchment. This vision takes into account, the current state of the water resource, the ecological, social, and economic aspects that are dependent on the resource. Once significant water resources have been classified through the WRCS, Resource Quality Objectives (RQOs) have to be determined to give effect to the class.

The Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS), initiated a study to determine the Water Resource Classes and RQOs for all significant water resources in the Usutu to Mhlathuze Catchment. The Usutu to Mhlathuze Catchments are amongst many water-stressed catchments in South Africa. These catchment areas are important for conservation, and contain a number of protected areas such as natural heritage sites, cultural and historic sites, as well as other conservation areas that need protection.

STUDY AREA

The study area is the Usutu to Mhlathuze Catchment, which has been divided into six drainage areas, as well as secondary catchment areas:

- W1 catchment (main river: Mhlathuze).
- W2 catchment (main river: Umfolozi).
- W3 catchment (main river: Mkuze).
- W4 catchment (main river: Pongola) - part of this catchment area falls within Eswatini.
- W5 catchment (main river: Usutu) - much of this catchment falls within Eswatini.
- W7 catchment (Kosi Bay and Lake Sibaya).

PURPOSE OF THIS REPORT

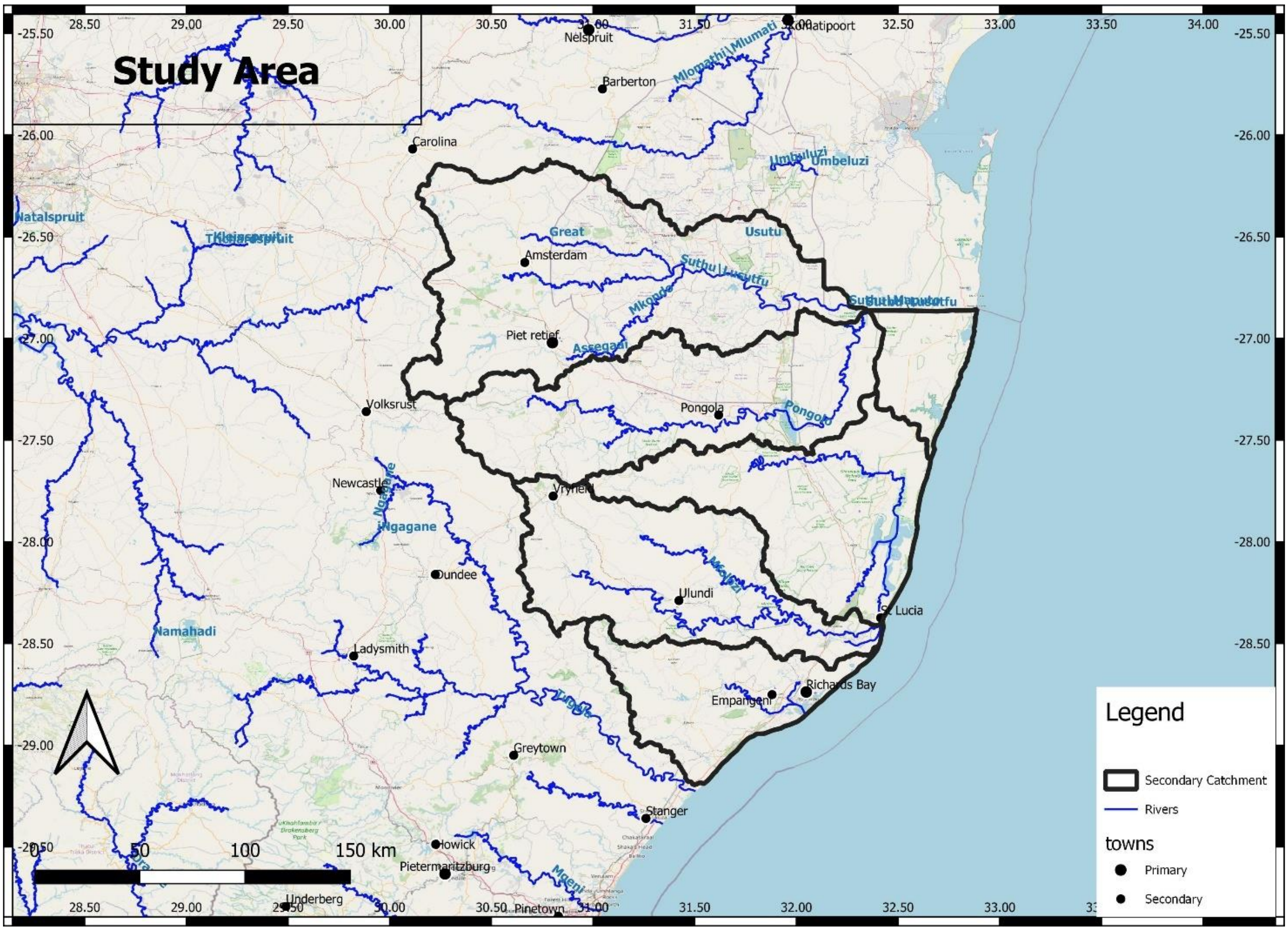
The purpose of this report is to document the results of the groundwater analysis as a key component of the Usutu-Mhlathuze Classification study. The objective of this task is to calculate the Groundwater Component of the Reserve and the Groundwater Classification.

METHODOLOGY

The Groundwater Component of the Reserve and Groundwater Classification is undertaken by calculating the Stress Index (SI) for each quaternary catchment based on abstraction (sourced from Registered use in the Water Allocation Registration Management System (WARMS) and the Schedule 1 water use for domestic and livestock based on StatsSA household survey) and revised figures for baseflow and recharge calibrated using Water Resources Simulation Model (WRSM Pitman - Pitman *et al*., 2006). Groundwater baseflow and the Basic Human Needs (BHN) component from groundwater are utilised to determine the Groundwater contribution to the Ecological Reserve.

OUTPUTS

A series of integrated maps of the basin or sub catchments which combine various spatial data sets and highlight crucial aspects of the groundwater systems (aquifers) in the project area were produced. Included are basin wide simplified geological and structural maps, aquifer distribution and type, borehole yield, recharge, stress index, baseflow and aquifer sustainable yield (productivity) maps, groundwater quality maps and recharge distribution maps. Tables are provided on groundwater resources, yield, and classification per catchment.



W1 MHLATUZE

Groundwater is minimally used and the stress index is below 0.05. Quaternary catchment classification is shown below.

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN[1] (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC[2]	Class	Groundwater Component of Reserve (Mm^3/a)
W11A	12.80	8.53	0.261	0.2692	0.02	A	I	8.80
W11B	3.73	2.44	0.121	0.0607	0.02	A	I	2.56
W11C	10.68	7.26	0.329	0.2315	0.02	A	I	7.59
W12A	18.91	9.05	0.176	0.1576	0.01	A	I	9.22
W12B	18.81	9.60	0.278	0.1216	0.01	A	I	9.88
W12C	17.82	8.53	0.197	0.1022	0.01	A	I	8.72
W12D	13.32	8.70	0.261	0.0924	0.01	A	I	8.96
W12E	6.71	3.76	0.158	0.0427	0.01	A	I	3.92
W12F	45.38	13.92	0.073	0.4185	0.01	A	I	13.99
W12G	10.01	4.92	0.075	0.0639	0.01	A	I	4.99

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN[1] (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC[2]	Class	Groundwater Component of Reserve (Mm^3/a)
W12H	13.02	7.34	0.111	0.3651	0.03	A	I	7.45
W12J	42.57	11.95	0.087	0.0931	0.00	A	I	12.04
W13A	6.47	3.95	0.201	0.2160	0.03	A	I	4.15
W13B	4.75	3.03	0.119	0.0456	0.01	A	I	3.15

1 Basic Human Needs

2 Present Status Category

W2 UMFOLOZI

Groundwater is minimally used and the stress index is below 0.12. Quaternary catchment classification is shown below.

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W21A	5.66	17.85	0.062	0.0729	0.01	A	I	17.91
W21B	7.52	23.08	0.112	0.1862	0.02	A	I	23.19
W21C	4.29	9.93	0.072	0.0671	0.02	A	I	10.00
W21D	6.67	12.33	0.123	0.1356	0.02	A	I	12.46
W21E	5.22	11.08	0.175	0.6204	0.12	B	I	11.25
W21F	3.03	5.68	0.08	0.0441	0.01	A	I	5.76
W21G	7.29	14.33	0.254	0.2245	0.03	A	I	14.58
W21H	5.51	13.52	0.208	0.0646	0.01	A	I	13.72
W21J	6.05	19.49	0.248	0.0851	0.01	A	I	19.74
W21K	11.37	26.37	0.355	0.0969	0.01	A	I	26.72
W21L	7.74	17.28	0.155	0.0765	0.01	A	I	17.43
W22A	3.92	12.95	0.046	0.0413	0.01	A	I	12.99
W22B	5.57	13.39	0.105	0.0555	0.01	A	I	13.49
W22C	2.58	9.10	0.045	0.0332	0.01	A	I	9.14
W22D	3.19	6.04	0.095	0.0298	0.01	A	I	6.14
W22E	4.60	29.61	0.16	0.0732	0.02	A	I	29.77
W22F	5.37	10.43	0.219	0.0563	0.01	A	I	10.65
W22G	4.39	7.55	0.297	0.0770	0.02	A	I	7.85
W22H	4.80	8.40	0.175	0.5773	0.12	B	I	8.57
W22J	10.92	15.54	0.46	0.1201	0.01	A	I	16.00
W22K	12.99	13.63	0.515	1.3207	0.10	B	I	14.15
W22L	5.47	8.38	0.072	0.0657	0.01	A	I	8.45
W23A	15.12	16.87	0.229	0.5405	0.04	A	I	17.10
W23B	7.09	10.52	0.054	0.3926	0.06	B	I	10.57
W23C	50.74	27.83	0.128	0.2212	0.00	A	I	27.95
W23D	47.13	17.63	0.211	0.5663	0.01	A	I	17.85

W3 MKUZE

Groundwater is minimally used and the stress index is below 0.05. Quaternary catchment classification is shown below.

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W31A	5.85	14.16	0.072	0.0661	0.01	A	I	14.23
W31B	4.31	11.32	0.06	0.0535	0.01	A	I	11.38

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W31C	3.38	8.60	0.033	0.065	0.02	A	I	8.64
W31D	4.22	10.64	0.076	0.0476	0.01	A	I	10.72
W31E	3.63	3.23	0.109	0.0484	0.01	A	I	3.34
W31F	6.68	5.17	0.475	0.1466	0.02	A	I	5.65
W31G	5.73	3.76	0.356	0.1755	0.03	A	I	4.11
W31H	4.11	2.80	0.163	0.0597	0.01	A	I	2.96
W31J	19.79	5.13	0.225	0.1164	0.01	A	I	5.36
W31K	10.94	7.68	0.659	0.2579	0.02	A	I	8.34
W31L	11.53	3.25	0.145	0.0578	0.01	A	I	3.39
W32A	45.16	9.31	0.103	0.096	0.00	A	I	9.42
W32B	142.13	38.24	0.174	0.2055	0.00	A	I	38.41
W32C	19.48	8.06	0.186	0.1274	0.01	A	I	8.25
W32D	6.04	4.60	0.165	0.1149	0.02	A	I	4.77
W32E	6.79	7.74	0.14	0.0895	0.01	A	I	7.88
W32F	7.51	3.53	0.106	0.0523	0.01	A	I	3.63
W32G	25.78	15.43	0.52	0.2202	0.01	A	I	15.95
W32H	188.09	65.72	0.673	0.6483	0.00	A	I	66.39

W4 PONGOLA

Groundwater is minimally used and the stress index is below 0.05. Quaternary catchment classification is shown below.

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W41A	3.34	2.63	0.014	0.0183	0.01	A	I	2.64
W41B	5.48	4.42	0.044	0.0433	0.01	A	I	4.46
W41C	3.95	3.16	0.051	0.0261	0.01	A	I	3.21
W41D	5.02	4.03	0.068	0.0332	0.01	A	I	4.10
W41E	4.75	3.06	0.087	0.0664	0.01	A	I	3.15
W41F	5.21	3.51	0.08	0.0552	0.01	A	I	3.59
W41G	1.58	0.99	0.024	0.0146	0.01	A	I	1.02
W42A	6.65	5.43	0.05	0.0386	0.01	A	I	5.48
W42B	8.50	6.95	0.104	0.0614	0.01	A	I	7.06
W42C	7.34	6.14	0.034	0.0557	0.01	A	I	6.18
W42D	10.27	8.29	0.096	0.0926	0.01	A	I	8.39
W42E	5.04	3.97	0.05	0.0415	0.01	A	I	4.02
W42F	6.94	5.24	0.034	0.1253	0.02	A	I	5.27
W42G	4.00	2.51	0.072	0.0374	0.01	A	I	2.58
W42H	4.67	2.82	0.069	0.0447	0.01	A	I	2.89
W42J	4.94	3.02	0.094	0.0399	0.01	A	I	3.11
W42K	6.33	4.23	0.026	0.2166	0.03	A	I	4.26
W42L	4.43	2.59	0.077	0.0312	0.01	A	I	2.67
W42M	9.31	6.77	0.109	0.0364	0.00	A	I	6.88
W43C	11.86	6.49	0.002	0.0006	0.00	A	I	6.49
W43F	9.24	4.09	0.299	0.08	0.01	A	I	4.39
W44A	3.12	1.34	0.09	0.037	0.01	A	I	1.43
W44B	5.85	2.45	0.122	0.4821	0.08	B	I	2.57
W44C	3.78	1.51	0.024	0.0077	0.00	A	I	1.53
W44D	2.64	0.96	0.076	0.0289	0.01	A	I	1.03
W44E	8.05	3.02	0.137	0.0455	0.01	A	I	3.15

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W45A	69.60	7.78	0.506	0.2887	0.00	A	I	8.29
W45B	31.43	3.17	0.12	0.1196	0.00	A	I	3.29

W5 USUTU

Groundwater is minimally used and the stress index is below 0.13. Quaternary catchment classification is shown below.

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W51A	10.39	8.27	0.04	0.2243	0.02	A	I	8.31
W51B	8.50	6.59	0.046	1.1142	0.13	B	I	6.63
W51C	12.53	9.99	0.076	0.4697	0.04	A	I	10.07
W51D	8.89	7.00	0.059	0.1635	0.02	A	I	7.06
W51E	6.11	4.20	0.002	0.0842	0.01	A	I	4.20
W51F	12.65	10.16	0.034	0.1683	0.01	A	I	10.20
W52A	5.03	3.85	0.027	0.1237	0.02	A	I	3.87
W52B	6.27	4.92	0.038	0.2076	0.03	A	I	4.96
W52C	3.35	2.59	0.02	0.0657	0.02	A	I	2.61
W52D	2.38	1.80	0.008	0.0148	0.01	A	I	1.81
W53A	10.25	7.95	0.044	0.4515	0.04	A	I	7.99
W53B	4.09	3.20	0.015	0.0199	0.00	A	I	3.21
W53C	5.82	4.66	0.035	0.0886	0.02	A	I	4.69
W53D	5.86	4.61	0.033	0.0559	0.01	A	I	4.65
W53E	8.96	7.20	0.02	0.0468	0.01	A	I	7.22
W53F	10.48	7.64	0	0.0002	0.00	A	I	7.64
W54A	3.99	3.33	0.017	0.0648	0.02	A	I	3.34
W54B	4.38	3.74	0.02	0.0261	0.01	A	I	3.76
W54C	1.85	1.58	0.007	0.0097	0.01	A	I	1.58
W54D	2.71	2.38	0.013	0.0544	0.02	A	I	2.39
W54E	3.68	3.28	0.002	0.005	0.00	A	I	3.28
W55A	11.10	9.82	0.052	0.0683	0.01	A	I	9.87
W55B	3.44	3.11	0.015	0.0206	0.01	A	I	3.13
W55C	15.02	13.90	0.053	0.1379	0.01	A	I	13.95
W55D	7.70	7.08	0.019	0.018	0.00	A	I	7.10
W55E	4.50	4.16	0	0.0001	0.00	A	I	4.16
W56A	13.91	12.80	0.026	0.0133	0.00	A	I	12.83
W56B	10.55	9.31	0.005	0.0019	0.00	A	I	9.31
W57J	6.29	2.90	0.042	0.0112	0.00	A	I	2.94
W57K	1.71	0.79	0.065	0.0174	0.01	A	I	0.85

W7 KOSI ESTUARY AND LAKE SIBAYA

The stress index calculated from the total present use and aquifer recharge is 0.01. Groundwater is minimally used. Quaternary catchment classification is shown below.

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W70A	340.15	63.61	0.4040	2.3432	0.01	A	I	64.01

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BHN	Basic Human Needs
CD: WEM	Chief Directorate: Water Ecosystems Management
CGS	Council for GeoScience
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Electrical conductivity
GRA II	Groundwater Resource Assessment Phase II
l/c/d	Litres per capita per day
LM	Local Municipality
mamsl	Metres above mean sea level
MAR	Mean Annual Runoff
mbgl	metres below ground level
NGA	National Groundwater Archive
NNMP	Nama-Natal Structural and Metamorphic Province
NWA	National Water Act
PSC	Present Status Category
Quat	Quaternary catchment
RQO	Resource Quality Objectives
S	Storativity
SI	Stress Index
WARMS	Water Allocation Registration Management System
WMS	Water Management System
WRCS	Water Resource Classification System
WRSM Pitman	Water Resources Simulation Model

SPELLING

There are multiple references to the spelling of various Rivers, Lakes, Dams and Estuaries, depending on the source of information. For the purposes of this report, the following Table presents the selected spelling of indicated water resources and places.

Selected Spelling for this Study	Alternate spellings
Usutu River	Usuthu River
Mhlathuze River	Mhlatuze, uMhlatuze River
Pongola (river, Town & Pongolapoort Dam)	Phongola, Phongolo
Lake Sibaya	Lake Sibiya, Lake Sibhayi, Lake Sibhaya
Eswatini	eSwatini
Umfolozi River	Mfolozi River
Amatigulu River	Amatikulu, Matigulu River
Goedertrouw Dam	Lake Phobane
Mfuli River	Mefule River
aMatigulu/iNyoni Estuary	
Sibiya Estuary	
Mlalazi Estuary	

Selected Spelling for this Study	Alternate spellings
uMhlathuze /Richards Bay Estuary	
iNhlabane Estuary	
uMfolozi/uMsunduze Estuary	
St Lucia Estuary	
uMgobezeleni Estuary	
Kosi Estuary	
Hluhluwe Game Reserve	
iMfolozi Game Reserve	
Ithala Game Reserve	
Ndumo Game Reserve	
Tembe Elephant Reserve	
iSimangaliso Wetland Park	
Kosi Bay and Coastal Forest Area	
uMkhuze Game Reserve	

GLOSSARY

Basic Human Needs — Water needs to be set aside for basic human needs such as drinking, food preparation, and health and hygiene purposes. This is referred to as the Basic Human Needs Reserve (BHNR).

Ecological Water Requirements (EWR) — The flow patterns (magnitude, timing and duration) and water quality needed to maintain a riverine ecosystem in a particular condition. This term is used to refer to both the quantity and quality components.

Ecosystem services — The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth.

Integrated Unit of Analysis (IUAs) — An IUA is a homogeneous area that can be managed as an entity. It is the basic unit of assessment for the Classification of water resources, and is defined by areas that can be managed together in terms of water resource operations, quality, socio-economics and ecosystem services.

Resource Quality Objectives (RQOs) — RQOs are numeric or descriptive goals or objectives that can be monitored for compliance to the Water Resource Classification, for each part of each water resource. “The purpose of setting RQOs is to establish clear goals relating to the quality of the relevant water resources” (NWA, 1998).

Sub-quaternary reaches (SQR) — A finer subdivision of the quaternary catchments (the catchment areas of tributaries of main stem rivers in quaternary catchments), to a sub-quaternary reach or quinary level.

Target Ecological Category (TEC) — This is the ecological category toward which a water resource will be managed once the Classification process has been completed and the Reserve has been finalised. The draft TECs are therefore related to the draft Classes and selected scenario.

Water Resource Class — The Water Resource Class (hereafter referred to as Class) is representative of those attributes that the DWS (as the custodian) and society require of different water resources. The decision-making toward a Class requires a wide range of trade-offs to be assessed and evaluated at a number of scales. Final outcome of the process is a set of desired characteristics for use and ecological condition of the water resources in a given catchment. The WRCS defines three management classes, Class I, II, and III, based on extent of use and alteration of ecological condition from the predevelopment condition.

1 INTRODUCTION

1.1 BACKGROUND

Chapter 3 of the National Water Act, 1998 (NWA) (Act 36 of 1998), deals with the protection of water resources. Section 12 of the NWA requires the Minister to develop a system to classify water resources. In response to this, the Water Resource Classification System (WRCS) was gazetted on 17 September 2010 and published in Government Gazette 33541 as Regulation 810. The WRCS is a stepwise process whereby water resources are categorised according to specific classes that represent a management vision of a particular catchment. This vision takes into account the current state of the water resource, the ecological, social and economic aspects that are dependent on the resource. Once significant water resources have been classified through the WRCS, Resource Quality Objectives (RQOs) must be determined to give effect to the class. The implementation of the WRCS therefore assesses the costs and benefits associated with utilisation versus protection of a water resource. Section 13 of the NWA requires that Water Resource Classes and RQOs be determined for all significant water resources.

Thus, the Chief Directorate: Water Ecosystems Management (CD: WEM) of the Department of Water and Sanitation (DWS) initiated a study for determining the Water Resource Classes and RQOs for all significant water resources in the Usutu to Mhlathuze Catchment. The Usutu to Mhlathuze Catchments are amongst many water-stressed catchments in South Africa. These catchment areas are important for conservation and contain a number of protected areas, natural heritage sites, cultural and historic sites as well as other conservation areas that need protection. There are five RAMSAR[1] sites within the catchment, which includes the world heritage site, St Lucia. The others are Sibaya, Kosi Bay, Ndumo Game Reserve and Turtle Beaches.

1.2 STUDY AREA

The study area is the Usutu to Mhlathuze Catchment that has been divided into six drainage areas and secondary catchment areas as follows (refer to the locality map provided as **Figure 1.1**):

- W1 catchment (main river: Mhlathuze).
- W2 catchment (main river: Umfolozi).
- W3 catchment (main river: Mkuze).
- W4 catchment (main river: Pongola) - part of this catchment area falls within Eswatini.
- W5 catchment (main river: Usutu) - much of this catchment falls within Eswatini.
- W7 catchment (Kosi Bay estuary and Lake Sibaya).

Note that all assessments within Eswatini are excluded apart from the hydrological modelling required to assess any downstream rivers in South Africa that either run through Eswatini or originate (source) in Eswatini.

[1] A Ramsar site is a wetland site designated to be of international importance under the Ramsar Convention, also known as "The Convention on Wetlands", an intergovernmental environmental treaty established in 1971 by UNESCO in the Iranian city of Ramsar, which came into force in 1975.

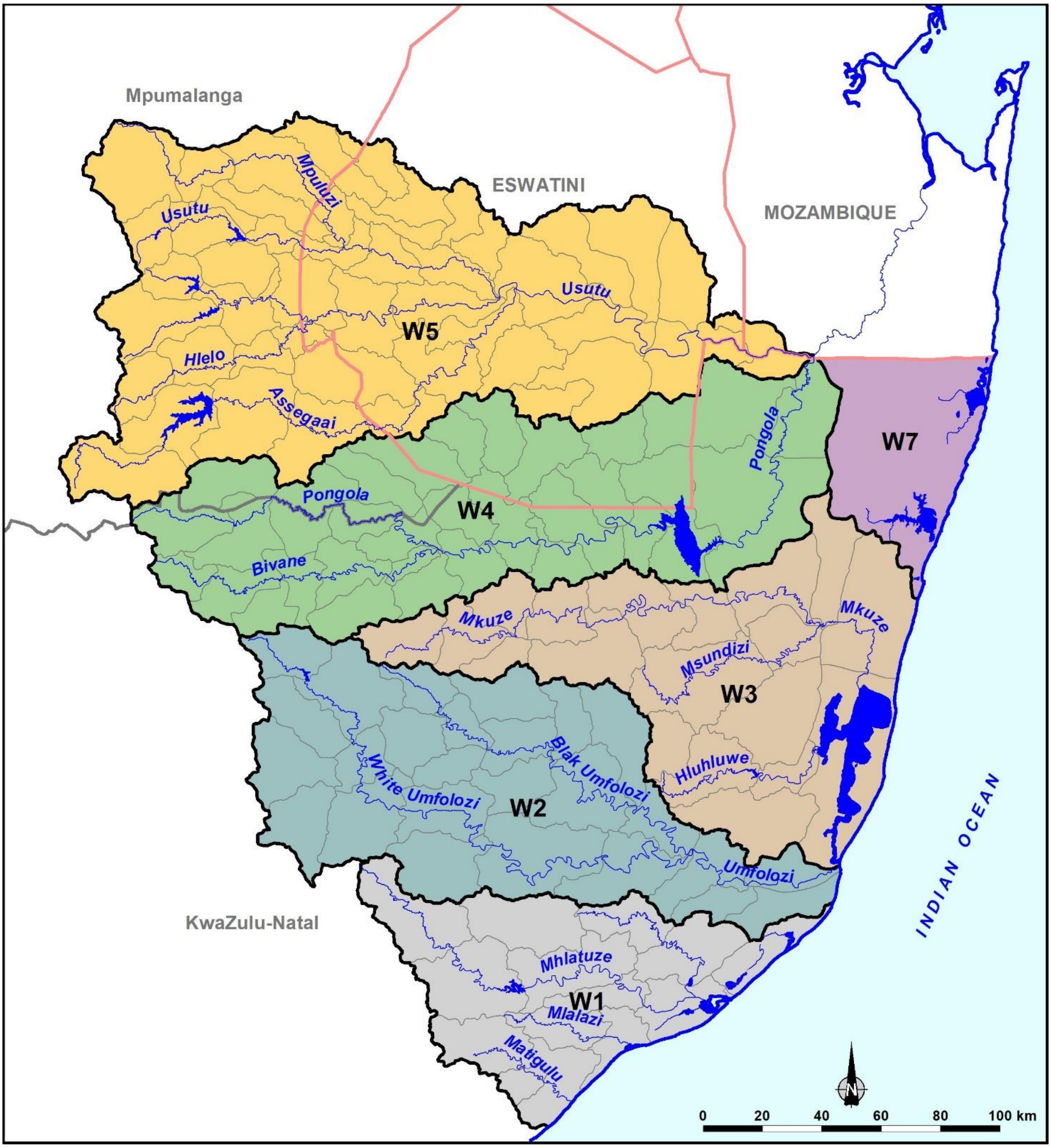

Figure 1.1 Locality Map of the Study Area

1.3 PURPOSE OF THIS REPORT

The purpose of this report is to document the results of the groundwater analysis as a key component of the Usutu-Mhlathuze Classification study and as per the Project Plan in **Figure 1.2**. The objective of this task is to calculate the Groundwater Component of the Reserve and the Groundwater Classification.

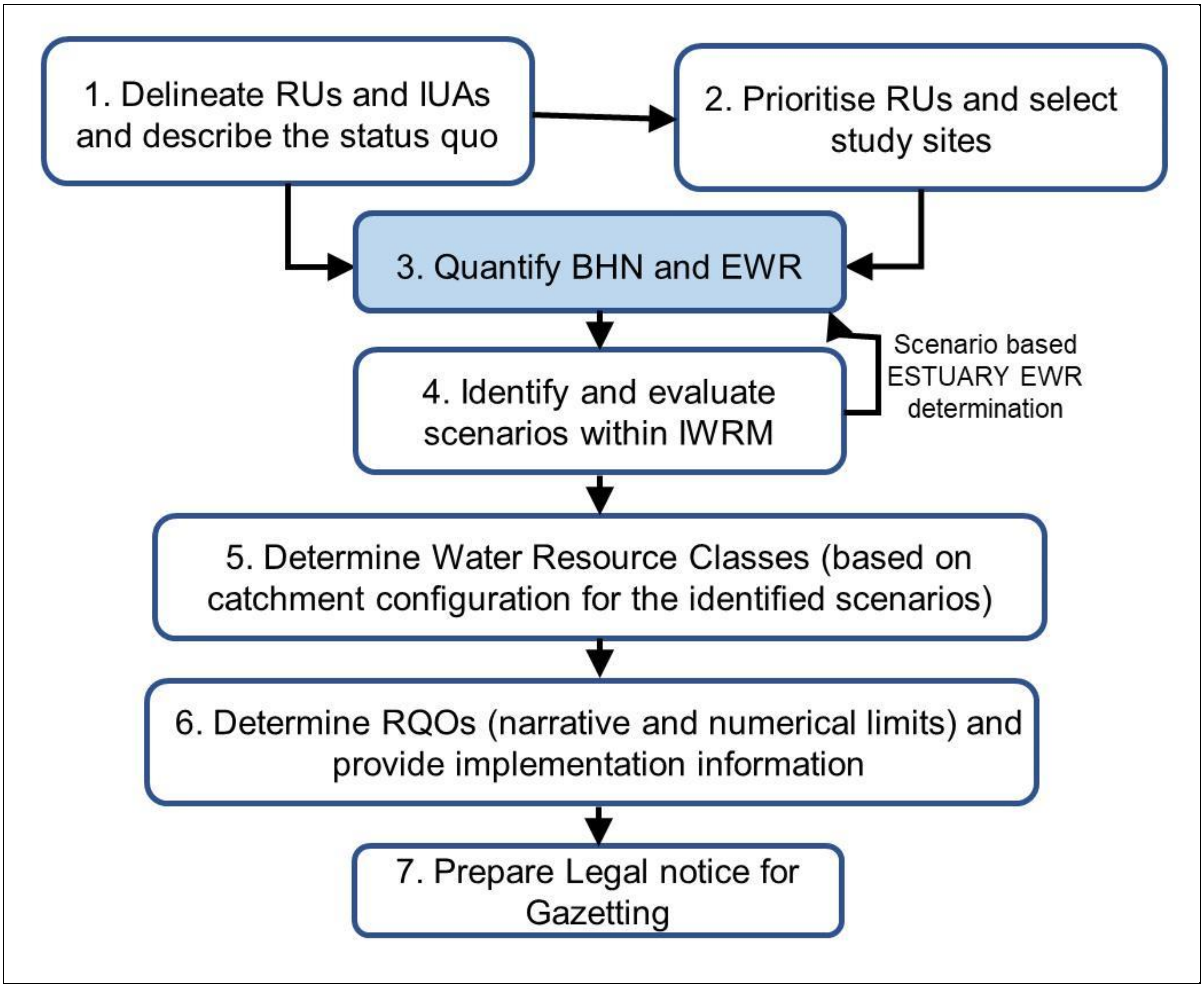

Figure 1.2 Project Plan for the Usutu-Mhlathuze Classification study

1.4 REPORT OUTLINE

The report outline is as follows:

- **Chapter 1** provides general background information on the study area and the Project Plan.
- **Chapter 2** outlines the methodologies used.
- **Chapter 3** describes the study area in terms of conditions of relevance to groundwater.
- **Chapters 4 - 9** of the report outline the findings for the various secondary catchments within the Usutu to Mhlathuze Catchment.

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2 METHODOLOGY

2.1 APPROACH

The Groundwater Component of the Reserve and Groundwater Classification was undertaken by calculating the Stress Index (SI) for each quaternary catchment based on abstraction (sourced from Registered use in Water use Authorization and Registration Management System (WARMS) and the Schedule 1 water use for domestic and livestock based on StatsSA household survey) and revised figures for baseflow and recharge calibrated using Water Resources Simulation Model (WRSM Pitman - Pitman *et al*., 2006). This included estimated Schedule 1 groundwater uses. Groundwater baseflow and the Basic Human Needs (BHN) component from groundwater will be utilised to determine the Groundwater contribution to the Ecological Reserve.

Variables that were utilised include:

- Baseflow and interflow contributions to total runoff and as a fraction of recharge, as derived from WRSM2000/Pitman and calibrated against observed flows.
- Recharge and aquifer recharge obtained via WRSM Pitman, compared to other estimates like the Groundwater Resource Assessment Phase II (GRA II) (DWAF, 2006).
- Groundwater quality.
- Groundwater level.

2.2 DATA SOURCES

The literature sources and databases accessed for groundwater information are shown in **Table 2.1**.

Table 2.1 Literature sources and databases accessed during this study

Type of Data	Data	Source
Catchment delineation	Quaternary catchment boundaries	WR2012
Population	Population	Stats SA
Climatic data	Rainfall and evaporation	WR2012
Geology	Lithology and structures	Council for GeoScience (CGS) geological maps
Hydrology	Baseflow	GRA II (DWAF, 2006)
Geohydrology	Harvest Potential Exploitation Potential Recharge Hydrochemistry Water levels Borehole yields	GRA II (DWAF, 2006) GRA II (DWAF, 2006) GRA II (DWAF, 2006) ZQM and Water Management System (WMS) database National Groundwater Archive (NGA) NGA
Groundwater use	Lawful water use Municipal water use Schedule 1 water use Livestock water use	Water use Authorization and Registration Management System (WARMS) Stats SA GRA II (DWAF, 2006)

The National Groundwater Archive (NGA) was used to collect information on borehole yield and the depth of water strike. Since this database contains data on blow yields when boreholes were established, it does not include subjective bias on sustainable yield, or recommendations, but is a measure of maximum borehole delivery and is thus generally higher than the sustainable yield of boreholes. Borehole yields were investigated by median yield and the percentage of boreholes yielding more than specified yield values to provide an indication of exploitability.

Borehole blow yields as listed in the NGA were grouped by lithology and per quaternary catchment to derive the geometric and median borehole yield, and the percentage of boreholes yielding more than a specified yield. Yields above 2 l/s are considered economical for motorised and reticulated water supply, while yields greater than 1 l/s are suitable for local water supply or wellfields. Yields below 0.5 l/s do not warrant exploitation for water supply at greater than a household level.

The GRA II data base (DWAF, 2006) provided information on baseflow, recharge, aquifer storage and available resources on a quaternary catchment level. The estimation of recharge is used to calculate both the stress index and the available groundwater volume for allocation per unit. This allocable volume ultimately determines whether or not additional groundwater use can be approved after considering the Reserve and other users. Because of the presence of high-lying springs, which occur due to the presence of diabase sills or low permeability layers, much of the recharge on the Escarpment re-emerges in high-lying areas and is lost as interflow before reaching the regional aquifer. Hence total recharge in a catchment is not a good indicator of the groundwater resources. Consequently, the estimate of aquifer recharge (recharge that reaches the aquifer after the subtraction of interflow) should be utilised for deriving aquifer resources and stresses. However, total recharge should be used to estimate baseflow and the groundwater component of the Reserve.

GRA II (DWAF, 2006) provided a methodology for calculating the Groundwater Resource Potential, which provides estimates of the maximum volumes of groundwater that are potentially available for abstraction on a sustainable basis based on recharge, baseflow, aquifer storage and a drought index. This calculation was revised based on recalculations of storage and the volumes of water held in aquifer storage in the aquifer, and the recharge from rainfall, less the natural baseflow.

It is however not possible to abstract all the ground water available. This is mainly due to economic and/or environmental considerations. The main contributing factor is the hydraulic conductivity or transmissivity of the aquifer systems. One of the most important of these is the inability to establish a network of suitably spaced production boreholes to ‘capture’ all the available water in an aquifer system or on a more regional scale. The factors limiting the ability to develop such a network of production boreholes, includes the low permeability or transmissivity of certain aquifer units, accessibility of terrain to drilling rigs, and unknown aquifer boundary conditions. The Exploitability Factor based on borehole yield and the probability of drilling boreholes of greater than 2 l/s was utilised to calculate the Groundwater Exploitation Potential.

The Water use Authorization and Registration Management System (WARMS) database was used to tabulate existing lawful water use per quaternary catchment. Schedule 1 water use was estimated from the percentage of household’s dependent on boreholes (excluding regional schemes) and the 2021 population at a consumption of 60 litre/capita/day (l/c/d).

The South Africa Water Quality Water Management System database characterizes groundwater quality per catchment and identifies water quality issues.

2.3 OUTPUTS

A series of integrated maps of the basin or sub catchments which combine various spatial data sets and highlight crucial aspects of the groundwater systems (aquifers) in the project area were produced. Included are basin wide simplified geological and structural maps, aquifer distribution and aquifer sustainable yield (productivity) maps, groundwater quality maps and recharge distribution maps. The results of the groundwater resources investigation were ultimately used to:

- Quantification of sustainable groundwater resources (aquifer yield);
- Evaluation of any existing over abstraction by stress indices;
- Classification of Present State and Management Class;
- Water quality Classification;
- Quantification of the groundwater reserve; and
- Quantification of Allocable groundwater.

2.4 REVISION OF DATBASES

It was found that significant errors exist in GRA II (DWAF, 2006), especially in international catchments. It appears variables were scaled incorrectly and did not account for trans-border resources. This results in some parameters being grossly underestimated because they are averaged over a much larger area than the portion of the catchment in South Africa. In addition, unrealistic storage parameters were found. This affected the following:

- Storativity, which affects groundwater resource and exploitation potential as well as aquifer storage.
- Exploitation factor which affects exploitation potential.
- Only groundwater baseflow was considered in exploitation potential calculations, while all of the recharge was utilised, even the component lost as interflow. This results in a large over estimation of exploitation potential in mountainous regions with a large interflow component, causing mountainous catchments to appear as having very large groundwater volumes.
- It was found that in many cases recharge in GRA II was less than baseflow, which is not possible and leads to a negative exploitation potential. This was corrected by utilising recharge and baseflow from WR2000 to ensure a water balance.

Revisions undertaken include the following:

- Upscaling parameters in catchments straddling international boundaries.
- Storativity (S) was recalculated for each catchment based on groundwater region, and the highest and lowest value in each region was verified.
- Only the groundwater stored in the upper 5 m, whether the weathered or fractured zone or a combination of the two was utilised to calculate Groundwater Resource Potential.
- The static water level used to calculate Storativity was the weighted mean depth of the saturated weathered and fractured zone.
- Total baseflow was used including interflow when calculating exploitation potential, since the recharge values in GRA II include recharge that drives interflow.
- Where corrected recharge values were available, these were used in preference to GRA II.

2.5 GROUNDWATER USE

Registered groundwater use (boreholes and springs) was obtained from WARMS. Schedule 1 water use was estimated from the percentage of household's dependent on boreholes (excluding regional schemes) and the 2021 population at a consumption of 60 l/c/d. Livestock water use was obtained from GRA II.

2.6 BOREHOLE YIELDS

Borehole blow yields as listed in the NGA were grouped by quaternary catchment to derive the geometric and median borehole yield, and the percentage of boreholes yielding more than a specified yield. Yields above 2 l/s are considered economical for motorised and reticulated water supply, while yields greater than 1 l/s are suitable for local water supply or wellfields. Yields below 0.5 l/s do not warrant exploitation for water supply at greater than a household level.

2.7 GROUNDWATER QUALITY

All hydrochemical data were collated and were assessed for potable use by using the Guidelines for Domestic Water Quality (DWAF, 1998) (**Table 2.2**). Potable groundwater is defined as water of Class 0 and 1.

Table 2.2 DWS Guidelines for Domestic Water Quality (DWAF, 1998)

Analyses	Unit	Classification				
		Class 0 IDEAL	Class I GOOD	Class II MARGINAL	Class III POOR	Class IV UNACCEPTABLE
pH		5.5 - 9.5	4.5 - 5.5 and 9.5 - 10	4 - 4.5 and 10 - 10.5	3 - 4 and 10.5 - 11	< 3 or > 11
Conductivity	mS/m	< 70	70 - 150	150 - 270	270 - 450	> 450
TDS	mg/l	< 450	450 - 1000	1000 - 2400	2400 - 3400	> 3400
Total Hardness	$CaCO_3$	< 200	200 - 300	300 - 600	> 600	
Calcium	mg/l	< 80	80 - 150	150 - 300	> 300	
Copper	mg/l	< 1	1 - 1.3	1.3 - 2	2 - 15	> 15
Iron	mg/l	< 0.5	0.5 - 1	1 - 5	5 - 10	> 10
Magnesium	mg/l	< 70	70 - 100	100 - 200	200 - 400	> 400
Manganese	mg/l	< 0.1	0.1 - 0.4	0.4 - 4	4 - 10	> 10
Potassium	mg/l	< 25	25 - 50	50 - 100	100 - 500	> 500
Sodium	mg/l	< 100	100 - 200	200 - 400	400 - 1000	> 1000
Chloride	mg/l	< 100	100 - 200	200 - 600	600 - 1200	> 1200
Fluoride	mg/l	< 0.7	0.7 - 1	1 - 1.5	1.5 - 3.5	> 3.5
Nitrate NO_3 - N	mg/l	< 6	6 - 10	10 - 20	20 - 40	> 40
Nitrite NO_2 - N	mg/l	< 6	6 - 10	10 - 20	20 - 40	> 40
Orthophosphate (PO_4 as P)	mg/l	< 0.1	0.1 - 0.25	0.25 - 1	> 1	
Sulphate (SO_4)	mg/l	< 200	200 - 400	400 - 600	600 - 1000	> 1000
MPN *E. coli*	/100ml	0	0 - 1	1 - 10	10 - 100	> 100

2.8 CLASSIFICATION

The groundwater stress index is used to reflect water availability versus groundwater used. The Stress Index (SI) for an assessment area is defined as follows:

SI = Groundwater use/Recharge

In calculating the SI, the variability of annual recharge is taken into account in the sense that not more than 65% of average annual recharge should be allocated on a catchment scale without caution and monitoring (stress index = 0.65). Stress index is calculated as groundwater use relative to aquifer recharge since the majority of recharge in the study area is lost as interflow and is not available as a groundwater resource to boreholes. Classification of stress is based on the DWS methodology (Parsons and Wentzel, 2007). After calculating the stress index, this guides the Present Status Category (PSC) of each groundwater unit (**Table 2.3**).

Table 2.3 Classification of groundwater by stress

Management Class	Description	Present Status Category	Stress Index
I	Minimally used	A	≤0.05
		B	0.05 - 0.2
II	Moderately used	C	0.2 - 0.4
		D	0.4 - 0.65
III	Heavily used	E	0.65 - 0.95
		F	>0.95

Water quality classification is based on the number of samples falling within each class of the South African Water Quality Guidelines Vol. 1 – Domestic use (DWAF, 1998) (**Table 2.2**) for the present status category assessment of a water resource (**Table 2.4)**

Table 2.4 Classification by water quality

Management Class	Description
I	>95% Class 0 or 1
II	>95% Class 0 - 2
III	Class 3 or 4 or <75% Class 0 - 2

The groundwater component of the Reserve is calculated as the sum of groundwater baseflow and the Basic Human Needs.

3 CATCHMENT DESCRIPTION

3.1 LOCATION

The study area consists of the Usutu to Mhlathuze Catchments. These are divided into 6 Secondary Catchments:

- W1 catchment (main river: Mhlathuze).
- W2 catchment (main river: Umfolozi).
- W3 catchment (main river: Mkuze).
- W4 catchment (main river: Pongola) - part of this catchment area falls within Eswatini.
- W5 catchment (main river: Usutu) - much of this catchment falls within Eswatini.
- W7 catchment (Kosi Bay estuary and Lake Sibaya).

They are located in Mpumalanga and KwaZulu-Natal Provinces The main towns in the study area are Amsterdam, Piet Retief, Pongola, St Lucia, Ulundi, Empageni and Richards Bay (**Figure 3.1**).

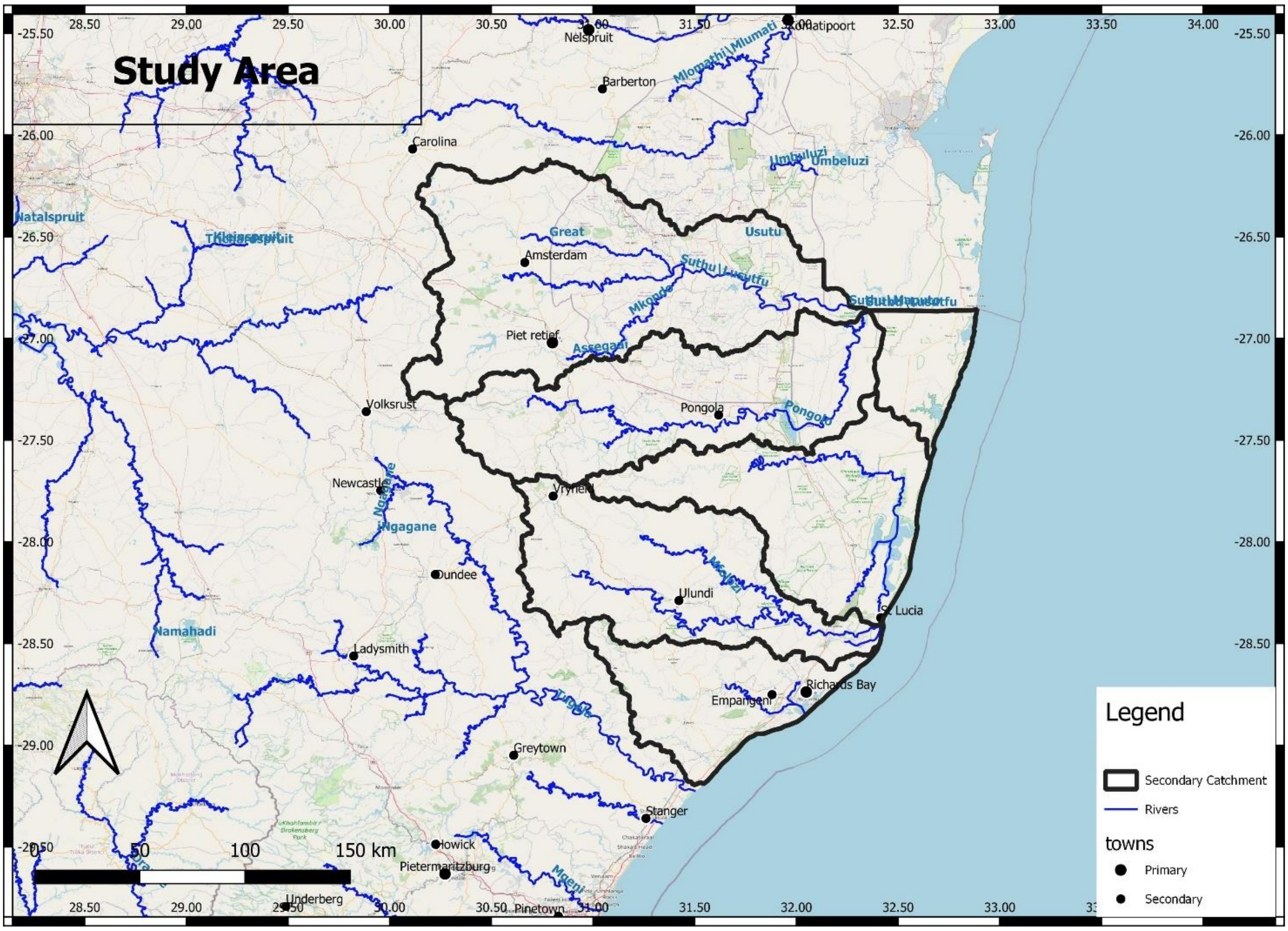

Figure 3.1 Study Area catchments

3.2 MUNICIPALITIES

There are 23 local municipalities within the basins as shown in **Figure 3.2**.

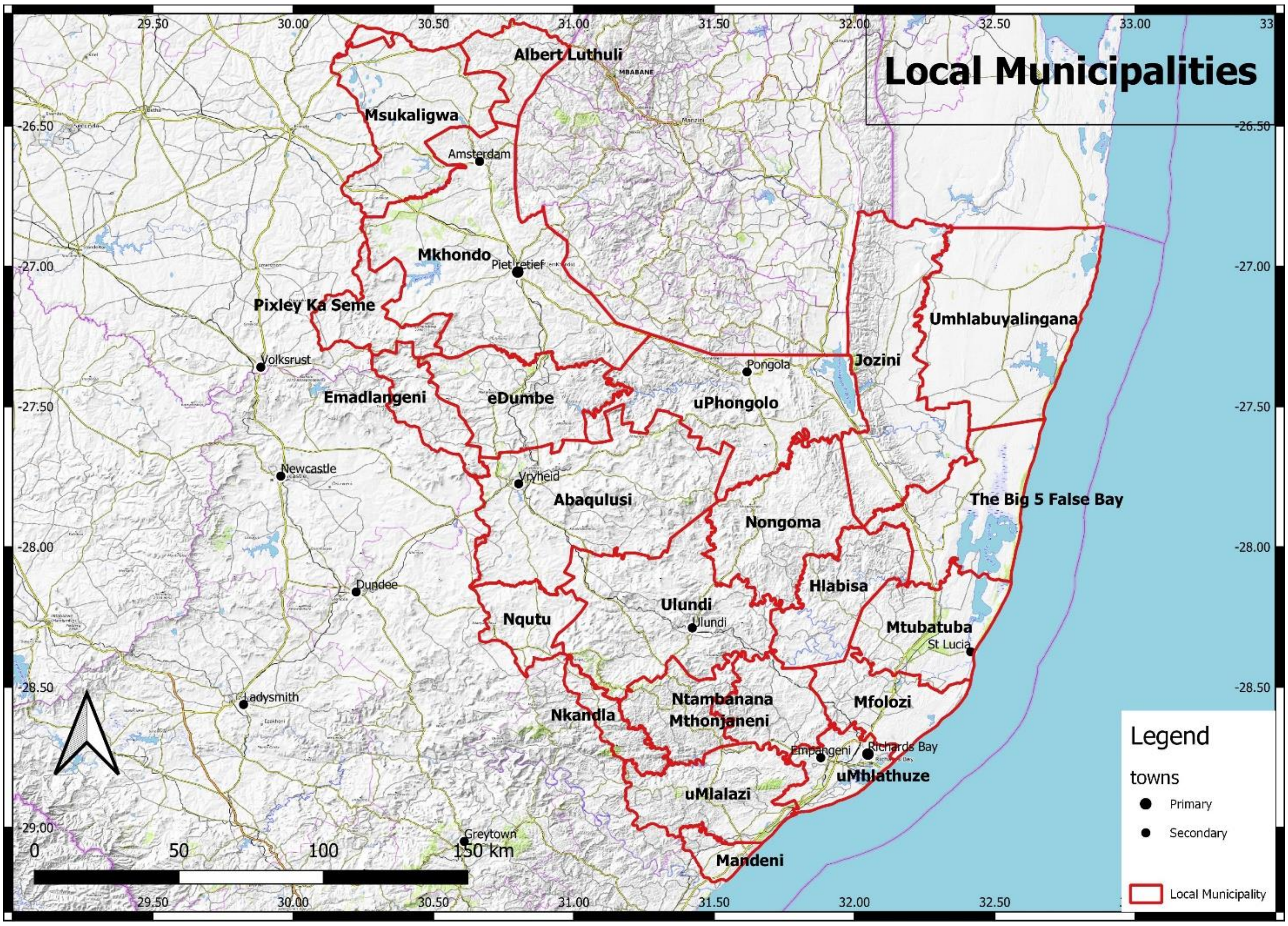

Figure 3.2 Local Municipalities

3.3 PHYSIOGRAPHY

The hydro-geology of the Usutu to Mhlathuze Catchment was first documented on a broad scale by the DWS KwaZulu-Natal Groundwater Resources Mapping and Characterisation Project in the 1990s. A broad overview is also given by the DWS 1:500 000 Hydro-geological Map Series: 2530 Nelspruit; 2730 Vryheid; and the 2928 Durban map sheets.

The Usutu to Mhlathuze Catchment is approximately 45 000 km² in total area. Of this, about 6000 km² comprises the Zululand Coastal Plain along the north-eastern coast. The elevation in the area varies from sea level in the east to an average of some 100 m over the width of the Zululand Coastal Plain. Inland, the north-south trending Lebombo range bounds this plain and rises to some 700 m, decreasing to the south. West of the Lebombo, the surface falls abruptly to only some 250 m in the similarly north-south trending Lowveld. Further inland the land rises progressively to a maximum elevation of some 2000 m on the Great Escarpment on the north-western boundary of the WMA.

Physio-graphically, the inland portion of the Usutu to Mhlathuze Catchment comprises a number of east or south-east trending basins of the major rivers that are separated by elevated interfluve ridges. The coastal portion of the area in the south, and the inland portion of the area west of the Zululand Coastal Plain, are generally characterised by steep and strongly dissected topographies.

Rainfall over the Usutu to Mhlathuze Catchment varies from about 1000 mm to 1200 mm annually along the coast, and on the elevated ridges and escarpments in the interior, to about 600 mm to 700 mm in the major river basins and valleys of the interior. It is similar on the inner margin of the

Zululand Coastal Plain and in the Lowveld, and inland of the Lebombo Mountain Range. On the elevated crest of the Lebombo Mountains the rainfall increases to over 800 mm/annum.

Geologically, the Usutu to Mhlathuze Catchments comprises three structurally distinct provinces.

3.3.1 Zululand Coastal Plain

In the east, the Zululand Coastal Plain is underlain mainly to be an eastward-thickening wedge of unfaulted Cretaceous marine sediments covered by a relatively thin veneer of unconsolidated, mainly Aeolian sandy sediments of Neogene age. The plain lies below 100 metres above mean sea level (mamsl) and widens progressively towards the north. It is bounded in the west by the Lebombo range, which is of Jurassic age.

The unfaulted wedge, of Cretaceous sediments, consists of gently seaward-dipping marine siltstones originating from the Makatini, Mzinene and St Lucia Formations. These formations are un-conformably overlain by younger, mainly unconsolidated, sandy Aeolian sediments of Miocene to Holocene age formations (i.e. Uloa, Umkwelane, Port Durnford, Kosi Bay, Kwambonambi and Sibayi Formations), that rest as a thin veneer consisting of a few tens of metres in thickness on the upper crust. In places along the inner margin of the coastal plain, deeply weathered dunes can be found that form Berea-type red sand.

In proximity to the coastline, the lower courses of the major rivers, and the coastal Kosi Lake and Lake Sibayi drainage systems are underlain by a considerable thickness of alluvial and estuarine sediments, the former being characteristically consisting of a sandy sediment and the latter consisting of a clay type sediment, as in the Richard’s Bay estuary (sandy) and the St Lucia Lake system (clay). Such sediments also underlie the course of the Pongola and Usutu Rivers and constitute the inner margins of the northern parts of the river plains. A characteristic of all the lower courses of these rivers is the formation of shallow marginal lakes, some of considerable extent, which represent alluvium rich marginal tributary valleys.

3.3.2 Southern Lebombo and Lowveld

Inland of the Zululand Coastal Plain and to the south of it, is the Lowveld with the Lebombo range separating them. The structure comprises fault blocks that are tilted increasingly steeply between major strike faults in a general easterly to south-easterly or seaward direction. This includes the major seaward dipping Lebombo structure which is a faulted ‘monocline’. In this portion of the Usutu to Mhlathuze Catchment the geology is complex due to the faulting that is Gondwana-breakup related and of Late-Jurassic age. In the southern faulted portion of the region, unconformably overlying the basement rocks, are a diverse rock-type assemblage of the Nama-Natal Structural and Metamorphic Province (NNMP). To the north of them are the sandstones of the Natal Group. In the central region are the rocks of the Pongola Supergroup, exposed where the overlying Karoo rocks have been removed. The remainder of the area is underlain by a down faulted sedimentary and Karoo dolerite-intruded succession of the Karoo Supergroup, which is capped by the Lebombo structure, and by the very thick faulted and Karoo dolerite dyke intruded volcanic Letaba basalt and Jozini rhyolite-dacite succession.

3.3.3 Middleveld and Escarpment

In the western portion of the Usutu to Mhlathuze Catchment, west of the Lowveld, the geology is generally gently westward-dipping and unfaulted Karoo Supergroup sedimentary rocks that lie unconformably overlie Archaean and Proterozoic rocks of the Kaap-Vaal craton. They are of various types and granite-intruded. They outcrop over much of the study area, especially in the northwest. The Karoo Supergroup rocks have at their base the Dwyka Group, which is largely tillite. It outcrops mostly in the south. It is overlain by a thick assemblage of sub horizontal shales, sandstones, and mudstones of the Ecca and Beaufort Groups. These rocks are intruded by sheets, and dykes, of Karoo dolerite.

3.4 GROUNDWATER

The study area covers several groundwater regions (**Figure 3.3**). These are described in **Table 3.1**.

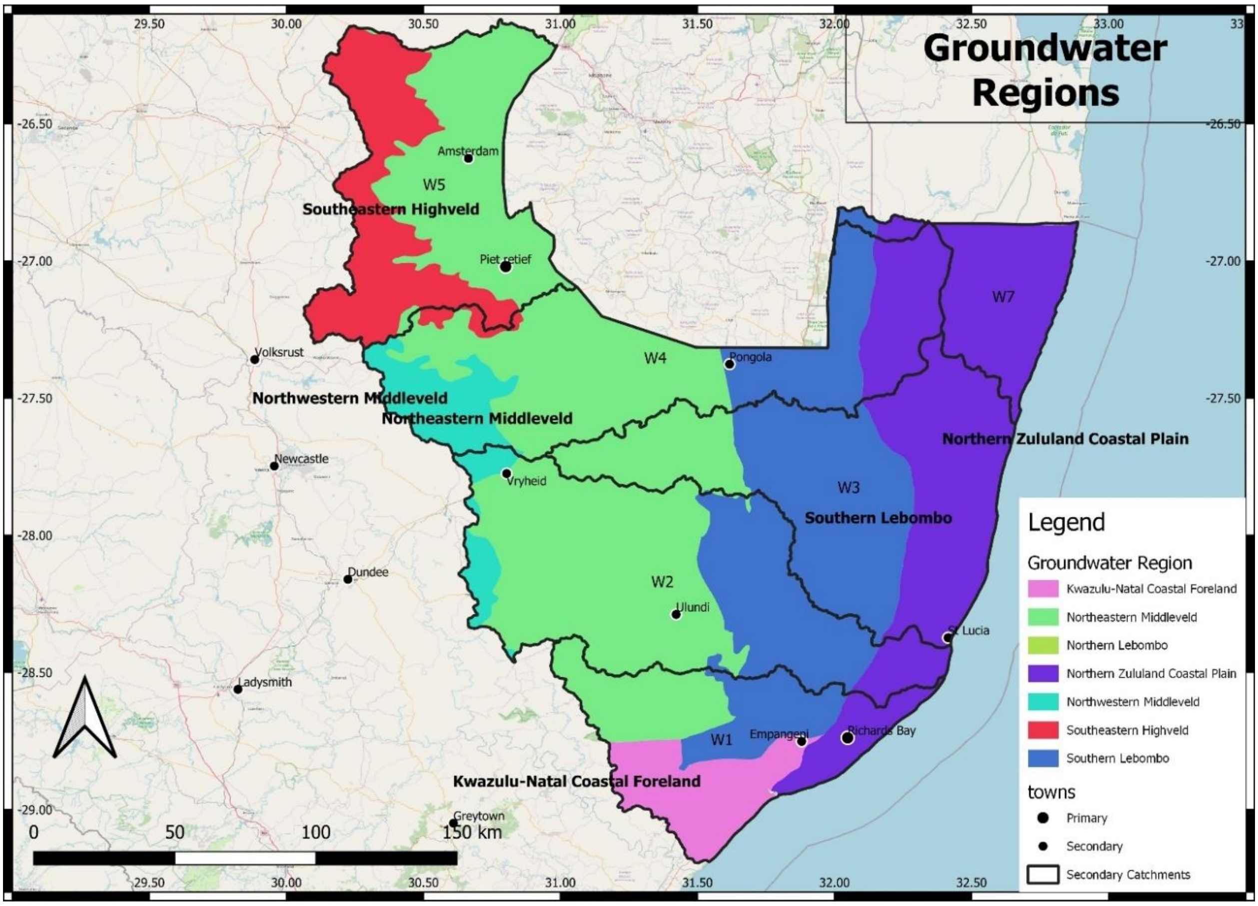

Figure 3.3 Local Municipalities

Table 3.1 Groundwater Regions of the Usutu to Mhlathuze Catchment

Groundwater Region	Description
Northern Zululand Coastal Plain	Primary aquifers of the Maputoland Group conglomerates, calcarenite, limestone and sand underlain by Cretaceous Zululand Group low permeability Formations
Southern Lebombo	Karoo SuperGroup shale, sandstone, mudstone, siltstone, basalt, rhyolite with inliers of Swazian metamorphics and granite, and Natal Group sandstone.
Northwestern Middleveld	Carbo-Triassic weathered and fractured aquifers from the Ecca Group to Drakensberg basalt. Consists of shale, sandstone, mudstone, siltstone, capped by basalt.
Kwazulu-Natal Coastal Foreland	A structural province consisting of Namibian age rocks of the Tugela terrane. These are the Ntingwe, Mfongozi and Tugela Groups. They are partially covered by Natal Group sandstone overlain by Dwyka tillite.
Southeastern Highveld	Compact Karoo and Ecca shales, sandstones, mudstones, dolerite.
Northeastern Middleveld	Swazian lavas and volcanics, sandstone, shale, conglomerate, Nondweni quartzite, schist and other metamorphics, various Swazian granites and gneisses, Randian gabbro, granite, quartzite, shale, Ordovician Natal Group sandstone and shale, Carboniferous Dwyka tillite and Ecca shale.

The distribution of Groundwater regions per secondary catchment is shown in **Table 3.2**.

Table 3.2 Groundwater Regions by Catchment

Catchment	Groundwater Region
W1	Kwazulu-Natal Coastal Foreland, Northern Zululand Coastal Plain, Southern Lebombo, Northeastern Middleveld.
W2	Northern Zululand Coastal Plain, Southern Lebombo, Northeastern Middleveld, Northwestern Middleveld.
W3	Northern Zululand Coastal Plain, Southern Lebombo, Northeastern Middleveld.
W4	Northern Zululand Coastal Plain, Southern Lebombo, Northeastern Middleveld, Northwestern Middleveld.
W5	Northeastern Middleveld, Southeastern Highveld.
W7	Northern Zululand Coastal Plain.

3.5 DRAINAGE

The study area is in Primary Region W, with the exception of Secondary region W6 (**Figure 3.4**). The main rivers draining the area and their Tertiary catchments are:

- W11 Matigulu
- W12 Mhlathuze
- W13 Mlalazi
- W21 White Mfolozi
- W22 Black Mfolozi
- W23 Mfolozi
- W31 Mkuze
- W32 Nyalazi, Mkuze, St Lucia
- W41 Bivane
- W42 Phongolo
- W43 Ngwavuma
- W44 Phongolo
- W45 Phongolo
- W51 Assegai
- W52 Hlelo
- W53 Ngwempisi
- W54 Usutu
- W55Mpuluzi
- W56 Lusuhwana
- W57 Suthu
- W70 No significant surface drainage

Parts of the W4 and W5 secondary catchments drain into or from Eswatini.

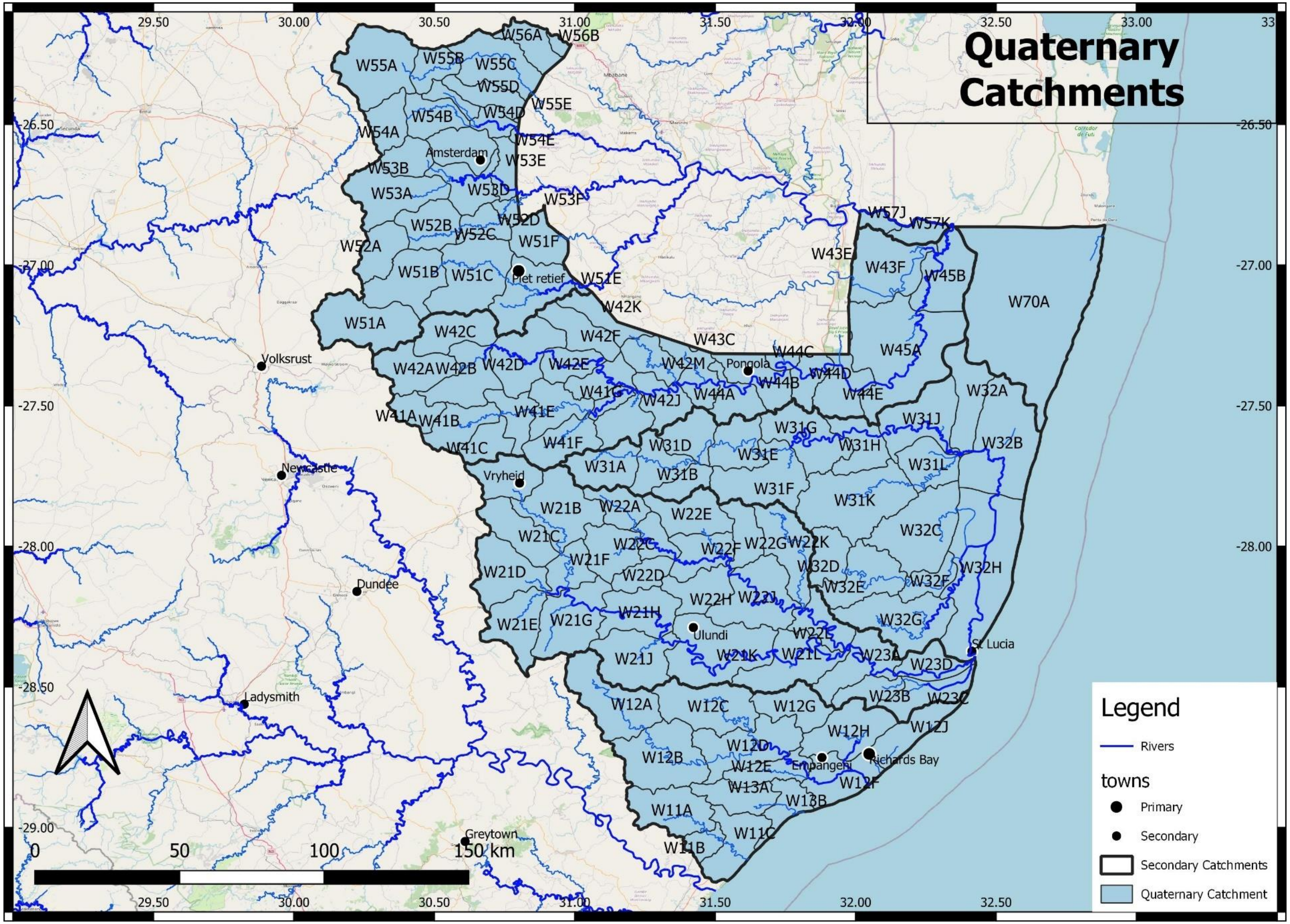

Figure 3.4 Quaternary catchments

3.6 CLIMATE TYPE

The climate type according to the Koeppen-Geiger classification system varies from west to east according to elevation.

The escarpment region above 1200 mamsl is classified as Cwb, or a sub-tropical highland climate with the coldest month averaging above 0 °C and all months with average temperatures below 22 °C, with at least four months averaging above 10 °C. There is 70% or more of average annual precipitation received in the warmest six months. Between 800 - 1200 mamsl, the climate is classified as Cwa, a humid subtropical climate with the coldest month averaging above 0 °C, at least one month's average temperature above 22 °C, 70% or more of average annual precipitation is received in the warmest six months.

The climate transitions to Cfb, a temperate oceanic climate towards the coast then Cfa, a humid subtropical climate on the coastal plain. In northern Zululand in catchment W70A the climate is Bsh, or hot semi-arid inland, and Aw tropical savannah climate

3.7 RAINFALL

Gridded rainfall shows that rainfall ranges from 500 mm/a inland in northern Zululand to 1500 mm/a on the coast near Richards Bay. Over most of the interior rainfall is 600 - 900 mm/a (**Figure 3.5**).

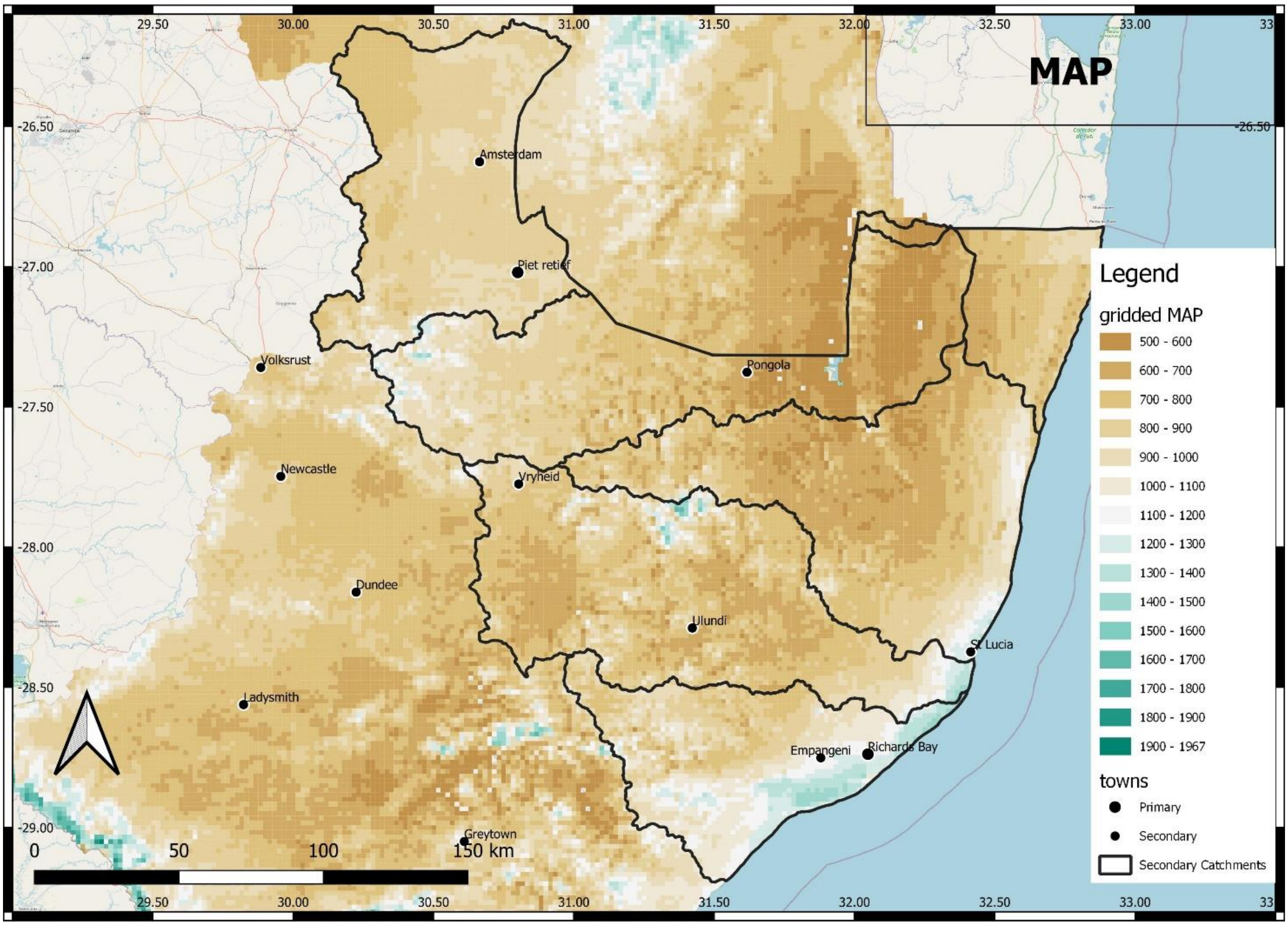

Figure 3.5 Mean Annual Precipitation

3.8 EVAPORATION

S-pan evaporation increases from 1300 mm/a at the escarpment and on the coast to 1600 mm/a in the interior (**Figure 3.6**).

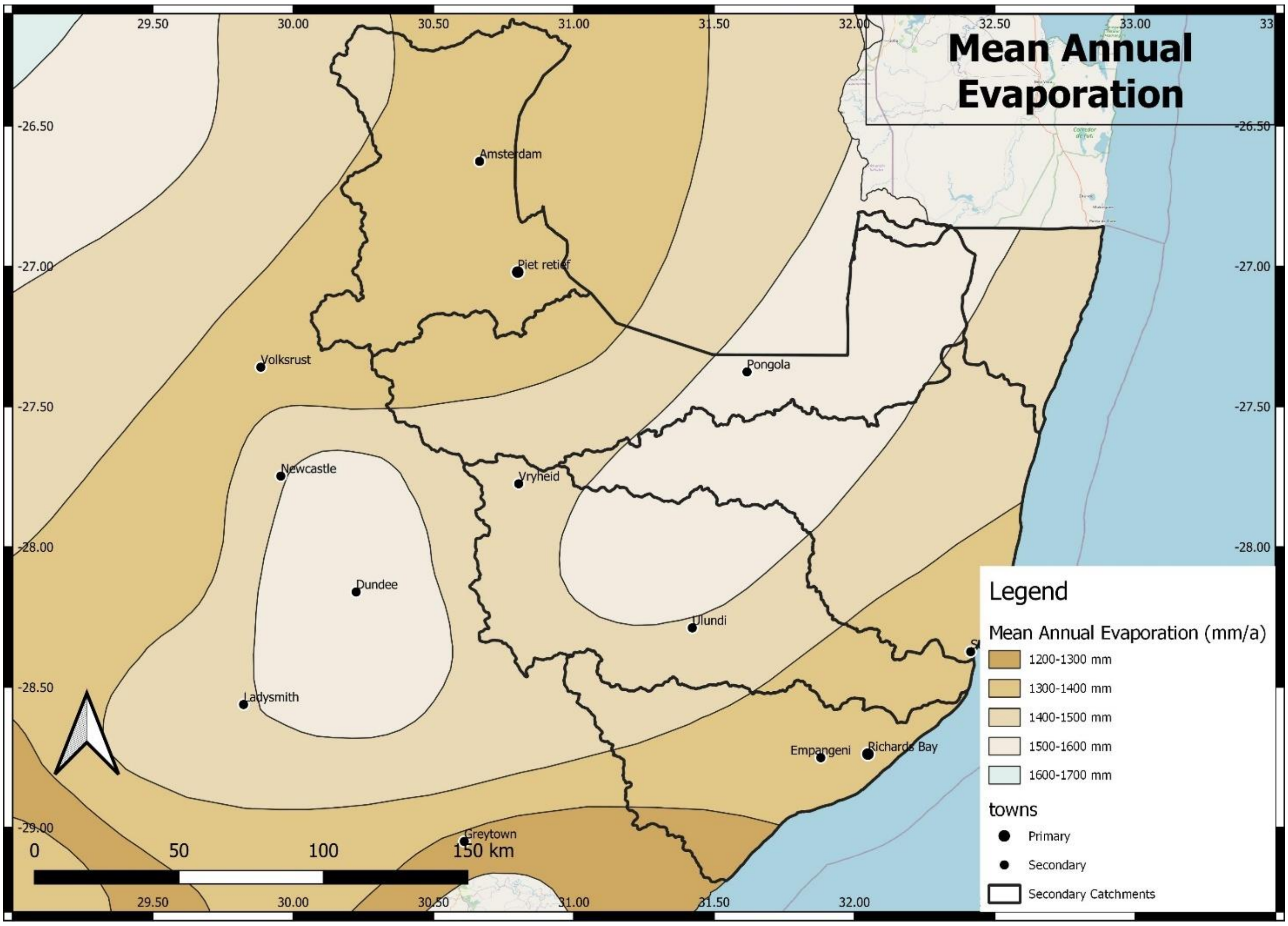

Figure 3.6 Mean annual S-pan Evaporation

3.9 POPULATION

The StatsSA 2021 midyear population estimate was obtained per Local Municipality (LM). These are shown in (**Table 3.3**). These were then allocated to the study area by the proportion of the LM area in the study catchments, and also allocated by quaternary catchment by proportional area to obtain a population estimate per quaternary catchment. The total population is 3.23 million.

Population densities range from less than 50 people to more than 10 000 people per km^2 (**Figure 3.7**). The population in dispersed settlements largely located on catchment boundaries (watersheds) and have limited access to piped water.

Table 3.3 Population

Municipality	Fraction on boreholes	Area in Catchments (km^2)	Population in catchments
Abaqulusi	0.116776	4149	250576
Big 5 Hlabisa	0.1	3256	124322
Chief Albert Luthuli	0.055166	877	32774
City of uMhlathuze	0.01854	1233	438537
Dr Pixley KaIsaka Seme	0.068771	964	69555
eDumbe	0.126093	1943	95683

Municipality	Fraction on boreholes	Area in Catchments (km^2)	Population in catchments
Emadlangeni	0.211588	813	9006
Jozini	0.094719	3442	210711
Mandeni	0.082304	321	93366
Mkhondo	0.179917	4880	209838
Msukaligwa	0.063184	2481	162677
Mthonjaneni	0.109609	1639	83338
Mtubatuba	0.072556	1739	216216
Nkandla	0.047785	520	34379
Nongoma	0.13628	2182	225785
Nquthu	0.272854	839	77787
Ulundi	0.081641	3247	219201
uMfolozi	0.122206	1299	153707
Umhlabuyalingana	0.296243	4386	183352
uMlalazi	0.074919	1723	184698
UPhongolo	0.107424	3110	150933
Total			**3226443**

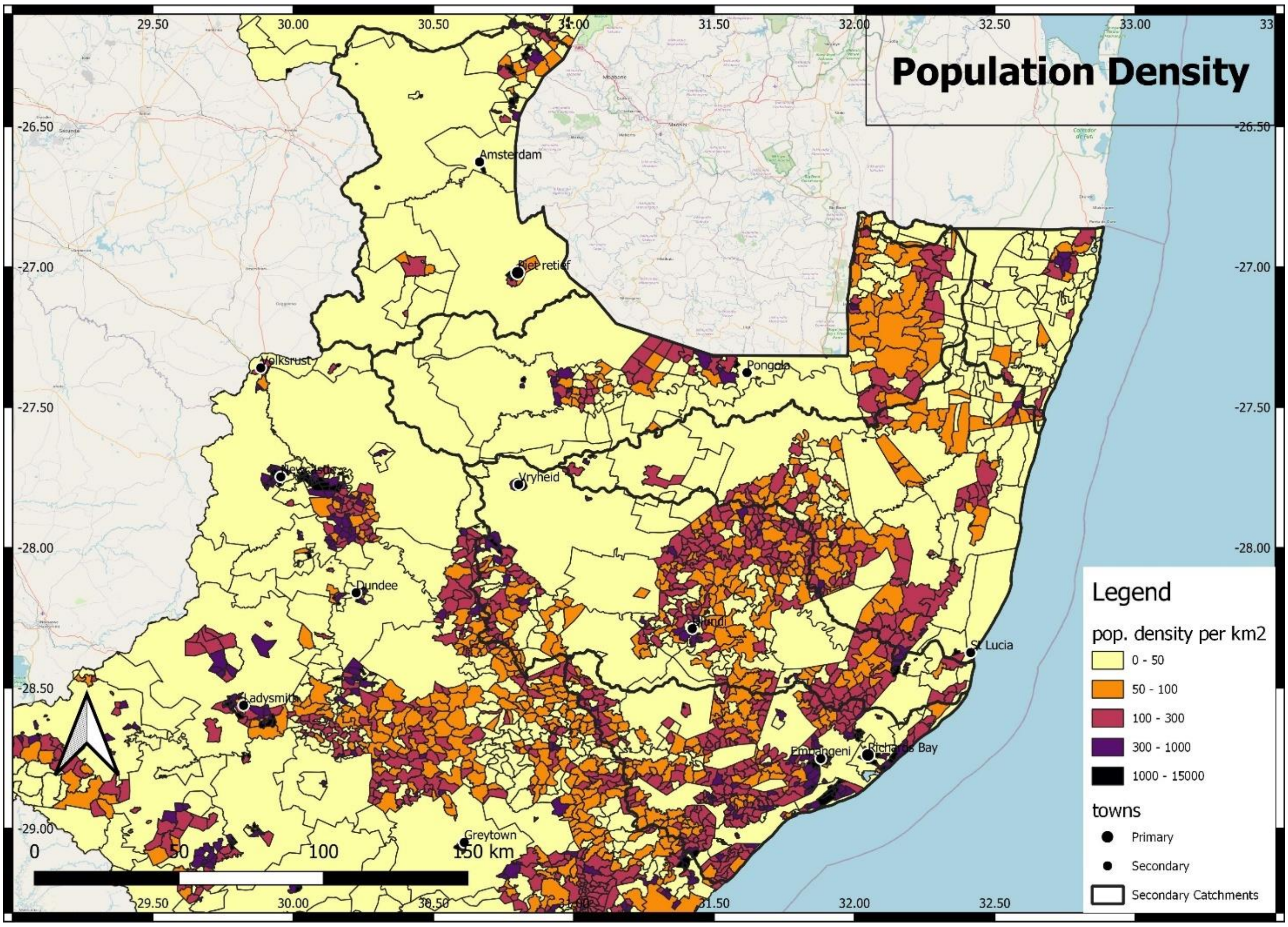

Figure 3.7 Population density

3.10 GEOLOGY

3.10.1 History

The stratigraphy of the study area is shown in **Table 3.6**. Geological maps are presented per secondary catchment in **Chapter 4**.

The basement of KwaZulu-Natal comprises of two distinct geological units; the Kaapvaal Craton and the Natal Metamorphic Province. These form separate continental blocks that have influenced the geological history, scenery and economic potential of the region. The study area is located largely on the Kaapvaal craton, which is found north of the Tugela River. It was formed when the Earth's basaltic crust was intruded by granite. The basalts are 3500 million years old and are preserved as greenstone fragments within the granite. Granite can be seen in the valley between Melmoth and Vryheid, and at quarries inland of Richards Bay. Basalt of the Nondweni Greenstone Belt south of Vryheid preserves ancient 'pillow structures'.

After formation, the Kaapvaal Craton was uplifted and exposed. This resulted in weathering, erosion, and transport of sediment into shallow basins. Both the Pongola Supergroup and the similar gold-rich Witwatersrand rocks were deposited in these early basins. The lower part of the Pongola Supergroup (Nsuze Group) is a succession of basalt, sandstone, and minor limestone. North of the Tugela Fault, the Pongola Supergroup rocks are gently dipping and relatively unaltered. Near the Tugela Fault, these rocks are folded and deformed during collision of the basement.

Overlying the Nsuze Group is a thick succession of sedimentary rocks called the Mozaan Group, which contains gold-bearing conglomerate. In northern KwaZulu-Natal and Swaziland, the Pongola Supergroup was intruded by granite. As these intrusions cooled, the surrounding rock was metamorphosed.

Approximately 1000 million years ago, subduction and collision along the southern margin of the Kaapvaal Craton produced the rocks of the Natal Metamorphic Province. The rocks were heated and deformed into a mountain range many thousands of kilometres long. Once plate collision with the Kaapvaal Craton had ceased, a long period of erosion exposed the deep mountain roots of granite and gneiss.

The first sedimentary sequence deposited on the new basement was the Cambrian to Ordovician Natal Group (490 million years ago). Structures preserved in these sandstones indicate that the sediments were transported and deposited by rivers that drained highlands to the north-east. Close to their source, in northern KwaZulu-Natal, deep valleys were infilled with thick accumulations of boulders and pebbles. Further south, the sediment is finer-grained and forms resistant sandstone cliffs.

The Dwyka Group forms the lowermost and oldest deposit in the Karoo Supergroup basin. The group consists mainly of diamictite (tillite), which is generally massive with little jointing, but may be stratified in places. Subordinate rock types are conglomerate, sandstone, - rhythmite and mudrock (both with and without dropstones). The Dwyka Group constitutes a very low-yielding fractured aquifer, and water is confined within narrow discontinuities like jointing and fracturing. They therefore tend to form aquitards rather than aquifers. Since the Dwyka sediments were mainly deposited under marine conditions, the water in these aquifers tends to be saline.

During the Karoo age, thick clay and silt beds were laid down in a large sea that occupied the Karoo basin. These sediments now form shales of the Pietermaritzburg Formation (Ecca Group). Overlying the shale is a thick sequence dominated by light grey sandstones, called the Vryheid Formation. These sandstones were deposited along ancient sandy shorelines, behind which lay vast swamplands with numerous Glossopteris plants. Vegetation buried in the swamps eventually formed coal, which is mined in the Vryheid area. Since the shales are very dense, they are often overlooked as significant sources of groundwater.

Dramatic outpourings of lava about 180 million years ago heralded the start of the Gondwana breakup. Remnants of these once extensive lavas now form the Lesotho Highlands and Lebombo Mountains. Crystallisation of magma within these fractures formed dolerite sills and dykes. Sills are horizontal intrusions of igneous rock. Dolerite sills are common throughout inland KZN in sedimentary rocks of the Karoo Supergroup. The final volcanic event produced rhyolite lava, which now forms the Lebombo mountains. These volcanic events were followed by uplift and faulting that eventually separated Africa and Antarctica. Evidence for this rifting is seen by the numerous faults concentrated along coastal KwaZulu-Natal. The largest of these - the Tugela Fault, has exploited the weakness between the Kaapvaal Craton and Natal Metamorphic Province.

The first deposits (Zululand Group) formed in the newly opened Indian Ocean were silt- and sandstone of Cretaceous age (145 - 65 million years ago). During the Cenozoic, sea levels began to fall from the high levels experienced during the Cretaceous. A series of large coast-parallel dune complexes developed along most of the KwaZulu-Natal coastline. In most areas, deep weathering of old dunes has produced dark red coloured sand called the Berea Red Sand. In more recent times, fluctuations in the sea level have continued to shape the KwaZulu-Natal coastline.

Table 3.4 Stratigraphy and lithology

Age	Label	Lithostratigraphy	Lithology
Quaternary	N-Qg	ALLUVIUM, COLLUVIUM, ELUVIUM, GRAVEL, SCREE, SAND, SOIL, DEBRIS	Alluvium, colluvium, eluvium, boulder gravel, gravel, scree, sand, soil, debris
Quaternary	N-Qm	MAPUTALAND GROUP	Sandy or clayey colluvial and alluvial sediments and palaeosols, red decalcified sand in inland dune cordons, conglomerate, coquina, calcarenite, redistributed sand
Cretaceous	Kst	ST LUCIA FORMATION	Fossiliferous glauconitic siltstone and fine-grained sandstone, conglomeratic towards the base
Cretaceous	Kmn	MZINENE FORMATION	Siltstone with shelly and concretionary layers
Cretaceous	Kmk	MAKATINI FORMATION	Sandstone, siltstone, conglomerate
Cretaceous	Kb	BUMBENI COMPLEX	Conglomerate, sandstone, siltstone, basalt, ash-flow tuff, rhyolite, trachyandesite, trachybasalt, minor granite
Jurassic	Jd	KAROO DOLERITE SUITE	Dolerite, minor ultrabasic rocks
Jurassic	Jmo	MOVENE FORMATION	Basaltic and subordinate rhyolite
Jurassic	Jj	JOZINI FORMATION	Rhyolite, some dacite, minor tuffs
Jurassic	Jl	LETABA SUBGROUP	Mafic volcanic rocks (tholeiites, picrite basalts and nephelinites)
Jurassic	Jc	CLARENS FORMATION	Massive white to cream, fine-grained sandstone, and reddish argillaceous sandstone with minor siltstone
Triassic	T-Je	ELLIOT FORMATION	Red and greenish grey mudstone, subordinate sandstone
Triassic	Tm	MOLTENO FORMATION	Alternating sandstone (pebbly in places), olive mudstone and dark grey shale (containing plant remains) with coal seams and thin conglomerate in places

Age	Label	Lithostratigraphy	Lithology
Permian	Pem	EMAKWEZINI FORMATION	Mudrock, sandstone, minor coal seams
Permian	Pbf	BALFOUR FORMATION	Greenish- to bluish-grey and greyish-red mudstone, siltstone, subordinate sandstone
Permian	Pvo	VOLKSRUST FORMATION	Shale, siltstone, minor sandstone
Permian	Pv	VRYHEID FORMATION	Fine- to coarse-grained sandstone, shale, coal seams
Permian	Pp	PIETERMARITZBURG FORMATION	Predominantly shale with thin siltstone and sandstone
Permian	Pe	ECCA GROUP	Shale, carbonaceous shale, siltstone, tuff, chert, phosphatic nodules, sandstone
Carboniferous	C-Pd	DWYKA GROUP	Diamictite, varved shale, siltstone, mudstone with dropstones, fluvioglacial gravel and sandstone
Ordovician	On	NATAL GROUP	Generally reddish, feldspathic, and micaceous sandstone with subordinate quartz arenite, mudrock, granulestone and conglomerate
Namibian	STos	ORIBI GORGE SUITE	Pyroxene granulite, garnet-bearing granulite
Namibian	STha	HALAMBU GNEISS	Fine- to medium-grained, granodioritic to granitic gneiss
Namibian	STbr	BULLS RUN COMPLEX	Alkaline/peralkaline syenitic and minor carbonatitic gneisses
Namibian	EC-STt	MATIGULU GROUP	Biotite-feldspar and subordinate biotite-hornblende-feldspar gneiss, sillimanite-garnet-biotite and quartz-biotite-garnet gneiss, amphibolite, subordinate quartzite, and dolomitic marble lenses
Namibian	ECf	MFONGOSI GROUP	Schist, subordinate amphibolite, quartzite, and iron-formation
Namibian	EC-STu	TUGELA GROUP	Amphibolite, gneiss, schist, metapelite, quartzite, magnetite quartzite, marble, serpentinite
Namibian	ECmf	TUGELA-RAND LAYERED SUITE, MACALA, HLOBANE, MLALAZI, SITHILO, NGOYE, MAMBULU COMPLEXES	Layered association of medium-grained mafic and ultramafic rocks (wehrlite, gabbronorite, clinopyroxenite, bronzitite, lherzolite, troctolite, serpentine, websterite, very minor chromitite), metagabbro, magnetite microgranite, riebeckite-bearing granite
Namibian	EC-STp	MAPUMULO GROUP	Streaky pink quartz-feldspar gneiss and migmatite, metapelitic gneiss, subordinate amphibolite, mafic granulite, calc-silicate rocks
Vaalian	Rd	DIABASE	Magnesium-rich tholeiite, melanorite
Randian	ANnz	NZIMANE GRANITE	Coarse-grained, porphyritic biotite granite/granodiorite, fine- to medium-grained granite.
Randian	ANmw	MSWATI SUITE	Coarse-grained, generally porphyritic granite
Randian	ANkw	KWETTA GRANITE	Coarse-grained, porphyritic rapakivi granite/granodiorite
Randian	ANdl	DUIVELSKLOOF LEUCOGRANITE	Leucocratic biotite granite, minor gneissic biotite granodiorite
Randian	AMte	THOLE SUITE	Harzburgite, pyroxenite, gabbronorite
Randian	AMse	SPEKBOOM GRANITE	Medium to coarse-grained, unfoliated granite
Randian	AMpz	MPULUZI GRANITE	Leucocratic pottasic granite, slightly porphyritic
Randian	AMpr	PIET RETIEF GABBRO SUITE	Quartz gabbro, sporadically developed ferrogabbro
Randian	AMp	POTASSIC GRANITOIDS (HEERENVEEN PLUTON)	Coarse porhyritic trondjemite, medium-grained granodiorite, quartz monzonite
Randian	AMng	NSELENI GNEISS	Fine- to medium-grained, strongly foliated,

Age	Label	Lithostratigraphy	Lithology
			leucocratic, granodioritic to tonalitic gneiss
Randian	AMho	HLELO GRANITE SUITE	Microgranite, commonly granophyric
Randian	AMhl	HLAGOTHI SUITE	Gabbro, leucogabbro
Randian	AM-APt	TONALITE AND TRONDHEMITE GNEISS, MIGMATITIC (STENTOR, ROOIHOOGTE, KAAP VALLEY, NELSHOOGTE, BADPLAAS, STOLZBURG, THEESPRUIT, UITGEVONDEN, HONINGKLIP, SCHAPENBURG, BATAVIA, NEDERLAND, UITGEVONDEN, WEERGEVONDEN PLUTONS)	Tonalite-trondhjemite and granodiorite gneiss, with migmatite with mafic and felsic xenoliths
Randian	AM-APg	UNDIFFERENTIATED TONALITE, GRANITE AND GNEISS	Potassic gneiss and migmatite, strongly porphyroblastic
Randian	AMam	AMSTERDAM FORMATION	Dark grey dacite, dacitic ash-flow tuffs, subordinate pyroclastic breccias, rhyolite
Randian	AMmo	MOZAAN GROUP	Quartzite, volcaniclastic rocks and shale, phyllite, feldspathic protoquartzite and orthoquartzite, shale, iron-formation, conglomerate, andesitic rocks, pyroclastics
Randian	AMnz	NSUZE GROUP	Basalt, amygdaloidal basalt, subordinate andesite, rhyolite, pyroclastic rocks, epiclastic volcanic breccia, tuff, lapilli and bomb tuff, minor quartzite, phyllite, iron-formation, gritstone, shale, stromatolitic dolomite, hornfels
Archean	APts	TSAWELA GNEISS	Mesocratic hornblende-biotite tonalite gneiss
Archean	APno	NONDWENI GROUP	Schistose basaltic metavolcanic rocks (amygdaloidal in places), quartzite, chert, mica schist, iron-formation, calc-silicate rocks
Archean	APon	ONVERWACHT GROUP	Grey, medium- to coarse-grained biotite-hornblende gneiss
Archean	APem	EMPANGENI METAMORPHIC SUITE	Foliated melanocratic granoblastites, gneisses, orthopyroxenite and enderbitic granolites
Archean	APdc	COMMONDALE, DE KRAALEN, ASSEGAAI, DWALILE METAMORPHIC SUITES	Mafic to ultramafic schist, metabasalt, banded iron-formation, quartzite, quartzitic chert, quartz-sericite chert, calc-silicate rocks
Archean	AP-AMmd	UNDIFFERENTIATED MAFIC AND ULTRAMAFIC ROCKS	Amphibolite, serpentinite, talc, schist, diorite, gabbro, pyroxenite
Archean	APag	ANHALT GRANITOID SUITE	Leucocratic biotite granite, porphyritic

3.10.2 Structure

Two major structural events affect the geology. The first was the Kibaran orogeny some 1 billion years ago, during which the Natal Metamorphic Province was formed, and widespread metamorphism occurred. This event was marked by thrusting from south to north. In the study area it is expressed as the Tugela Fault and associated E-W Thrust faults in the south of W1 catchment. This fault approximates the northern margin of the Natal Metamorphic Province.

The second was the break-up of Gondwanaland. This event caused extensive faulting, such as tilted fault blocks and horst and graben structures. Most of the blocks are tilted seaward. The faults have a conjugate shear fracture pattern and are oriented N-S and SW-NE. All of the faulting is of the tensional normal fault type (**Figure 3.8**).

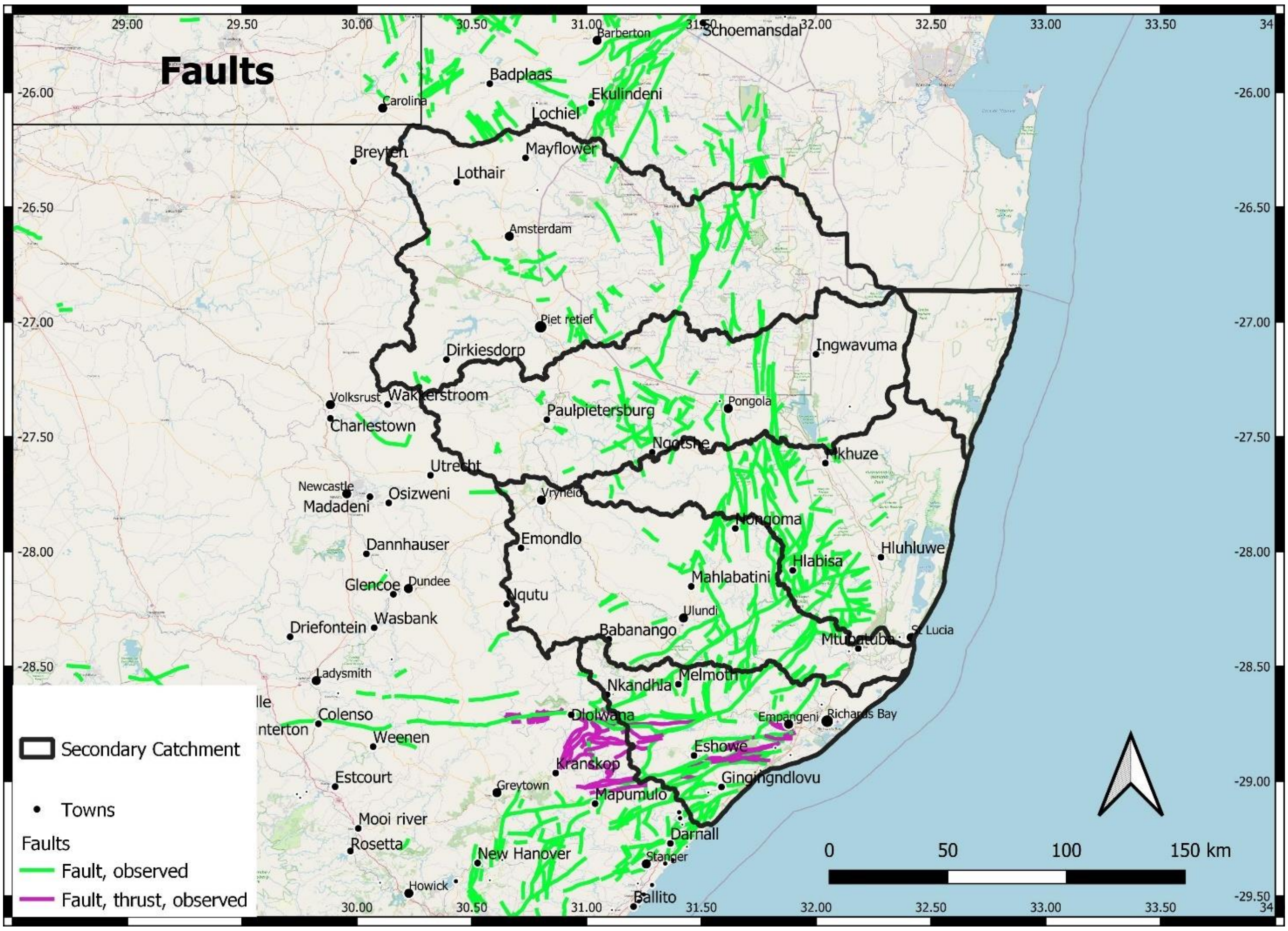

Figure 3.8 Faults

3.11 AQUIFER TYPES

The western or inland portion of the Usutu to Mhlathuze Catchment, and a limited portion south of the Zululand Coastal Plain at Mtunzini comprises hard rock fractured and weathered aquifers with secondary porosity. Faults, joints, and intrusive Karoo dolerite sheet and dyke contacts are zones of significant groundwater occurrence. These fractured and weathered aquifers include deeply weathered granite and granite-gneiss rocks, and the rocks of the Karoo Supergroup. The Natal Group and the Dwyka Tillites form fractured aquifers with little storage.

By contrast, the aquifers of the Zululand Coastal Plain are of the primary porosity or intergranular type. The Cretaceous siltstones which underlie the coastal plain at depth are an extremely poor groundwater aquifer. The minimal groundwater present is generally highly saline.

Two primary porosity aquifers underlie portions of the coastal plain. Immediately overlying the Cretaceous sediments, but subject to variable thickness and erratic areal distribution, are the karst-weathered shelly coquina and calcarenites of the Mio-Pliocene age Uloa and Umkwelane Formations, which constitute the 'deep' coastal plain aquifer. It is generally 30 to 40 metres below ground level (mbgl). Where present, the sandy lower portion of the overlying Kosi Bay Formation can contribute materially to this Aquifer as a leaky layer. By contrast, the shallow coastal plain aquifer comprises saturated fine sand at the base of the surficial Kwambonambi Formation, and occurs at 1 - 6 mbgl, perched above the much less permeable and more clayey Kosi Bay and Port Durnford Formations. It is not present over the western drier portions of the coastal plain.

3.12 SURFACE GROUNDWATER INTERACTIONS

In terms of groundwater-surface water interaction, several aspects need to be highlighted:

- Baseflow from high-lying springs as interflow.
- Baseflow from aquifers as groundwater baseflow.
- Interaction of groundwater and lakes.
- Wetlands.

It should be noted that abstraction from lakes and wetlands largely dependent on groundwater is a groundwater use, and abstraction of groundwater from aquifers could deplete groundwater baseflow to these systems.

The interaction of groundwater with surface water depends on the physiography, geology, and climate setting of the region. The factors of importance include topography, aquifer type, groundwater levels, rainfall and recharge, and permeability.

Interactions can be expressed as rivers (or lakes) gaining baseflow from groundwater, rivers losing water to groundwater, or riverine vegetation evapotranspirating groundwater in shallow groundwater regions.

Hydrographs indicate where baseflow exists. Hydrographs can consist of three components: direct surface runoff, interflow from temporary perched or high lying springs that respond rapidly to rainfall but are above the regional groundwater level, and groundwater baseflow from the saturated zone that can be impacted by groundwater abstraction. The term baseflow is the delayed flow component from the latter two sources. Interflow is generally not affected by groundwater abstraction since it occurs in high lying areas separated from the regional aquifer by impermeable layers.

4 GROUNDWATER RESOURCES IN W1 MHLATHUZE

4.1 GEOLOGY

The coastal margin of the catchment is underlain by sediments of the Maputoland Group (**Figure 4.1**). Cretaceous rocks of the Zululand Group only outcrop near Richards Bay. Letaba Basalts and other Karoo Supergroup rocks are found to the west and on the northwest watershed, where Pietermaritzburg shale outcrops. Dwyka tillite covers large areas at the margins of Ecca Group outcrops. A large part of the central part of the catchment is underlain by Natal Group sandstone. Natal Metamorphic Province rocks bisect the Karoo basin in the south and cover significant tracts of the southern margin. Intrusive granite gneiss underly large portions of the part of the basin and separate the coastal sands from the Karoo basin in the northeast.

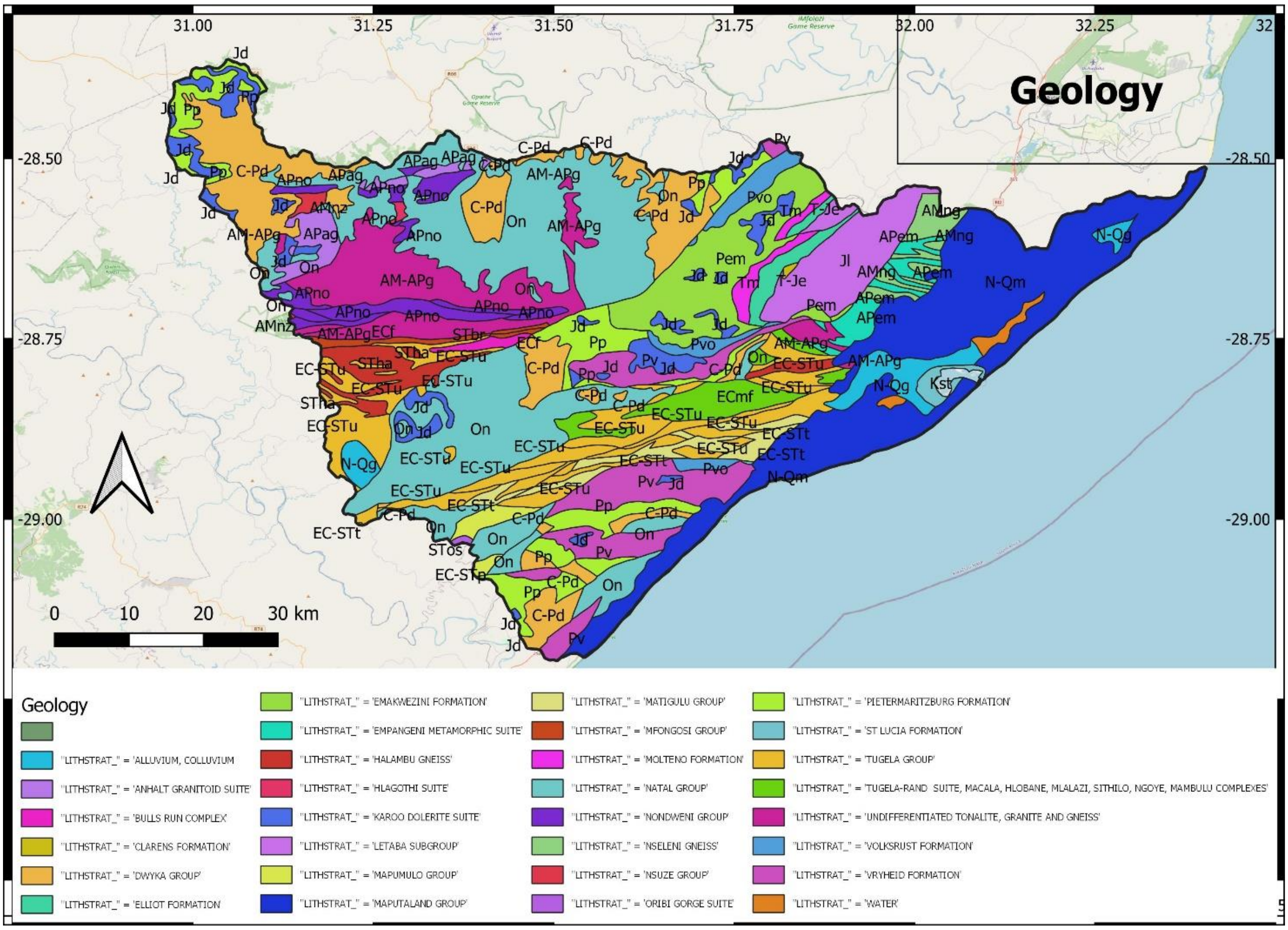

Figure 4.1 Geology of W1

4.2 AQUIFER TYPES

The coastal margin consists of a moderately yielding intergranular aquifer of less than 2 l/s. The remainder of the catchment consists of low to moderately yielding fractured or fractured and weathered aquifers, depending on lithology (**Figure 4.2**).

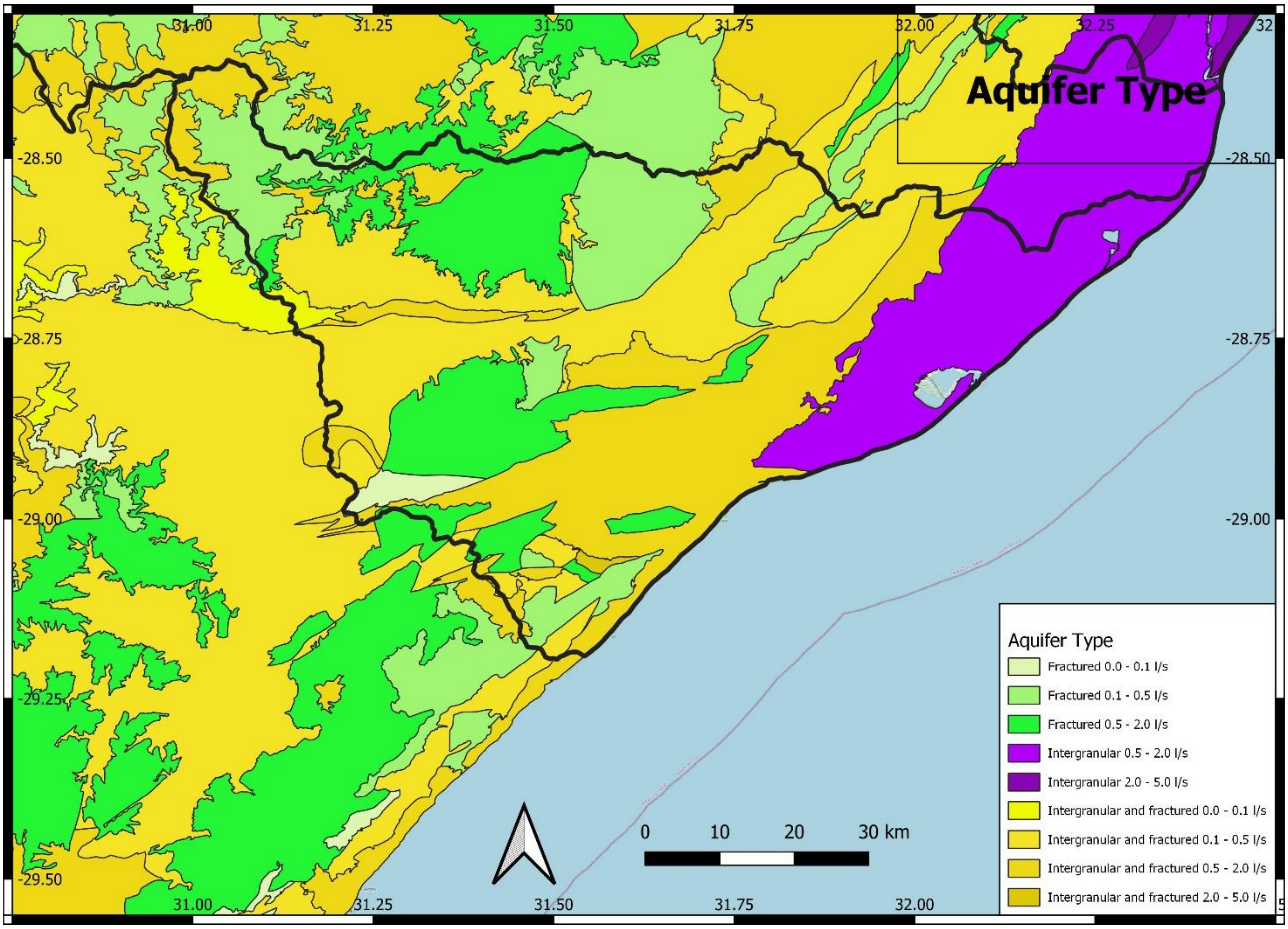

Figure 4.2 Aquifer types in W1

4.3 BOREHOLE YIELD

Median yields of 0.8 - 2 l/s are found in the Northern Zululand Coastal Plain. Moderate yields of above 1 l/s are also encountered in the Kwazulu-Natal Coastal Foreland except where it is underlain by Natal Group sandstone. The Southern Lebombo has low yields (< 0.6 l/s). The Northeastern Middleveld has moderate yields of 0.8-1 l/s, except where underlain by Natal Group sandstone (**Figure 4.3**). The distribution of yields by catchment is shown in **Table 4.1**.

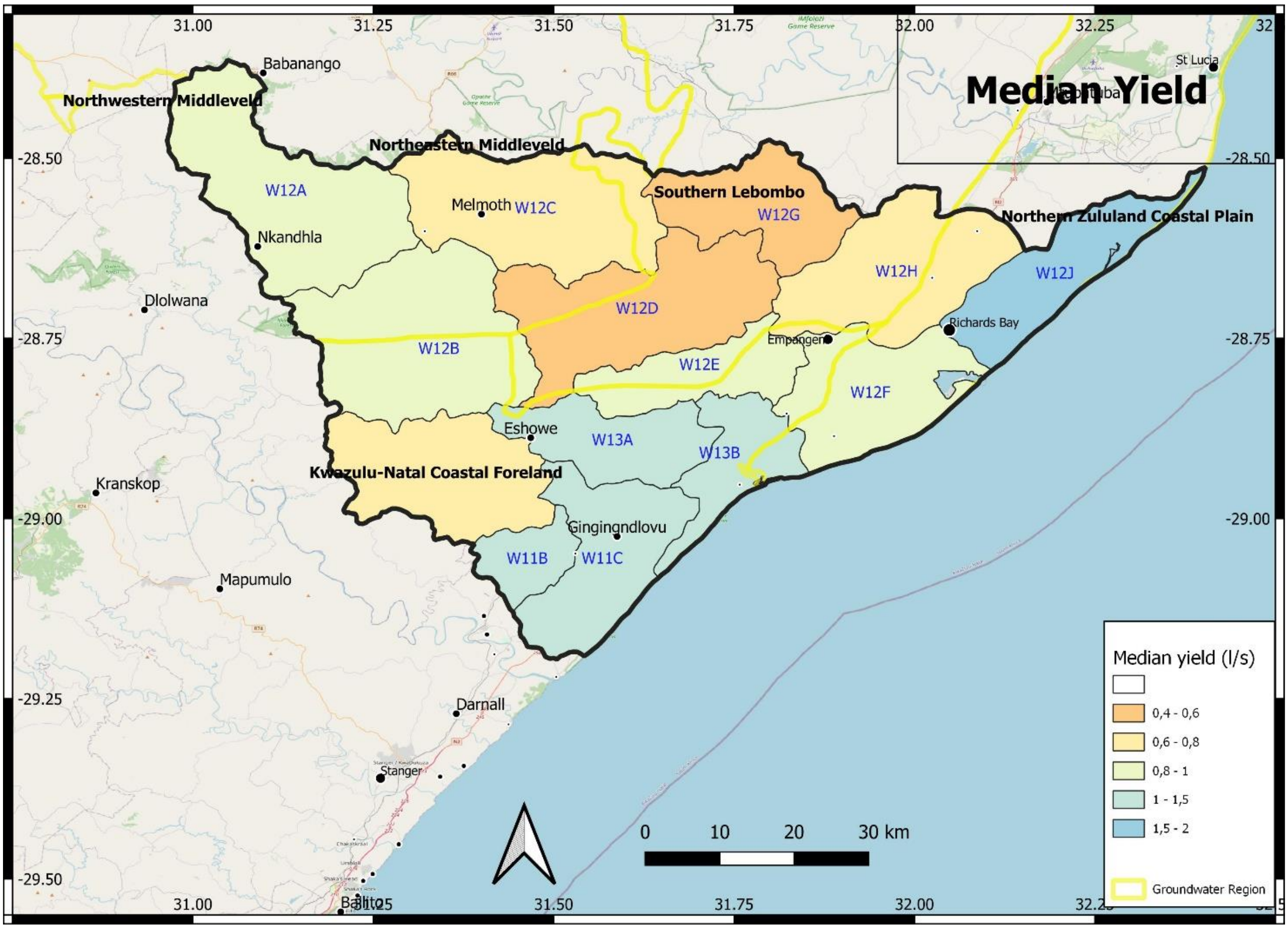

Figure 4.3 Median yields in W1

Table 4.1 Borehole yield distribution in W1

Quaternary (Quat)	Average (l/s)	Median (l/s)	% > 0.5 l/s	% > 2 l/s	% > 5 l/s
W11A	1.30	0.70	67.3	18.7	3.3
W11B	1.70	1.40	92	36.1	0
W11C	1.66	1.26	81.6	32.7	0.9
W12A	1.64	0.99	70	24.5	6.7
W12B	1.18	0.90	62.7	18.6	0
W12C	1.88	0.76	79	26.4	4.6
W12D	0.89	0.49	49.5	10.2	1.9
W12E	1.17	0.86	71.8	16.3	0
W12F	2.20	0.87	71.5	13.8	9
W12G	0.78	0.46	48.4	6.9	1.1
W12H	0.94	0.68	64	10.7	0
W12J	5.72	1.63	83.4	44.5	21.9
W13A	1.75	1.06	73.5	22.5	4.1
W13B	1.77	1.28	72.5	40.5	0

4.4 RECHARGE

Recharge can be considered in terms of:

- Total recharge, which drives baseflow and recharges aquifers.
- Groundwater recharge which recharges the aquifers and is available to boreholes. This excludes the recharge that generates interflow from high-lying springs.

Recharge is shown in **Figures 4.4** and **4.5**. Recharge declines from over 200 mm/a on the Northern Zululand Coastal Plain to 50 - 60 mm/a inland. Aquifer recharge is 100 - 150 mm/a on the coastal plain and only 20 - 40 mm/a inland.

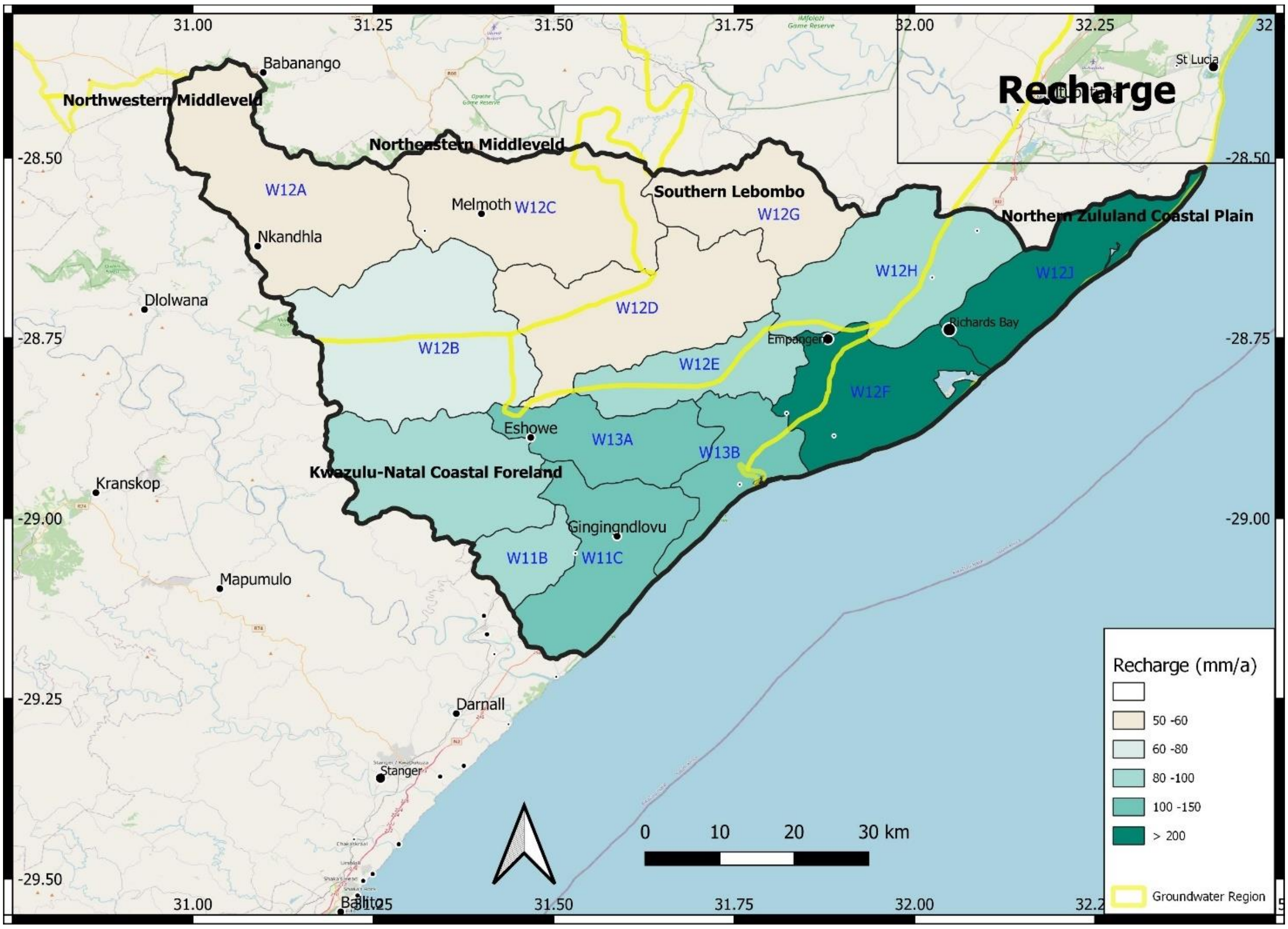

Figure 4.4 Recharge in W1

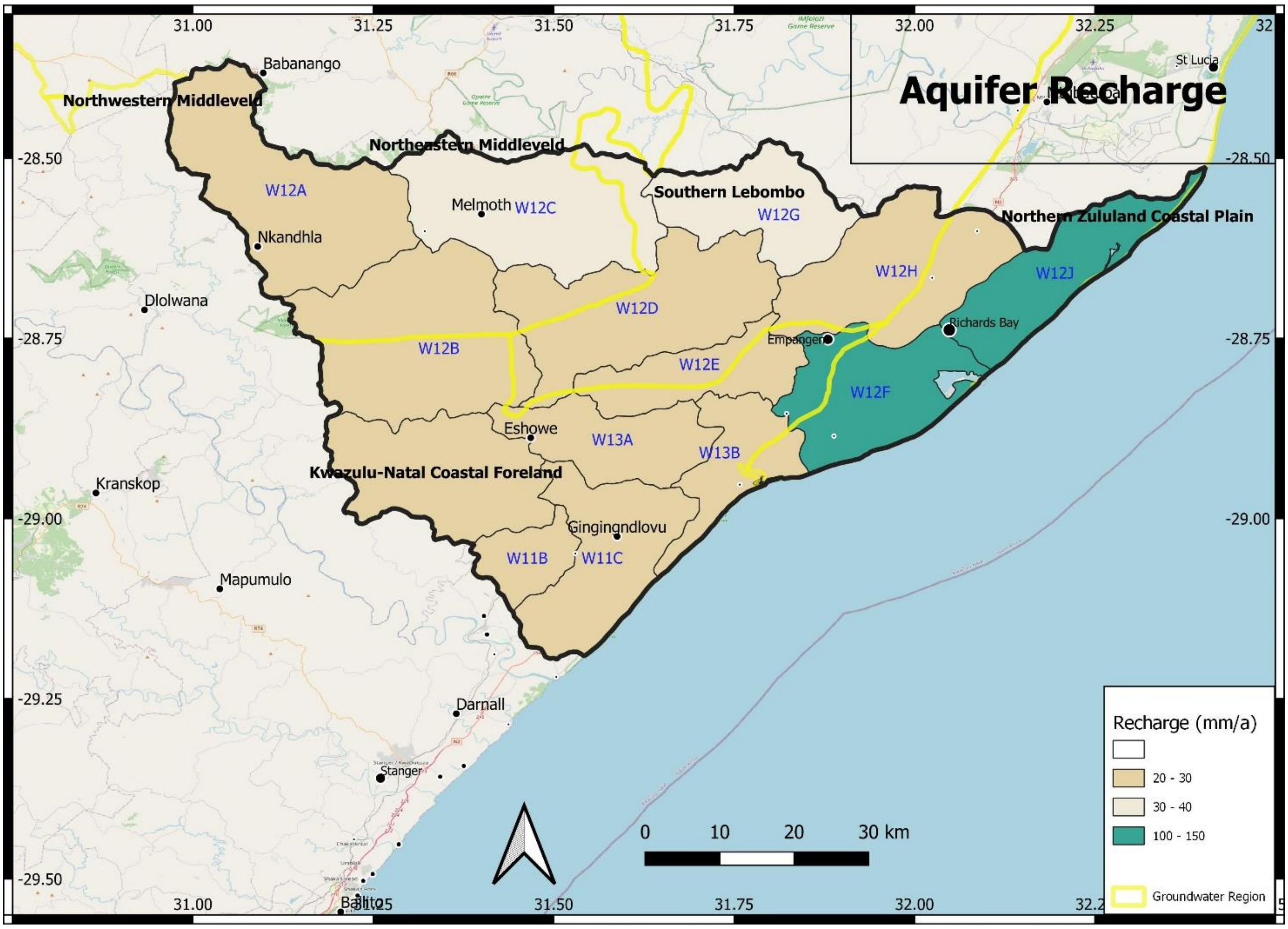

Figure 4.5 Aquifer recharge in W1

4.5 BASEFLOW

Two factors are of importance when considering baseflow. Total baseflow, provides the volume of water available to sustain low flows, and groundwater baseflow which is the volume emanating from the regional aquifers and is subject to depletion by groundwater abstraction. The percentage that is ground baseflow provides an index of vulnerability of the low flows in rivers to groundwater abstraction. Baseflow and the percentage of baseflow of groundwater origin is shown in **Figures 4.6** and **4.7**.

Baseflow generation decreases inland from 135 mm/a to 40 mm/a. On the Middleveld and Lowveld, 30 - 40% of baseflow is from groundwater. The percentage declines towards the coast and in the more rugged Kwazulu-Natal Coastal Foreland.

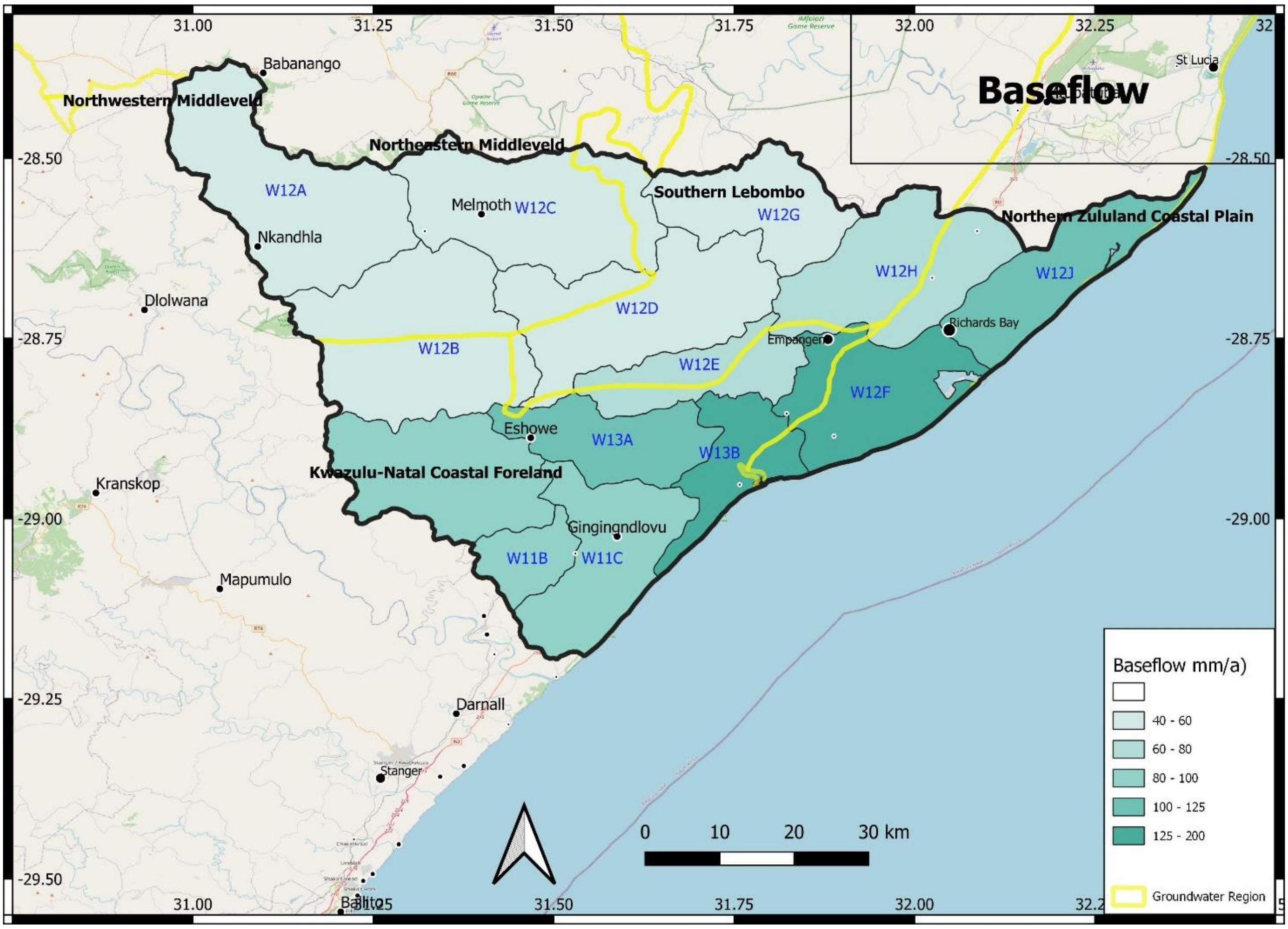

Figure 4.6 Baseflow in W1

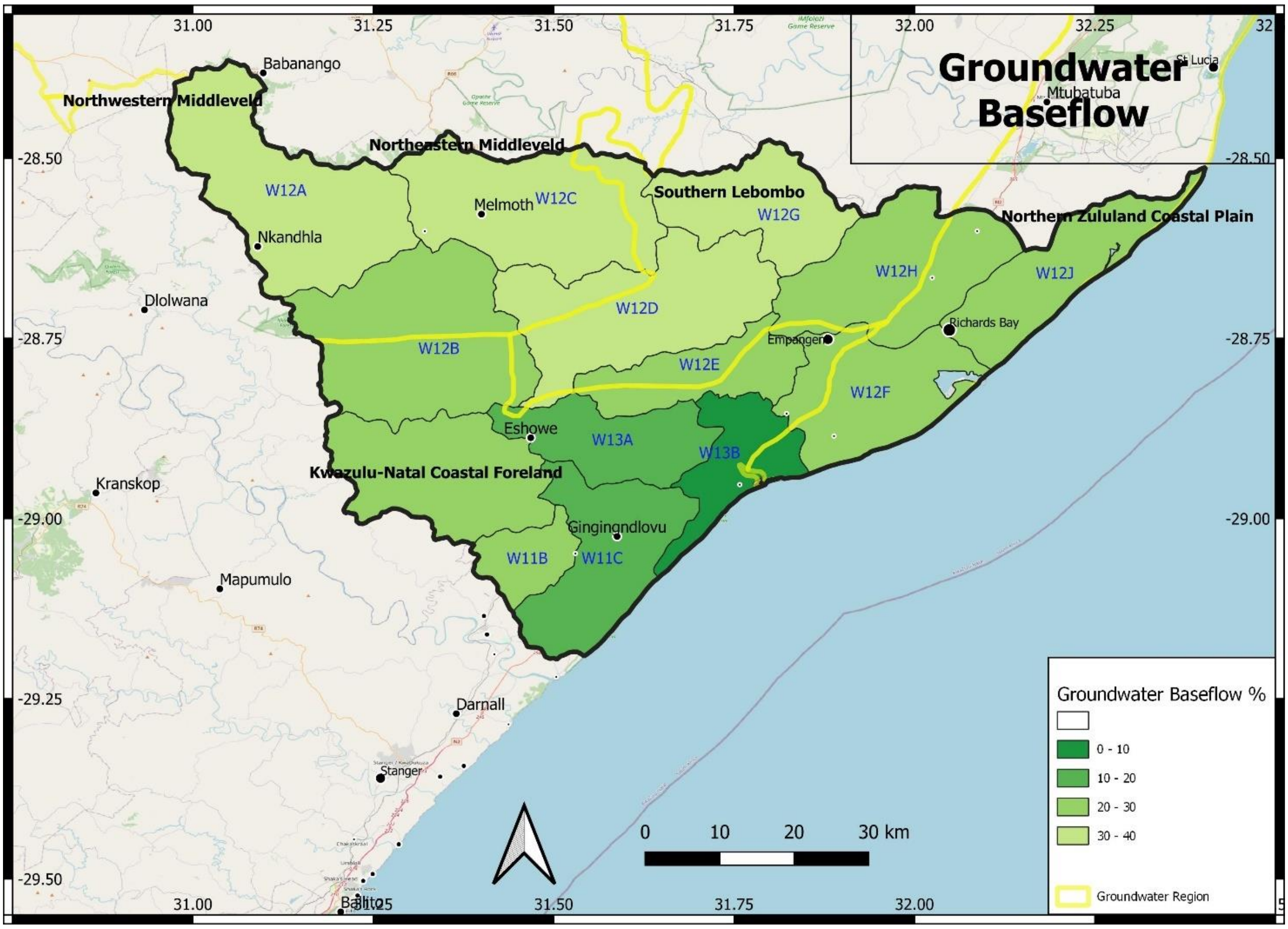

Figure 4.7 Groundwater baseflow as a percentage of total baseflow in W1

4.6 USE

Groundwater use is listed in **Table 4.2**. 1.76 Mm³/a of use in catchment W12H is actually from Lake Nsezi.

Table 4.2 Groundwater use in W1

Quat	Irrigation (Mm³/a)	Industrial (Mm³/a)	Mining (Mm³/a)	Water Supply (Mm³/a)	Livestock (Mm³/a)	Schedule 1 (Mm³/a)	Total (Mm³/a)
W11A	0.1826	0.0000		0.0003	0.0000	0.0863	0.2692
W11B					0.0013	0.0594	0.0607
W11C	0.0900	0.0018		0.0000	0.0078	0.1319	0.2315
W12A	0.0000	0.0000		0.0900	0.0084	0.0592	0.1576
W12B	0.0400	0.0000		0.0000	0.0000	0.0816	0.1216
W12C	0.0326	0.0000		0.0000	0.0001	0.0696	0.1022
W12D	0.0000	0.0000		0.0000	0.0066	0.0858	0.0924
W12E					0.0004	0.0423	0.0427
W12F	0.3600	0.0000		0.0000	0.0028	0.0557	0.4185
W12G	0.0040	0.0000		0.0000	0.0021	0.0578	0.0639
W12H	0.2300	0.0003		1.7832	0.0029	0.1087	2.1251
W12J					0.0000	0.0931	0.0931
W13A	0.1675	0.0000		0.0000	0.0000	0.0485	0.2160
W13B	0.0000	0.0015		0.0000	0.0058	0.0384	0.0456
Total	**1.1067**	**0.0035**	**0.0000**	**1.8734**	**0.0382**		**4.0402**

4.7 GROUNDWATER RESOURCES

The groundwater recharge, exploitation potential and use for the W1 Catchment is shown in **Table 4.3**

Table 4.3 W1 Catchment: Groundwater recharge and exploitation potential

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exploitation potential (Mm^3/a)	GRA II Exploitation potential (Mm^3/a)	Harvest potential (Mm^3/a)	Use (Mm^3/a)
W11A	445.15	39.56	12.80	3.12	12.23	34.40	0.2692
W11B	126.82	11.00	3.73	1.28	4.51	5.30	0.0607
W11C	383.02	40.52	10.68	3.82	17.24	8.60	0.2315
W12A	623.31	27.23	18.91	4.64	7.48	21.29	0.1576
W12B	656.33	35.93	18.81	4.96	10.84	34.38/	0.1216
W12C	570.07	23.38	17.82	4.22	5.94	10.52	0.1022
W12D	568.94	25.02	13.32	3.77	8.01	27.30	0.0924
W12E	248.59	20.45	6.71	1.95	6.46	7.02	0.0427
W12F	387.31	53.37	45.38	20.70	18.68	84.99	0.4185
W12G	326.36	14.24	10.01	3.19	4.71	4.33	0.0639
W12H	484.57	44.68	13.02	15.46	14.98	37.23	2.1251
W12J	332.85	46.59	42.57	25.19	22.70	117.31	0.0931
W13A	275.84	28.35	6.47	2.04	9.76	12.16	0.2160
W13B	222.76	31.00	4.75	3.30	10.26	10.42	0.0456

4.8 GROUNDWATER QUALITY

4.8.1 Electrical conductivity

The distribution of Electrical conductivity (EC) is shown in **Figure 4.8** and **Table 4.4**. Groundwater is largely of Class 0 inland and 0 - 1 on the coast. Poor water quality of Class 2 - 4 exists in the lower Mhlathuze (W12D-G). Boreholes in the Emakwezini formation are of Class 2 - 4 in W12G and W12D.

Table 4.4 Distribution of EC in mS/m by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W11A	25.94	40.48	52	68.76	226	0.958
W11B	156	288	420	432	433	0.19
W11C	63.12	90.44	142.8	198.2	374	0.631
W12A	6.96	7.82	10.46	20.84	49.4	1
W12B	15.8	38.8	48.7	60.8	154	0.981
W12C	25.16	31.72	47.24	70.64	446	0.939
W12D	15.48	25.66	81.32	235	714	0.685
W12E	111.06	186.24	308.6	524	786	0.329
W12F	32.4	43.16	55.38	90.16	1033.3	0.913
W12G	117.6	186	301	516	1480	0.283
W12H	72.48	97.24	121.5	169	582	0.697
W12J	44.2	46.3	54	64.4	68.5	1
W13A	28.2	44.84	71.26	111.78	223	0.891
W13B	35.1	38.3	53.4	70.4	100.9	1

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W11A	56	11	3	0	0	I
W11B	1	0	1	4	0	III
W11C	5	7	5	3	0	III
W12A	5	0	0	0	0	I
W12B	17	3	1	0	0	I
W12C	31	6	1	2	0	III
W12D	28	7	9	7	1	III
W12E	1	2	1	2	2	III
W12F	13	4	1	0	1	III
W12G	2	11	14	7	12	III
W12H	12	29	15	2	1	III
W12J	6	0	0	0	0	I
W13A	14	7	3	0	0	II
W13B	12	4	0	0	0	I

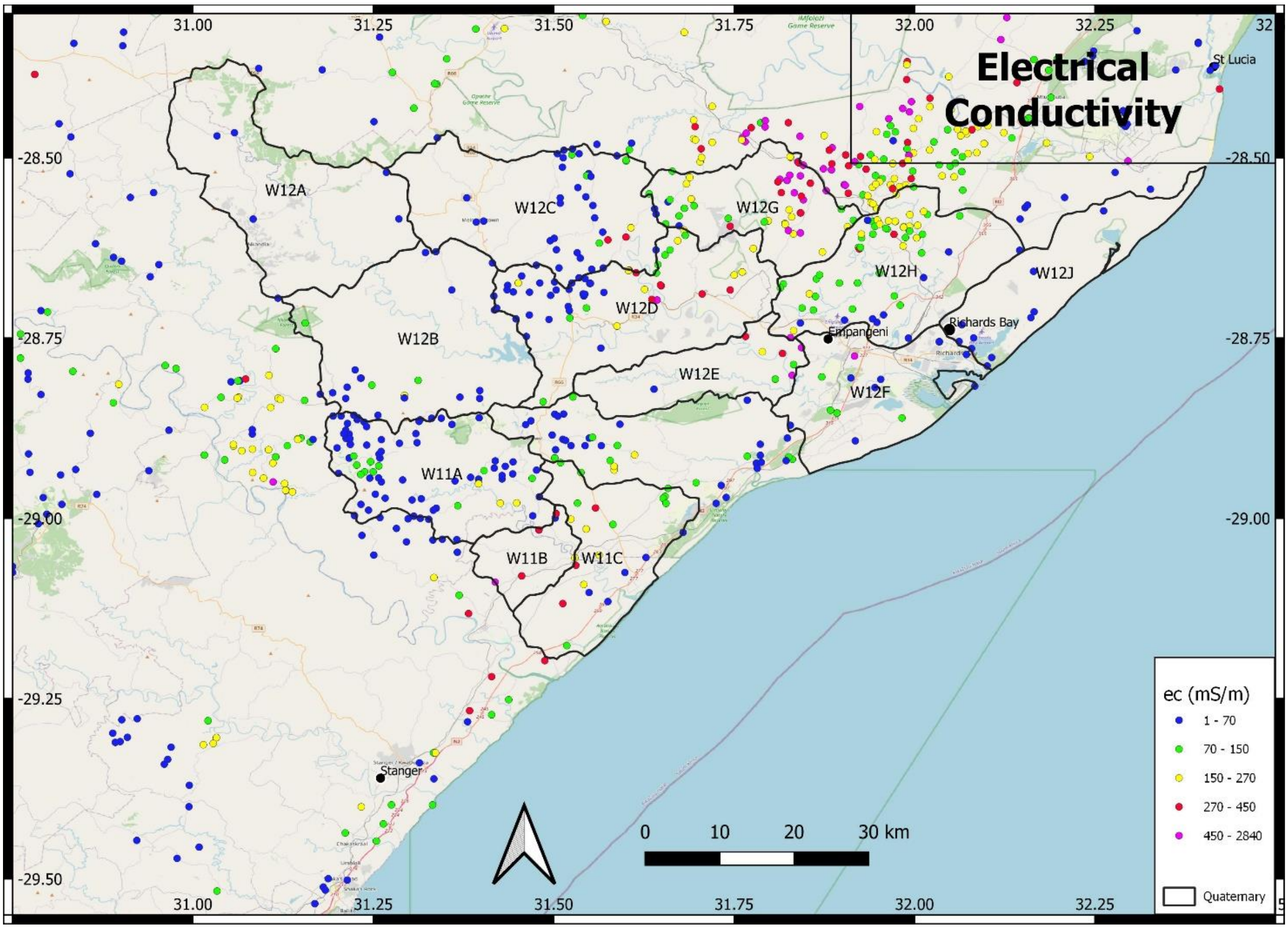

Figure 4.8 Electrical Conductivity in W1

4.8.2 Nitrate

Water quality is mostly of Class 0 - 1 with respect to Nitrate. Nitrate of Class 3 - 4 are found in the lower Mhlathuze W12G-H (**Figure 4.9**). The distribution of nitrate concentrations in each quaternary is shown in **Table 4.5**.

Table 4.5 Distribution of nitrates in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W11A	0.0464	0.4244	2.0988	4.337	36.918	0.956
W11B	0.02	0.048	0.427	0.487	0.553	1
W11C	0.02	0.3726	0.9144	1.4872	12.349	0.965
W12A	0.036	0.082	0.3808	1.1864	2.784	1
W12B	0.228	0.36	1.163	1.77	5.205	1
W12C	0.036	0.1902	0.5546	1.145	6.72	1
W12D	0.0692	0.3244	0.8158	1.7286	31.287	0.961
W12E	0.1666	0.3904	0.6406	2.0328	36.147	0.888
W12F	0.04	0.0682	0.5492	2.8228	7.6	1
W12G	0.05	0.182	1.43	5.081	43.565	0.915
W12H	0.0742	0.4044	4.2236	8.7396	23.307	0.87
W12J	0.02	0.02	0.02	0.02	0.171	1
W13A	0.0878	0.5442	1.2252	3.1474	18.265	0.965
W13B	0.02	0.187	1.359	6.817	15.664	0.859

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W11A	60	7	2	1	0	I
W11B	6	0	0	0	0	I
W11C	18	1	1	0	0	II
W12A	5	0	0	0	0	I
W12B	21	0	0	0	0	I
W12C	39	1	0	0	0	I
W12D	48	2	1	1	0	I
W12E	7	0	0	1	0	II
W12F	18	1	0	0	0	I
W12G	38	4	2	1	1	II
W12H	42	9	7	1	0	II
W12J	6	0	0	0	0	I
W13A	21	2	1	0	0	I
W13B	12	1	3	0	0	I

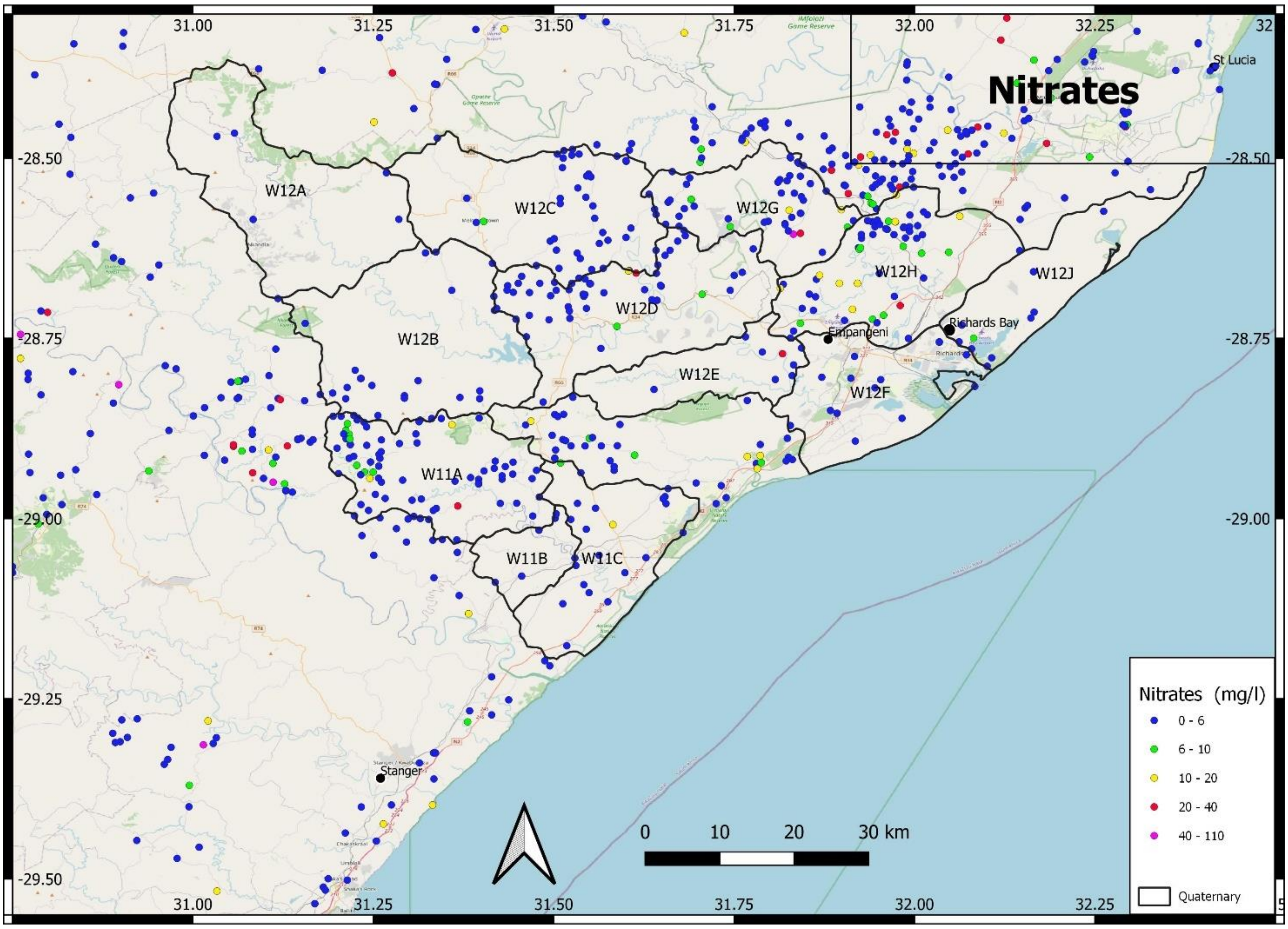

Figure 4.9 Distribution of Nitrate in W1

4.8.3 Fluoride

Water quality is highly variable. Significant areas of high Fluoride exist in isolated areas, especially in the upper Karoo volcanics, and in some the some intrusive and extrusive granitoids, volcanics and metamorphics (**Figure 4.10**). The distribution of fluoride concentrations in each quaternary is shown in **Table 4.6**.

Table 4.6 Distribution of Fluoride in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W11A	0.21	0.33	0.544	0.862	1.83	0.988
W11B	0.37	0.38	0.48	0.52	0.79	1
W11C	0.314	0.408	0.48	0.604	2.39	0.969
W12A	0.222	0.274	0.286	0.31	0.34	1
W12B	0.19	0.22	0.32	0.51	3.39	0.87
W12C	0.24	0.3	0.4	0.544	1.07	1
W12D	0.312	0.42	0.596	0.826	9.19	0.943
W12E	0.201	0.266	0.596	1.418	2.6	0.812
W12F	0.118	0.156	0.204	0.476	2.164	0.923
W12G	0.53	0.64	0.79	1.36	4.22	0.841
W12H	0.21	0.25	0.394	0.51	1.03	1
W12J	0.16	0.21	0.21	0.26	0.37	1
W13A	0.28	0.444	0.684	1.014	3.29	0.853
W13B	0.2	0.25	0.38	0.98	4.29	0.936

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W11A	51	10	8	1	0	II
W11B	5	1	0	0	0	I
W11C	18	1	0	1	0	II
W12A	4	0	0	0	0	I
W12B	17	0	1	3	0	II
W12C	35	3	2	0	0	II
W12D	34	9	6	1	2	II
W12E	5	1	0	2	0	III
W12F	17	0	0	2	0	II
W12G	22	8	8	5	3	III
W12H	54	3	2	0	0	I
W12J	6	0	0	0	0	I
W13A	14	5	1	4	0	II
W13B	12	1	2	0	1	II

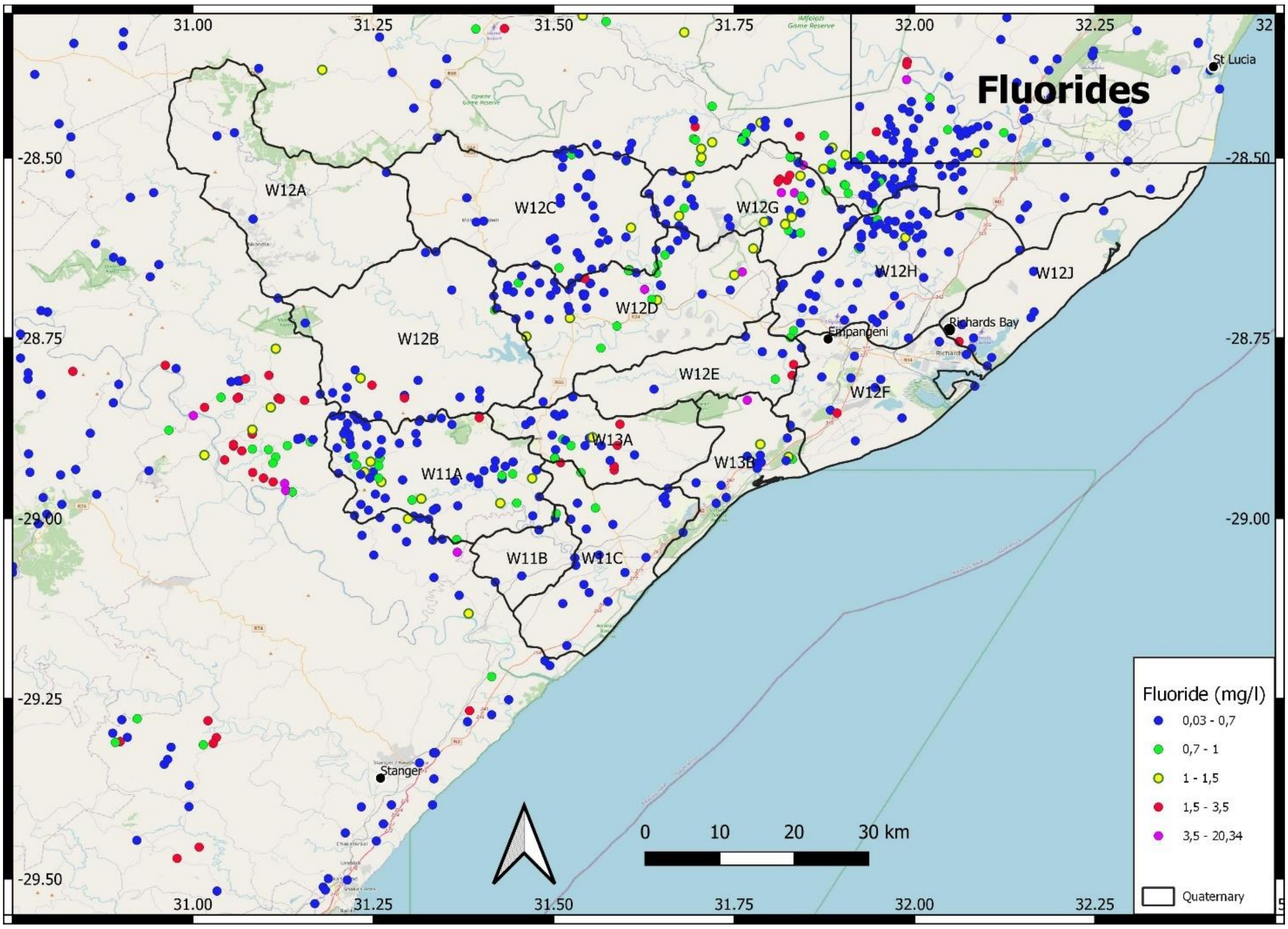

Figure 4.10 Distribution of Fluoride in W1

4.9 CLASSIFICATION

The stress index calculated from the total present use and aquifer recharge is shown in **Figure 4.11**, together with the location of known motorised pump systems. Groundwater is minimally used, and the stress index is below 0.05.

Quaternary catchment classification is shown in **Table 4.7**.

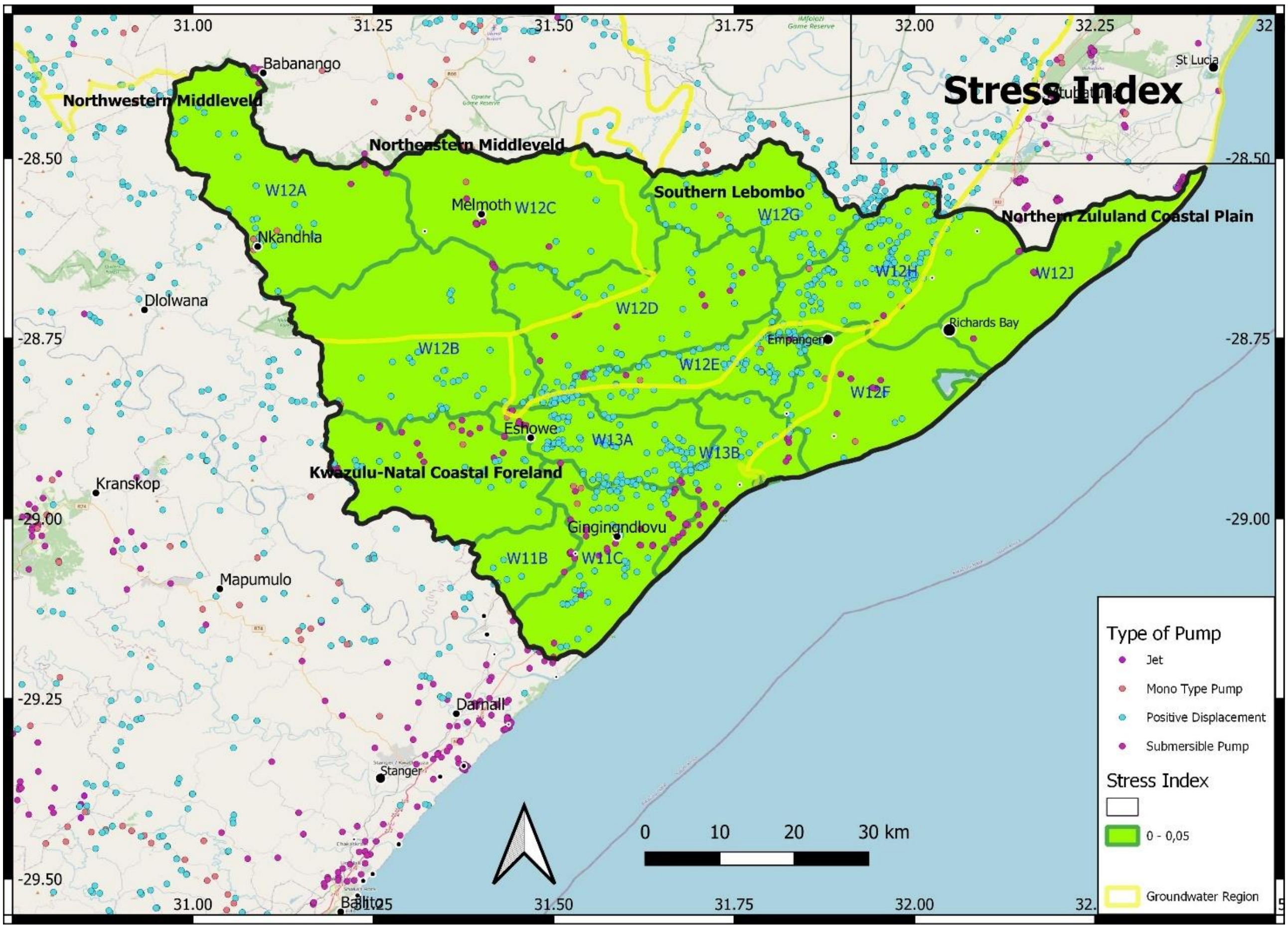

Figure 4.11 Stress Index in W1

Table 4.7 Classification status for W1

Quaternary	Aquifer Recharge (Mm³/a)	Groundwater baseflow (Mm³/a)	BHN (Mm³/a)	Use (Mm³/a)	Stress Index	PSC[1]	Class	Groundwater Component of Reserve (Mm³/a)
W11A	12.80	8.53	0.261	0.2692	0.02	A	I	8.80
W11B	3.73	2.44	0.121	0.0607	0.02	A	I	2.56
W11C	10.68	7.26	0.329	0.2315	0.02	A	I	7.59
W12A	18.91	9.05	0.176	0.1576	0.01	A	I	9.22
W12B	18.81	9.60	0.278	0.1216	0.01	A	I	9.88
W12C	17.82	8.53	0.197	0.1022	0.01	A	I	8.72
W12D	13.32	8.70	0.261	0.0924	0.01	A	I	8.96
W12E	6.71	3.76	0.158	0.0427	0.01	A	I	3.92
W12F	45.38	13.92	0.073	0.4185	0.01	A	I	13.99
W12G	10.01	4.92	0.075	0.0639	0.01	A	I	4.99
W12H	13.02	7.34	0.111	0.3651	0.03	A	I	7.45
W12J	42.57	11.95	0.087	0.0931	0.00	A	I	12.04
W13A	6.47	3.95	0.201	0.2160	0.03	A	I	4.15
W13B	4.75	3.03	0.119	0.0456	0.01	A	I	3.15

1 Present Status Category

5 GROUNDWATER RESOURCES IN W2 UMFOLOZI

5.1 GEOLOGY

The coastal margin is covered by Maputoland sediments (**Figure 5.1**). These are bounded to the west by Letaba basalts. Further west are Triassic age mudstones and sandstones of the upper Karoo. To the west and on the western watershed, Permian age Ecca group rocks outcrop. Much of the central part of the basin is underlain by Dwyka tillite. Natal Group sandstone outcrops on the south-central margin. The remainder of the central part of the catchment consists of intrusive granites and volcanics of the Nsuze group.

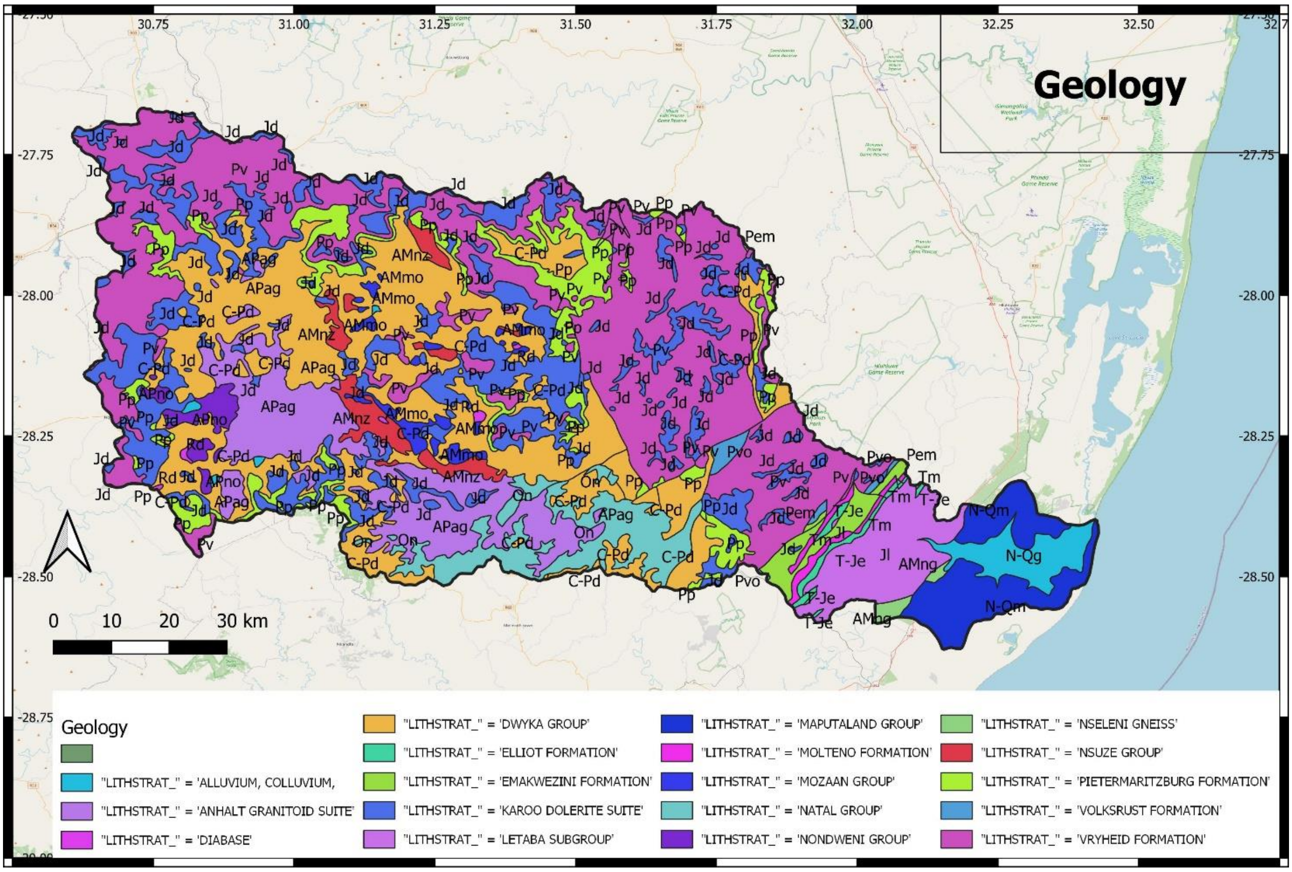

Figure 5.1 Geology of W2

5.2 AQUIFER TYPES

Most of the catchment consists of moderately yielding weathered and fractured aquifers, except for the intergranular aquifer on the coast and Natal Group sandstones and Dwyka tillies, which are fractured (**Figure 5.2**).

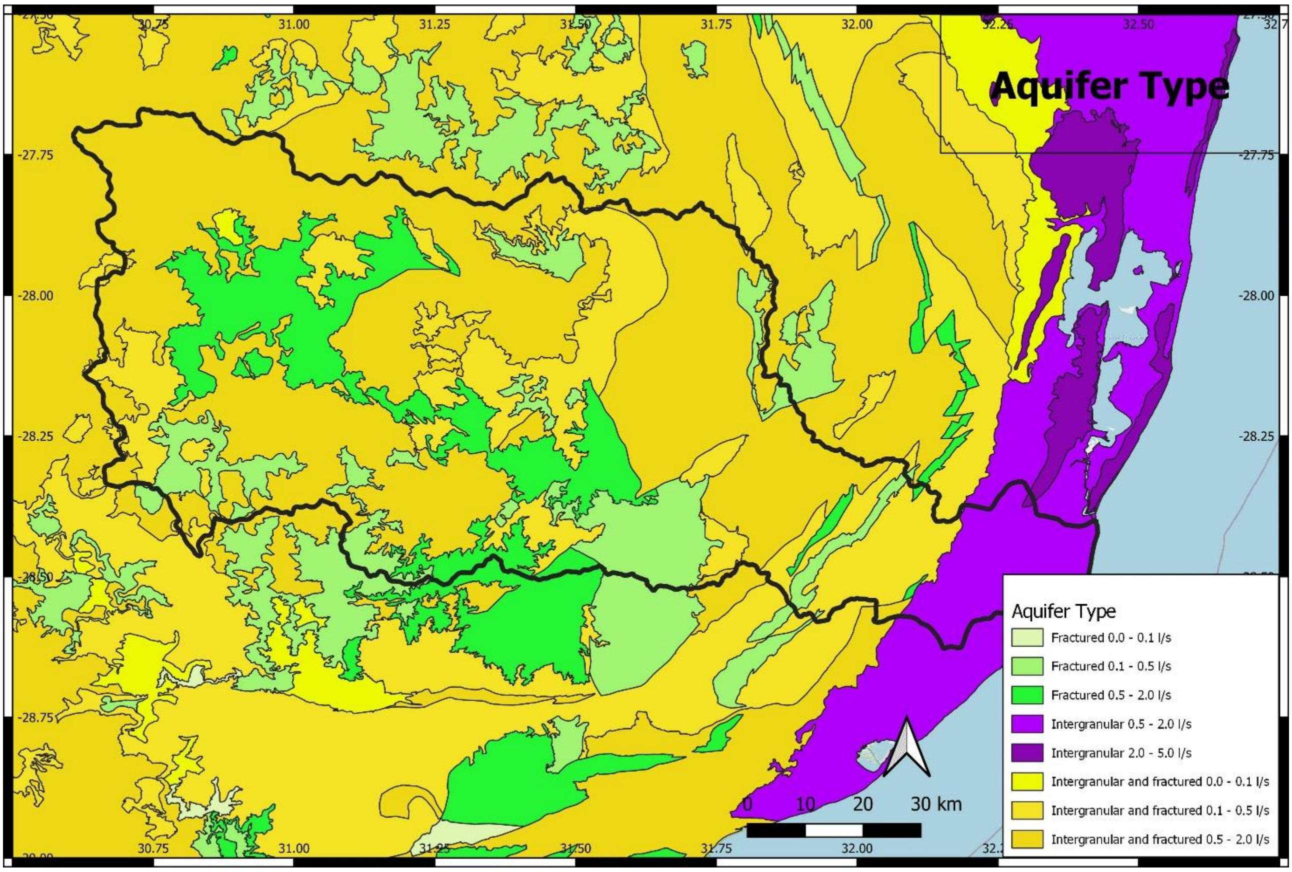

Figure 5.2 Aquifer types in W2

5.3 BOREHOLE YIELD

Median yields of 1 - 1.5 l/s are found in the Northern Zululand Coastal Plain. The Southern Lebombo and Northeastern Middleveld regions have very variable yields depending on lithology and structure, with the lowest yields in the Letaba Formation (**Figure 5.3**). The distribution of yields by catchment is shown in **Table 5.1**.

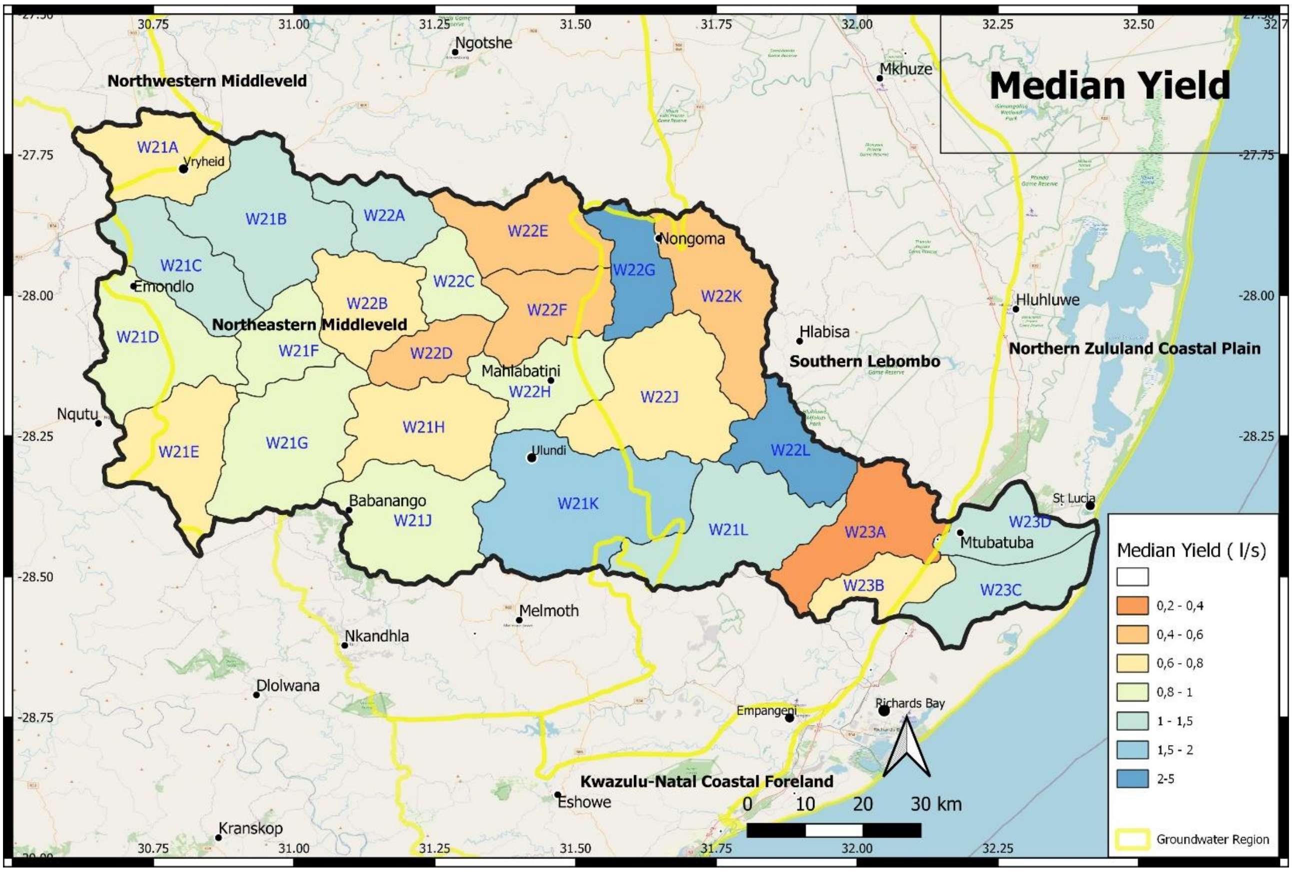

Figure 5.3 Median borehole yields in W2

Table 5.1 Borehole yield distribution in W2

Quaternary	Average (l/s)	Median (l/s)	% > 0.5 l/s	% > 2 l/s	% > 5 l/s
W21A	1.21	0.71	72.5	22.8	0
W21B	2.34	1.30	84.9	25.8	6.1
W21C	1.50	1.01	70.9	21.6	4
W21D	1.85	0.85	64.3	25.8	10
W21E	3.07	0.62	57.8	19.2	5.7
W21F	1.23	0.81	72.6	7.9	3.5
W21G	1.41	0.84	77.8	30.1	0.3
W21H	1.58	0.77	69.8	18.8	5.9
W21J	1.29	0.94	69.1	17.7	0
W21K	4.97	1.97	79.3	49.1	30.2
W21L	3.30	1.50	81.3	45.7	11.8
W22A	1.38	1.50	58.7	30	0
W22B	0.92	0.67	57.7	13	0
W22C	1.86	0.88	71.8	23.1	6.7
W22D	0.34	0.44	0	0	0
W22E	1.02	0.50	53.9	15.4	0
W22F	0.68	0.50	50	4.1	0
W22G	5.02	2.15	72	51.2	17.2
W22H	1.45	0.88	60	23.4	4.3
W22J	1.51	0.67	61.6	23.9	3.9
W22K	1.48	0.52	50.6	20.9	4.7
W22L	2.64	2.64	0	71	0
W23A	2.32	0.39	43.8	18.6	9.2
W23B	2.45	0.71	60	20	8.2

Quaternary	Average (l/s)	Median (l/s)	% > 0.5 l/s	% > 2 l/s	% > 5 l/s
W23C	1.14	1.13	78.9	9.2	0
W23D	1.34	1.09	86.8	17.6	0

5.4 RECHARGE

Recharge can be considered in terms of:

- Total recharge, which drives baseflow and recharges aquifers.
- Groundwater recharge which recharges the aquifers and is available to boreholes. This excludes the recharge that generates interflow from high-lying springs.

These are shown in **Figures 5.4** and **5.5** Recharge declines from over 200 mm/a on the Northern Zululand Coastal Plain to 30 - 40 mm/a inland on the Lowveld and Middleveld. Aquifer recharge is over 150 mm/a on the coastal plain. It declines rapidly to less than 40 mm/a inland and is only 10 - 20 mm/a over the Middleveld and Lowveld.

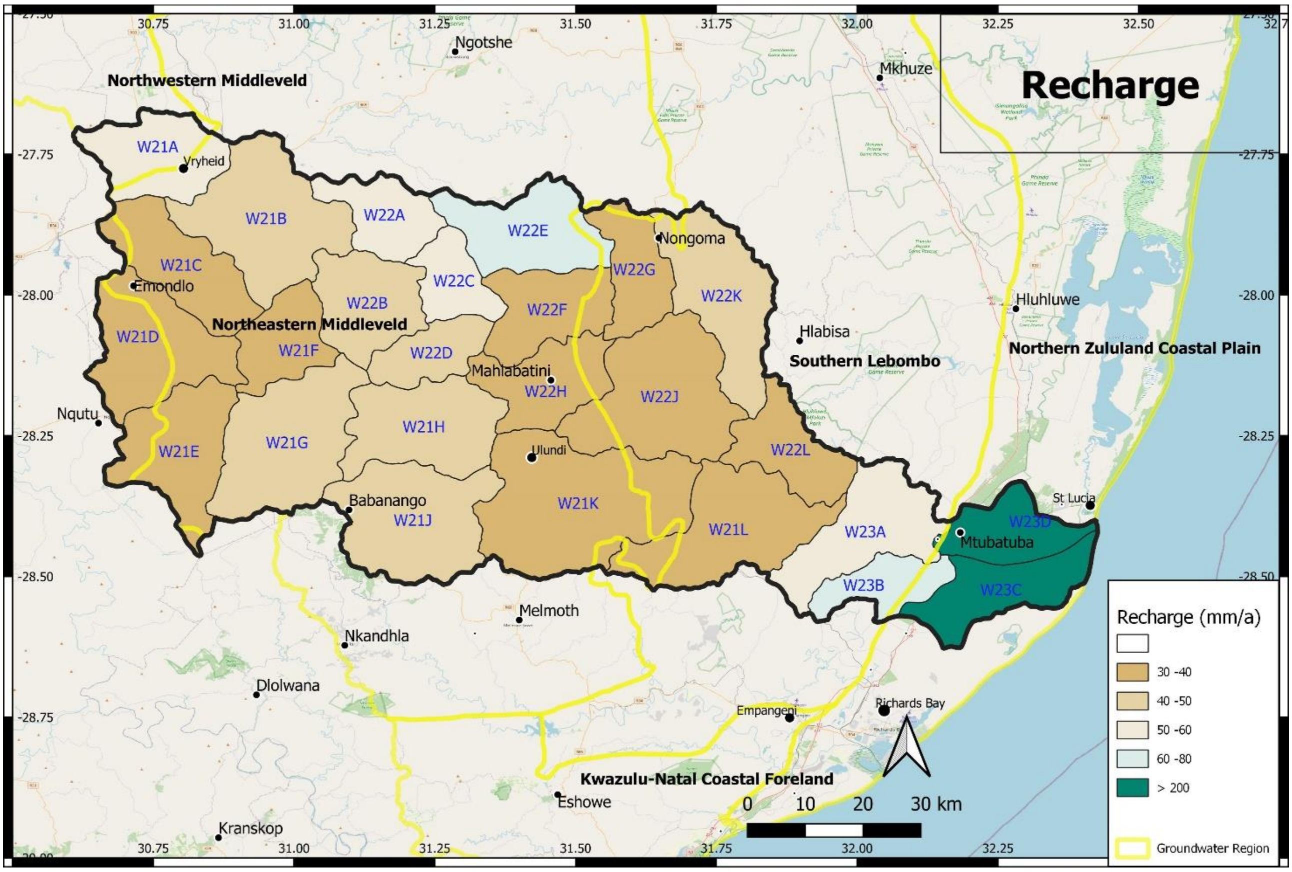

Figure 5.4 Recharge in W2

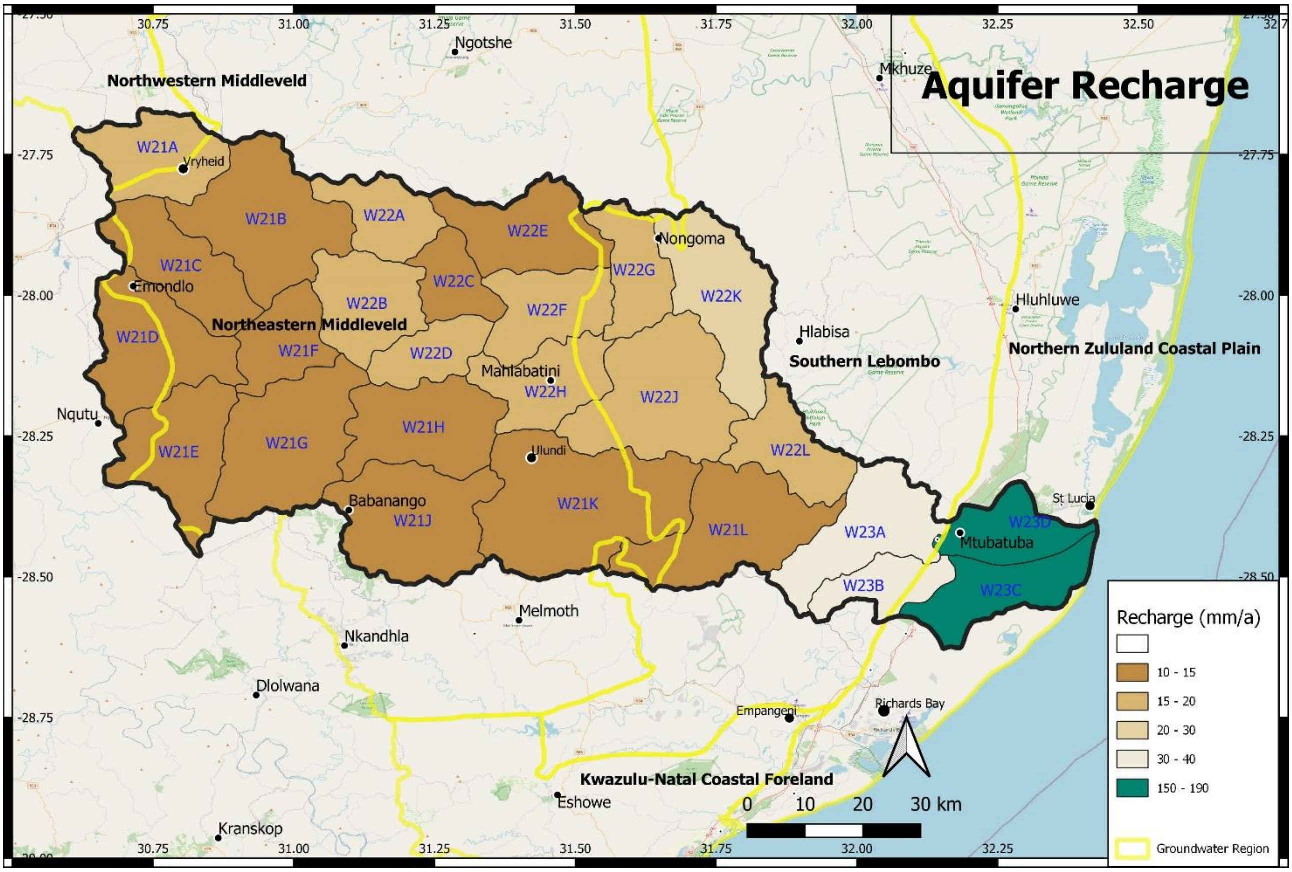

Figure 5.5 Aquifer recharge in W2

5.5 BASEFLOW

Two factors are of importance when considering baseflow. Total baseflow provides the volume of water available to sustain low flows, and groundwater baseflow which is the volume emanating from the regional aquifers and is subject to depletion by groundwater abstraction. The percentage that is ground baseflow provides an index of vulnerability of the low flows in rivers to groundwater abstraction. Baseflow and the percentage of baseflow of groundwater origin is shown in **Figures 5.6** and **5.7**.

Baseflow generation decreases inland from 80 mm/a to 10 mm/a. Groundwater baseflow increases proportionally from 20% to over 40% of baseflow towards the coast.

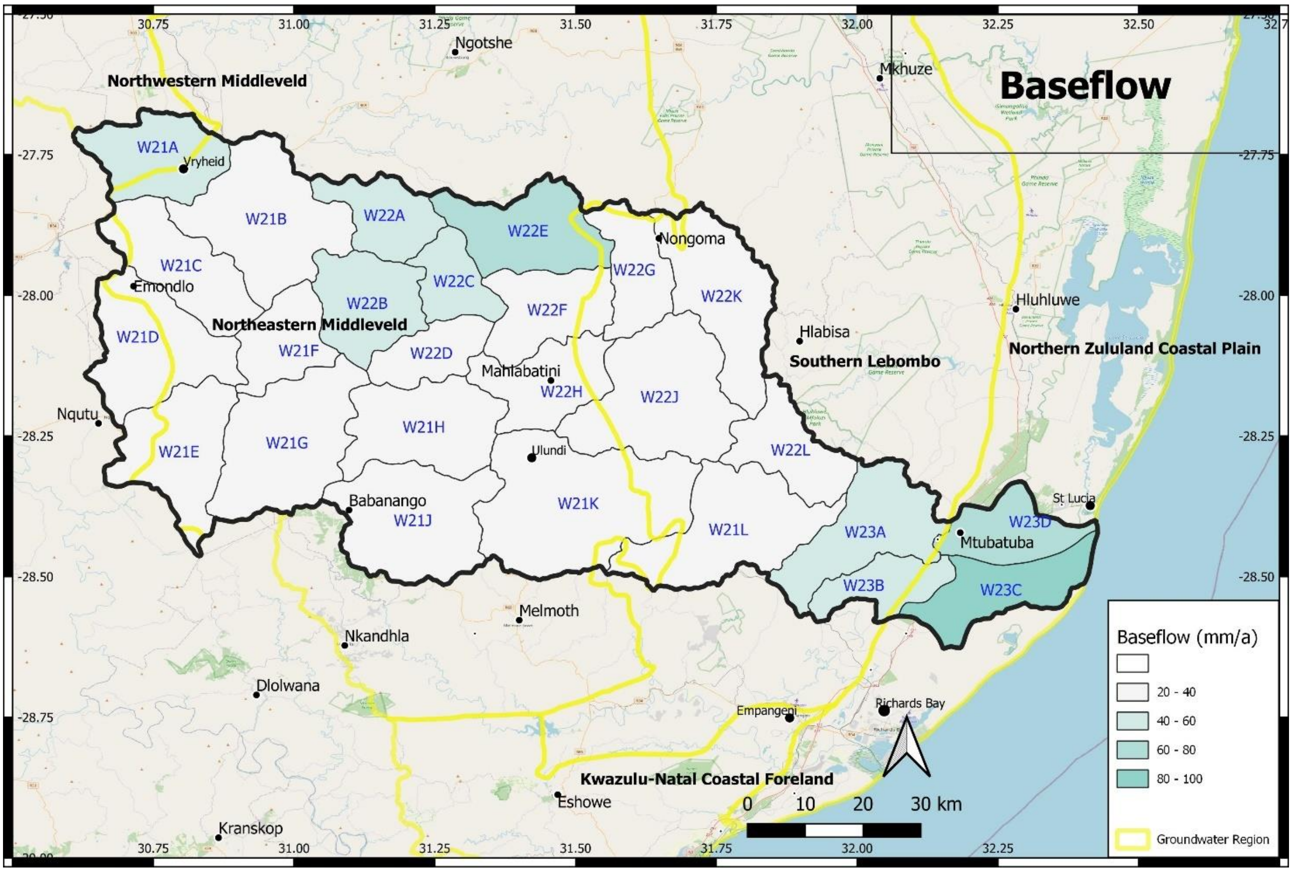

Figure 5.6 Baseflow in W2

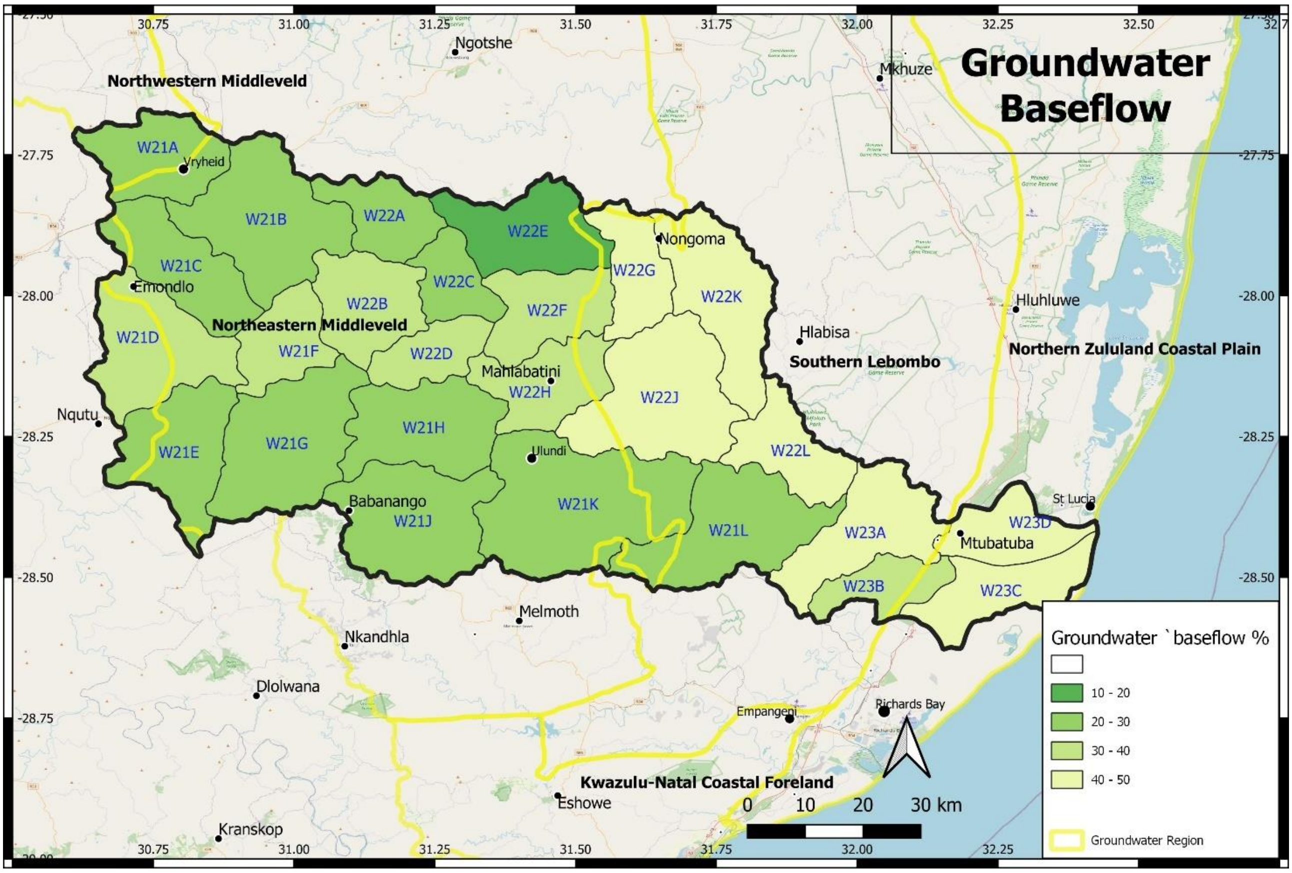

Figure 5.7 Groundwater baseflow as a percentage of baseflow in W2

5.6 USE

Groundwater use is listed in **Table 5.2**.

Table 5.2 Groundwater use in W2

Quat	Irrigation (Mm^3/a)	Industrial (Mm^3/a)	Mining (Mm^3/a)	Water Supply (Mm^3/a)	Livestock (Mm^3/a)	Schedule 1 (Mm^3/a)	Total (Mm^3/a)
W21A	0.0237	0.0000	0.0000	0.0001	0.0004	0.0487	0.0729
W21B	0.0530	0.0300	0.0000	0.0000	0.0136	0.0896	0.1862
W21C	0.0000	0.0000	0.0000	0.0000	0.0100	0.0571	0.0671
W21D					0.0076	0.1280	0.1356
W21E	0.0000	0.0000	0.0000	0.3900	0.0000	0.2304	0.6204
W21F					0.0068	0.0373	0.0441
W21G	0.0000	0.0000	0.0000	0.0250	0.0133	0.1862	0.2245
W21H					0.0124	0.0522	0.0646
W21J					0.0211	0.0640	0.0851
W21K					0.0005	0.0964	0.0969
W21L	0.0000	0.0000	0.0000	0.0000	0.0090	0.0675	0.0765
W22A					0.0044	0.0369	0.0413
W22B					0.0090	0.0465	0.0555
W22C					0.0056	0.0276	0.0332
W22D					0.0059	0.0239	0.0298
W22E	0.0000	0.0000	0.0000	0.0000	0.0058	0.0674	0.0732
W22F					0.0001	0.0562	0.0563
W22G					0.0000	0.0770	0.0770
W22H	0.0000	0.0000	0.0000	0.5332	0.0000	0.0441	0.5773
W22J	0.0000	0.0007	0.0000	0.0000	0.0000	0.1194	0.1201
W22K	0.0529	0.0065	1.1200	0.0000	0.0067	0.1346	1.3207
W22L					0.0422	0.0235	0.0657
W23A	0.4200	0.0000	0.0000	0.0000	0.0118	0.1087	0.5405
W23B	0.3315	0.0000	0.0000	0.0000	0.0000	0.0611	0.3926
W23C	0.1296	0.0004	0.0000	0.0000	0.0000	0.0912	0.2212
W23D	0.0000	0.0000	0.0000	0.5010	0.0149	0.0504	0.5663
Total	1.0107	0.0376	1.1200	1.4493	0.2011	2.0260	5.8447

5.7 GROUNDWATER RESOURCES

The groundwater recharge, exploitation potential and use for the W2 Catchment is shown in **Table 5.3**.

Table 5.3 W2 Catchment: Groundwater recharge and exploitation potential

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exploitation potential (Mm^3/a)	GRA II Exploitation potential (Mm^3/a)	Harvest potential (Mm^3/a)	Use (Mm^3/a)
W21A	340.14	19.37	5.66	1.64	6.89	5.72	0.0729
W21B	580.39	26.67	7.52	2.83	8.55	9.03	0.1862
W21C	369.64	10.63	4.29	1.54	3.54	5.93	0.0671
W21D	468.70	13.33	6.67	2.18	5.07	8.57	0.1356
W21E	415.98	12.85	5.22	1.80	4.45	7.54	0.6204
W21F	242.75	7.43	3.03	1.34	2.50	4.87	0.0441
W21G	562.85	22.60	7.29	4.34	7.38	13.53	0.2245
W21H	432.82	17.79	5.51	2.52	6.01	10.65	0.0646
W21J	530.05	21.19	6.05	2.01	7.25	18.92	0.0851
W21K	797.46	26.27	11.37	3.02	8.14	43.71	0.0969

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exploitation potential (Mm^3/a)	GRA II Exploitation potential (Mm^3/a)	Harvest potential (Mm^3/a)	Use (Mm^3/a)
W21L	532.82	17.41	7.74	2.99	6.56	11.75	0.0765
W22A	238.71	13.45	3.92	0.70	4.10	3.89	0.0413
W22B	331.69	13.58	5.57	1.00	3.60	4.55	0.0555
W22C	185.61	9.91	2.58	0.66	3.13	2.69	0.0332
W22D	197.48	8.15	3.19	1.15	2.43	2.69	0.0298
W22E	385.42	30.34	4.60	0.94	9.10	5.78	0.0732
W22F	312.04	11.67	5.37	1.31	3.25	4.71	0.0563
W22G	249.36	8.37	4.39	1.21	2.20	3.39	0.0770
W22H	306.12	10.81	4.80	1.65	3.28	4.17	0.5773
W22J	604.95	16.85	10.92	3.19	4.53	8.23	0.1201
W22K	475.54	13.81	12.99	4.03	4.24	6.47	1.3207
W22L	279.30	8.40	5.47	1.69	2.71	3.80	0.0657
W23A	413.72	17.15	15.12	4.65	5.36	5.54	0.5405
W23B	192.79	11.44	7.09	4.56	3.89	13.87	0.3926
W23C	312.69	37.46	50.74	27.46	15.70	103.71	0.2212
W23D	247.88	26.32	47.13	22.86	9.21	42.07	0.5663

5.8 GROUNDWATER QUALITY

5.8.1 Electrical conductivity

The distribution of EC is shown in **Figure 5.8** and **Table 5.4**. Groundwater is largely of Class 0 inland and deteriorates to 1 - 2 towards the coast and 0 - 1 on the coast. Poor water quality of Class 2 - 4 exists in the lower Mfolozi (W21L, W22L and W23) in boreholes in the Emakwezini and Letaba Formations of the Karoo Supergroup.

Table 5.4 Distribution of EC in mS/m by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W21A	24.88	34.6	37.24	42.66	46.8	1
W21B	44.88	49.96	55.04	60.12	65.2	1
W21C	35	47	56.18	62.54	68.9	1
W21D	10.6	23	53.94	75.76	122.4	1
W21E	21	29.8	46.3	47.5	63.3	1
W21F	40.84	55.38	69.92	84.46	99	1
W21G	16	28.9	36.8	40.5	63.4	1
W21H	17.04	20.52	22.44	24.08	82.5	1
W21J	19.62	29.18	41.24	88.28	134	1
W21K	96.7	113.04	135.2	191	248	0.706
W21L	164	242.8	446.6	592	696	0.178
W22B	36.84	39.58	42.32	45.06	47.8	1
W22C	63.3	63.3	63.3	63.3	63.3	1
W22D	2.9	2.9	2.9	2.9	2.9	1
W22E	38.1	43.7	51.72	62.16	72.6	1
W22F	17.1	42.94	124.3	212.8	503	0.653
W22G	25.74	29.58	57.6	109.8	162	0.954
W22H	43.82	66.5	76.7	131.26	208	0.848
W22J	16.28	24.96	71.64	156.32	241	0.785
W22K	51.44	79.46	127.2	321.76	843	0.636
W22L	161	161	161	161	161	#N/A
W23A	158.4	211.2	324.8	516.4	2030	0.186
W23B	137.2	163.6	184.6	232.2	578	0.308

W23C	45.96	54.22	57.1	176.6	2010	0.725
W23D	51.44	60.98	71.08	103.58	390	0.88

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W21A	8	0	0	0	0	I
W21B	2	0	0	0	0	I
W21C	3	0	0	0	0	I
W21D	7	3	0	0	0	I
W21E	6	0	0	0	0	I
W21F	1	1	0	0	0	I
W21G	6	0	0	0	0	I
W21H	6	1	0	0	0	I
W21J	5	2	0	0	0	I
W21K	1	5	3	0	0	II
W21L	2	2	8	4	7	III
W22B	2	0	0	0	0	I
W22C	1	0	0	0	0	I
W22D	1	0	0	0	0	I
W22E	2	1	0	0	0	I
W22F	4	2	2	0	1	III
W22G	2	0	1	0	0	II
W22H	2	1	1	0	0	II
W22J	2	0	1	0	0	II
W22K	3	2	1	1	1	III
W22L	0	0	1	0	0	II
W23A	1	7	14	12	10	III
W23B	0	13	25	3	1	III
W23C	6	0	2	0	1	III
W23D	8	3	1	1	0	III

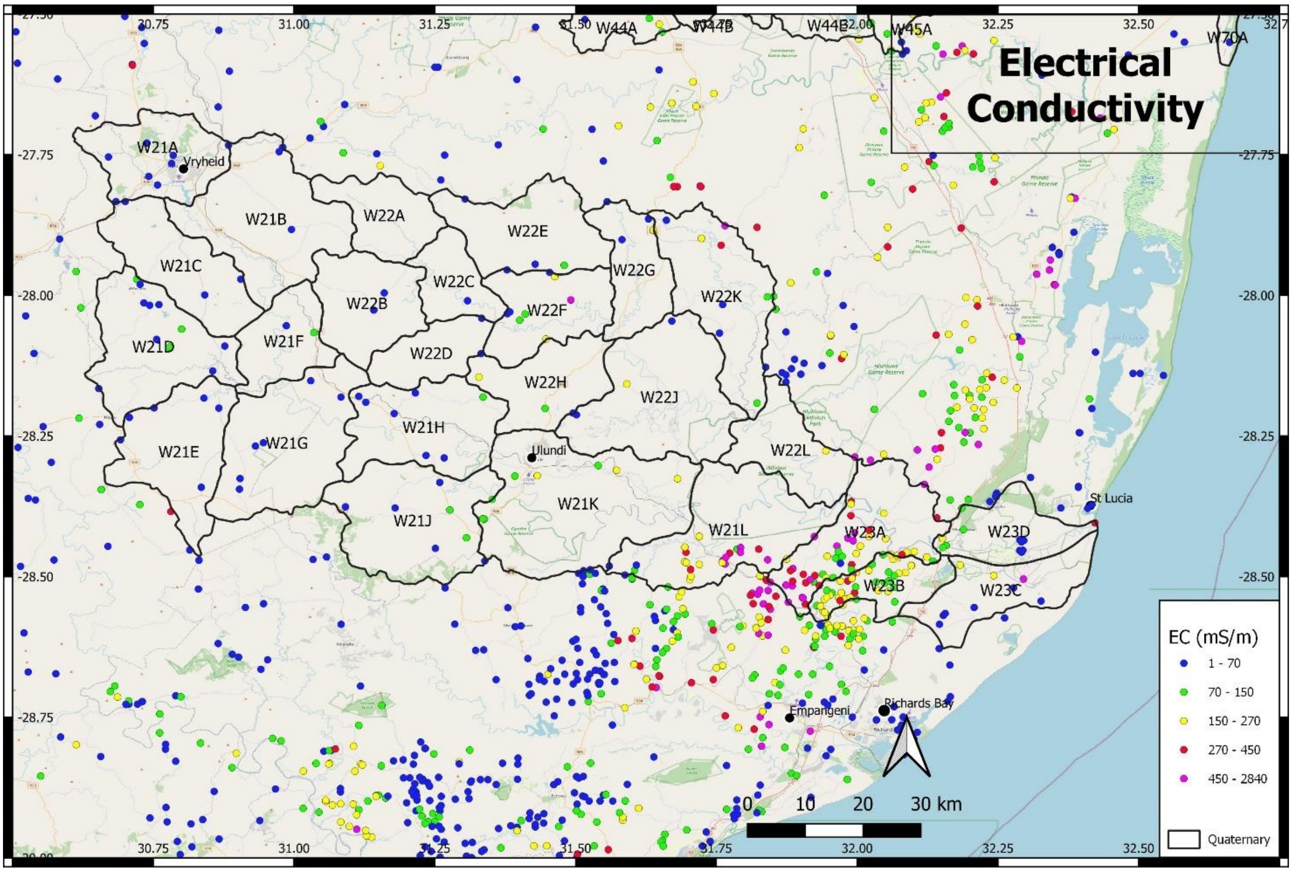

Figure 5.8 EC in W2

5.8.2 Nitrate

Nitrate is generally of Class 0, except in the lower catchments of W23 where localised concentrations of Class 2 - 3 exist (**Figure 5.9**). The distribution of nitrate concentrations in each quaternary is shown in **Table 5.5**.

Table 5.5 Distribution of nitrates in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W21A	0.0614	0.092	0.7652	3.8776	24.85	0.894
W21B	0.2014	0.2038	0.2062	0.2086	0.211	1
W21C	0.02	0.02	0.0264	0.0392	0.052	1
W21D	0.02	0.0548	0.147	1.288	2.232	1
W21E	0.174	0.64	2.898	3.197	23.56	0.866
W21F	0.8856	0.9862	1.0868	1.1874	1.288	1
W21G	0.187	0.373	0.955	1.919	3.968	1
W21H	0.02	0.0804	0.291	0.6798	1.355	1
W21J	0.3364	0.4584	2.1114	13.4426	31.809	0.755
W21K	1.1738	2.6708	5.2436	7.5398	10.554	0.867
W21L	0.073	0.8844	1.3546	2.7504	19.401	0.958
W22B	0.0724	0.1248	0.1772	0.2296	0.282	1
W22C	0.072	0.072	0.072	0.072	0.072	1
W22D	0.049	0.049	0.049	0.049	0.049	1
W22E	0.0468	0.0736	0.6804	1.8672	3.054	1
W22F	0.0724	0.2104	0.7824	3.716	42.385	0.882
W22G	0.0404	0.0608	0.1466	0.2978	0.449	1
W22H	0.02	0.0366	0.0864	1.0074	2.364	1
W22J	0.02	0.02	0.0264	0.0392	0.052	1

W22K	0.0724	0.654	2.3368	3.1382	8.103	1
W22L	0.483	0.483	0.483	0.483	0.483	1
W23A	0.0344	0.0948	0.2466	12.7268	37.566	0.787
W23B	0.0902	0.3076	2.259	5.6542	29.374	0.881
W23C	0.1804	0.3652	0.754	5.4164	34.916	0.882
W23D	0.138	0.256	0.794	4.6224	20.423	0.922

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W21A	7	0	0	1	0	III
W21B	2	0	0	0	0	I
W21C	3	0	0	0	0	I
W21D	10	0	0	0	0	I
W21E	5	0	0	1	0	III
W21F	2	0	0	0	0	I
W21G	6	0	0	0	0	I
W21H	7	0	0	0	0	I
W21J	5	0	1	1	0	III
W21K	7	0	2	0	0	II
W21L	20	2	1	0	0	I
W22B	2	0	0	0	0	I
W22C	1	0	0	0	0	I
W22D	1	0	0	0	0	I
W22E	3	0	0	0	0	I
W22F	7	1	0	0	1	III
W22G	3	0	0	0	0	I
W22H	4	0	0	0	0	I
W22J	3	0	0	0	0	I
W22K	7	1	0	0	0	I
W22L	1	0	0	0	0	I
W23A	34	0	4	6	0	III
W23B	34	3	3	2	0	II
W23C	7	1	0	1	0	III
W23D	10	2	0	1	0	III

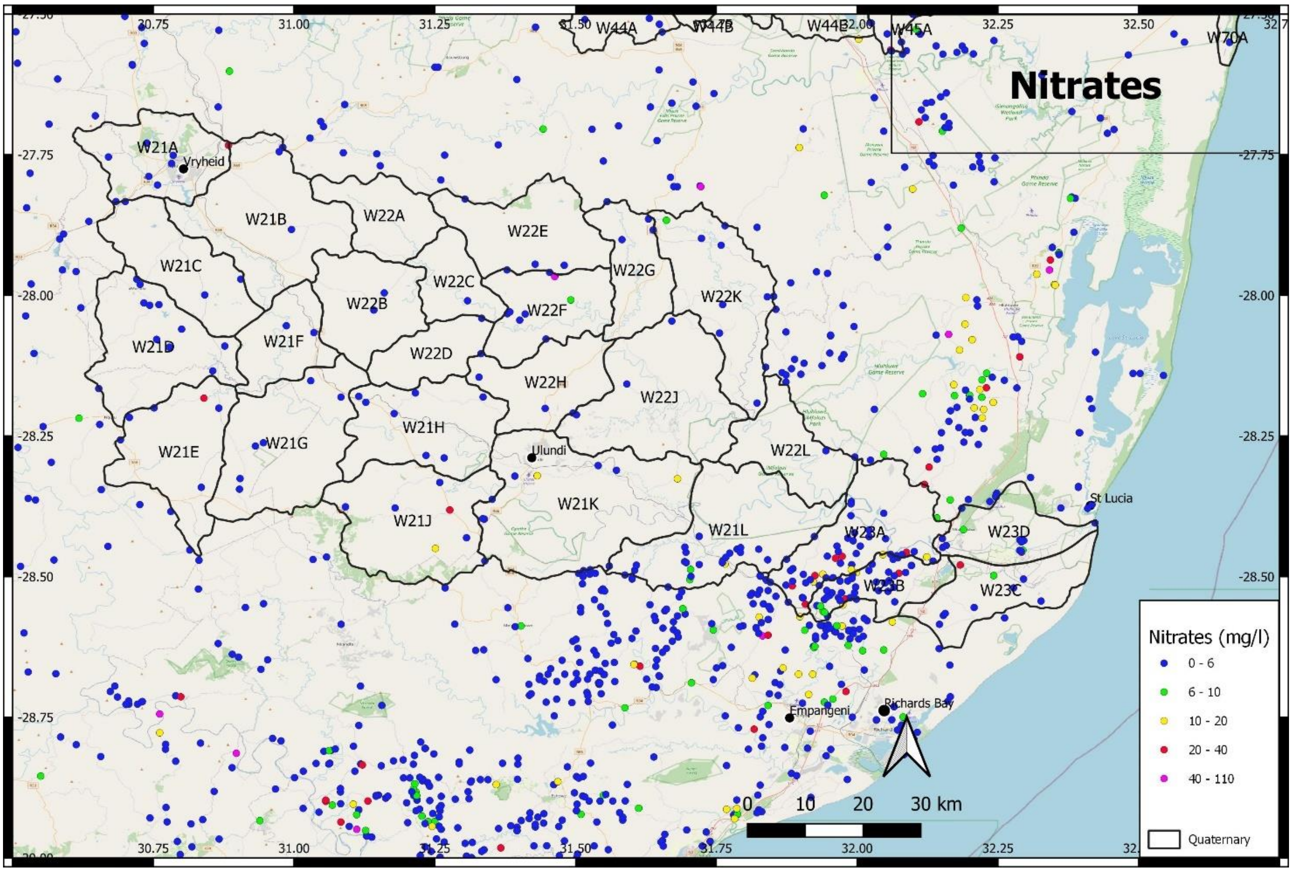

Figure 5.9 Distribution of Nitrate in W2

5.8.3 Fluoride

Water quality is highly variable. Significant areas of high Fluoride exist in isolated areas, especially in the upper Karoo volcanics, and in some the some intrusive and extrusive granitoids, volcanics and metamorphics (**Figure 5.10**). The distribution of fluoride concentrations in each quaternary is shown in **Table 5.6**.

Table 5.6 Distribution of Fluoride in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W21A	0.208	0.228	0.242	0.28	0.5	1
W21B	0.202	0.214	0.226	0.238	0.25	1
W21C	0.448	0.796	1.194	1.642	2.09	0.736
W21D	0.372	0.496	0.524	0.558	1.93	0.963
W21E	0.25	0.26	0.3	0.45	2.6	0.897
W21F	0.43	0.54	0.65	0.76	0.87	1
W21G	0.27	0.38	0.42	0.51	0.69	1
W21H	0.312	0.376	0.436	0.484	1.7	0.972
W21J	0.31	0.33	0.43	0.54	1.37	1
W21K	0.354	0.52	0.992	1.118	1.56	0.981
W21L	0.544	0.668	0.92	1.034	2.5	0.918
W22B	0.712	1.014	1.316	1.618	1.92	0.721
W22C	20.34	20.34	20.34	20.34	20.34	#N/A
W22D	0.12	0.12	0.12	0.12	0.12	1
W22E	0.24	0.26	0.308	0.384	0.46	1
W22F	0.332	0.668	0.804	1.208	1.75	0.854
W22G	0.19	0.19	0.192	0.196	0.2	1
W22H	0.328	0.408	0.492	0.532	0.55	1

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W22J	0.334	0.358	0.406	0.478	0.55	1
W22K	0.148	0.23	0.4168	0.6516	1.1	1
W22L	0.55	0.55	0.55	0.55	0.55	1
W23A	0.3	0.38	0.576	0.886	6.37	0.919
W23B	0.228	0.348	0.448	0.56	1.31	1
W23C	0.186	0.252	0.26	0.28	0.59	1
W23D	0.158	0.196	0.303	0.4026	0.59	1

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W21A	8	0	0	0	0	I
W21B	2	0	0	0	0	I
W21C	1	1	0	1	0	III
W21D	9	0	0	1	0	III
W21E	5	0	0	1	0	III
W21F	1	1	0	0	0	I
W21G	6	0	0	0	0	I
W21H	6	0	0	1	0	III
W21J	5	0	1	0	0	II
W21K	4	1	3	1	0	III
W21L	10	7	4	2	0	III
W22B	1	0	0	1	0	III
W22C	0	0	0	0	1	III
W22D	1	0	0	0	0	I
W22E	3	0	0	0	0	I
W22F	4	3	0	2	0	III
W22G	3	0	0	0	0	I
W22H	4	0	0	0	0	I
W22J	3	0	0	0	0	I
W22K	6	1	1	0	0	II
W22L	1	0	0	0	0	I
W23A	29	8	3	3	1	III
W23B	38	3	1	0	0	I
W23C	9	0	0	0	0	I
W23D	13	0	0	0	0	I

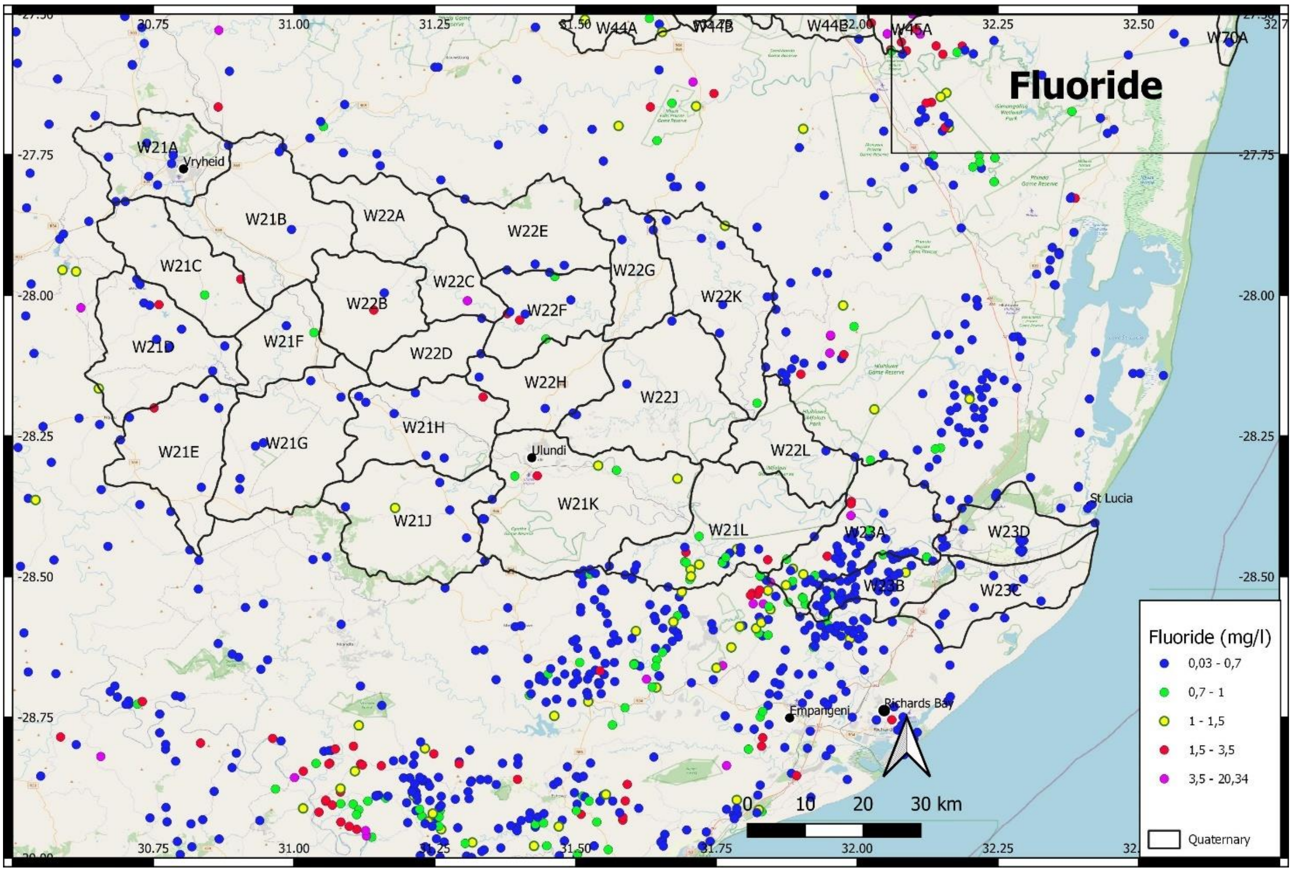

Figure 5.10 Distribution of Fluoride in W2

5.9 CLASSIFICATION

The stress index calculated from the total present use and aquifer recharge is shown in **Figure 5.11**, together with the location of known motorised pump systems. Groundwater is minimally used, and the stress index is below 0.12.

Quaternary catchment classification is shown in **Table 5.7**.

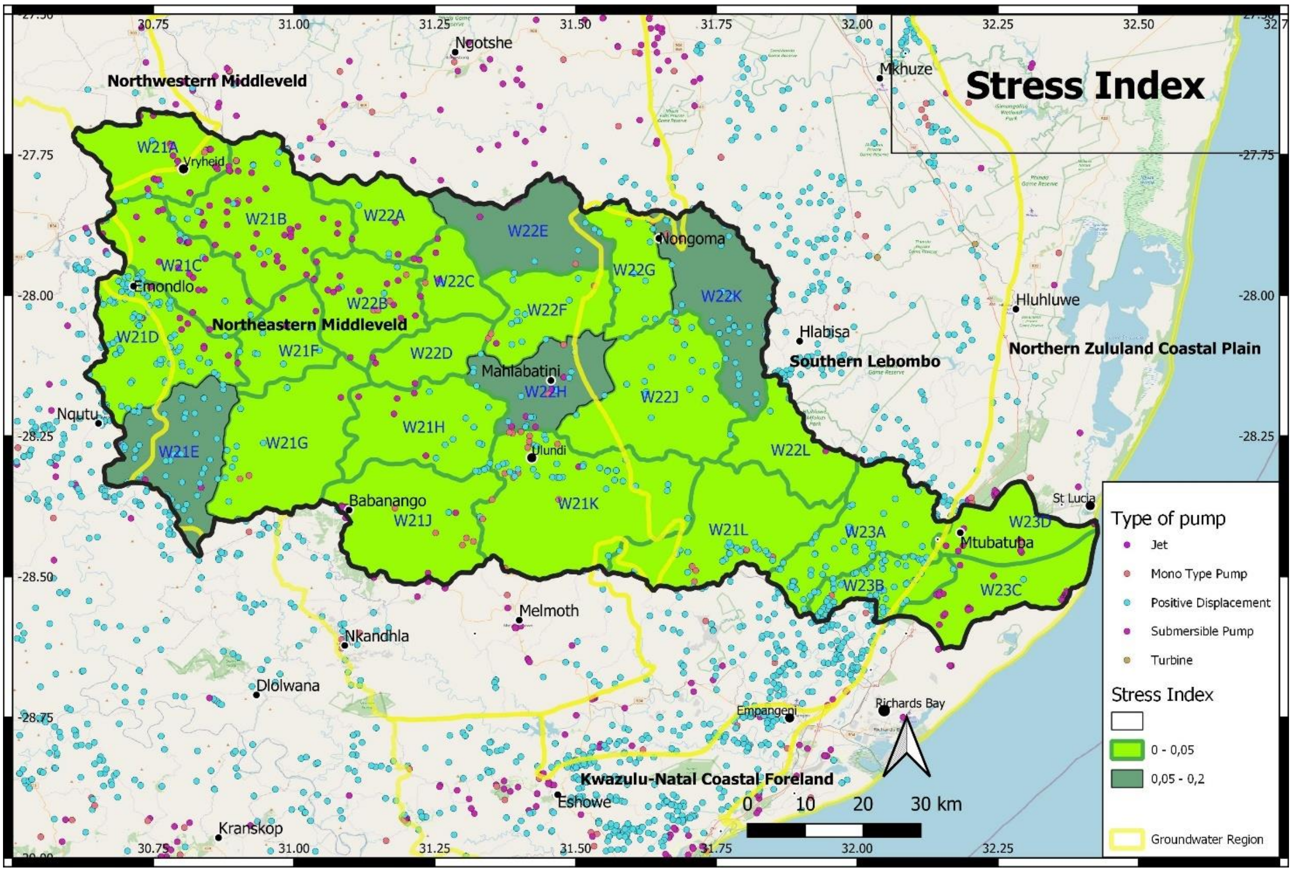

Figure 5.11 Stress Index in W2

Table 5.7 Classification status for W2

Quaternary	Aquifer Recharge (Mm³/a)	Groundwater baseflow (Mm³/a)	BHN (Mm³/a)	Use (Mm³/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm³/a)
W21A	5.66	17.85	0.062	0.0729	0.01	A	I	17.91
W21B	7.52	23.08	0.112	0.1862	0.02	A	I	23.19
W21C	4.29	9.93	0.072	0.0671	0.02	A	I	10.00
W21D	6.67	12.33	0.123	0.1356	0.02	A	I	12.46
W21E	5.22	11.08	0.175	0.6204	0.12	B	I	11.25
W21F	3.03	5.68	0.08	0.0441	0.01	A	I	5.76
W21G	7.29	14.33	0.254	0.2245	0.03	A	I	14.58
W21H	5.51	13.52	0.208	0.0646	0.01	A	I	13.72
W21J	6.05	19.49	0.248	0.0851	0.01	A	I	19.74
W21K	11.37	26.37	0.355	0.0969	0.01	A	I	26.72
W21L	7.74	17.28	0.155	0.0765	0.01	A	I	17.43
W22A	3.92	12.95	0.046	0.0413	0.01	A	I	12.99
W22B	5.57	13.39	0.105	0.0555	0.01	A	I	13.49
W22C	2.58	9.10	0.045	0.0332	0.01	A	I	9.14
W22D	3.19	6.04	0.095	0.0298	0.01	A	I	6.14
W22E	4.60	29.61	0.16	0.0732	0.02	A	I	29.77
W22F	5.37	10.43	0.219	0.0563	0.01	A	I	10.65
W22G	4.39	7.55	0.297	0.0770	0.02	A	I	7.85
W22H	4.80	8.40	0.175	0.5773	0.12	B	I	8.57
W22J	10.92	15.54	0.46	0.1201	0.01	A	I	16.00
W22K	12.99	13.63	0.515	1.3207	0.10	B	I	14.15
W22L	5.47	8.38	0.072	0.0657	0.01	A	I	8.45
W23A	15.12	16.87	0.229	0.5405	0.04	A	I	17.10

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W23B	7.09	10.52	0.054	0.3926	0.06	B	I	10.57
W23C	50.74	27.83	0.128	0.2212	0.00	A	I	27.95
W23D	47.13	17.63	0.211	0.5663	0.01	A	I	17.85

6 GROUNDWATER RESOURCES IN W3 MKUZE

6.1 GEOLOGY

The coastal margin is underlain by Maputoland sediments, bounded to the west by Zululand Group rocks then Jurassic Basalt and Rhyolite (**Figure 6.1**). The western watershed and the central part of the Basin are underlain by Ecca Group rocks. Large tracts of the basin are also covered by Dwyka tillites or intrusive granites

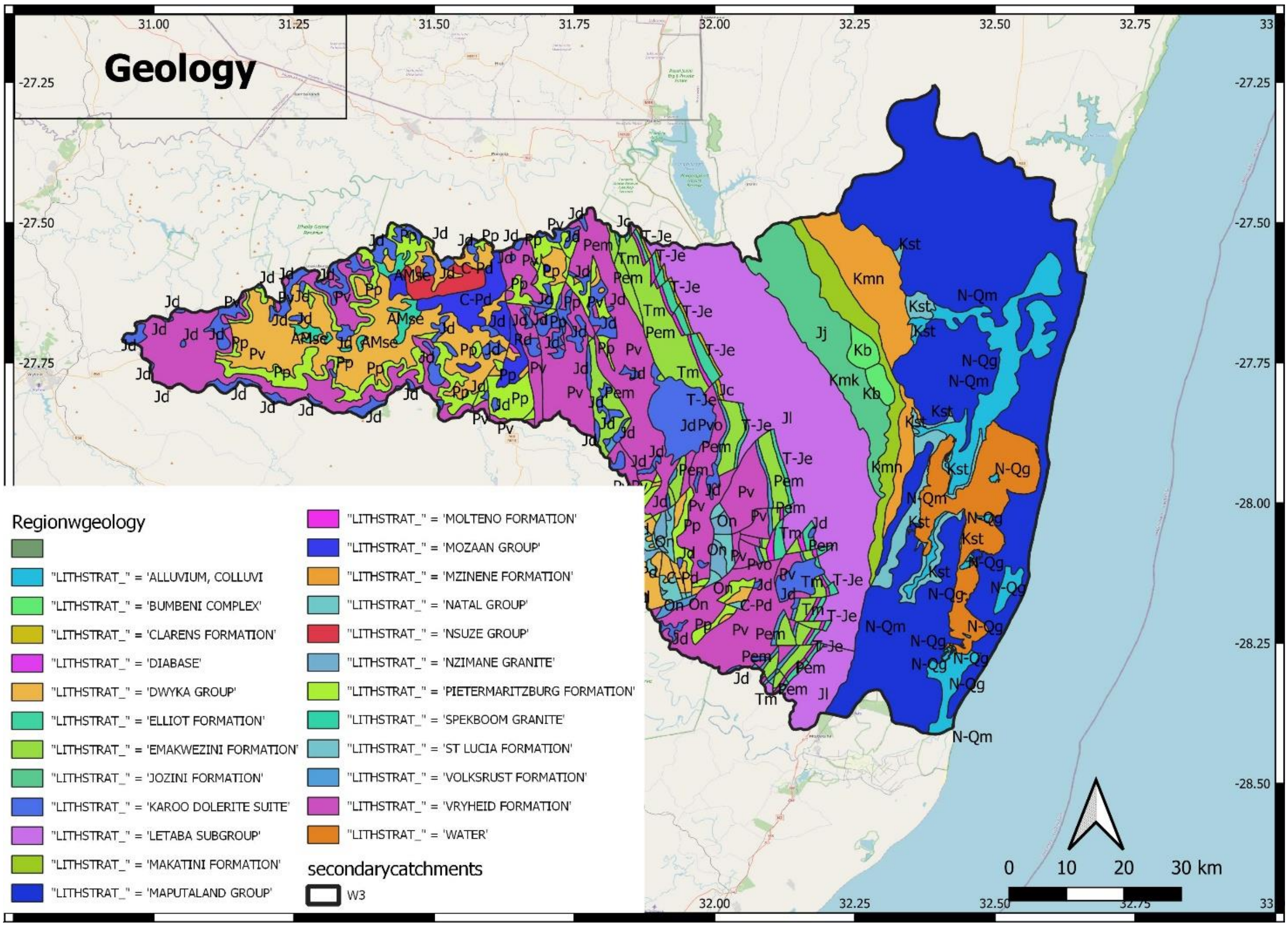

Figure 6.1 Geology of W3

6.2 AQUIFER TYPES

The catchment largely has moderately yielding aquifers of the fractured and weathered type, except for the intergranular costal aquifer and fractured Dwyka tillite (**Figure 6.2**). High yields are found near the costal lakes, where boreholes tap permeable calcarenites of the basal Uloa Formation of the Maputoland Group. This formation makes a significant contribution to the lake water balances.

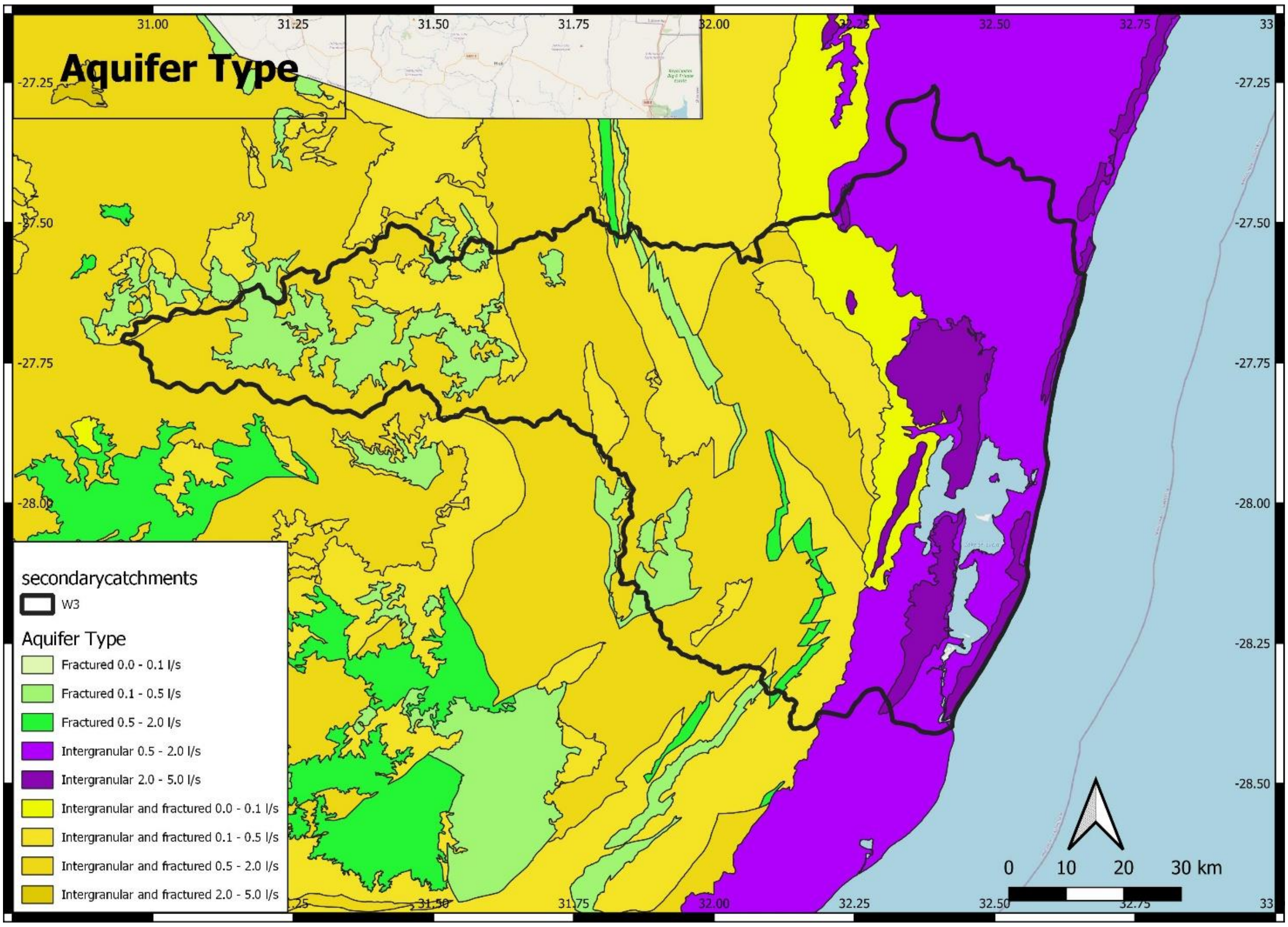

Figure 6.2 Aquifer types in W3

6.3 BOREHOLE YIELD

Median yields are low to moderate (0.6 - 1 l/s) in the Northern Zululand Coastal Plain. The Southern Lebombo has yields of below 0.8 l/s and is the lowest yielding, Groundwater Region. The Northeastern Middleveld region has yields above 1 l/s except in the headwater area (**Figure 6.3**). The distribution of yields by catchment is shown in **Table 6.1**.

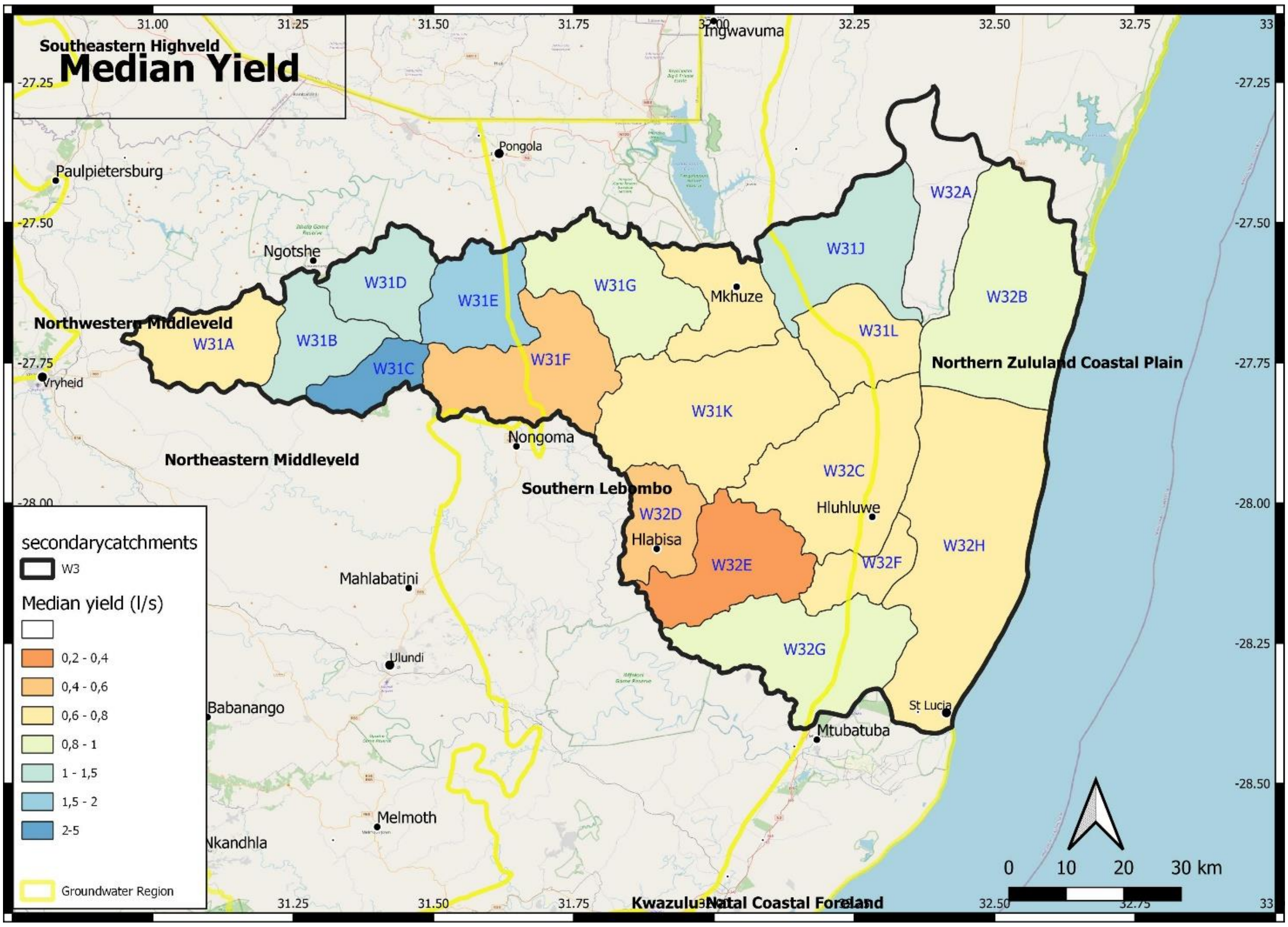

Figure 6.3 Median yield of boreholes in W3

Table 6.1 Borehole yield distribution in W3

Quaternary	Average (l/s)	Median (l/s)	% > 0.5 l/s	% > 2 l/s	% > 5 l/s
W31A	1.10	0.72	70.2	20.7	0
W31B	2.16	1.25	67.6	39	11.8
W31C	2.99	2.99	0	0	0
W31D	1.69	1.11	79.1	38.5	0
W31E	4.79	1.60	79.3	14.3	12.8
W31F	0.79	0.50	48.4	5.4	0
W31G	1.05	0.82	59.9	13.3	0.7
W31H	1.56	0.61	58.6	19	7.7
W31J	1.89	1.29	76	44.1	4
W31K	1.39	0.61	58.7	17.7	2.7
W31L	1.05	0.62	58.9	11.4	0
W32A					
W32B	1.70	0.94	81	26.9	4.2
W32C	1.86	0.73	64.8	10.1	1.8
W32D	0.98	0.55	60	11.2	0
W32E	0.94	0.28	31.6	12.7	0
W32F	1.14	0.78	79	15.8	0
W32G	1.87	0.83	70.3	24.7	9.2
W32H	1.39	0.75	66.7	6.7	4.2

6.4 RECHARGE

Recharge can be considered in terms of:

- Total recharge, which drives baseflow and recharges aquifers.
- Groundwater recharge which recharges the aquifers and is available to boreholes. This excludes the recharge that generates interflow from high-lying springs.

These are shown in **Figures6.4** and **6.5**. Recharge declines from 150 - 200 mm/a on the Northern Zululand Coastal Plain to 20 - 30 mm/a inland on the Lowveld and Middleveld. Aquifer recharge is 100 - 190 mm/a on the sandy coastal plain where interflow is minor, and decreases from 40 mm/a to 10 mm/a inland.

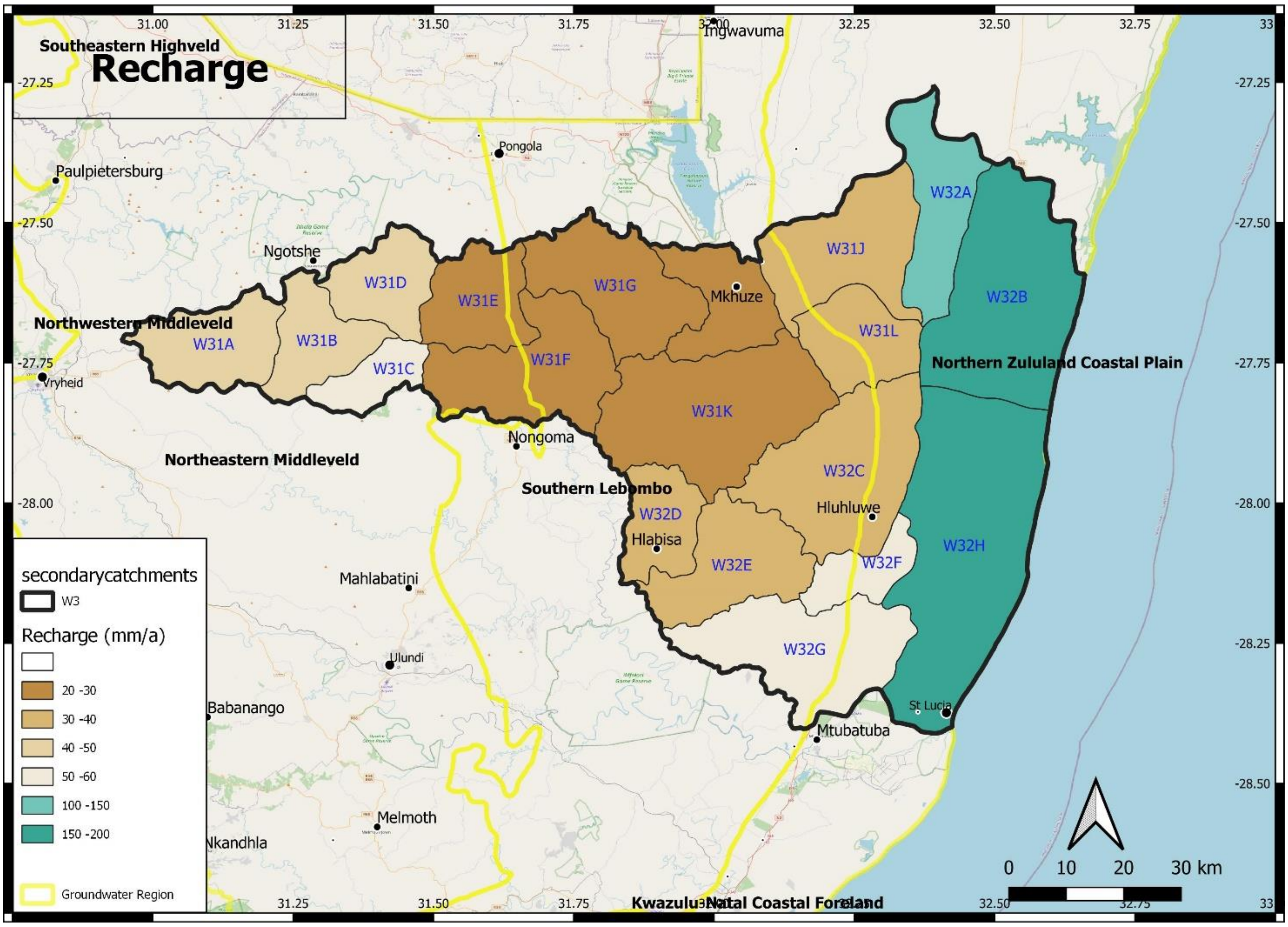

Figure 6.4 Recharge in W3

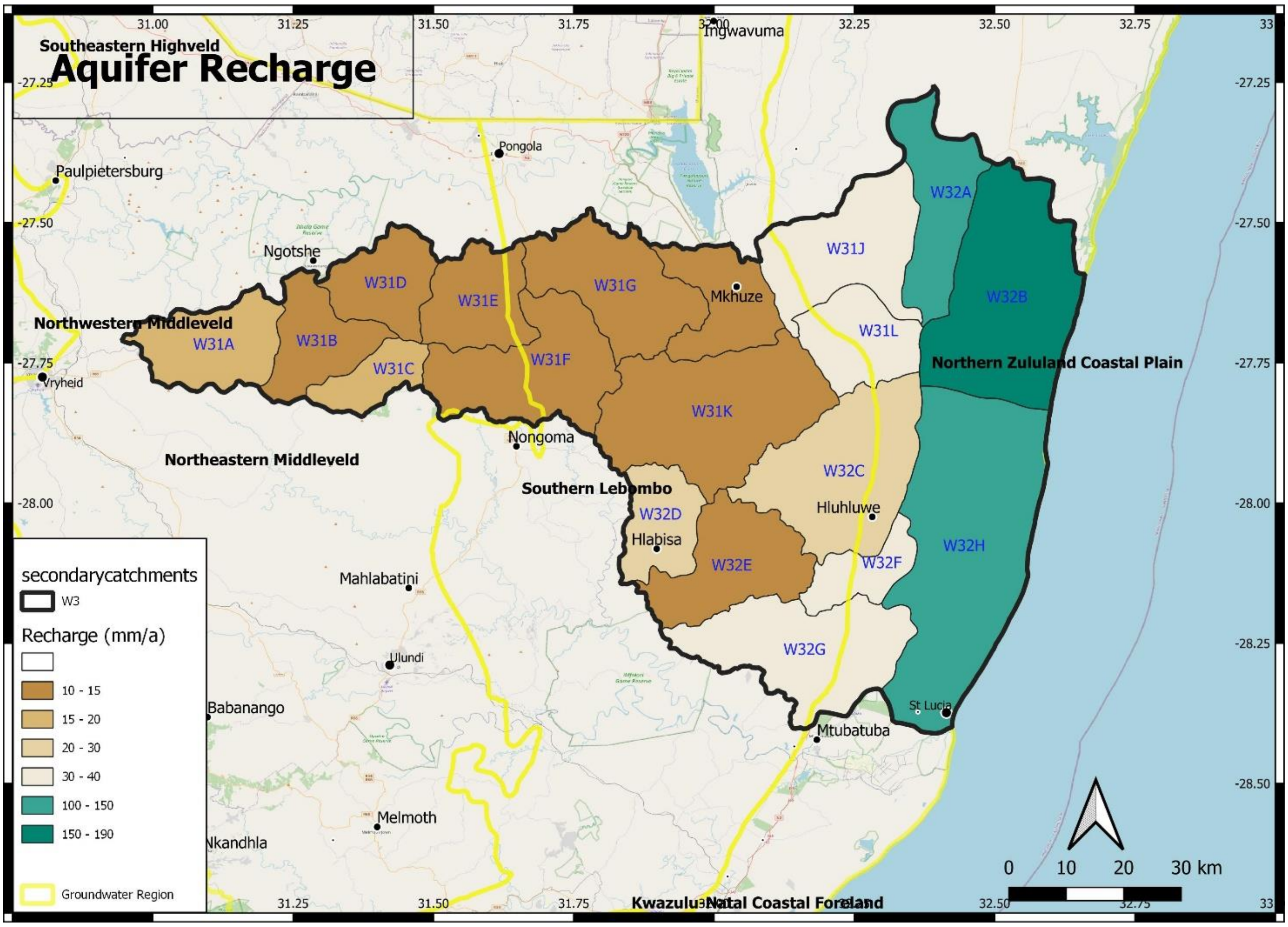

Figure 6.5 Aquifer recharge in W3

6.5 BASEFLOW

Two factors are of importance when considering baseflow. Total baseflow provides the volume of water available to sustain low flows, and groundwater baseflow which is the volume emanating from the regional aquifers and is subject to depletion by groundwater abstraction. The percentage that is ground baseflow provides an index of vulnerability of the low flows in rivers to groundwater abstraction. Baseflow and the percentage of baseflow of groundwater origin is shown in **Figures 6.6** and **6.7**.

Baseflow generation decreases inland from 60 mm/a to 6 mm/a. With the broadening of the flat coastal plain northwards, interflow becomes less significant and over 60% of baseflow is from groundwater in the Lowveld and coastal plain. In the Middleveld it is less than 30%.

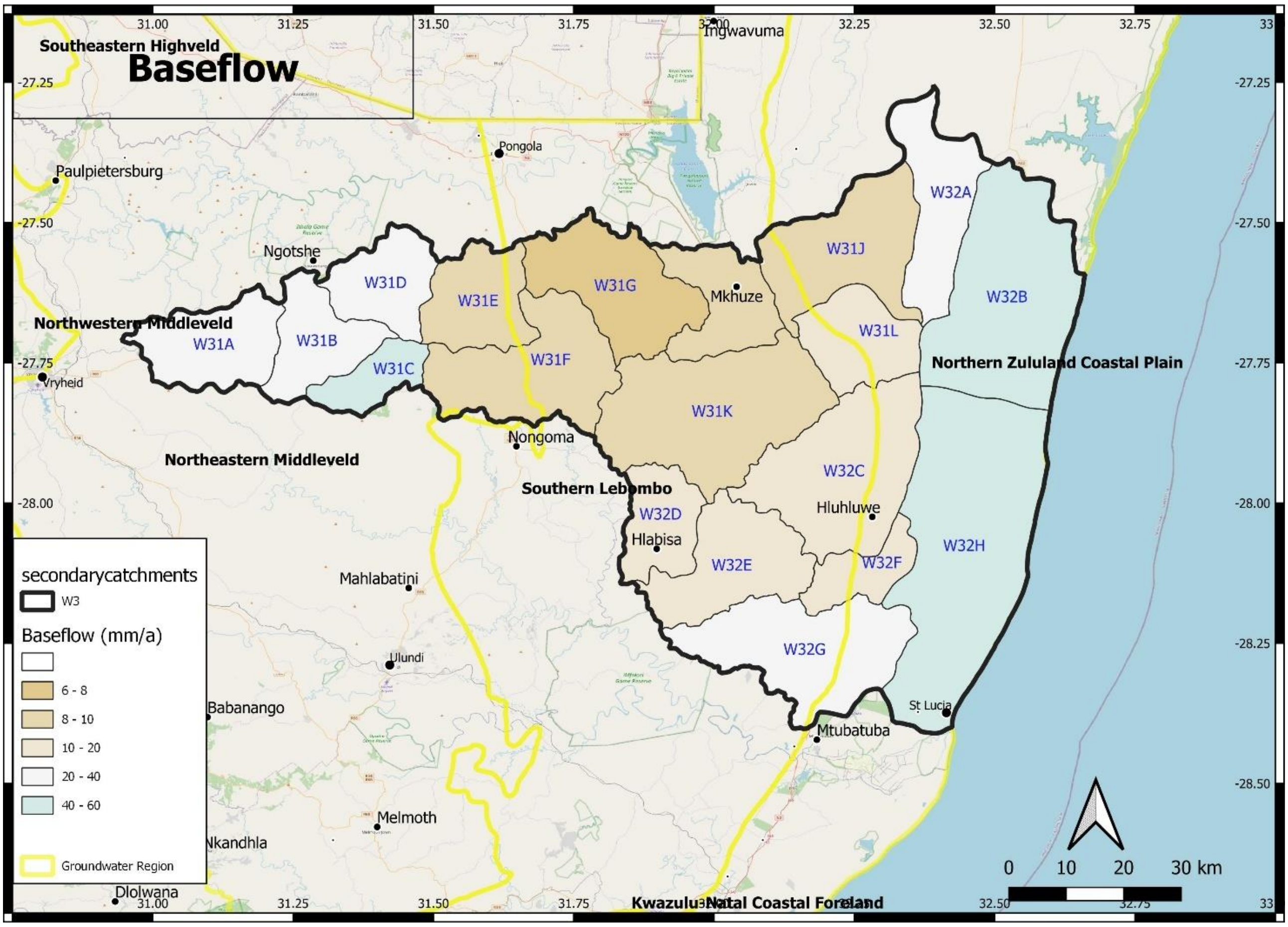

Figure 6.6 Baseflow in W3

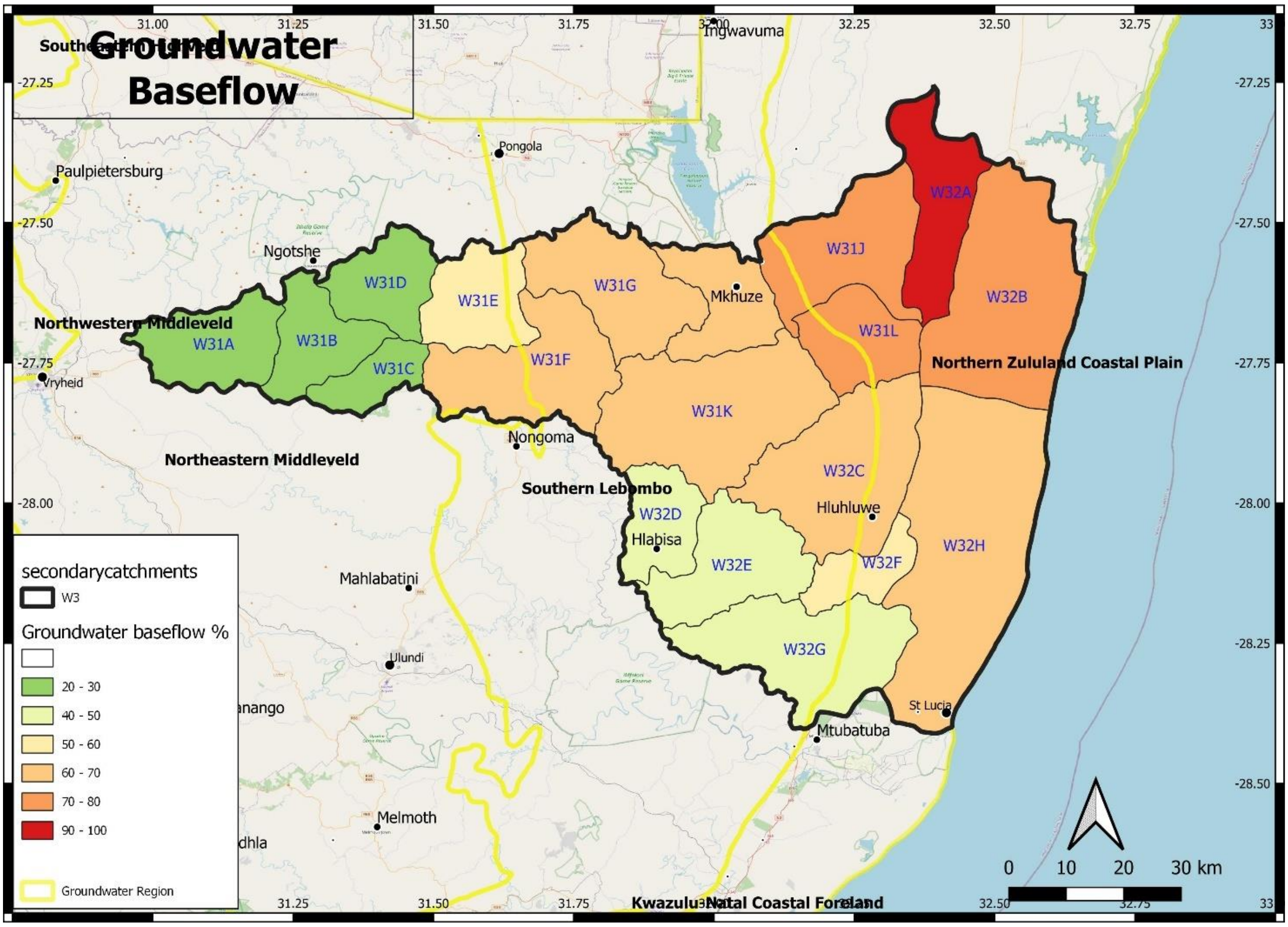

Figure 6.7 Groundwater baseflow as a proportion of baseflow in W3

6.6 USE

Groundwater use is listed in **Table 6.2**.

Table 6.2 Groundwater use in W3

Quat	Irrigation (Mm^3/a)	Industrial (Mm^3/a)	Mining (Mm^3/a)	Water Supply (Mm^3/a)	Livestock (Mm^3/a)	Schedule 1 (Mm^3/a)	Total (Mm^3/a)
W31A					0.0090	0.0571	0.0661
W31B					0.0066	0.0469	0.0535
W31C	0.0000	0.0000	0.0000	0.0355	0.0030	0.0265	0.0650
W31D					0.0070	0.0406	0.0476
W31E					0.0079	0.0405	0.0484
W31F	0.0000	0.0000	0.0000	0.0000	0.0146	0.1320	0.1466
W31G	0.0600	0.0000	0.0000	0.0000	0.0167	0.0988	0.1755
W31H					0.0145	0.0452	0.0597
W31J	0.0000	0.0000	0.0000	0.0000	0.0292	0.0872	0.1164
W31K	0.0327	0.0052	0.0000	0.0009	0.0447	0.1744	0.2579
W31L					0.0185	0.0393	0.0578
W32A					0.0000	0.0960	0.0960
W32B					0.0000	0.2055	0.2055
W32C	0.0000	0.0000	0.0000	0.0146	0.0517	0.0611	0.1274
W32D	0.0000	0.0000	0.0000	0.0533	0.0161	0.0456	0.1149
W32E	0.0000	0.0000	0.0000	0.0110	0.0361	0.0424	0.0895
W32F	0.0119	0.0000	0.0000	0.0000	0.0142	0.0262	0.0523

Quat	Irrigation (Mm^3/a)	Industrial (Mm^3/a)	Mining (Mm^3/a)	Water Supply (Mm^3/a)	Livestock (Mm^3/a)	Schedule 1 (Mm^3/a)	Total (Mm^3/a)
W32G	0.0000	0.0000	0.0000	0.0814	0.0203	0.1185	0.2202
W32H	0.0000	0.0000	0.0000	0.4003	0.0782	0.1698	0.6483
Total	0.1046	0.0052	0.0000	0.5969	0.3883	1.5537	2.6487

6.7 GROUNDWATER RESOURCES

The groundwater recharge, exploitation potential and use for the W3 Catchment is shown in **Table 6.3**.

Table 6.3 W3 Catchment: Groundwater recharge and exploitation potential

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exploitation potential (Mm^3/a)	GRA II Exploitation potential (Mm^3/a)	Harvest potential (Mm^3/a)	Use (Mm^3/a)
W31A	369.72	16.76	5.85	1.71	5.41	5.92	0.0661
W31B	304.28	12.66	4.31	1.12	3.85	4.21	0.0535
W31C	171.56	9.10	3.38	0.81	2.90	2.33	0.0650
W31D	294.57	12.49	4.22	1.27	3.57	4.00	0.0476
W31E	334.19	9.65	3.63	2.61	2.98	4.14	0.0484
W31F	583.35	14.01	6.68	4.90	5.65	7.93	0.1466
W31G	519.77	11.26	5.73	5.26	5.45	6.90	0.1755
W31H	322.59	6.94	4.11	2.82	3.21	4.62	0.0597
W31J	552.60	12.78	19.79	11.59	4.65	60.48	0.1164
W31K	855.31	18.77	10.94	8.22	8.98	11.35	0.2579
W31L	321.38	8.03	11.53	12.79	3.11	19.25	0.0578
W32A	417.40	18.75	45.16	27.72	7.88	80.69	0.0960
W32B	934.44	89.22	142.13	87.84	42.39	234.12	0.2055
W32C	728.23	21.55	19.48	21.74	8.76	27.64	0.1274
W32D	267.22	8.67	6.04	2.51	3.51	3.63	0.1149
W32E	455.92	16.99	6.79	5.43	6.68	6.11	0.0895
W32F	187.34	9.56	7.51	9.71	3.46	10.68	0.0523
W32G	647.50	36.63	25.78	23.34	13.15	25.39	0.2202
W32H	1276.01	113.79	188.09	94.63	40.97	252.66	0.6483

6.8 GROUNDWATER QUALITY

6.8.1 Electrical conductivity

The distribution of EC is shown in **Figure 6.8** and **Table 6.4**. Groundwater is highly variable from Class 0 - 4. The worst water quality is in areas underlain by Karoo rocks in the parts W31 and W32 catchments.

Table 6.4 Distribution of EC in mS/m by percentile and class

Quat	20^{th} percentile	40^{th} percentile	60^{th} percentile	80^{th} percentile	100^{th} percentile	Potable fraction
W31A	33.64	42.94	68.12	82.62	160	0.98
W31B	14.1	24.14	36.42	48.1	56.9	1
W31D	17.34	23.78	37.76	59.28	80.8	1
W31E	60.24	81.08	125	175	183	0.678
W31F	94.24	163.8	234.6	407.6	487	0.358
W31G	209	209	209	209	209	#N/A
W31H	100.84	129.04	165.6	199.8	245	0.467
W31J	167.1	204.4	297	438.2	1279	0.181

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W31K	140.6	171	210.8	287.8	316	0.27
W31L	91.4	96.8	139	224	326	0.708
W32A	75.7	82.2	142	238	297	0.616
W32B	26.74	38.02	78.18	559.4	1407	0.704
W32C	63.6	207	264	451	546	0.256
W32D	15.54	36.96	116.08	143.1	334	0.813
W32E	17.92	26.42	86.58	207.8	359	0.725
W32F	134.32	164.2	195.6	207	278	0.362
W32G	120.8	148	254	499	1097	0.422
W32H	34.58	46.06	56.94	114.24	824	0.829

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W31A	5	2	1	0	0	II
W31B	5	0	0	0	0	I
W31D	2	1	0	0	0	I
W31E	2	1	2	0	0	II
W31F	2	2	4	3	1	III
W31G	0	0	1	0	0	II
W31H	1	3	5	0	0	II
W31J	2	1	6	3	3	III
W31K	1	3	5	4	0	III
W31L	0	8	1	2	0	III
W32A	1	3	1	1	0	III
W32B	5	1	1	0	2	III
W32C	4	0	6	2	4	III
W32D	8	6	2	1	0	III
W32E	5	1	1	2	0	III
W32F	0	6	8	1	0	III
W32G	3	10	7	3	8	III
W32H	17	1	1	1	2	III

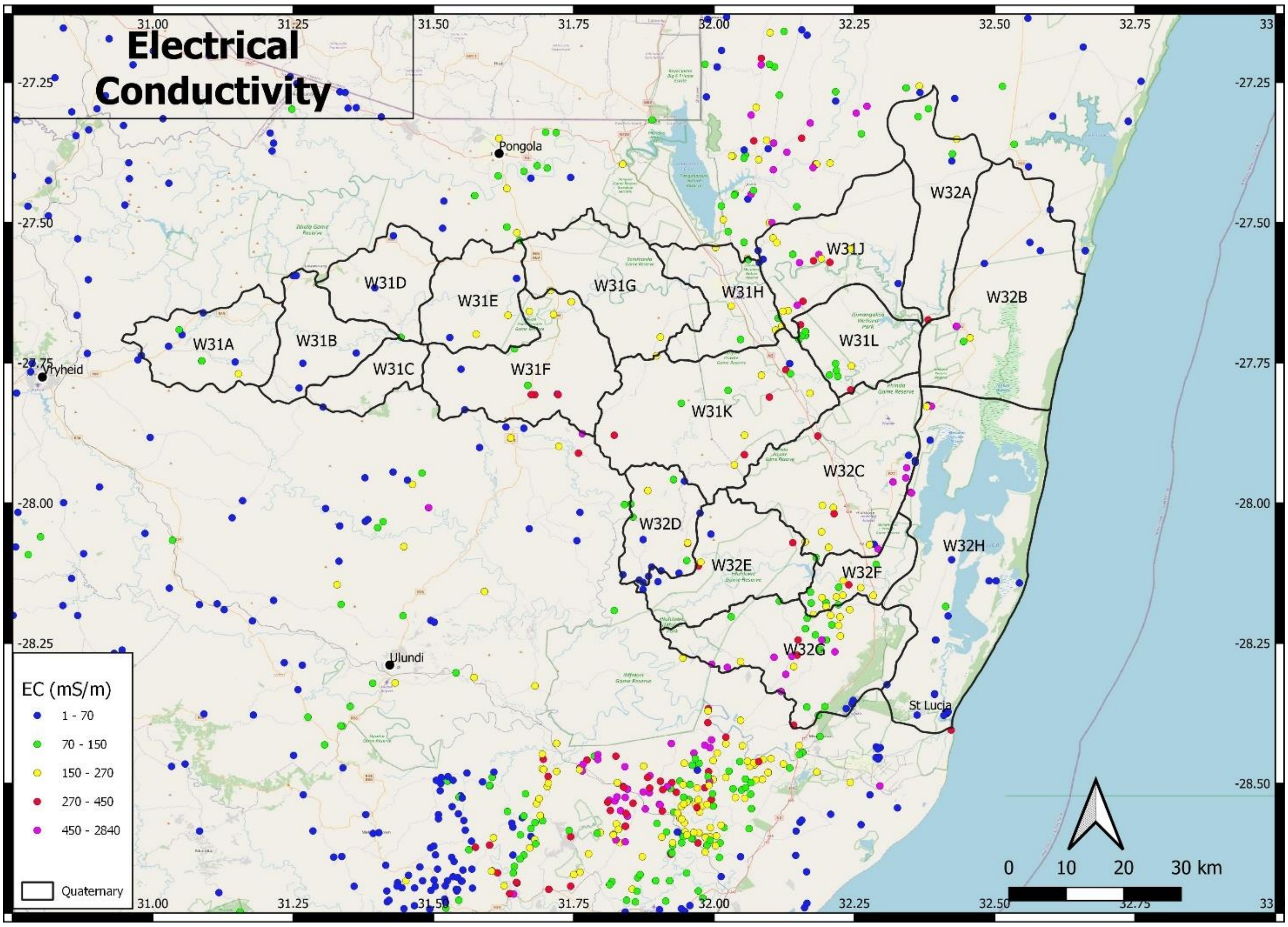

Figure 6.8 EC in W3

6.8.2 Nitrate

Nitrate is generally of Class 0, except in the lower catchments of W32 where localised concentrations of Class 2 - 4 exist (**Figure 6.9**). The distribution of nitrate concentrations in each quaternary is shown in **Table 6.5**.

Table 6.5 Distribution of nitrates in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W31A	0.0486	0.0526	0.0664	0.1136	2.215	1
W31B	0.0664	0.1032	0.1288	0.6436	2.65	1
W31D	0.1786	0.2442	2.0636	5.6368	9.21	1
W31E	0.2354	0.8564	1.5124	2.535	5.027	1
W31F	0.0568	0.184	0.3584	1.6006	100.798	0.914
W31G	1.223	1.223	1.223	1.223	1.223	1
W31H	0.128	0.659	4.831	22.8886	46.023	0.673
W31J	0.02	0.0948	0.2604	0.7124	6.535	1
W31K	0.165	1.5488	2.1138	7.4008	16.444	0.836
W31L	0.047	0.166	0.561	1.117	6.148	1
W32A	0.02	0.405	0.477	0.683	25.01	0.876
W32B	0.04	0.044	0.2632	0.5604	4.172	1
W32C	1.401	6.01	11.294	13.881	43.497	0.582
W32D	0.0402	0.0798	0.37	1.1582	3.578	1
W32E	0.061	0.2096	1.52	3.4786	12.459	0.958
W32F	1.3244	5.846	7.5712	14.1042	26.08	0.74
W32G	0.049	0.315	5.091	9.801	37.145	0.805

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W32H	0.0754	0.1574	0.2804	0.8336	16.543	0.923

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W31A	8	0	0	0	0	I
W31B	5	0	0	0	0	I
W31D	2	1	0	0	0	I
W31E	5	0	0	0	0	I
W31F	11	0	0	0	1	III
W31G	1	0	0	0	0	I
W31H	6	0	1	1	1	III
W31J	14	1	0	0	0	I
W31K	10	1	2	0	0	II
W31L	10	1	0	0	0	I
W32A	5	0	0	1	0	III
W32B	9	0	0	0	0	I
W32C	6	3	4	1	2	III
W32D	17	0	0	0	0	I
W32E	8	0	1	0	0	II
W32F	6	5	2	2	0	III
W32G	21	4	4	2	0	III
W32H	19	1	2	0	0	II

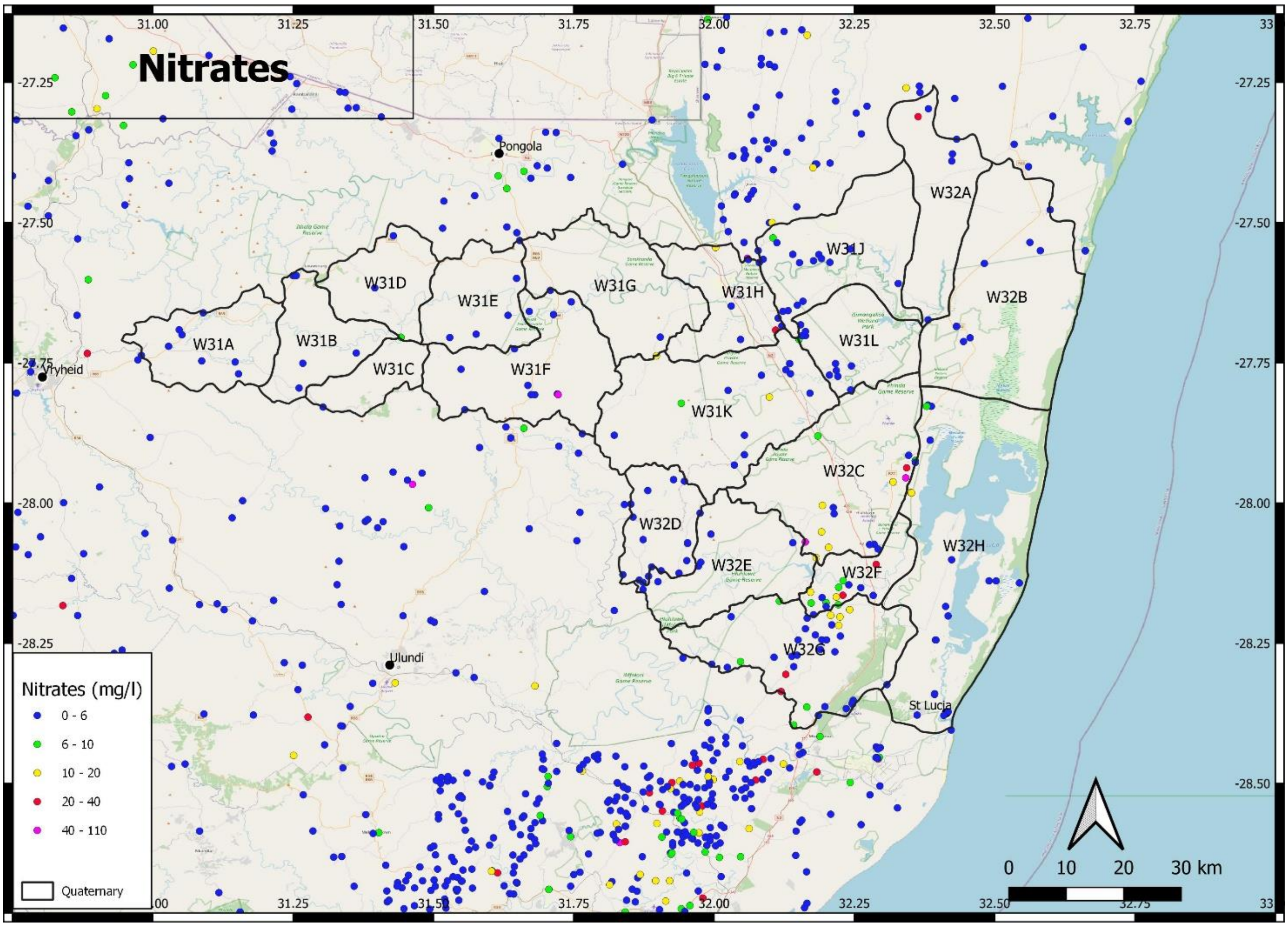

Figure 6.9 Distribution of Nitrate in W3

6.8.3 Fluoride

Water quality is highly variable. Significant areas of high Fluorides exist in in the upper Karoo volcanics, and in some the some intrusive and extrusive granitoids, volcanics and metamorphics (**Figure 6.10**). The distribution of fluoride concentrations in each Quaternary is shown in **Table 6.6**.

Table 6.6 Distribution of Fluoride in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W31A	0.366	0.452	0.488	0.568	0.71	1
W31B	0.092	0.138	0.192	0.326	0.5	1
W31D	0.352	0.404	0.456	0.508	0.56	1
W31E	0.46	0.82	1.084	1.52	2.88	0.797
W31F	0.346	0.564	0.726	1.054	4.39	0.833
W31G	1.44	1.44	1.44	1.44	1.44	1
W31H	0.51	0.592	0.632	0.806	1.51	0.997
W31J	0.62	1.116	1.742	2.182	5.41	0.492
W31K	0.348	0.376	0.41	0.532	0.73	1
W31L	0.55	0.72	0.78	0.85	1.54	0.991
W32A	0.32	0.39	0.47	0.77	0.8	1
W32B	0.05	0.1	0.1144	0.1212	0.41	1
W32C	0.132	0.18	0.32	0.33	0.52	1
W32D	0.26	0.2822	0.386	1.22	14.75	0.818
W32E	0.508	0.586	0.674	1.262	3.28	0.83
W32F	0.16	0.196	0.234	0.282	1.19	1
W32G	0.178	0.31	0.438	0.54	1.39	1
W32H	0.129	0.168	0.25	0.37	1.891	0.986

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W31A	7	1	0	0	0	I
W31B	4	0	0	0	0	I
W31D	3	0	0	0	0	I
W31E	2	0	2	1	0	III
W31F	7	2	1	1	1	III
W31G	0	0	1	0	0	II
W31H	7	1	0	1	0	III
W31J	4	1	2	7	1	III
W31K	12	1	0	0	0	I
W31L	4	5	1	1	0	III
W32A	4	2	0	0	0	I
W32B	9	0	0	0	0	I
W32C	16	0	0	0	0	I
W32D	13	0	1	1	2	III
W32E	6	1	0	2	0	III
W32F	14	0	1	0	0	II
W32G	26	3	1	0	0	I
W32H	20	0	0	1	0	I

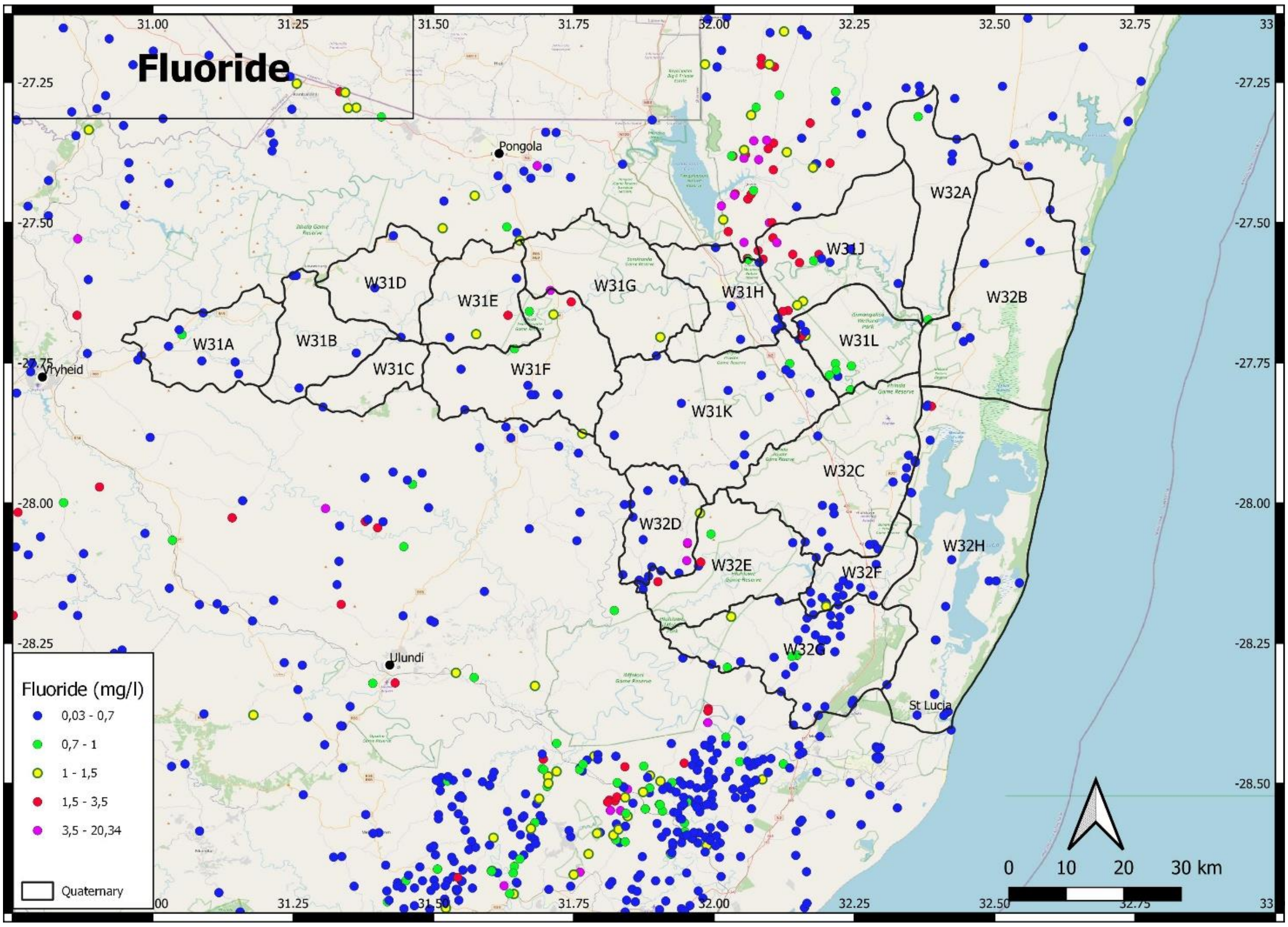

Figure 6.10 Distribution of Fluoride in W3

6.9 CLASSIFICATION

The stress index calculated from the total present use and aquifer recharge is shown in **Figure 6.11**, together with the location of known motorised pump systems. Groundwater is minimally used, and the stress index is below 0.05.

Quaternary catchment classification is shown in **Table 6.7**.

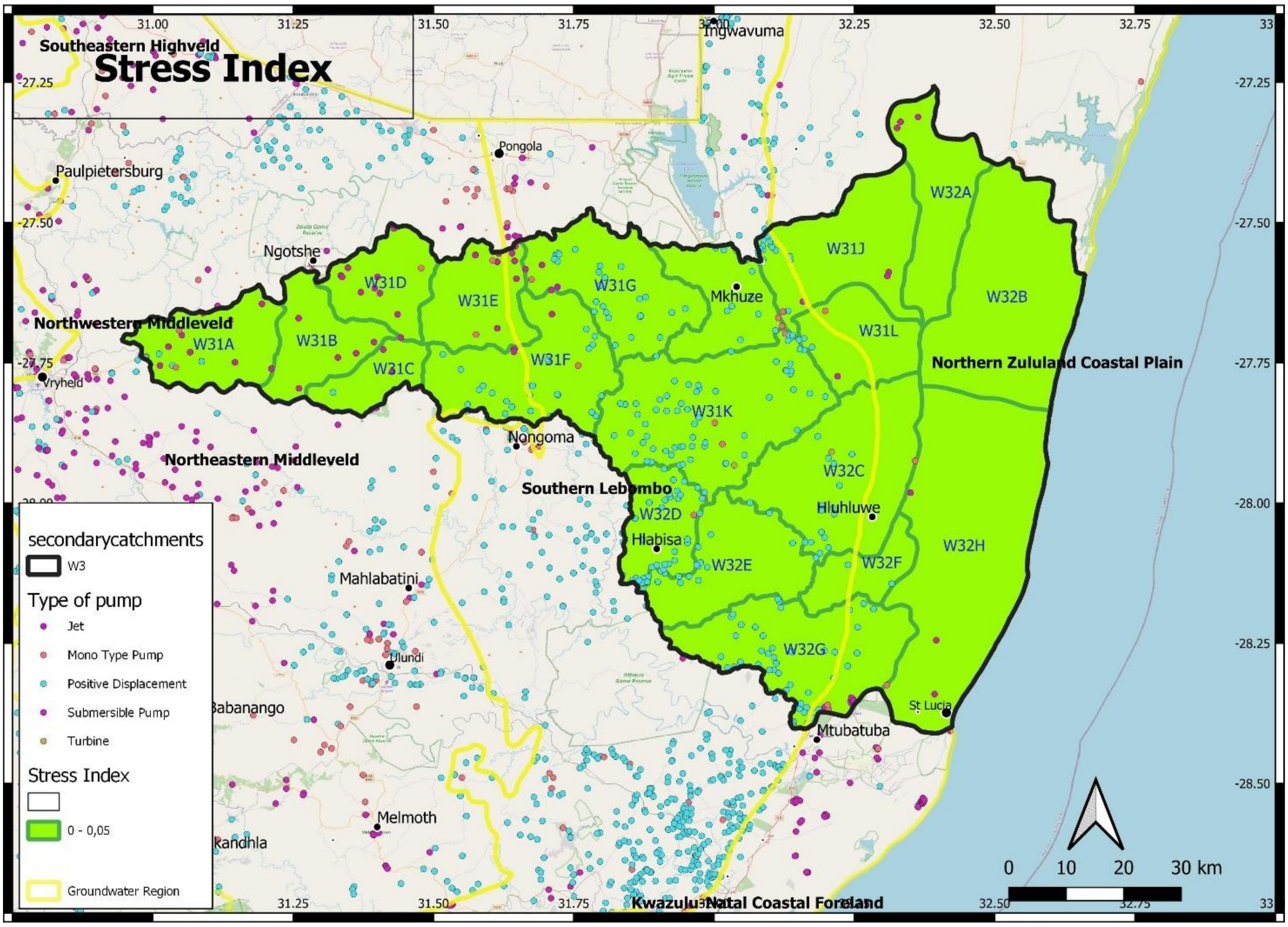

Figure 6.11 Stress Index in W3

Table 6.7 Classification status for W3

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W31A	5.85	14.16	0.072	0.0661	0.01	A	I	14.23
W31B	4.31	11.32	0.06	0.0535	0.01	A	I	11.38
W31C	3.38	8.60	0.033	0.065	0.02	A	I	8.64
W31D	4.22	10.64	0.076	0.0476	0.01	A	I	10.72
W31E	3.63	3.23	0.109	0.0484	0.01	A	I	3.34
W31F	6.68	5.17	0.475	0.1466	0.02	A	I	5.65
W31G	5.73	3.76	0.356	0.1755	0.03	A	I	4.11
W31H	4.11	2.80	0.163	0.0597	0.01	A	I	2.96
W31J	19.79	5.13	0.225	0.1164	0.01	A	I	5.36
W31K	10.94	7.68	0.659	0.2579	0.02	A	I	8.34
W31L	11.53	3.25	0.145	0.0578	0.01	A	I	3.39
W32A	45.16	9.31	0.103	0.096	0.00	A	I	9.42
W32B	142.13	38.24	0.174	0.2055	0.00	A	I	38.41
W32C	19.48	8.06	0.186	0.1274	0.01	A	I	8.25
W32D	6.04	4.60	0.165	0.1149	0.02	A	I	4.77
W32E	6.79	7.74	0.14	0.0895	0.01	A	I	7.88
W32F	7.51	3.53	0.106	0.0523	0.01	A	I	3.63
W32G	25.78	15.43	0.52	0.2202	0.01	A	I	15.95
W32H	188.09	65.72	0.673	0.6483	0.00	A	I	66.39

7 GROUNDWATER RESOURCES IN W4 PONGOLA

7.1 GEOLOGY

The eastern margin is covered by Maputoland Group sediments and Zululand Group rocks (**Figure 7.1**). These are bounded to the west by a thick belt of Karoo volcanics, then by a belt of Ecca Group rocks of the Vryheid Formation, which also underlies the western part of the catchment. The remainder of the catchment consist of intrusive granite-gneisses and metamorphics.

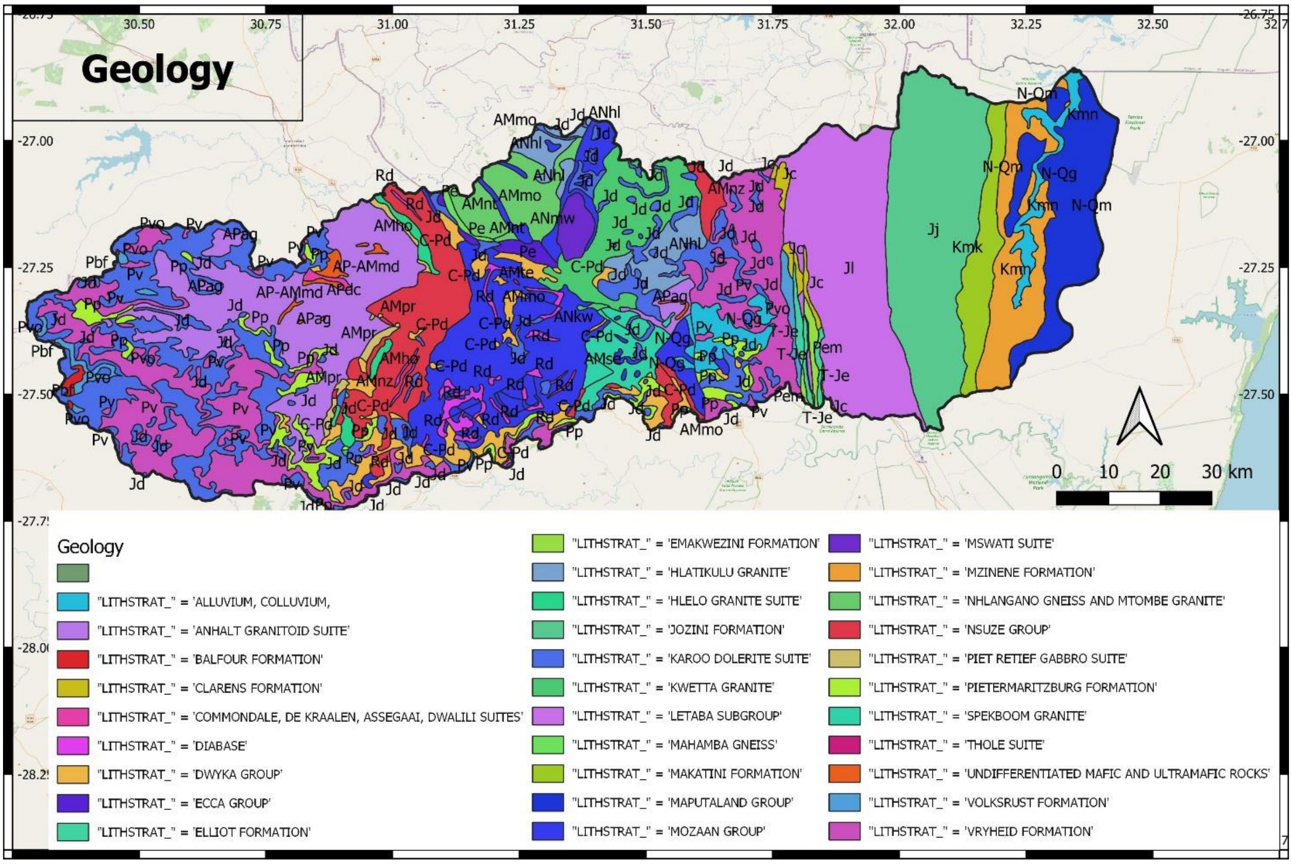

Figure 7.1 Geology of W4

7.2 AQUIFER TYPES

The aquifers are almost exclusively moderately yielding weathered and fractured. Low permeability fractured aquifers are found in the Karoo volcanics (**Figure 7.2**).

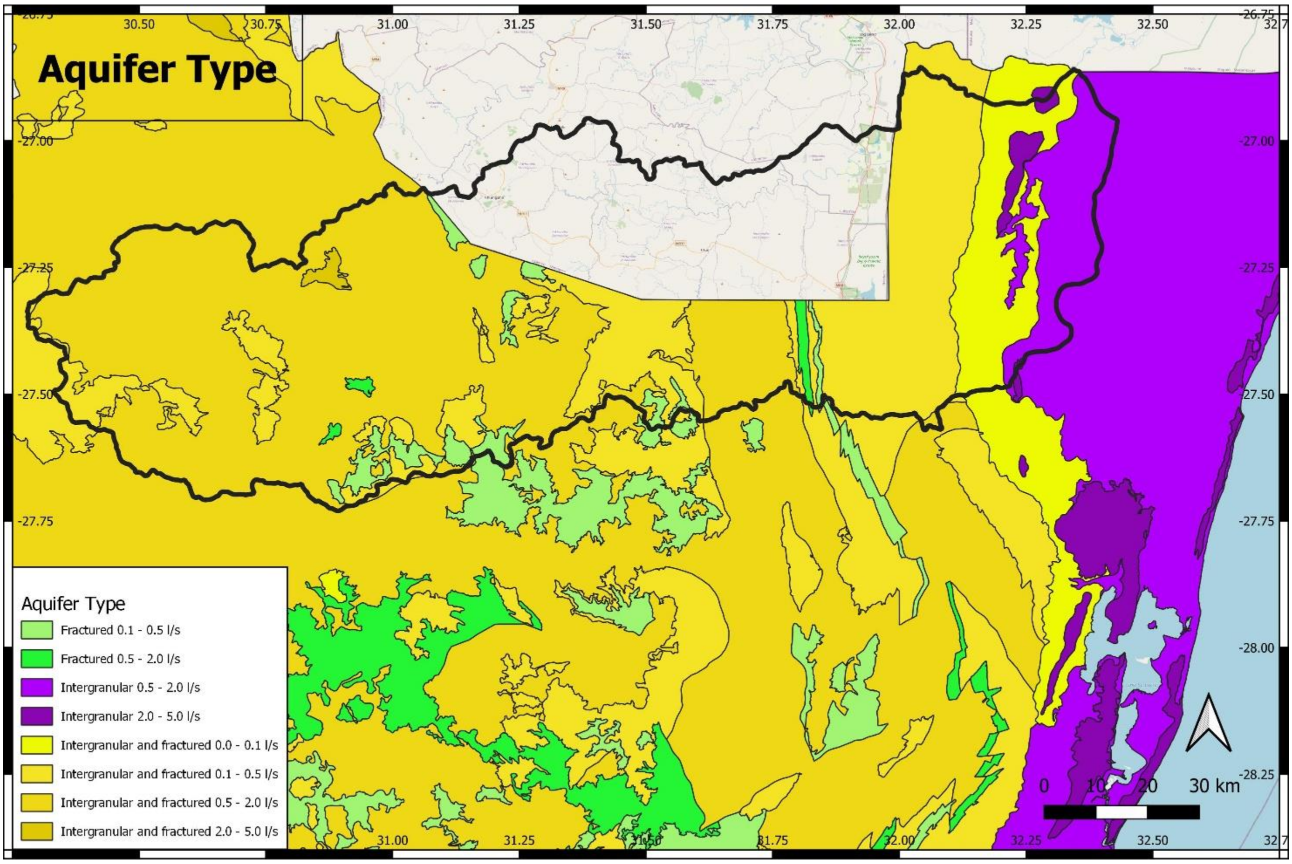

Figure 7.2 Aquifer types in W4

7.3 BOREHOLE YIELD

Median yields are low in the western portion of the Northern Zululand Coastal Plain, where calcarenites do not exist. The Southern Lebombo has moderate yields of below 0.8 l/s. The Northeastern Middleveld region has variable yields, dependent on geology, but yields are higher towards the west. The escarpment area of the Northwestern Middleveld has yields of below 1 l/s (**Figure 7.3**). The distribution of yields by catchment is shown in **Table 7.1**.

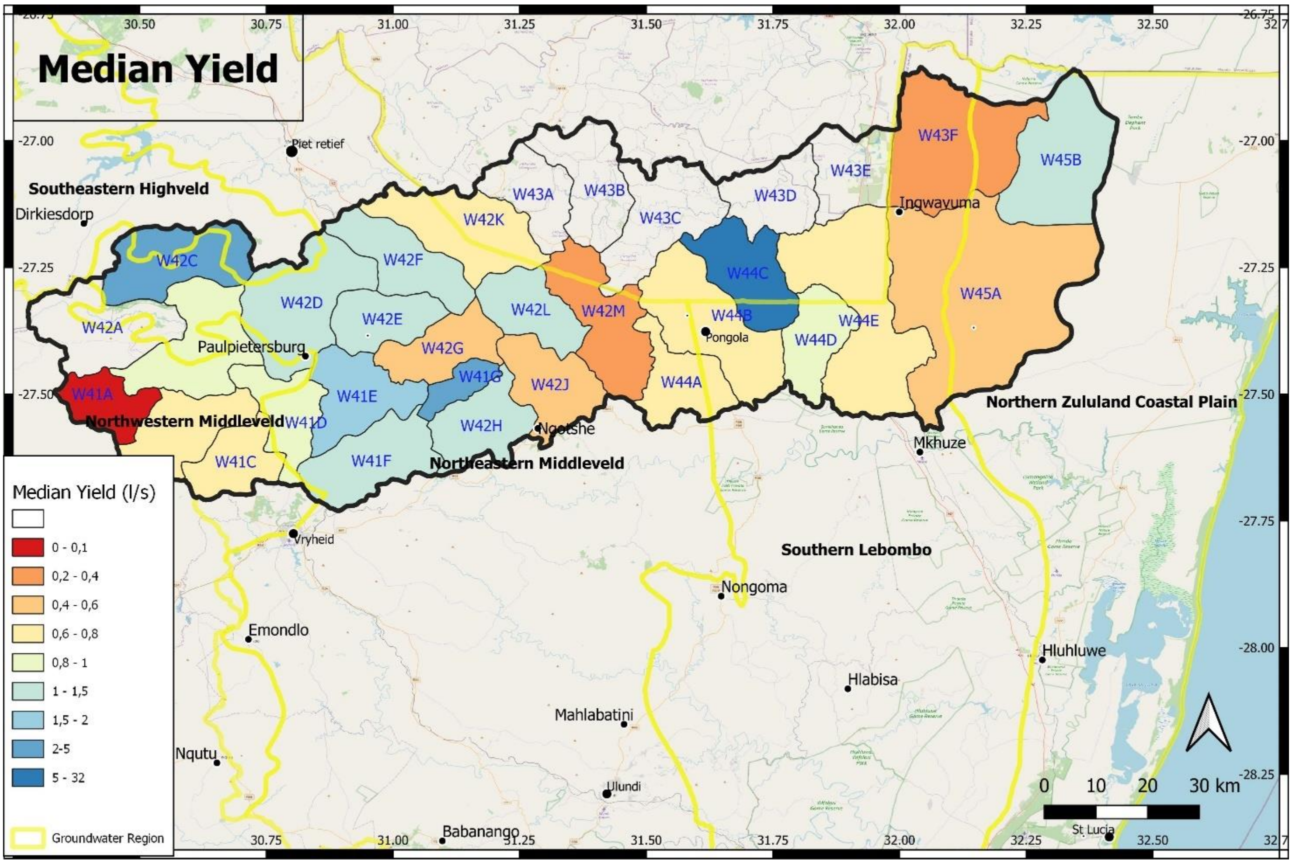

Figure 7.3 Median borehole yields in W4

Table 7.1 Borehole yield distribution in W4

Quaternary	Average (l/s)	Median (l/s)	% > 0.5 l/s	% > 2 l/s	% > 5 l/s
W41A	0.01	0.01	0	0	0
W41B	1.78	0.71	53.7	25.2	9.6
W41C	2.01	0.70	58.7	14	5.9
W41D	1.11	0.84	62.5	18.2	0
W41E	2.50	1.51	85.5	35.1	15.9
W41F	2.11	1.46	81	26.6	10.2
W41G	3.28	3.28	95.5	70.9	21.8
W42B	3.21	0.82	75	29.2	16.7
W42C	1.98	2.16	0	69.2	0
W42D	1.97	1.30	80.5	37.5	5.3
W42E	1.66	1.33	88.7	25	2.7
W42F	1.54	1.01	78	18.7	3.3
W42G	1.60	0.43	48	14.2	6.9
W42H	1.68	1.20	73.7	33.2	0
W42J	2.35	0.44	46.6	23.8	15.9
W42K	1.14	0.79	81	11.8	0
W42L	1.38	1.01	63.7	18.2	3
W42M	0.52	0.32	36.5	0	0
W43F	1.09	0.34	36.9	20.7	0
W44A	1.30	0.60	58.2	15.9	4.1
W44B	1.36	0.72	61.2	19.6	3
W44C	9.00	9.00	0	0	0
W44D	1.50	0.84	76.5	20.4	5.9
W44E	2.41	0.78	63.3	17.7	5.4

Quaternary	Average (l/s)	Median (l/s)	% > 0.5 l/s	% > 2 l/s	% > 5 l/s
W45A	1.10	0.55	51.7	15.1	1.9
W45B	1.11	1.11	0	0	0

7.4 RECHARGE

Recharge can be considered in terms of:

- Total recharge, which drives baseflow and recharges aquifers.
- Groundwater recharge which recharges the aquifers and is available to boreholes. This excludes the recharge that generates interflow from high-lying springs.

These are shown in **Figures 7.4** and **7.5**. Recharge is only 10 - 20 mm/a on the drier Lowveld west of the Lebombo range. The highest recharge is on the escarpment of the Northwestern Highveld, where it reaches 100 - 150 mm/a. Aquifer recharge is over 40 mm/a on the Northern Zululand Coastal Plain, but only 10 - 15 mm/a in the Lowveld. It is 15 - 30 mm/a in the Northeastern and Northwestern Middlevelds.

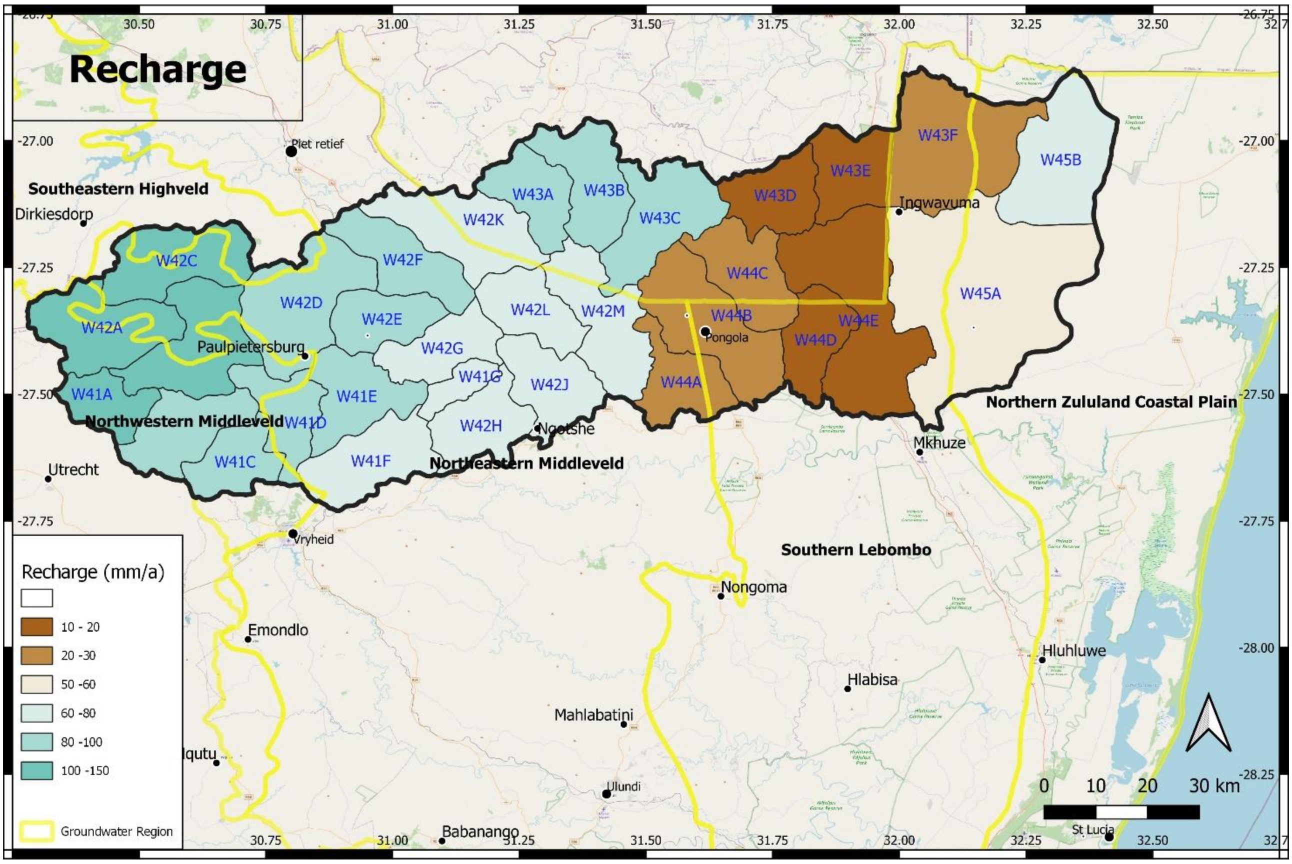

Figure 7.4 Recharge in W4

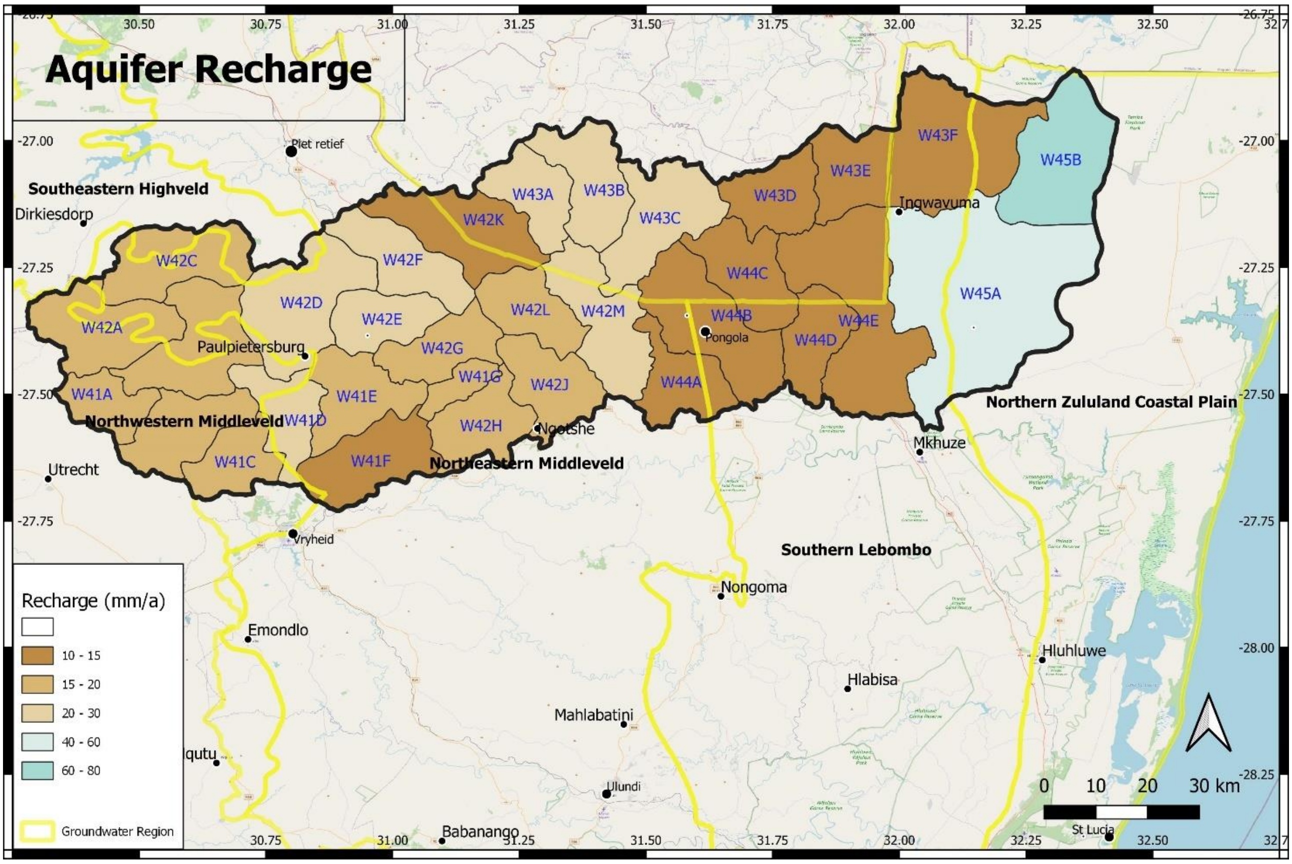

Figure 7.5 Aquifer recharge in W4

7.5 BASEFLOW

Two factors are of importance when considering baseflow. Total baseflow, provides the volume of water available to sustain low flows, and groundwater baseflow which is the volume emanating from the regional aquifers and is subject to depletion by groundwater abstraction. The percentage that is ground baseflow provides an index of vulnerability of the low flows in rivers to groundwater abstraction. Baseflow and the percentage of baseflow of groundwater origin is shown in **Figures 7.6** and **7.7**.

Baseflow generation decreases to the east from 125 mm/a on the escarpment to 6 mm/a in the Lowveld. The proportion of groundwater baseflow increases from 10% to 70% towards the east.

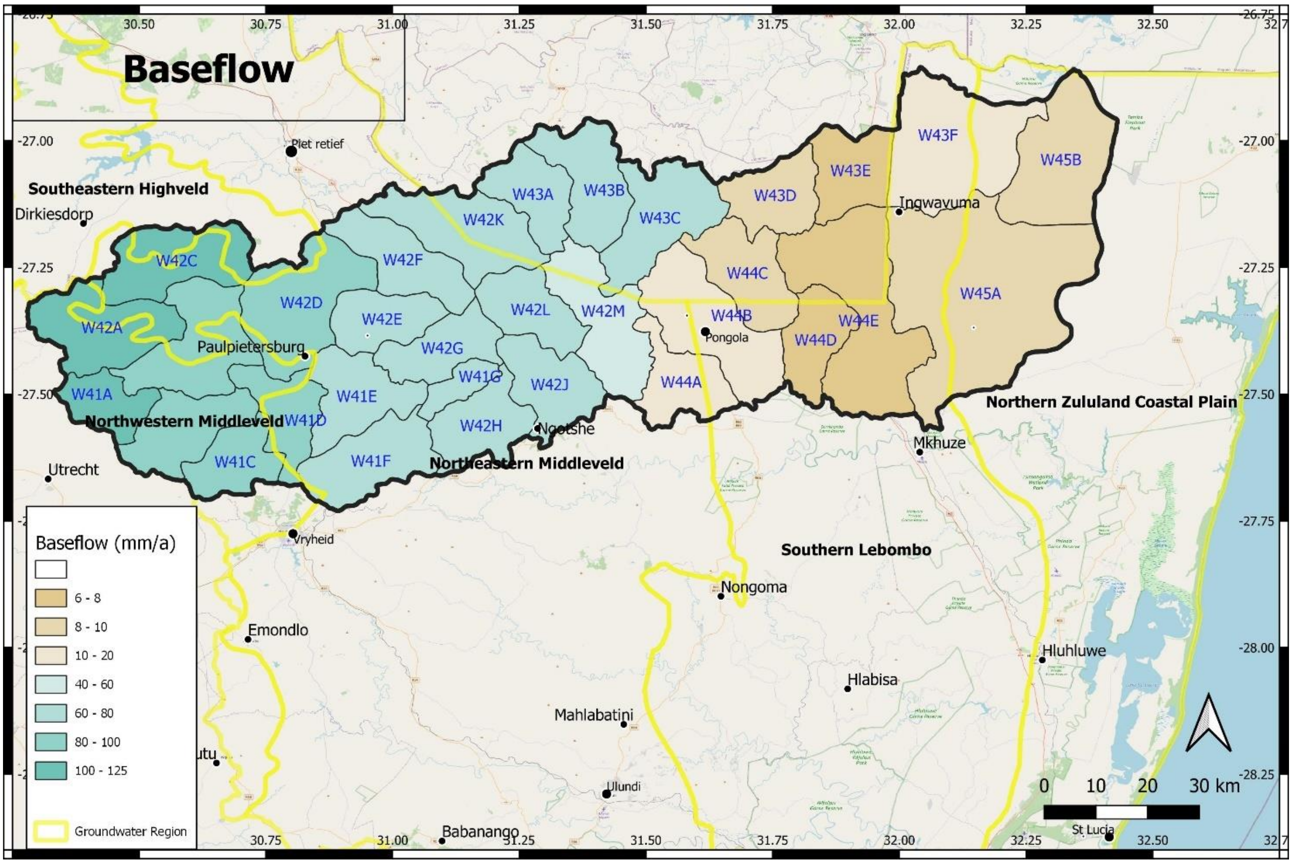

Figure 7.6 Baseflow in W4

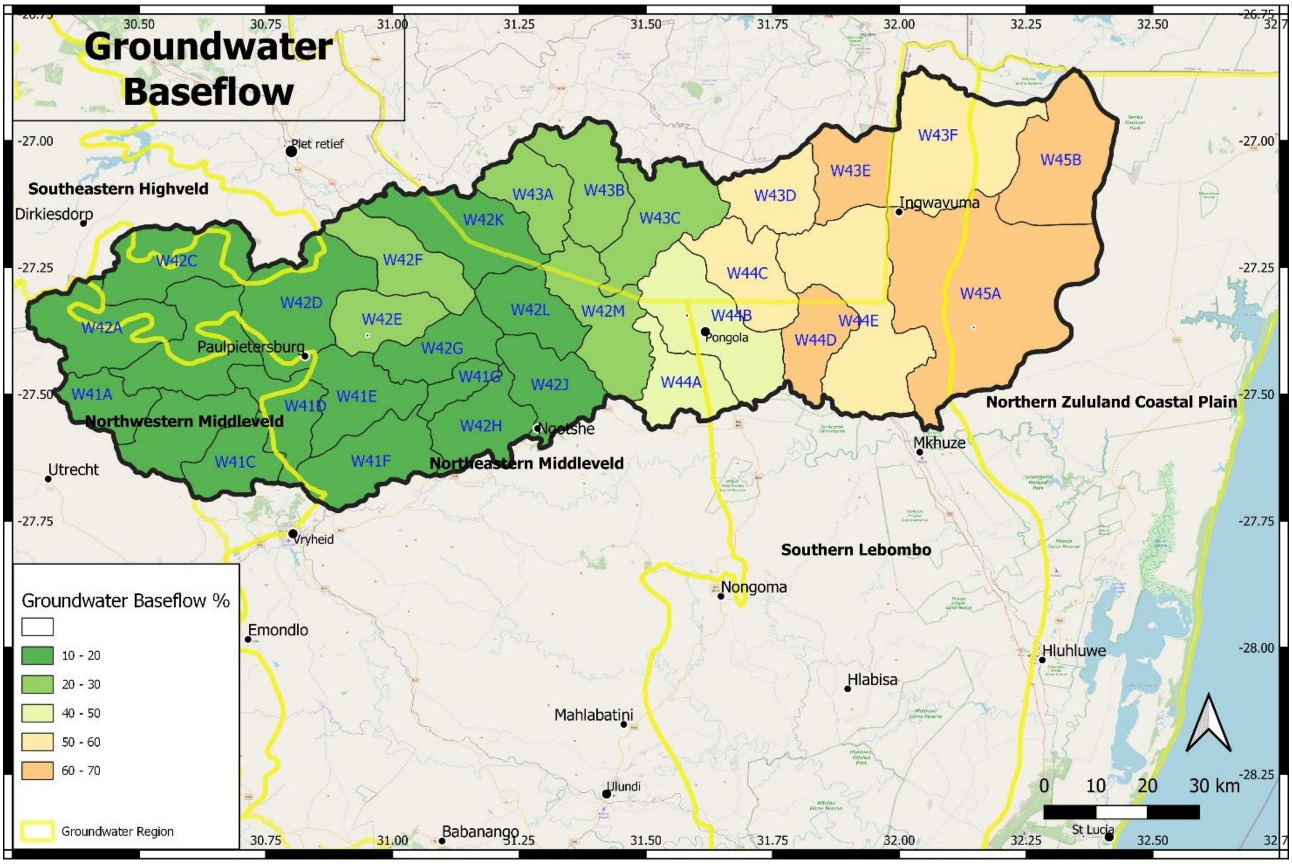

Figure 7.7 Groundwater baseflow as a percentage of baseflow in W4

7.6 USE

Groundwater use is listed in **Table 7.2**.

Table 7.2 Groundwater use in W4

Quat	Irrigation (Mm^3/a)	Industrial (Mm^3/a)	Mining (Mm^3/a)	Water Supply (Mm^3/a)	Livestock (Mm^3/a)	Schedule 1 (Mm^3/a)	Total (Mm^3/a)
W41A					0.0087	0.0096	0.0183
W41B	0.0000	0.0000	0.0137	0.0000	0.0053	0.0243	0.0433
W41C	0.0000	0.0000	0.0000	0.0000	0.0007	0.0254	0.0261
W41D					0.0007	0.0325	0.0332
W41E	0.0200	0.0010	0.0000	0.0000	0.0041	0.0413	0.0664
W41F	0.0000	0.0000	0.0000	0.0000	0.0048	0.0504	0.0552
W41G					0.0008	0.0138	0.0146
W42A					0.0090	0.0296	0.0386
W42B					0.0068	0.0546	0.0614
W42C					0.0004	0.0553	0.0557
W42D					0.0174	0.0752	0.0926
W42E					0.0067	0.0348	0.0415
W42F	0.0015	0.0720	0.0000	0.0000	0.0000	0.0518	0.1253
W42G	0.0000	0.0000	0.0000	0.0030	0.0014	0.0330	0.0374
W42H					0.0067	0.0380	0.0447
W42J	0.0000	0.0000	0.0000	0.0010	0.0035	0.0354	0.0399
W42K	0.1793	0.0000	0.0000	0.0000	0.0000	0.0374	0.2166
W42L					0.0000	0.0312	0.0312
W42M	0.0005	0.0000	0.0000	0.0000	0.0007	0.0352	0.0364
W43C						0.0006	0.0006
W43F						0.0800	0.0800
W44A					0.0079	0.0291	0.0370
W44B	0.4410	0.0000	0.0000	0.0000	0.0018	0.0393	0.4821
W44C					0.0000	0.0077	0.0077
W44D	0.0000	0.0000	0.0000	0.0018	0.0027	0.0244	0.0289
W44E					0.0030	0.0425	0.0455
W45A	0.0137	0.0000	0.0000	0.0355	0.0282	0.2113	0.2887
W45B	0.0000	0.0000	0.0000	0.0000	0.0004	0.1192	0.1196
Total	0.6560	0.0730	0.0137	0.0413	0.1217	1.2627	2.1684

7.7 GROUNDWATER RESOURCES

The groundwater recharge, exploitation potential and use for the W4 Catchment is shown in **Table 7.3**.

Table 7.3 W4 Catchment: Groundwater recharge and exploitation potential

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exploitation potential (Mm^3/a)	GRA II Exploitation potential (Mm^3/a)	Harvest potential (Mm^3/a)	Use (Mm^3/a)
W41A	187.61	20.57	3.34	0.76	7.39	3.16	0.0183
W41B	305.61	29.37	5.48	1.35	10.72	5.41	0.0433
W41C	217.31	20.67	3.95	0.99	7.44	3.84	0.0261
W41D	238.02	20.33	5.02	1.19	7.09	6.68	0.0332
W41E	303.17	23.74	4.75	1.72	9.16	4.84	0.0664
W41F	343.46	25.49	5.21	1.59	7.95	4.76	0.0552
W41G	95.80	6.39	1.58	0.31	1.53	1.07	0.0146
W42A	397.37	46.75	6.65	1.70	17.68	9.87	0.0386

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exploitation potential (Mm^3/a)	GRA II Exploitation potential (Mm^3/a)	Harvest potential (Mm^3/a)	Use (Mm^3/a)
W42B	416.55	39.21	8.50	2.23	14.50	12.28	0.0614
W42C	376.56	41.61	7.34	2.25	15.71	11.05	0.0557
W42D	489.41	41.79	10.27	2.96	15.55	18.68	0.0926
W42E	231.74	18.00	5.04	1.37	6.52	5.73	0.0415
W42F	305.53	23.96	6.94	1.76	8.21	8.76	0.1253
W42G	248.17	18.34	4.00	1.01	5.42	2.78	0.0374
W42H	272.90	17.99	4.67	1.01	4.50	3.37	0.0447
W42J	290.46	17.61	4.94	1.07	4.54	4.11	0.0399
W42K	415.98	30.16	6.33	1.89	5.85	6.70	0.2166
W42L	250.66	16.23	4.43	0.90	3.78	2.81	0.0312
W42M	391.57	23.11	9.31	1.44	4.71	8.77	0.0364
W43C	395.08	26.24	11.86	2.74	0.09	9.88	0.0006
W43F	631.45	14.33	9.24	11.69	5.83	28.76	0.0800
W44A	254.71	7.45	3.12	1.97	2.38	4.07	0.0370
W44B	486.09	11.96	5.85	4.04	3.55	7.98	0.4821
W44C	314.30	6.29	3.78	2.95	0.70	5.16	0.0077
W44D	236.43	4.38	2.64	2.07	2.08	2.73	0.0289
W44E	711.45	13.68	8.05	6.51	3.52	10.52	0.0455
W45A	1289.09	23.41	69.60	34.80	7.84	84.62	0.2887
W45B	508.13	13.09	31.43	21.09	6.77	74.18	0.1196

7.8 GROUNDWATER QUALITY

7.8.1 Electrical conductivity

The distribution of EC is shown in **Figure 7.8** and **Table 7.4**. Groundwater is highly variable from Class 0 - 4. The upper catchment has water of Class 0. The worst water quality is in areas underlain by Karoo rocks in the part W43F and W45.

Table 7.4 Distribution of EC in mS/m by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W41A	10.54	12.58	13.7	13.9	14.1	1
W41B	25.88	36.66	42.24	49.9	58.6	1
W41C	17.6	19.68	25.32	138.72	306	0.813
W41D	11.4	12.5	15.38	18.42	27.3	1
W41E	17.12	24.78	31.92	39.26	46.7	1
W41F	38	38	38	38	38	1
W42A	12.08	13.96	15.84	17.72	19.6	1
W42B	12.56	23.12	59.72	108.7	484	0.853
W42C	6.3	6.3	6.3	6.3	6.3	1
W42D	11.5	19.6	27.1	33.3	56.5	1
W42E	11.26	13.32	17.58	24.6	33	1
W42F	21.36	25.12	28.02	30.06	32.1	1
W42G	18.98	19.76	20.54	21.32	22.1	1
W42K	14.62	17.94	26.24	39.52	52.8	1
W42L	18.96	22.64	29.96	58.72	98.2	1
W42M	17.1	17.66	18.62	26.8	54	1
W43F	53.42	79.26	175.2	270.4	708	0.58
W44A	51	87.4	124.1	152	175	0.785
W44B	62.04	82.48	98.26	121.62	161.1	0.946
W44C	93.6	96.4	99.2	102	104.8	1

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W44D	118.76	128.32	137.88	147.44	157	0.853
W44E	89.2	133.16	144	157.4	222	0.685
W45A	51.12	89.42	204.8	478.2	1690	0.539
W45B	114.26	179.42	215.8	223.4	231	0.309

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W41A	3	0	0	0	0	I
W41B	4	0	0	0	0	I
W41C	3	0	0	1	0	III
W41D	22	0	0	0	0	I
W41E	4	0	0	0	0	I
W41F	1	0	0	0	0	I
W42A	2	0	0	0	0	I
W42B	36	11	4	3	1	III
W42C	1	0	0	0	0	I
W42D	11	0	0	0	0	I
W42E	4	0	0	0	0	I
W42F	3	0	0	0	0	I
W42G	2	0	0	0	0	I
W42K	3	0	0	0	0	I
W42L	3	1	0	0	0	I
W42M	5	0	0	0	0	I
W43F	6	3	3	2	1	III
W44A	2	2	2	0	0	II
W44B	2	4	1	0	0	II
W44C	0	2	0	0	0	I
W44D	0	1	1	0	0	II
W44E	1	4	3	0	0	II
W45A	13	13	8	4	11	III
W45B	1	0	2	0	0	II

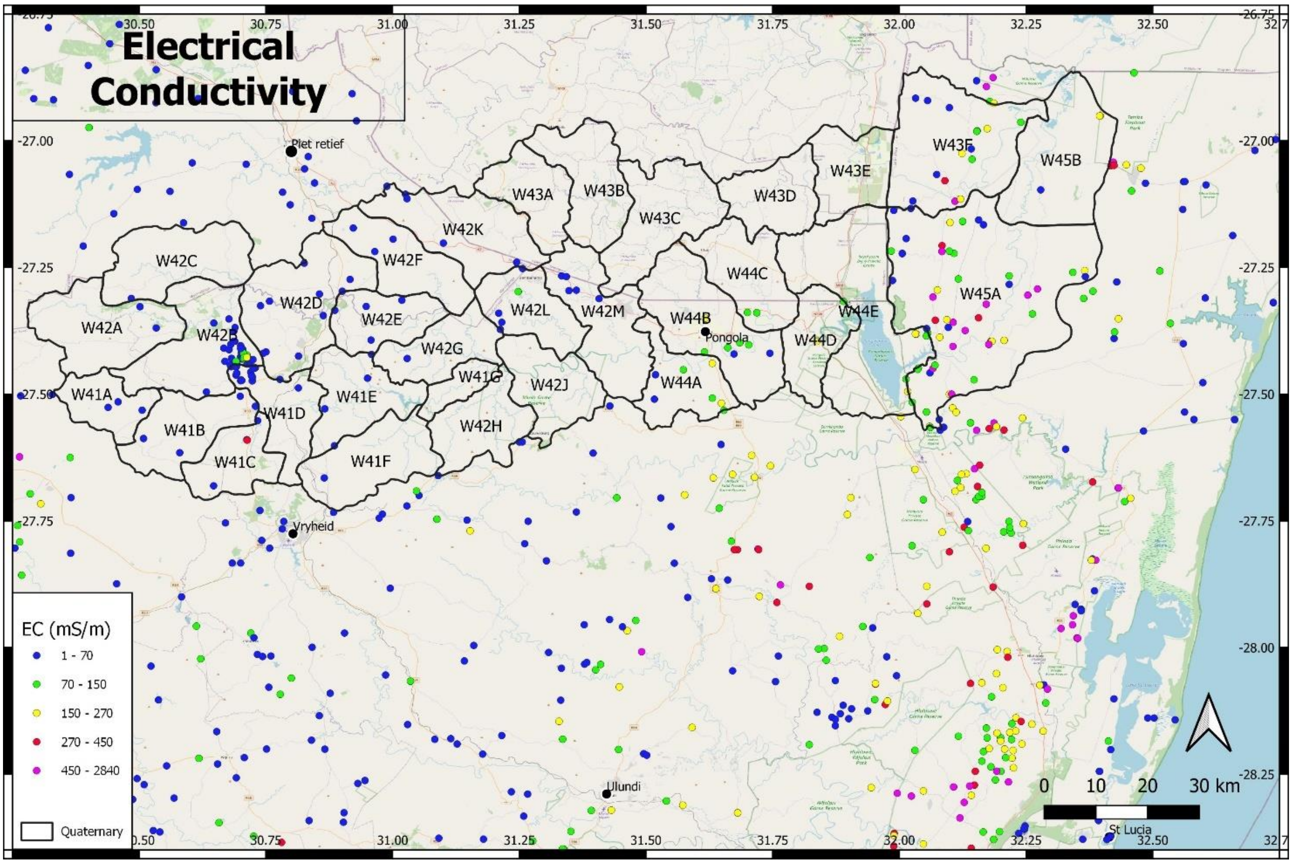

Figure 7.8 EC in W4

7.8.2 Nitrate

Nitrate is generally of Class 0 - 2 throughout the catchment (**Figure 7.9**). The distribution of nitrate concentrations in each quaternary is shown in **Table 7.5**.

Table 7.5 Distribution of nitrates in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W41A	0.0488	0.0776	0.1262	0.1946	0.263	1
W41B	0.02	0.1316	0.4664	1.2144	2.169	1
W41C	1.363	2.3172	3.2238	3.7012	3.964	1
W41D	0.02	0.1096	0.3318	0.8588	2.186	1
W41E	0.02	0.2066	0.7664	3.3446	6.932	1
W41F	1.802	1.802	1.802	1.802	1.802	1
W42A	0.034	0.048	0.062	0.076	0.09	1
W42B	0.02	0.0578	0.189	0.706	10.468	0.998
W42C	0.02	0.02	0.02	0.02	0.02	1
W42D	0.507	1.64	5.432	8.331	17.524	0.916
W42E	1.224	1.8716	3.3584	5.4504	7.845	1
W42F	3.7248	6.0836	9.0838	12.7254	16.367	0.65
W42G	1.997	2.228	2.459	2.69	2.921	1
W42K	1.329	1.895	2.3148	2.5884	2.862	1
W42L	1.1564	2.1624	2.9076	3.9284	5.087	1
W42M	0.2598	0.9996	2.418	4.093	5.105	1
W43F	0.02	0.056	0.3892	2.2974	26.615	0.946
W44A	0.054	0.081	0.343	1.068	8.222	1
W44B	1.4728	2.5908	4.1424	6.3676	9.151	1
W44C	3.7852	3.8734	3.9616	4.0498	4.138	1

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W44D	0.3904	0.5538	0.7172	0.8806	1.044	1
W44E	0.02	0.02	0.0548	0.2766	1.806	1
W45A	0.02	0.0484	0.439	2.4106	19.767	0.922
W45B	0.2356	0.3612	2.6822	7.1986	11.715	0.924

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W41A	3	0	0	0	0	I
W41B	4	0	0	0	0	I
W41C	4	0	0	0	0	I
W41D	22	0	0	0	0	I
W41E	3	1	0	0	0	I
W41F	1	0	0	0	0	I
W42A	2	0	0	0	0	I
W42B	54	0	1	0	0	I
W42C	1	0	0	0	0	I
W42D	7	3	1	0	0	II
W42E	3	1	0	0	0	I
W42F	1	1	1	0	0	II
W42G	2	0	0	0	0	I
W42K	3	0	0	0	0	I
W42L	4	0	0	0	0	I
W42M	5	0	0	0	0	I
W43F	14	0	0	1	0	III
W44A	5	1	0	0	0	I
W44B	5	2	0	0	0	I
W44C	2	0	0	0	0	I
W44D	2	0	0	0	0	I
W44E	8	0	0	0	0	I
W45A	44	1	4	0	0	II
W45B	2	0	1	0	0	II

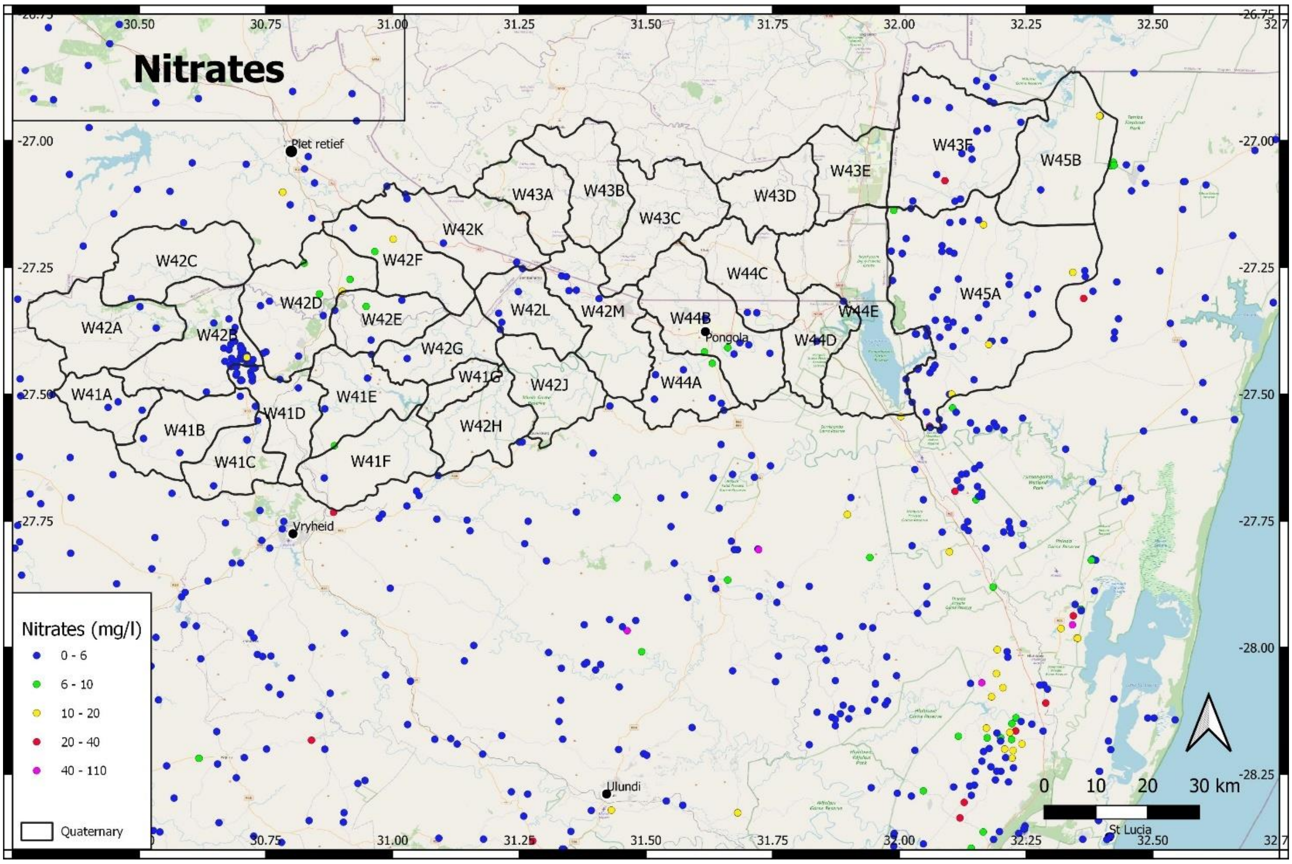

Figure 7.9 Distribution of Nitrate in W4

7.8.3 Fluoride

Water quality is highly variable. Significant areas of high Fluoride exist in in the upper Karoo volcanics, and in some the some intrusive and extrusive granitoids, volcanics and metamorphics (**Figure 7.10**). The distribution of fluoride concentrations in each quaternary is shown in **Table 7.6**.

Table 7.6 Distribution of Fluoride in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W41A	0.14	0.16	0.172	0.176	0.18	1
W41B	0.208	0.222	0.228	0.262	0.31	1
W41C	0.176	0.21	0.24	0.254	0.26	1
W41D	0.05	0.124	0.166	0.234	0.43	1
W41E	0.278	0.386	0.554	3.65	8.21	0.705
W41F	2.28	2.28	2.28	2.28	2.28	#N/A
W42A	0.13	0.13	0.13	0.13	0.13	1
W42B	0.05	0.12	0.21	0.292	1.49	1
W42C	0.14	0.14	0.14	0.14	0.14	1
W42D	0.136	0.156	0.188	0.31	0.47	1
W42E	0.164	0.202	0.268	0.646	1.18	1
W42F	0.18	0.2	0.262	0.366	0.47	1
W42G	0.512	0.514	0.516	0.518	0.52	1
W42K	0.12	0.12	0.132	0.156	0.18	1
W42L	0.298	0.406	0.454	0.69	1.02	1
W42M	1.036	1.06	1.112	1.374	2.11	0.834
W43F	0.688	1.148	1.574	4.088	5.55	0.585
W44A	0.57	0.66	0.83	1.05	1.21	1
W44B	0.11	0.43	0.5	0.5	4.71	0.847

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W44C	0.294	0.308	0.322	0.336	0.35	1
W44D	0.2198	0.2896	0.3594	0.4292	0.499	1
W44E	1.206	2.078	2.476	3.368	4.91	0.322
W45A	0.34	0.716	1.3348	2.13	18.45	0.614
W45B	0.1008	0.1016	0.2456	0.5328	0.82	1

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W41A	3	0	0	0	0	I
W41B	4	0	0	0	0	I
W41C	4	0	0	0	0	I
W41D	22	0	0	0	0	I
W41E	3	0	0	0	1	III
W41F	0	0	0	1	0	III
W42A	1	0	0	0	0	I
W42B	51	1	3	0	0	II
W42C	1	0	0	0	0	I
W42D	9	0	0	0	0	I
W42E	3	0	1	0	0	II
W42F	3	0	0	0	0	I
W42G	2	0	0	0	0	I
W42K	3	0	0	0	0	I
W42L	3	0	1	0	0	II
W42M	0	1	3	1	0	III
W43F	3	1	5	2	4	III
W44A	3	1	2	0	0	II
W44B	5	0	0	0	1	III
W44C	2	0	0	0	0	I
W44D	2	0	0	0	0	I
W44E	0	1	2	3	2	III
W45A	19	5	6	13	6	III
W45B	2	1	0	0	0	I

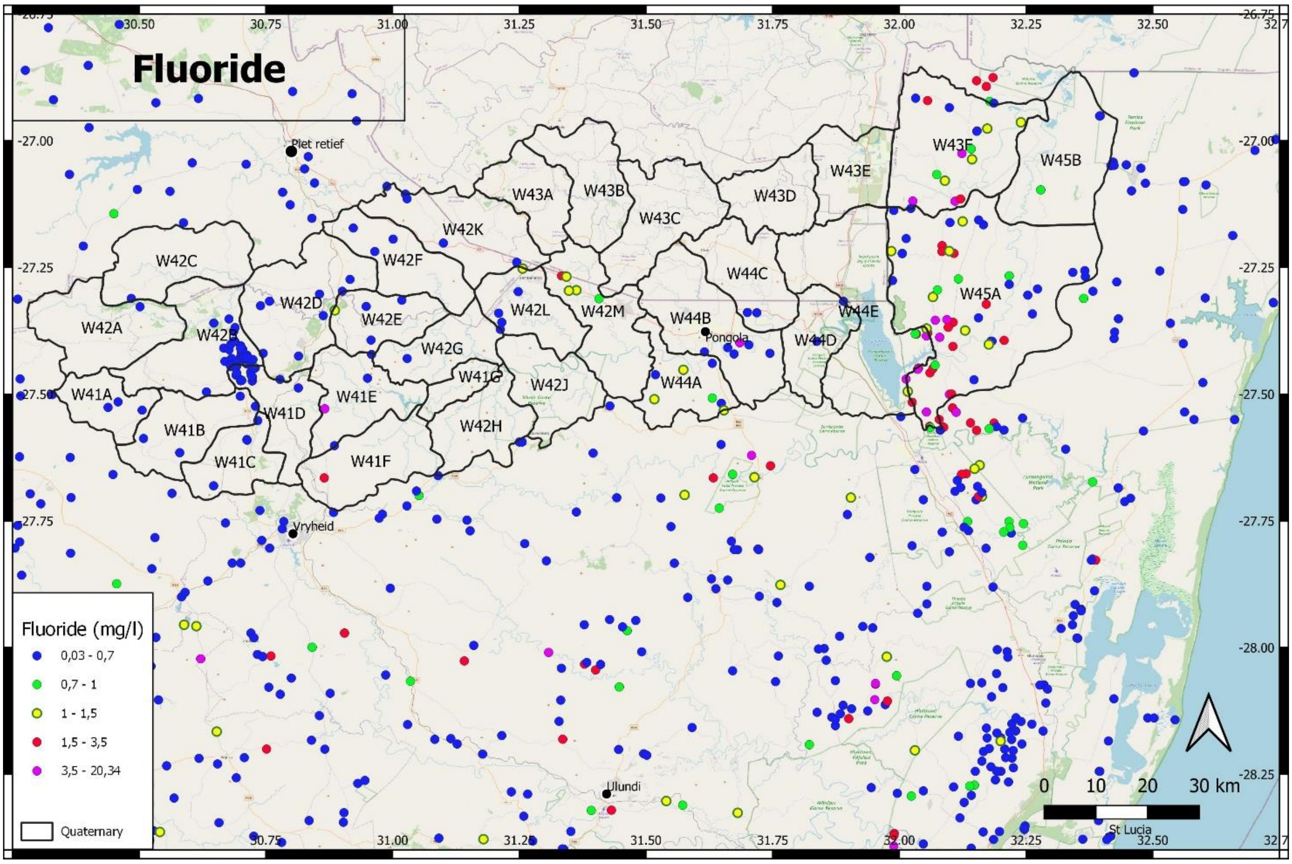

Figure 7.10 Distribution of Fluoride in W4

7.9 CLASSIFICATION

The stress index calculated from the total present use and aquifer recharge is shown in **Figure 7.11**, together with the location of known motorised pump systems. Groundwater is minimally used, and the stress index is below 0.05.

Quaternary catchment classification is shown in **Table 7.7**.

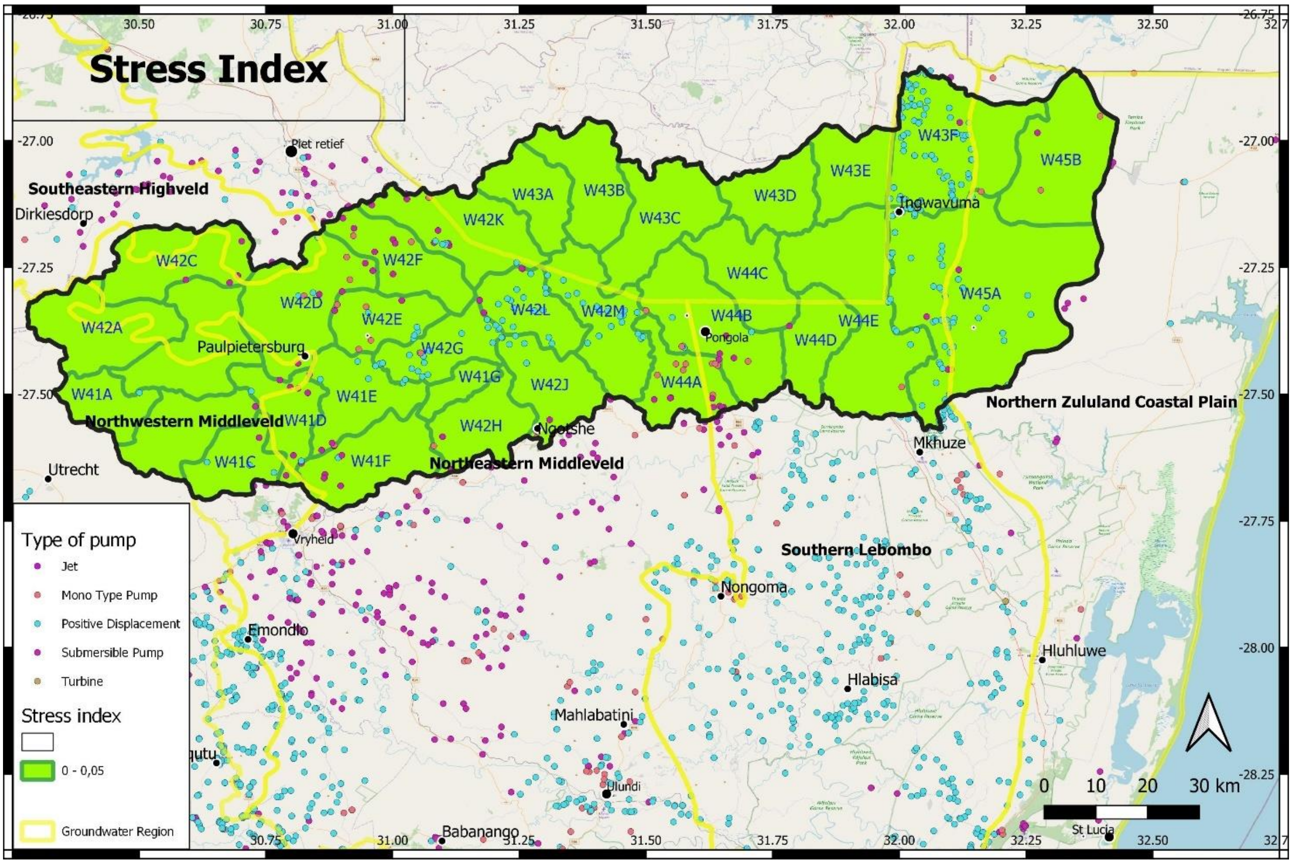

Figure 7.11 Stress Index in W4

Table 7.7 Classification status for W4

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W41A	3.34	2.63	0.014	0.0183	0.01	A	I	2.64
W41B	5.48	4.42	0.044	0.0433	0.01	A	I	4.46
W41C	3.95	3.16	0.051	0.0261	0.01	A	I	3.21
W41D	5.02	4.03	0.068	0.0332	0.01	A	I	4.10
W41E	4.75	3.06	0.087	0.0664	0.01	A	I	3.15
W41F	5.21	3.51	0.08	0.0552	0.01	A	I	3.59
W41G	1.58	0.99	0.024	0.0146	0.01	A	I	1.02
W42A	6.65	5.43	0.05	0.0386	0.01	A	I	5.48
W42B	8.50	6.95	0.104	0.0614	0.01	A	I	7.06
W42C	7.34	6.14	0.034	0.0557	0.01	A	I	6.18
W42D	10.27	8.29	0.096	0.0926	0.01	A	I	8.39
W42E	5.04	3.97	0.05	0.0415	0.01	A	I	4.02
W42F	6.94	5.24	0.034	0.1253	0.02	A	I	5.27
W42G	4.00	2.51	0.072	0.0374	0.01	A	I	2.58
W42H	4.67	2.82	0.069	0.0447	0.01	A	I	2.89
W42J	4.94	3.02	0.094	0.0399	0.01	A	I	3.11
W42K	6.33	4.23	0.026	0.2166	0.03	A	I	4.26
W42L	4.43	2.59	0.077	0.0312	0.01	A	I	2.67
W42M	9.31	6.77	0.109	0.0364	0.00	A	I	6.88
W43C	11.86	6.49	0.002	0.0006	0.00	A	I	6.49
W43F	9.24	4.09	0.299	0.08	0.01	A	I	4.39
W44A	3.12	1.34	0.09	0.037	0.01	A	I	1.43
W44B	5.85	2.45	0.122	0.4821	0.08	B	I	2.57

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W44C	3.78	1.51	0.024	0.0077	0.00	A	I	1.53
W44D	2.64	0.96	0.076	0.0289	0.01	A	I	1.03
W44E	8.05	3.02	0.137	0.0455	0.01	A	I	3.15
W45A	69.60	7.78	0.506	0.2887	0.00	A	I	8.29
W45B	31.43	3.17	0.12	0.1196	0.00	A	I	3.29

8 GROUNDWATER RESOURCES IN W5 USUTU

8.1 GEOLOGY

The western part of the catchment in South Africa is largely underlain by the Vryheid Formation. The remainder in Swaziland is largely granitoid (**Figure 8.1**).

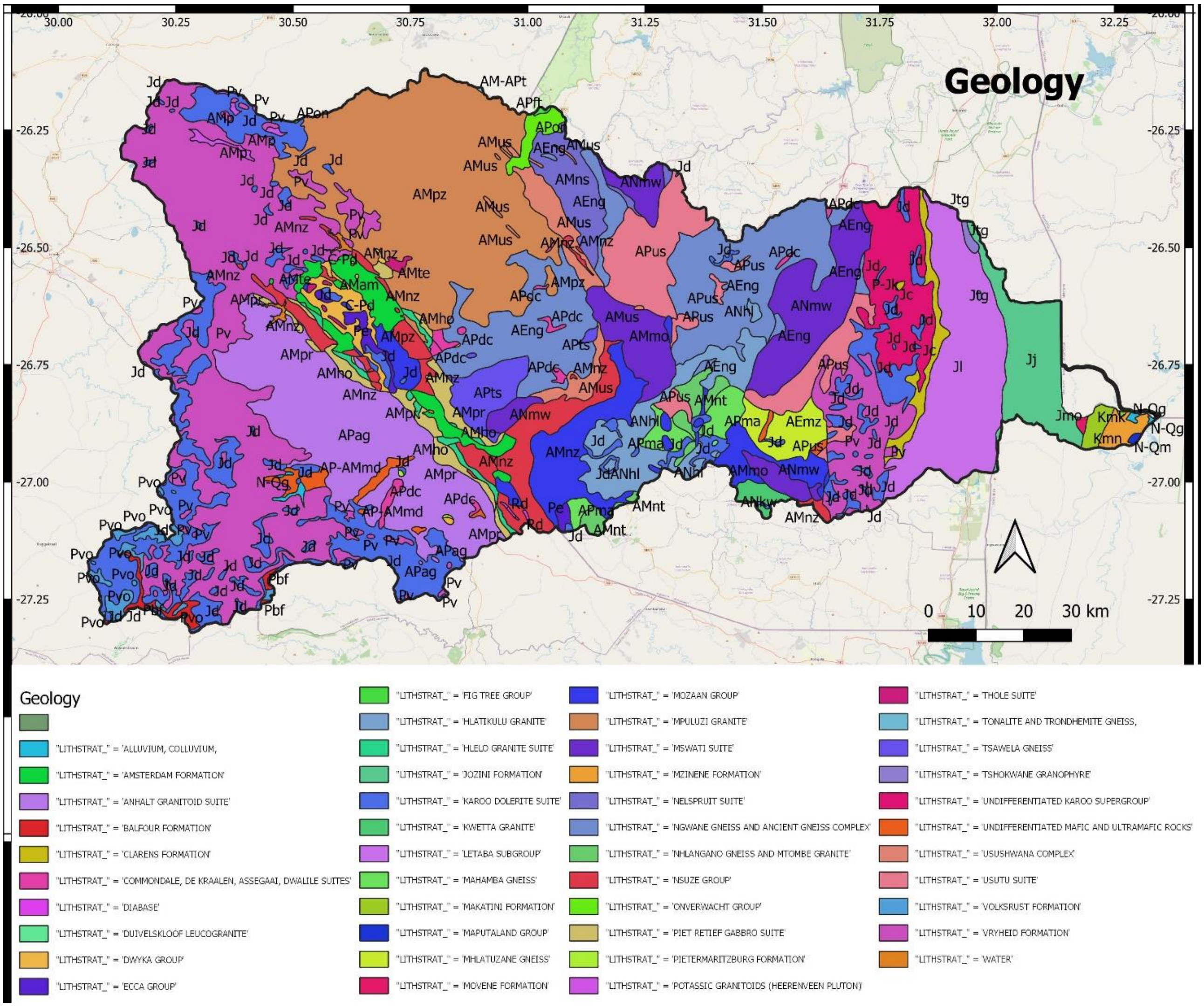

Figure 8.1 Geology of W5

8.2 AQUIFER TYPES

The aquifers are moderately yielding fractured and weathered (**Figure 8.2**).

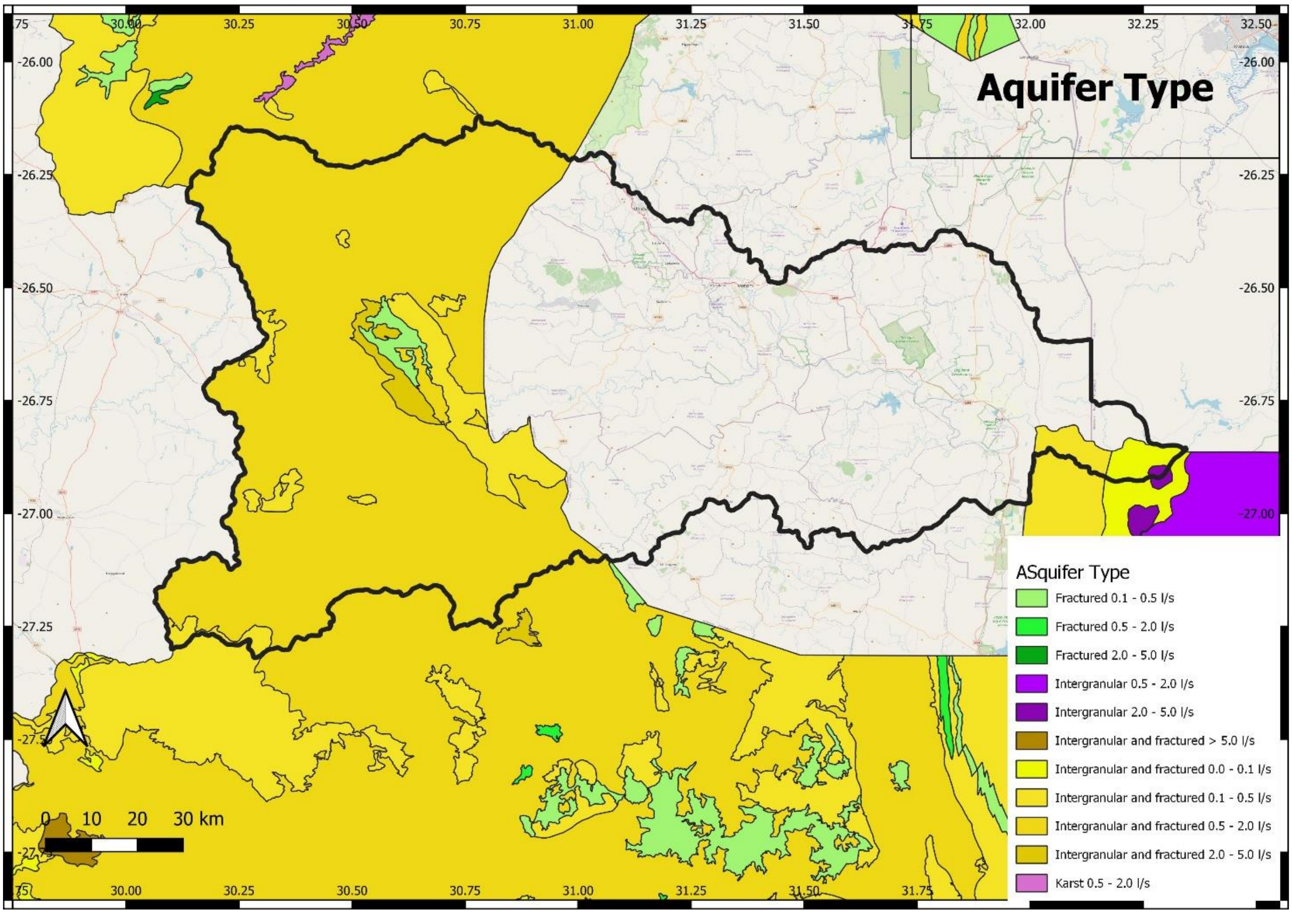

Figure 8.2 Aquifer types in W5

8.3 BOREHOLE YIELD

The overlying Port Durnford and unconsolidated sands of the Kosi Bay, Kwabonambi and Sibayi Formations are fine grained with some course layers, and are generally low yielding but serve as storage and function as a leaky aquifer layer. The highest yielding aquifer is the basal Uloa calcarenite which can yield up to 15 l/s. However, it is intermittent which does not allow extensive development. The median yield is 1.5 - 2 l/s.

The Northeastern Middleveld and Southeastern Highveld Regions have variable yields, dependent on geology (**Figure 8.3**). The distribution of yields by catchment is shown in **Table 8.1**.

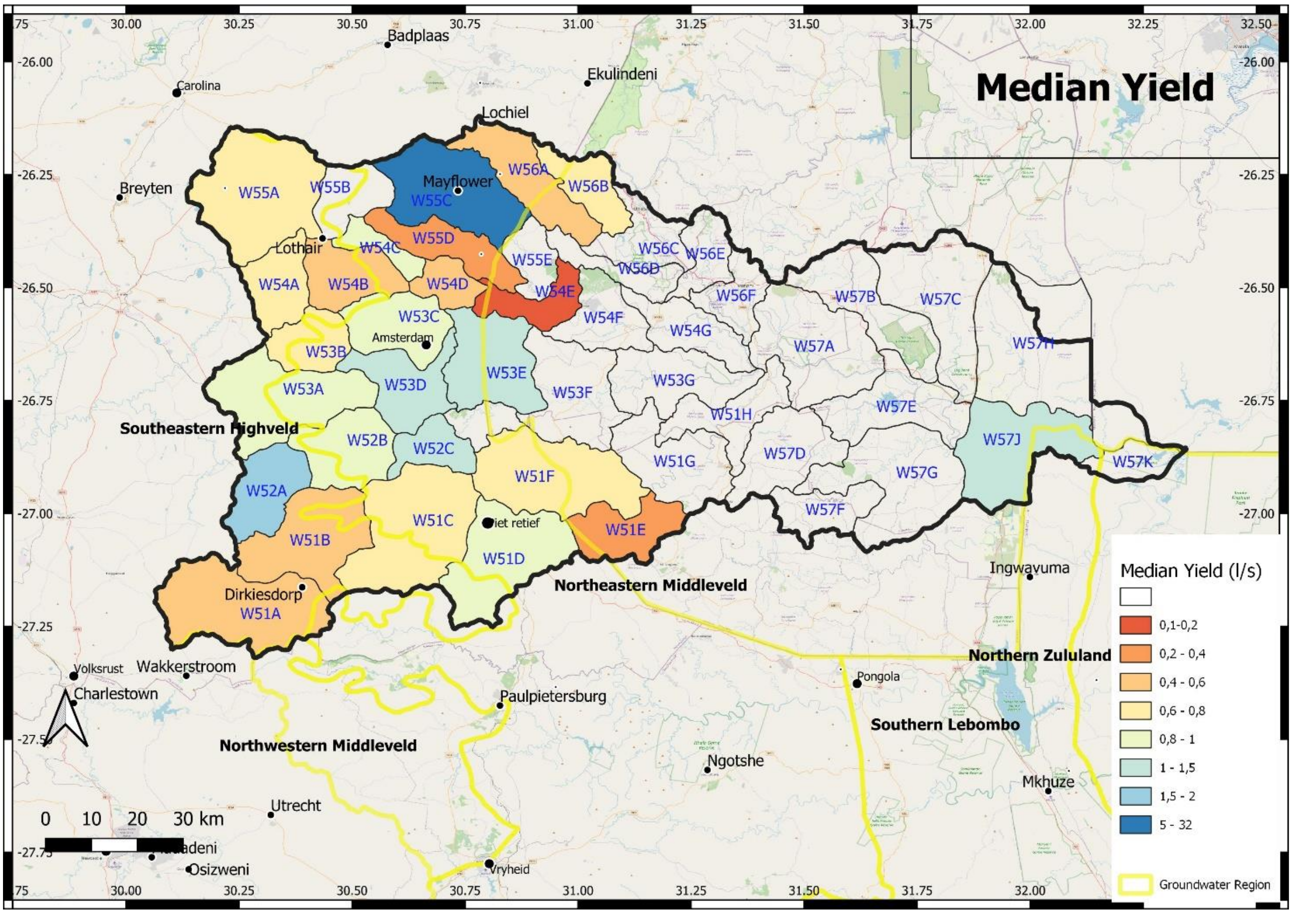

Figure 8.3 Median borehole yields in W5

Table 8.1 Distribution of borehole yields in W5

Quaternary	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
W54A	1.10	0.79	62.3	9	0
W54B	1.15	0.58	57.2	9.3	4.9
W54C	0.92	0.98	71.9	0	0
W54D	1.22	0.56	57.7	15.7	0
W54E	0.14	0.14	0	0	0
W55A	1.28	0.67	61.5	15.7	1.2
W55C	5.08	5.10	65.7	60.6	50.4
W55D	0.49	0.30	36.5	0	0
W56A	3.10	0.58	56.9	36.3	10.5

Quaternary	Average (l/s)	Median (l/s)	% > 0.5 l/s	% > 2 l/s	% > 5 l/s
W56B	0.84	0.70	65.3	11.2	0
W57J	1.70	1.26	0	26.6	0

8.4 RECHARGE

Recharge can be considered in terms of:

- Total recharge, which drives baseflow and recharges aquifers.
- Groundwater recharge which recharges the aquifers and is available to boreholes. This excludes the recharge that generates interflow from high-lying springs.

These are shown in **Figures 8.4** and **8.5**. Recharge in the South African portion of the catchment ranges from 50 - 100 mm/a increasing eastward. Aquifer recharge is only 15 - 30 mm/a. Due to hilly nature of the catchment, much of the recharge is lost as interflow.

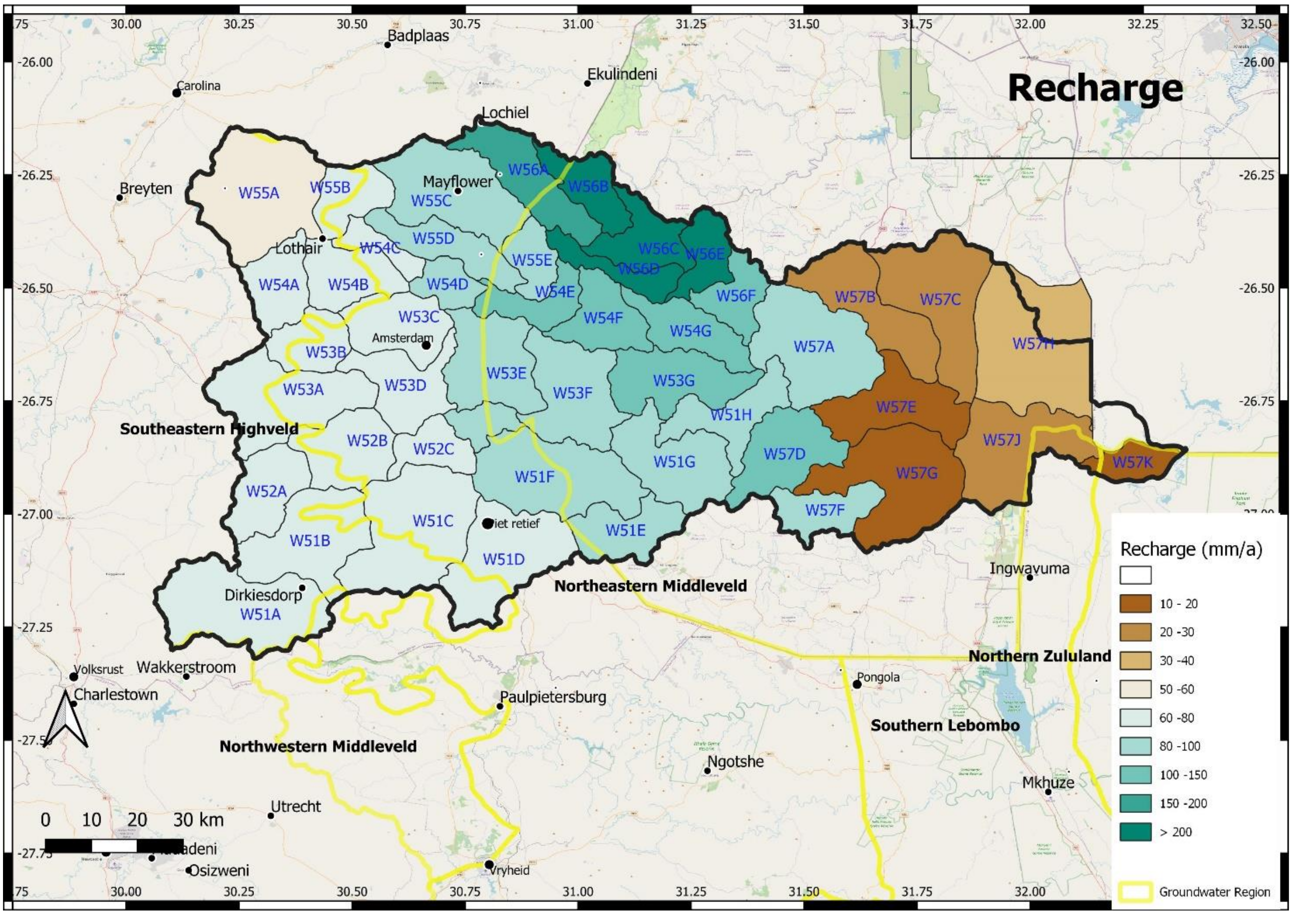

Figure 8.4 Recharge in W5

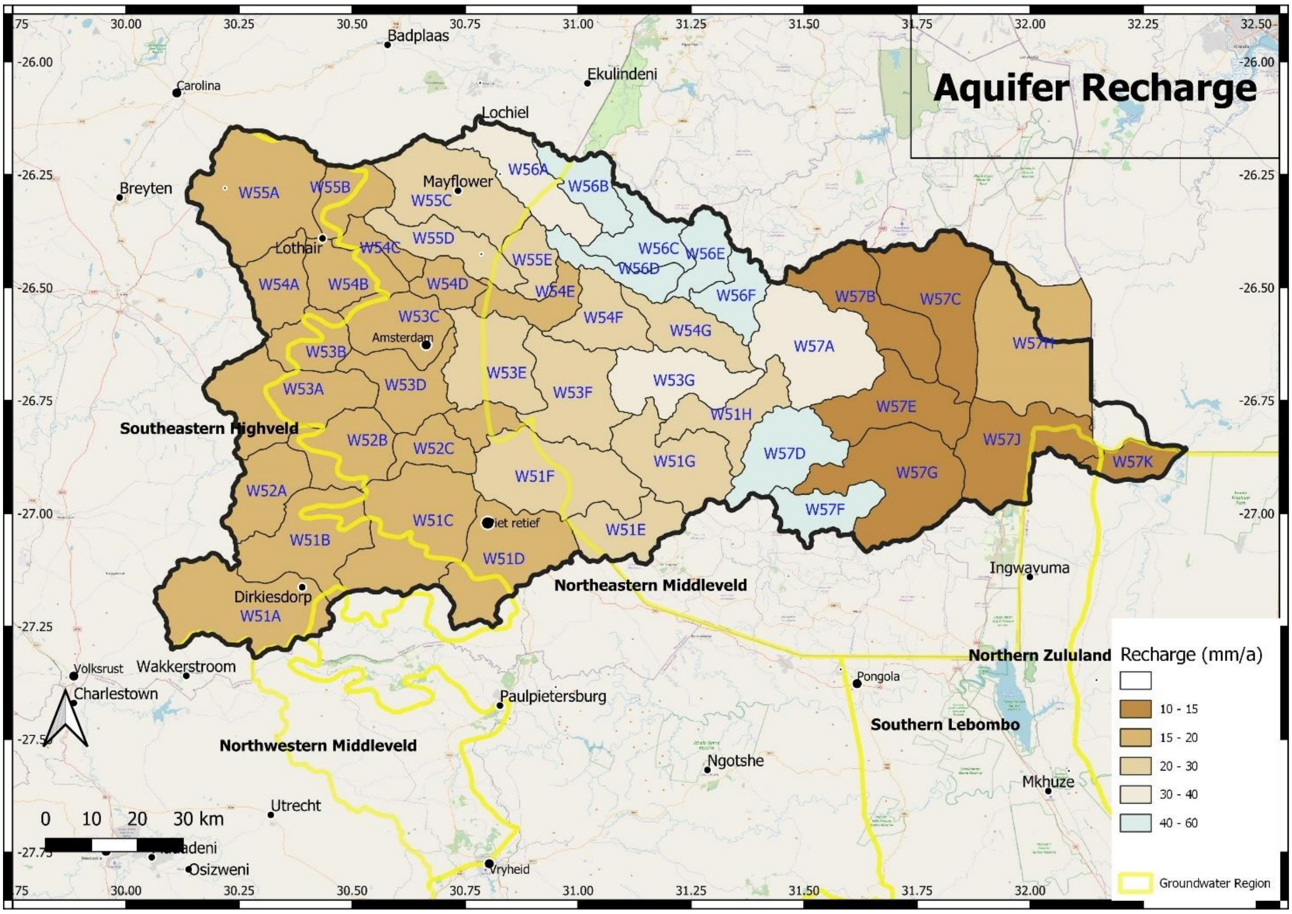

Figure 8.5 Aquifer recharge in W5

8.5 BASEFLOW

Baseflow

Two factors are of importance when considering baseflow. Total baseflow, provides the volume of water available to sustain low flows, and groundwater baseflow which is the volume emanating from the regional aquifers and is subject to depletion by groundwater abstraction. The percentage that is ground baseflow provides an index of vulnerability of the low flows in rivers to groundwater abstraction. Baseflow and the percentage of baseflow of groundwater origin is shown in **Figures 8.6 and 8.7**.

Baseflow generation increases to the east from 20 mm/a on the Highveld to 100 mm/a at the border in the Middleveld. escarpment to 6 mm/a in the Lowveld. Groundwater baseflow is 10 - 30% of total baseflow.

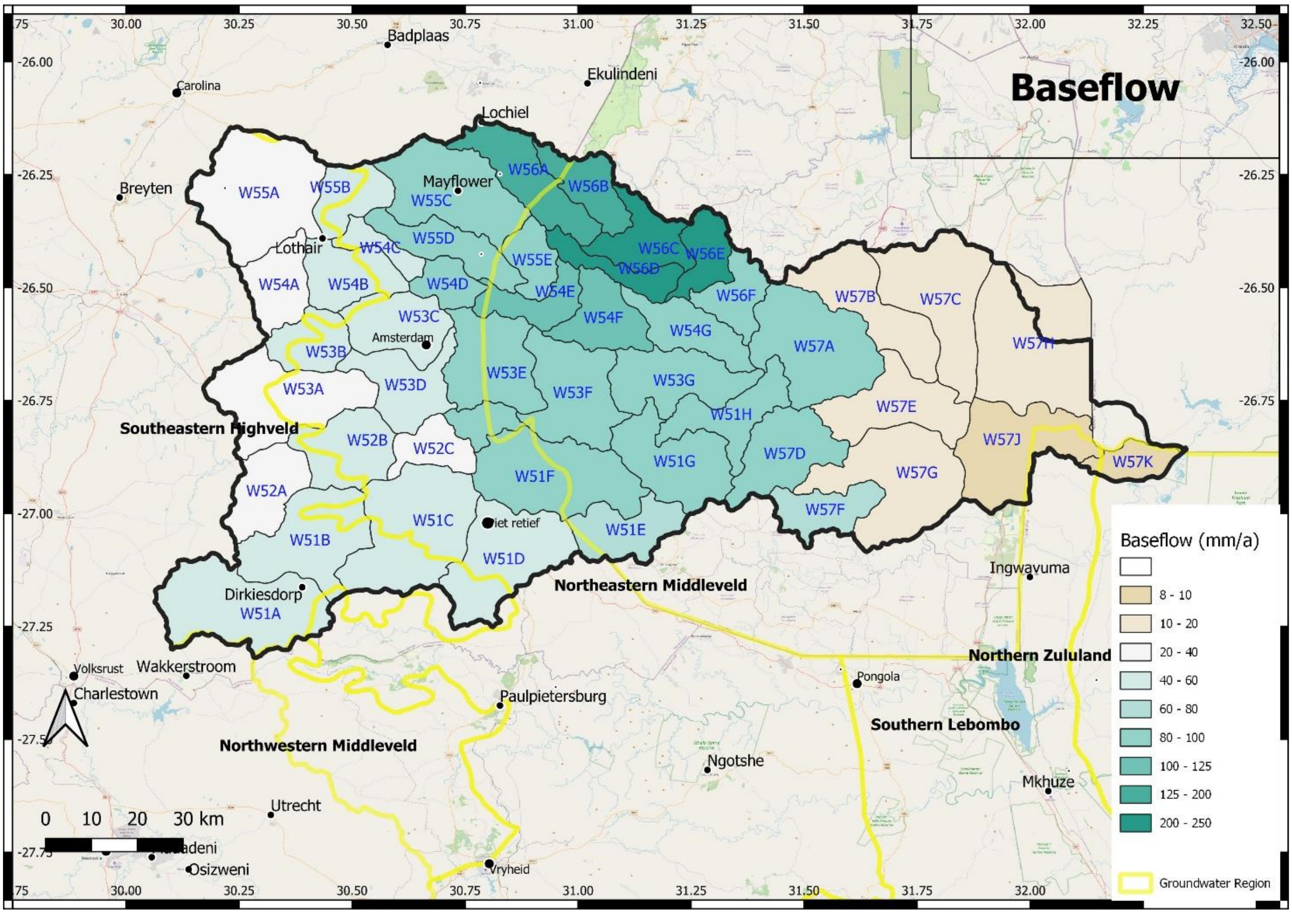

Figure 8.6 Baseflow in W5

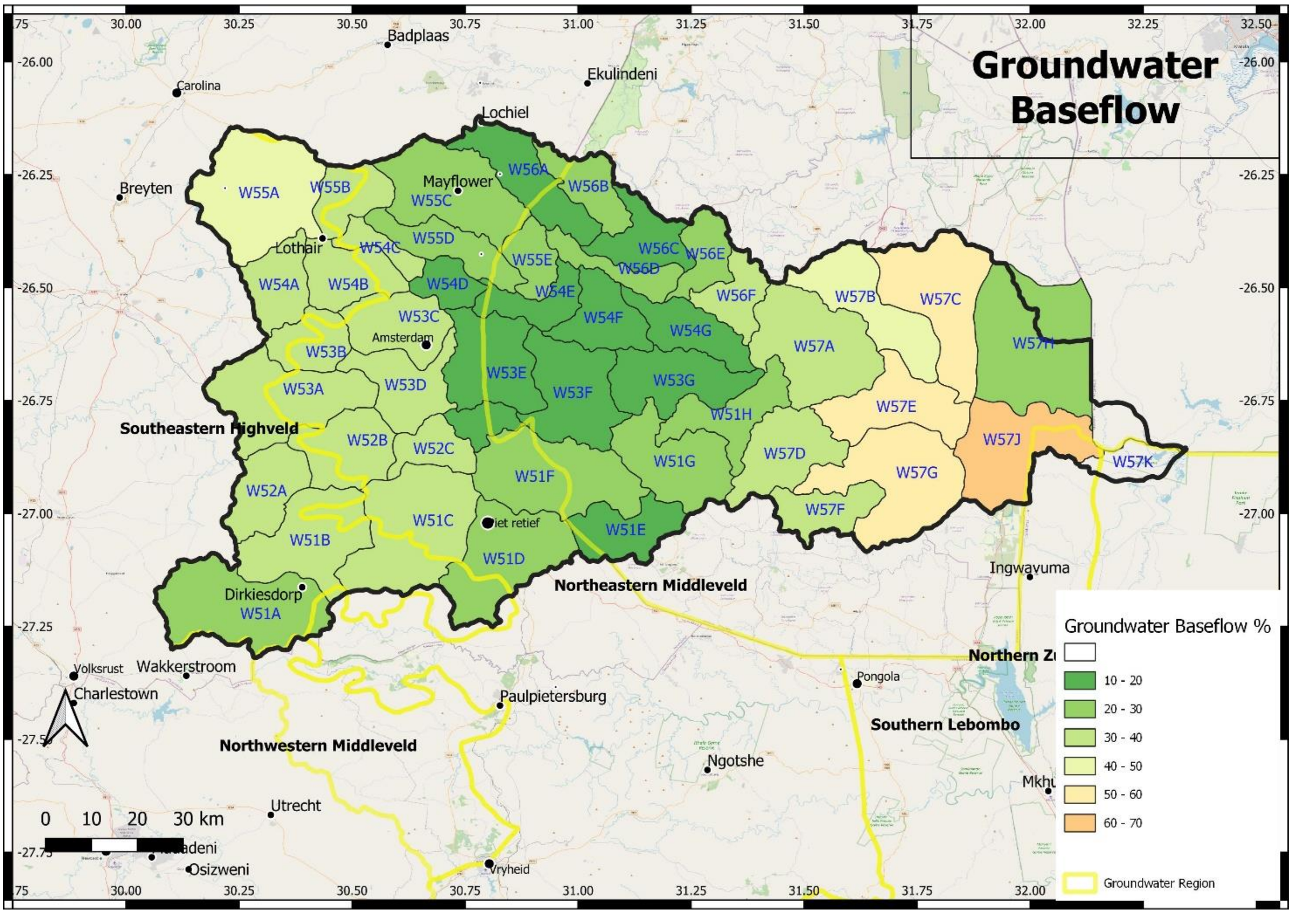

Figure 8.7 Groundwater baseflow as a percentage of baseflow in W5

8.6 USE

Groundwater use is listed in **Table 8.2**.

Table 8.2 Groundwater use in W5

Quat	Irrigation (Mm^3/a)	Industrial (Mm^3/a)	Mining (Mm^3/a)	Water Supply (Mm^3/a)	Livestock (Mm^3/a)	Schedule 1 (Mm^3/a)	Total (Mm^3/a)
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
W54A	0.0000	0.0394	0.0000	0.0026	0.0228	0.0000	0.0648
W54B					0.0261	0.0000	0.0261
W54C					0.0097	0.0000	0.0097
W54D	0.0000	0.0372	0.0000	0.0000	0.0144	0.0028	0.0544
W54E					0.0026	0.0024	0.0050
W55A	0.0097	0.0000	0.0000	0.0000	0.0585	0.0000	0.0683
W55B	0.0000	0.0009	0.0000	0.0000	0.0197	0.0000	0.0206
W55C	0.0870	0.0000	0.0000	0.0110	0.0293	0.0106	0.1379
W55D					0.0172	0.0008	0.0180
W55E					0.0001	0.0000	0.0001
W56A					0.0106	0.0027	0.0133
W56B					0.0019	0.0000	0.0019
W57J					0.0112	0.0000	0.0112
W57K					0.0174	0.0000	0.0174
Total	0.7977	0.3688	0.8868	0.0923	1.0011	0.6011	3.7478

8.7 GROUNDWATER RESOURCES

The groundwater recharge, exploitation potential and use for the W5 Catchment is shown in **Table 8.3**.

Table 8.3 W5 Catchment: Groundwater recharge and exploitation potential

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exploitation potential (Mm^3/a)	GRA II Exploitation potential (Mm^3/a)	Harvest potential (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

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exploitation potential (Mm^3/a)	GRA II Exploitation potential (Mm^3/a)	Harvest potential (Mm^3/a)	Use (Mm^3/a)
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
W54A	251.08	15.73	3.99	4.01	5.26	5.47	0.0648
W54B	281.94	19.73	4.38	4.53	6.78	4.70	0.0261
W54C	107.45	7.72	1.85	1.58	2.53	4.55	0.0097
W54D	138.75	12.20	2.71	0.69	4.01	5.63	0.0544
W54E	194.12	19.62	3.68	1.39	0.72	8.54	0.0050
W55A	688.70	39.75	11.10	12.04	15.62	15.16	0.0683
W55B	217.83	14.66	3.44	3.10	4.87	7.21	0.0206
W55C	532.20	48.66	15.02	2.51	14.29	21.41	0.1379
W55D	270.86	24.39	7.70	1.38	6.04	11.92	0.0180
W55E	161.23	15.43	4.50	1.19	0.11	7.09	0.0001
W56A	359.72	65.68	13.91	2.08	13.33	15.83	0.0133
W56B	224.66	45.02	10.55	1.80	2.62	9.89	0.0019
W57J	519.42	12.87	6.29	6.01	0.91	18.46	0.0112
W57K	137.42	2.42	1.71	4.24	0.92	10.64	0.0174

8.8 GROUNDWATER QUALITY

8.8.1 Electrical conductivity

The distribution of EC is shown in **Figure 8.8** and **Table 8.4**. Groundwater is Class 0 in the upper catchment, with only isolated poor water quality. The lower Usutu underlain by Karoo and Cretaceous rocks has highly variable to poor water quality.

Table 8.4 Distribution of EC in mS/m by percentile and class

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
W53C	11.92	12.08	16.64	25.2	238	0.93
W53D	5.6	5.6	5.6	5.6	5.6	1
W53E	3.6	3.6	3.6	3.6	3.6	1
W54E	34.4	34.4	34.4	34.4	34.4	1
W55A	5.26	10.92	14.64	21.26	32	1
W55C	7.74	10.532	20.54	25.28	69.6	1

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W55D	8.28	9.76	11.98	14.94	17.9	1
W56A	7.5	8.9	9.6	10.5	15.6	1
W56B	7.76	9.22	10.68	12.14	13.6	1
W57K	133.02	210.8	480.8	1227.2	2840	0.252

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
W54E	1	0	0	0	0	I
W55A	10	0	0	0	0	I
W55C	10	0	0	0	0	I
W55D	3	0	0	0	0	I
W56A	11	0	0	0	0	I
W56B	2	0	0	0	0	I
W57K	1	1	1	0	2	III

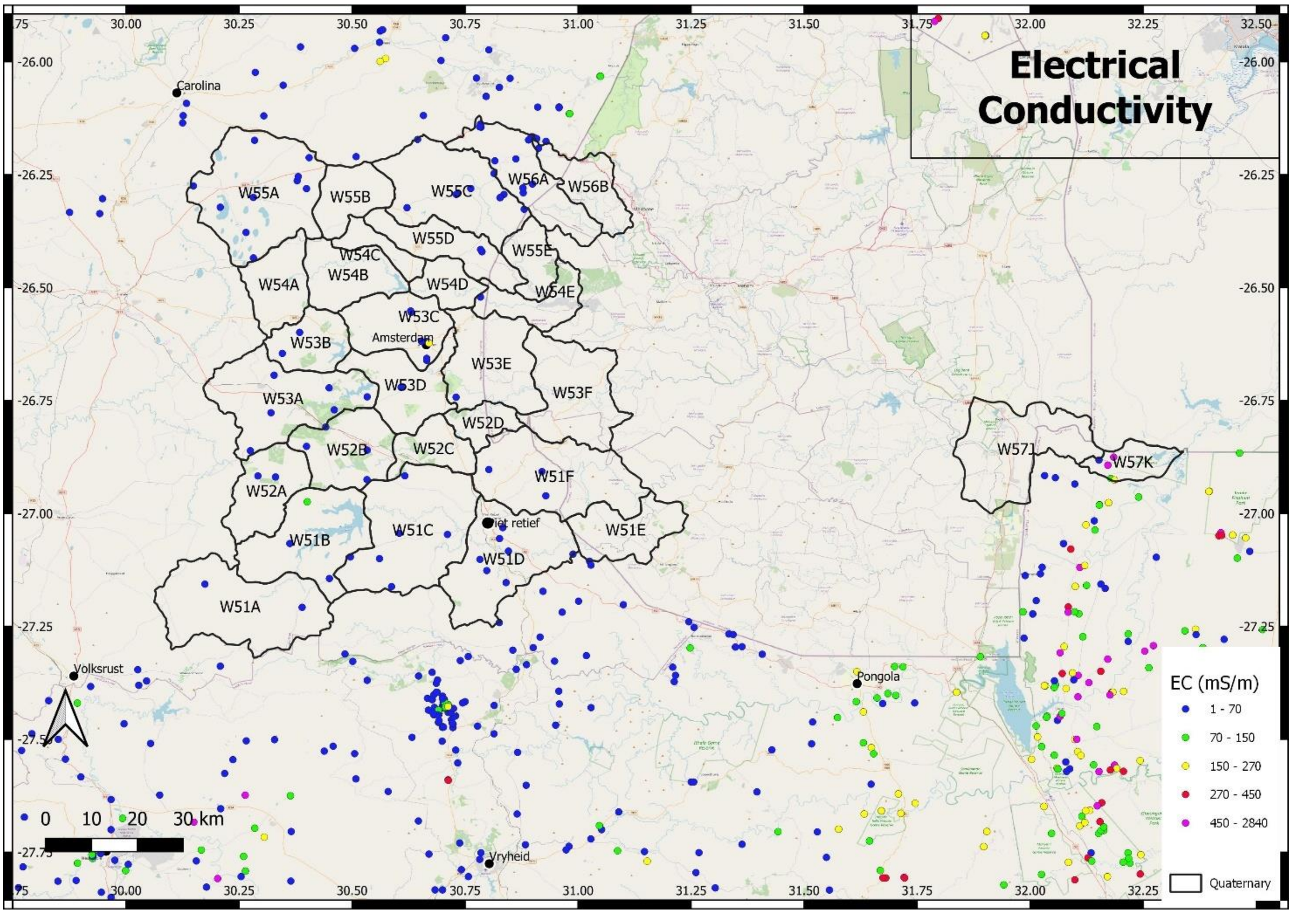

Figure 8.8 EC in W5

8.8.2 Nitrate

Nitrate is generally of Class 0 throughout the catchment (**Figure 8.9**). The distribution of nitrate concentrations in each quaternary is shown in **Table 8.5**.

Table 8.5 Distribution of nitrates in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W51A	0.079	0.086	0.093	0.1	0.107	1
W51B	0.2858	0.5266	0.9378	1.5194	2.101	1
W51C	1.13	1.192	1.238	3.802	3.987	1
W51D	0.8596	1.0408	2.6524	5.5144	11.974	0.945
W51E	2.305	2.305	2.305	2.305	2.305	1
W51F	0.8326	1.3142	1.8928	2.5684	3.244	1
W52A	0.02	0.02	0.02	0.02	0.02	1
W52B	0.062	0.212	0.578	1.6992	3.198	1
W53A	0.02	0.044	0.18	0.698	0.883	1
W53B	0.494	0.968	1.442	1.916	2.39	1
W53C	0.2064	0.2728	0.28	0.5672	12.047	0.97
W53D	0.09	0.09	0.09	0.09	0.09	1
W53E	0.138	0.138	0.138	0.138	0.138	1
W54E	0.147	0.147	0.147	0.147	0.147	1
W55A	0.02	0.1038	0.3402	2.162	10.905	0.978
W55C	0.1108	0.3432	0.7986	1.601	3.499	1
W55D	0.1692	0.2584	0.4602	0.7746	1.089	1
W56A	0.156	0.211	0.524	0.647	4.157	1
W56B	0.1144	0.1608	0.2072	0.2536	0.3	1

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W57K	0.02	0.02	0.03	0.1268	0.454	1

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W51A	2	0	0	0	0	I
W51B	3	0	0	0	0	I
W51C	6	0	0	0	0	I
W51D	6	0	1	0	0	II
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
W54E	1	0	0	0	0	I
W55A	8	1	1	0	0	II
W55C	10	0	0	0	0	I
W55D	3	0	0	0	0	I
W56A	11	0	0	0	0	I
W56B	2	0	0	0	0	I
W57K	5	0	0	0	0	I

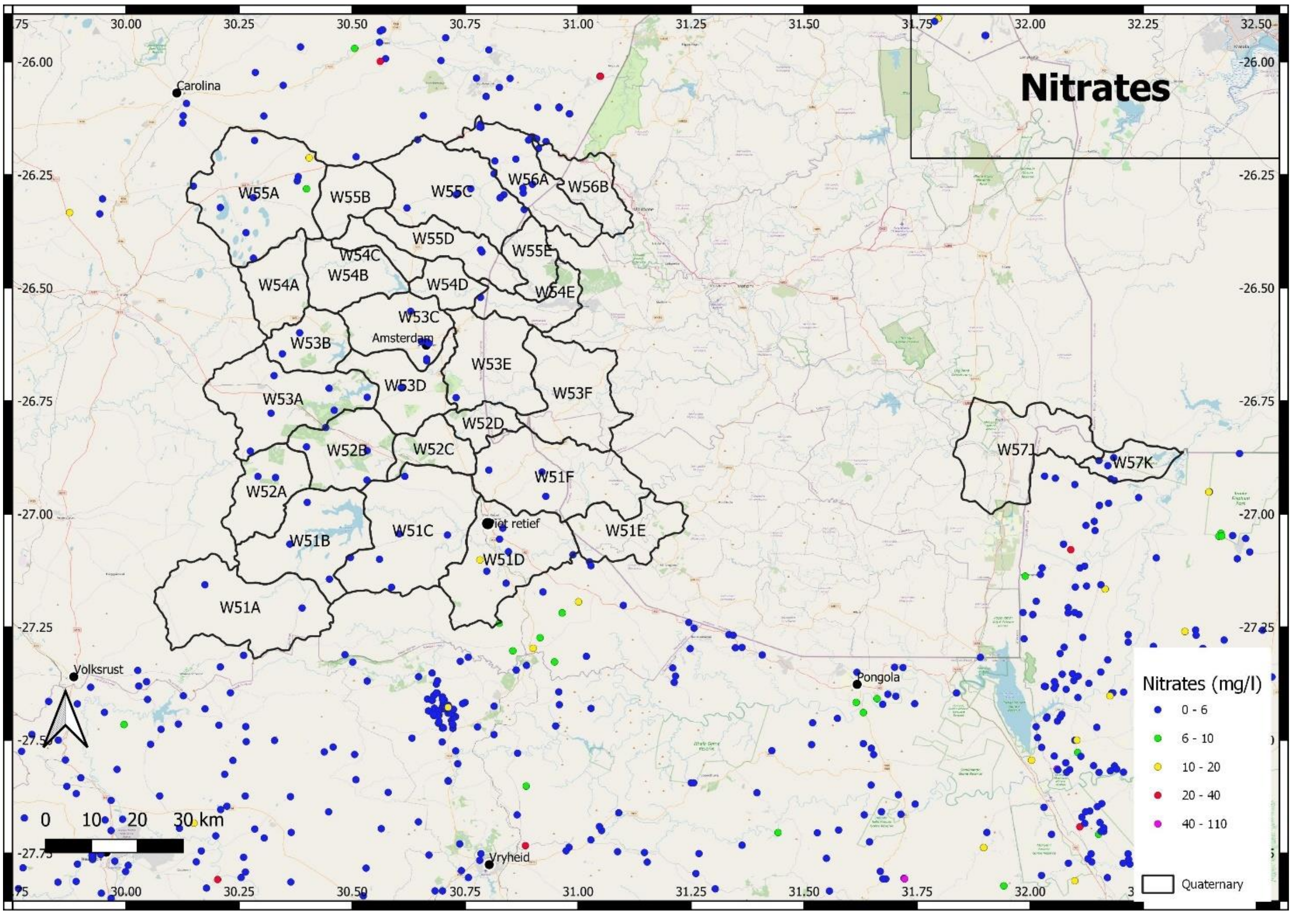

Figure 8.9 Distribution of Nitrate in W5

8.8.3 Fluoride

Water quality is highly variable. Significant areas of high Fluoride exist in in the upper Karoo volcanics, and in some the some intrusive and extrusive granitoids, volcanics and metamorphics (**Figure 8.10**). The distribution of fluoride concentrations in each quaternary is shown in **Table 8.6**.

Table 8.6 Distribution of Fluoride in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W51A	0.434	0.438	0.442	0.446	0.45	1
W51B	0.334	0.358	0.438	0.574	0.71	1
W51C	0.13	0.17	0.18	0.25	0.51	1
W51D	0.106	0.134	0.146	0.206	0.24	1
W51E	0.11	0.11	0.11	0.11	0.11	1
W51F	0.11	0.11	0.116	0.128	0.14	1
W52A	0.3	0.3	0.3	0.3	0.3	1
W52B	0.164	0.168	0.172	0.176	0.18	1
W53A	0.16	0.206	0.27	0.392	0.64	1
W53B	0.134	0.138	0.142	0.146	0.15	1
W53C	0.182	0.194	0.2	3.424	5.25	0.72
W53E	0.12	0.12	0.12	0.12	0.12	1
W54E	0.84	0.84	0.84	0.84	0.84	1
W55A	0.05	0.12	0.144	0.184	0.34	1
W55C	0.1182	0.158	0.316	0.696	1.24	1
W55D	0.074	0.098	0.162	0.266	0.37	1
W56A	0.12	0.13	0.17	0.17	0.33	1
W56B	0.176	0.202	0.228	0.254	0.28	1
W57K	0.73	1.76	2.568	2.952	3.48	0.359

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	1	0	0	0	0	I
W52B	2	0	0	0	0	I
W53A	5	0	0	0	0	I
W53B	2	0	0	0	0	I
W53C	5	0	0	0	2	III
W53E	1	0	0	0	0	I
W54E	0	1	0	0	0	I
W55A	10	0	0	0	0	I
W55C	8	1	1	0	0	II
W55D	3	0	0	0	0	I
W56A	11	0	0	0	0	I
W56B	2	0	0	0	0	I
W57K	1	1	0	3	0	III

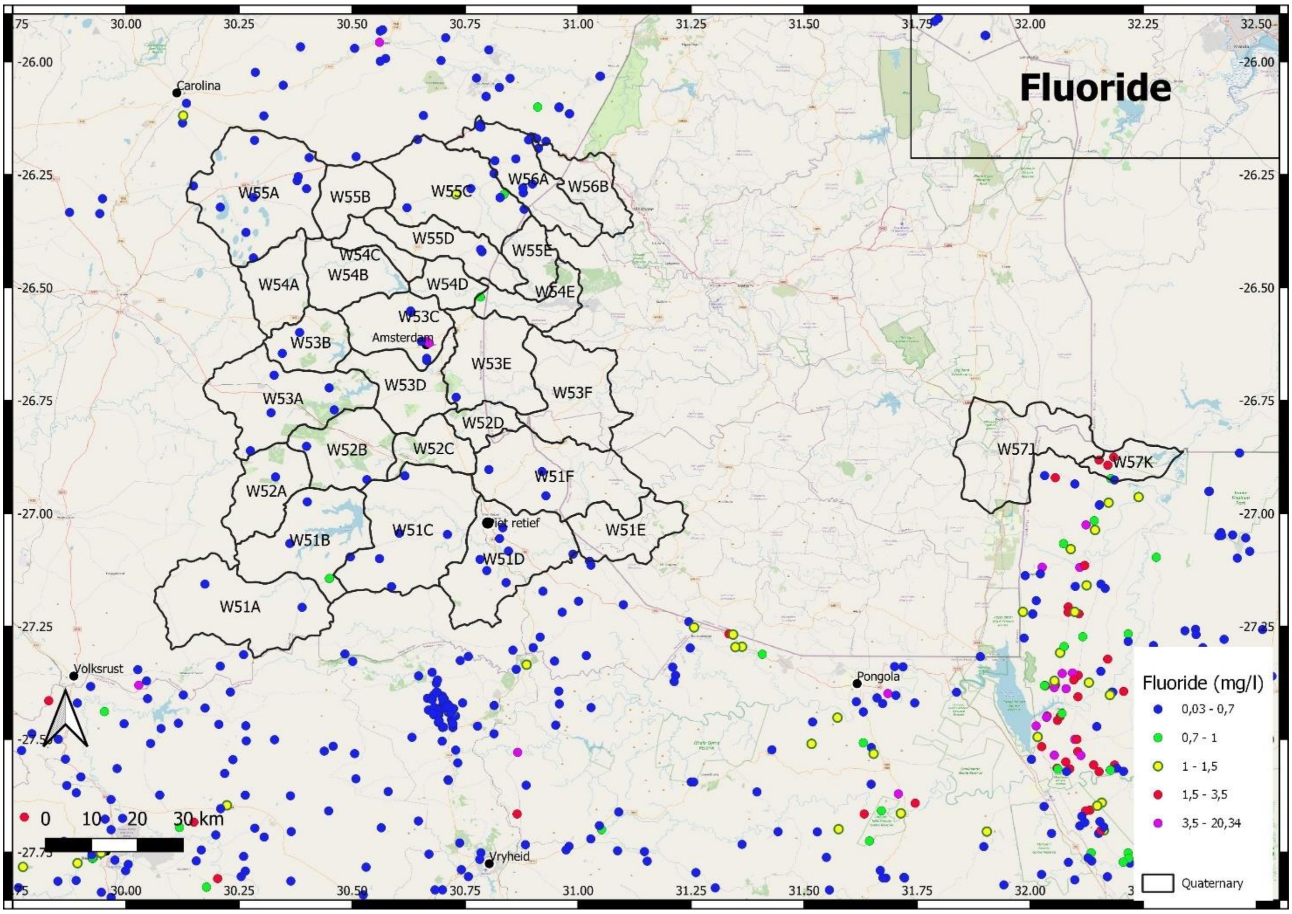

Figure 8.10 Distribution of Fluoride in W5

8.9 CLASSIFICATION

The stress index calculated from the total present use and aquifer recharge is shown in **Figure 8.11**, together with the location of known motorised pump systems. Groundwater is minimally used, and the stress index is below 0.13.

Quaternary catchment classification is shown in **Table 8.7**.

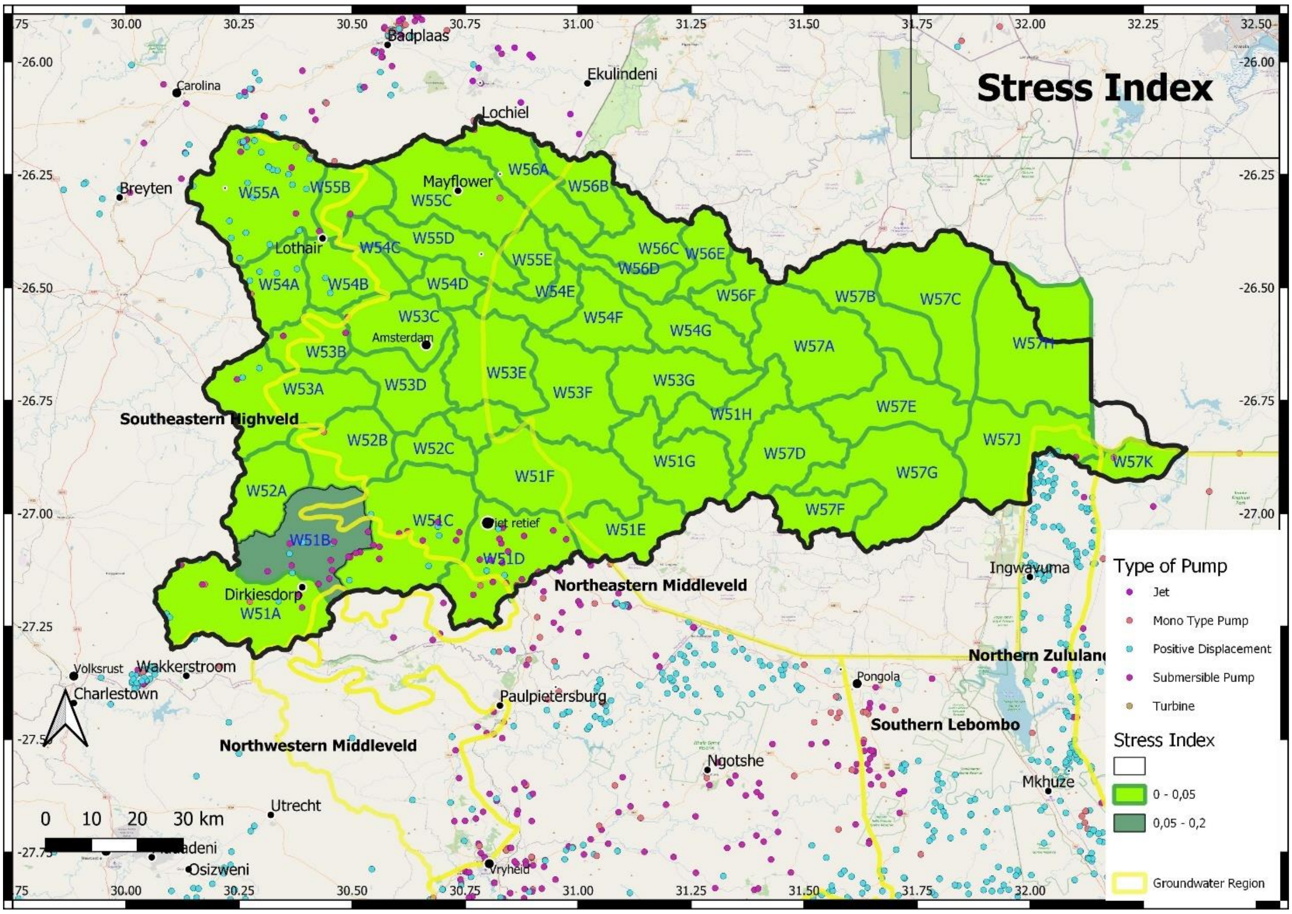

Figure 8.11 Stress Index in W5

Table 8.7 Classification status for W5

Quaternary	Aquifer Recharge (Mm³/a)	Groundwater baseflow (Mm³/a)	BHN (Mm³/a)	Use (Mm³/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm³/a)
W51A	10.39	8.27	0.04	0.2243	0.02	A	I	8.31
W51B	8.50	6.59	0.046	1.1142	0.13	B	I	6.63
W51C	12.53	9.99	0.076	0.4697	0.04	A	I	10.07
W51D	8.89	7.00	0.059	0.1635	0.02	A	I	7.06
W51E	6.11	4.20	0.002	0.0842	0.01	A	I	4.20
W51F	12.65	10.16	0.034	0.1683	0.01	A	I	10.20
W52A	5.03	3.85	0.027	0.1237	0.02	A	I	3.87
W52B	6.27	4.92	0.038	0.2076	0.03	A	I	4.96
W52C	3.35	2.59	0.02	0.0657	0.02	A	I	2.61
W52D	2.38	1.80	0.008	0.0148	0.01	A	I	1.81
W53A	10.25	7.95	0.044	0.4515	0.04	A	I	7.99
W53B	4.09	3.20	0.015	0.0199	0.00	A	I	3.21
W53C	5.82	4.66	0.035	0.0886	0.02	A	I	4.69
W53D	5.86	4.61	0.033	0.0559	0.01	A	I	4.65
W53E	8.96	7.20	0.02	0.0468	0.01	A	I	7.22
W53F	10.48	7.64	0	0.0002	0.00	A	I	7.64
W54A	3.99	3.33	0.017	0.0648	0.02	A	I	3.34
W54B	4.38	3.74	0.02	0.0261	0.01	A	I	3.76
W54C	1.85	1.58	0.007	0.0097	0.01	A	I	1.58
W54D	2.71	2.38	0.013	0.0544	0.02	A	I	2.39
W54E	3.68	3.28	0.002	0.005	0.00	A	I	3.28

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W55A	11.10	9.82	0.052	0.0683	0.01	A	I	9.87
W55B	3.44	3.11	0.015	0.0206	0.01	A	I	3.13
W55C	15.02	13.90	0.053	0.1379	0.01	A	I	13.95
W55D	7.70	7.08	0.019	0.018	0.00	A	I	7.10
W55E	4.50	4.16	0	0.0001	0.00	A	I	4.16
W56A	13.91	12.80	0.026	0.0133	0.00	A	I	12.83
W56B	10.55	9.31	0.005	0.0019	0.00	A	I	9.31
W57J	6.29	2.90	0.042	0.0112	0.00	A	I	2.94
W57K	1.71	0.79	0.065	0.0174	0.01	A	I	0.85

9 GROUNDWATER RESOURCES IN W7 KOSI ESTUARY AND LAKE SIBAYA

9.1 GEOLOGY

The entire catchment is underlain by sediments of the Maputoland Group (**Figure 9.1**).

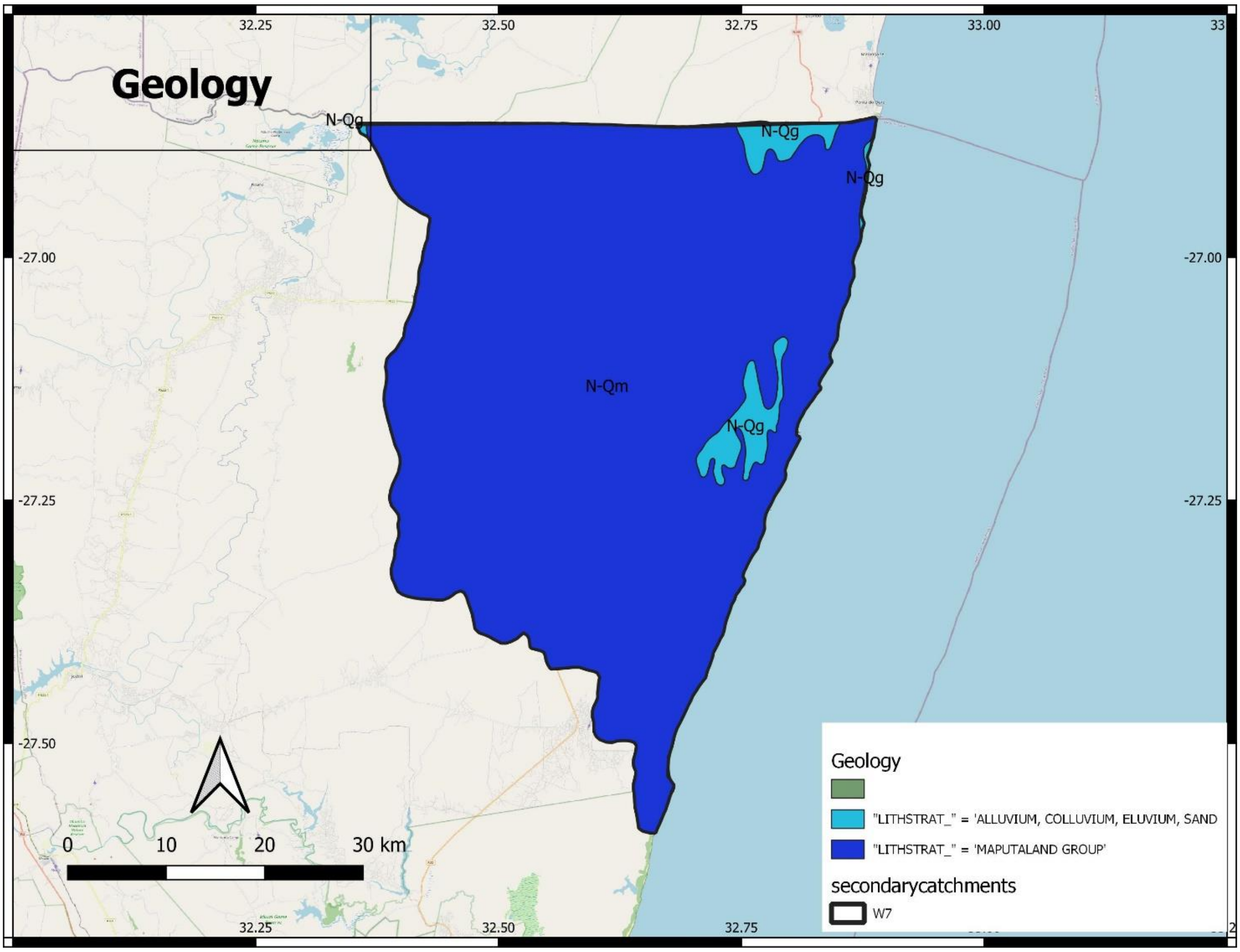

Figure 9.1 Geology of W7

9.2 AQUIFER TYPES

The entire catchment is underlain by low to moderately yielding intergranular aquifers, except the coastal margin, where the Uloa Formation is a basal unit below the cover sands with a higher yield (**Figure 9.2**).

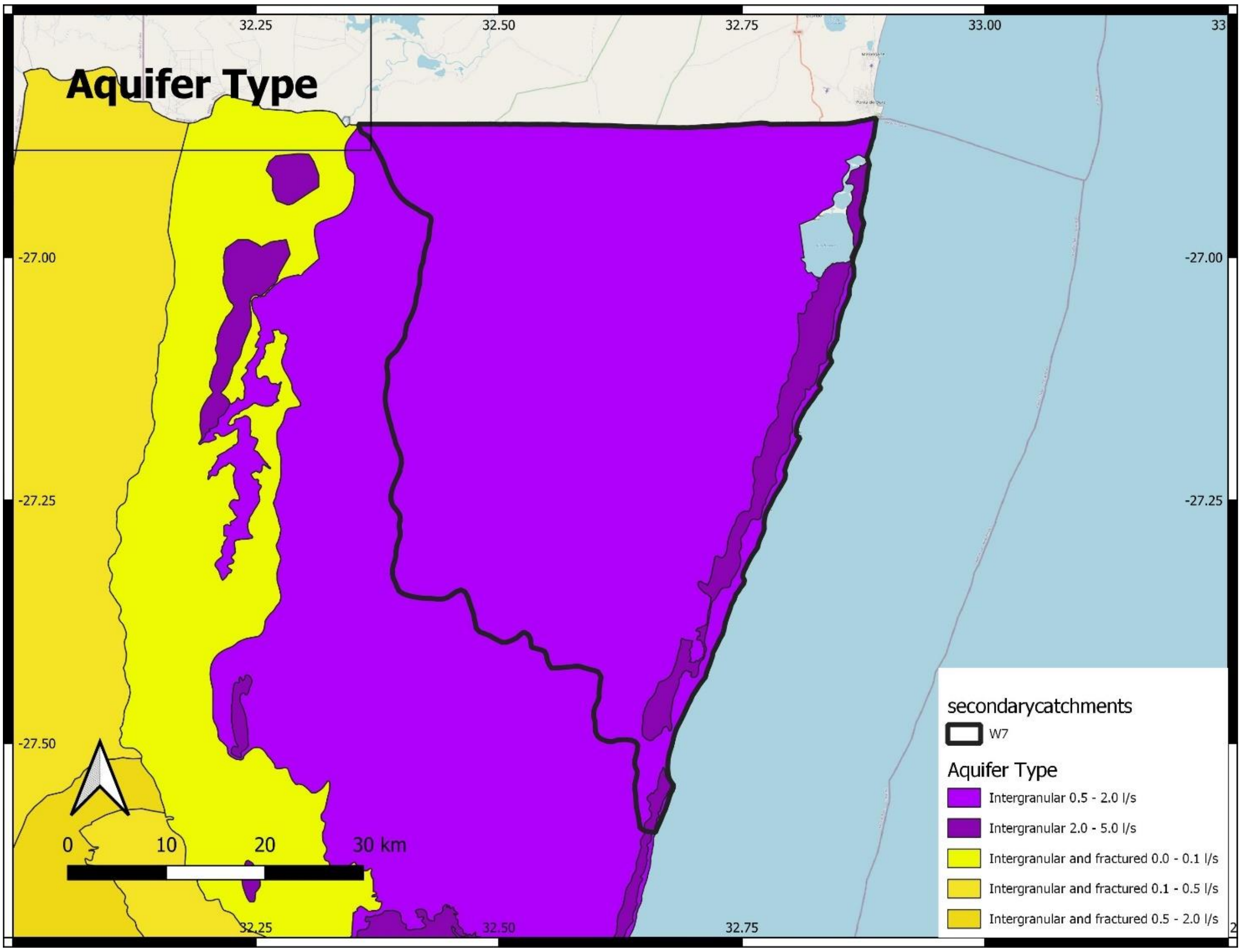

Figure 9.2 Aquifer types in W7

9.3 BOREHOLE YIELD

The overlying Port Durnford and unconsolidated sands of the Kosi Bay, Kwabonambi and Sibayi Formations are fine grained with some course layers, and are generally low yielding but serve as storage and function as a leaky aquifer layer. The highest yielding aquifer is the basal Uloa calcarenite which can yield up to 15 l/s. However, it is intermittent which does not allow extensive development. The median yield is 1.5 - 2 l/s.

9.4 RECHARGE

Recharge to W70A is 133 mm/a. Aquifer recharge is 132 mm/a. Due to the flat sandy nature of the catchment, interflow does not occur and all recharge percolates to the regional aquifer as aquifer recharge.

9.5 BASEFLOW

Baseflow in the catchment is 25 mm/a. The majority of baseflow is not to rivers, but as through flow to coastal lakes where they cut into the Uloa Formation. 97% of baseflow is from groundwater baseflow.

9.6 USE

Groundwater use is listed in **Table 9.1**. The use for water supply is largely from lakes (**Table 9.2**).

Table 9.1 Groundwater use in W7

Quat	Irrigation (Mm^3/a)	Industrial (Mm^3/a)	Mining (Mm^3/a)	Water Supply (Mm^3/a)	Livestock (Mm^3/a)	Schedule 1 (Mm^3/a)	Total[1] (Mm^3/a)
W70A	0.1107	0.0109	0.0000	4.3686	0.0000	0.6987	5.1888

1 Includes of water use from the lakes.

Table 9.2 Use from lakes

Lake	Use (Mm^3/a)
Sibaya	2.4742
Shengeza	0.2774
Mgoboseleni	0.094
Total	**2.8456**

9.7 GROUNDWATER RESOURCES

The groundwater recharge, exploitation potential and use for the W7 Catchment is shown in **Table 9.3**. Groundwater use excludes use directly from lakes.

Table 9.3 W7 Catchment: Groundwater recharge and exploitation potential

Quat	Area (km^2)	Recharge (Mm^3/a)	Aquifer recharge (Mm^3/a)	Exploitation potential (Mm^3/a)	GRA II Exploitation potential (Mm^3/a)	Harvest potential (Mm^3/a)	Use (Mm^3/a)
W70A	2577.95	205.55	340.15	216.18	97.08	649.41	2.3432

9.8 GROUNDWATER QUALITY

9.8.1 Electrical conductivity

The distribution of EC is shown in **Figure 9.3** and **Table 9.4**. Groundwater is Class 0 except in the Cretaceous deposits.

Table 9.4 Distribution of EC in mS/m by percentile and class

Quat	20^{th} percentile	40^{th} percentile	60^{th} percentile	80^{th} percentile	100^{th} percentile	Potable fraction
W70A	20.48	30	49.84	104.04	498	0.843

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W70A	0	23	2	2	1	III

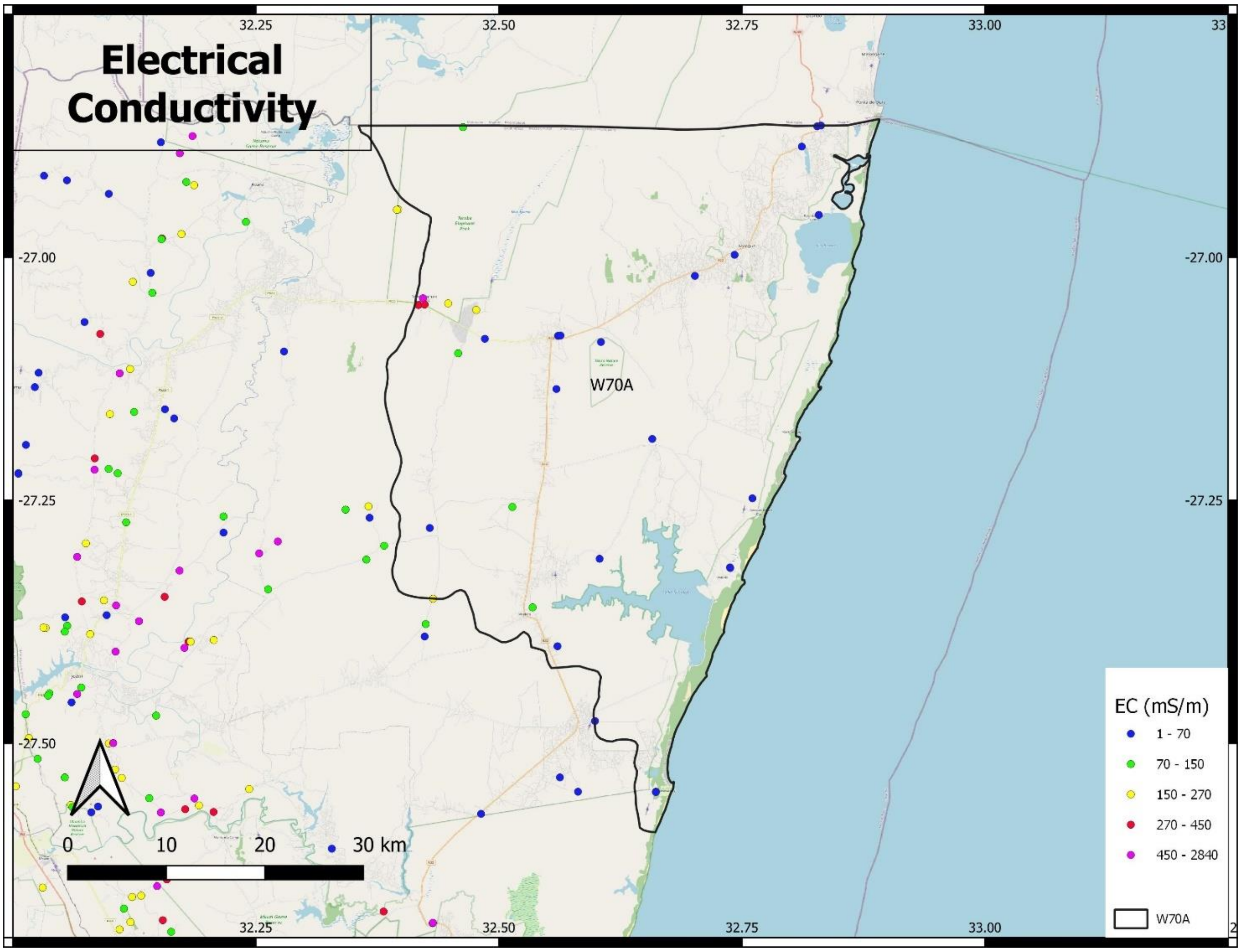

Figure 9.3 EC in W7

9.8.2 Nitrates

Nitrate is generally of Class 0 - 1 throughout the catchment (**Figure 9.4**). The distribution of nitrate concentrations is shown in **Table 9.5**.

Table 9.5 Distribution of nitrates in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W70A	0.02	0.098	1.0912	1.8292	8.129	1

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W70A	25	3	0	0	0	I

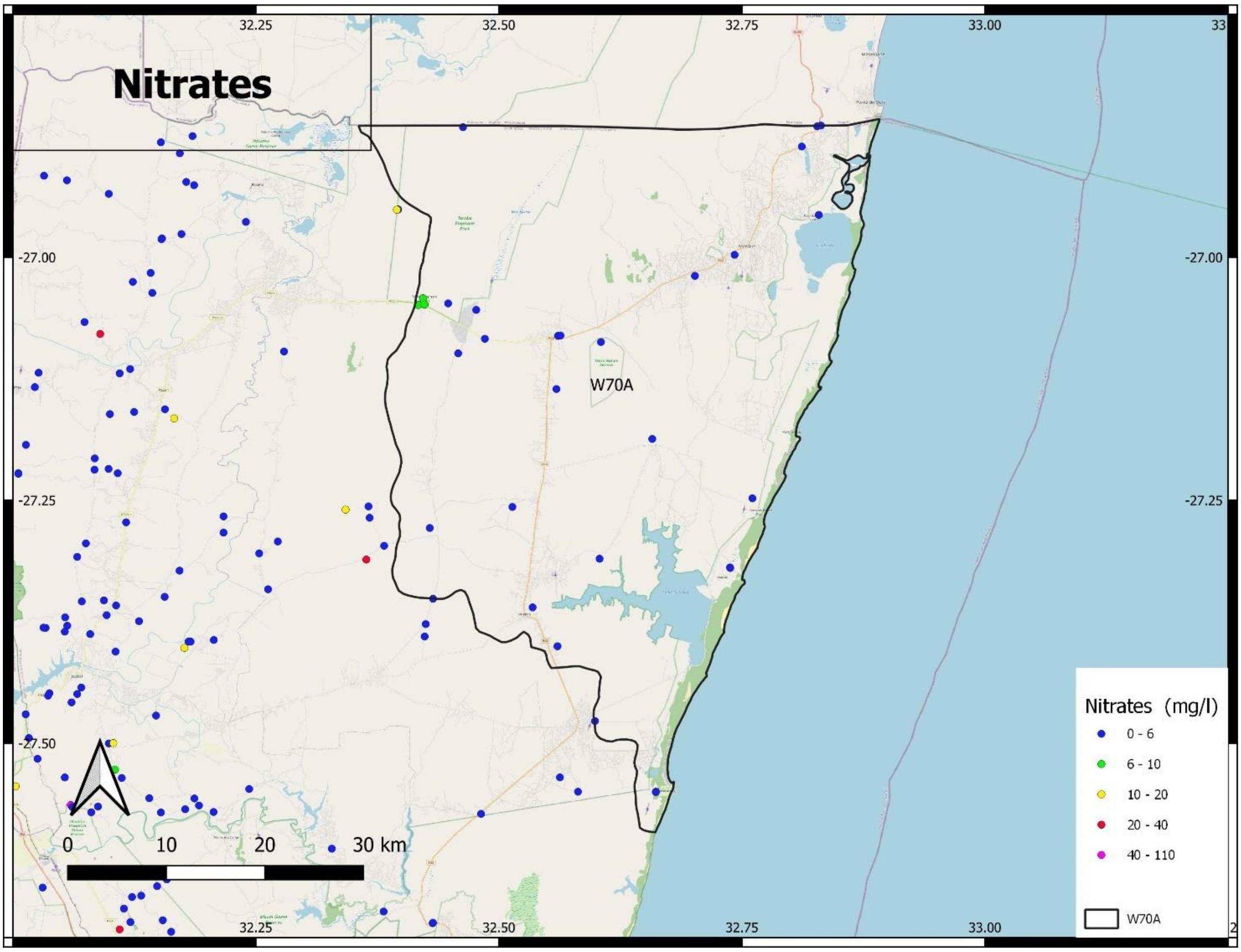

Figure 9.4 Distribution of Nitrate in W7

9.8.3 Fluoride

Water quality is of Class 0 (**Figure 9.5**). The distribution of fluoride concentrations is shown in **Table 9.6**.

Table 9.6 Distribution of Fluoride in mg/l by percentile and class

Quat	20th percentile	40th percentile	60th percentile	80th percentile	100th percentile	Potable fraction
W70A	0.1	0.128	0.15	0.2	0.48	1

Quaternary	Class 0	Class 1	Class 2	Class 3	Class 4	Classification
W70A	28	0	0	0	0	I

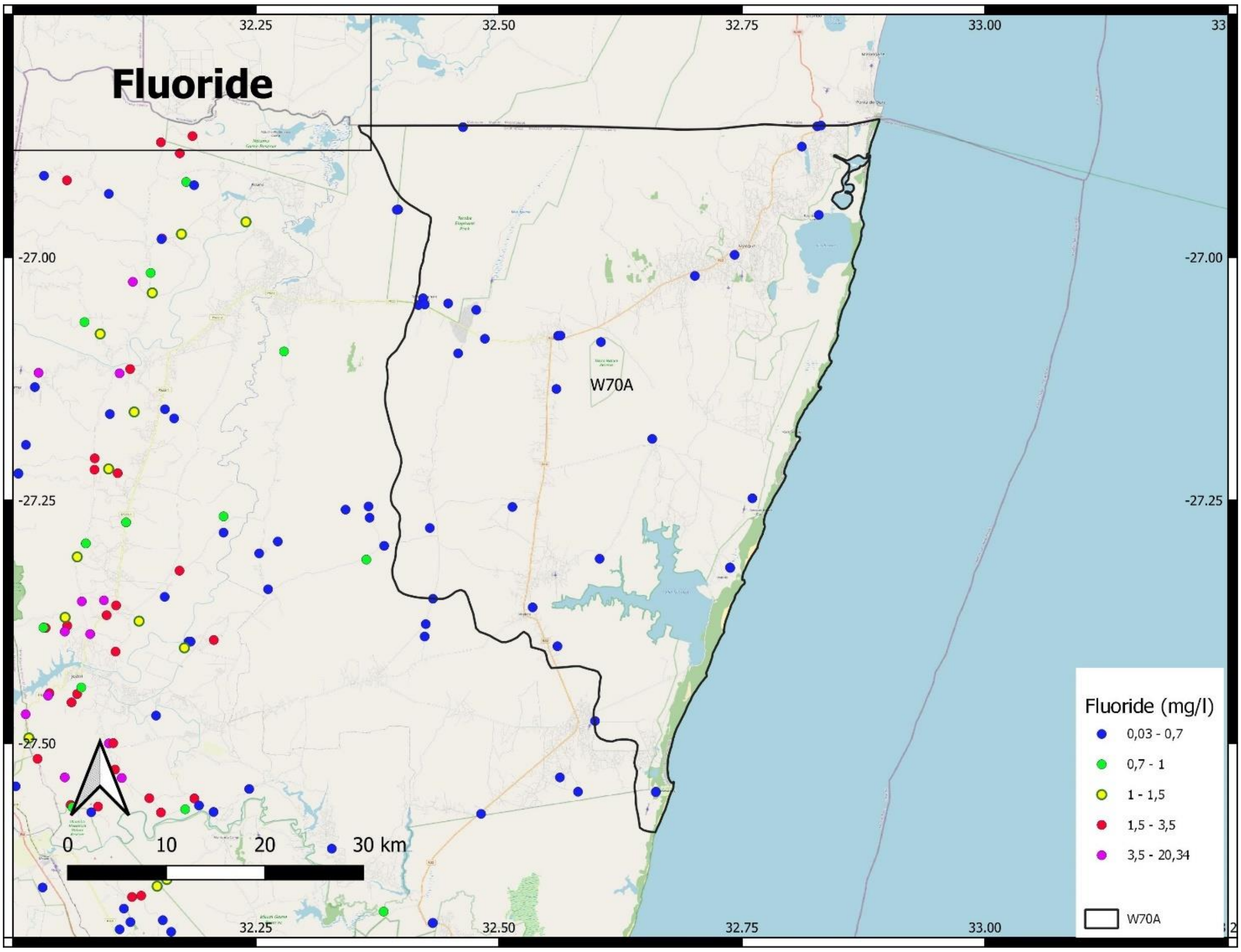

Figure 9.5 Distribution of Fluoride in W7

9.9 CLASSIFICATION

The stress index calculated from the total present use and aquifer recharge is 0.01. Groundwater is minimally used. Quaternary catchment classification is shown in **Table 9.7**.

Table 9.7 Classification status for W7

Quaternary	Aquifer Recharge (Mm^3/a)	Groundwater baseflow (Mm^3/a)	BHN (Mm^3/a)	Use (Mm^3/a)	Stress Index	PSC	Class	Groundwater Component of Reserve (Mm^3/a)
W70A	340.15	63.61	0.4040	2.3432	0.01	A	I	64.01

10 CONCLUSIONS

The report documents the results of the groundwater analysis of the Usutu to Mhlathuze Catchments.

The Groundwater Component of the Reserve and Groundwater Classification is undertaken by calculating the Stress Index for each quaternary catchment based on abstraction and revised figures for baseflow and recharge calibrated using Water Resources Simulation Model (WRSM Pitman - Pitman *et al*., 2006). Groundwater baseflow and the BHN component from groundwater are utilised to determine the Groundwater contribution to the Ecological Reserve.

In summary:

- W1 Mhlathuze Catchment: Groundwater is minimally used and the stress index is below 0.05.
- W2 Umfolozi Catchment: Groundwater is minimally used and the stress index is below 0.12.
- W3 Mkuze Catchment: Groundwater is minimally used and the stress index is below 0.05.
- W4 Pongola Catchment: Groundwater is minimally used and the stress index is below 0.05.
- W5 Usutu Catchment: Groundwater is minimally used and the stress index is below 0.13.
- W7 Catchment the stress index is 0.01. Groundwater is minimally used. Groundwater is critical to maintaining coastal lakes.

11 REFERENCES

Department of Water Affairs and Forestry (DWAF), South Africa. 1998. Quality of Domestic Water Supplies. Volume 1: Assessment Guide. Second Edition. Water Research Commission Report No. TT 101/98.

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Parsons, R.P. and Wentzel, J. 2007. Groundwater Resource Directed Measures (GRDM) Manual. Water Research Commission Report No. TT 299/07, with support from FETWater.

Pitman, W.V., Bailey, A.K., and Kakebeeke, J.P. 2006. WRSM2000: Water Resources Simulation Model for Windows – User's Guide. Steward Scott Consulting Engineers and TiSD, Johannesburg.

12 APPENDIX A: COMMENTS AND RESPONSE REGISTER

No.	Section	Comment	From	Addressed?
1		Several pages: Please change DAWF to DWAF.	M Sekoele	Corrected.
2	Sec. 2.3 Pg. 2-2	"The results of the groundwater resources investigation were ultimately **be** used **to** for…" - Delete be and to	M Sekoele	Corrected.
3	Sec. 2.3 Pg. 2-3	3rd bullet: "Classification of Present State Classification and Management Class" - Consider revising this phrase.	M Sekoele	Corrected.
4	Sec. 2.3 Pg. 2-4	"REVISIONS TO DATBASES" - insert A	M Sekoele	Changed heading.
5	Pg 2 after cover page	Page 2 after cover page. Month should be August not July.	K Makanda	Corrected.
6	Page xii	Is the abbreviation of mean sea level correct?	K Makanda	Corrected.
7	Page xii	WRCS means Water Resource Classification System.	K Makanda	Corrected.
8	Sec. 10	References, standardise referencing format.	K Makanda	
9	Sec. 3.9 Pg 3-8	Second sentence: The word "are" after the word "study" is meant to read "area".	R Pillay	Corrected.
10	Tables 4.2, 5.2, 6.2, 7.2, 8.2 and 9.1	Include the units in the column titled "Total". Should these units be in Mm^3/a?	R Pillay	Corrected.
11	Table 9.1	The column titled "Total" - Indicate if this total is inclusive of water use from the lakes.	R Pillay	Corrected.
12	Sec. 9.7 Table 9.3	The sentences refer to the "W5" catchment. This should be changed to "W7". Change the words "W5" to "W7".	R Pillay	Corrected.