water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

2030 NDP
NATIONAL DEVELOPMENT PLAN
Our Future - make it work

RESERVE DETERMINATION STUDY FOR SELECTED SURFACE WATER, GROUNDWATER, ESTUARIES AND WETLANDS IN THE F60 AND G30 CATCHMENTS WITHIN THE BERG-OLIFANTS WATER MANAGEMENT AREA (WMA 9)

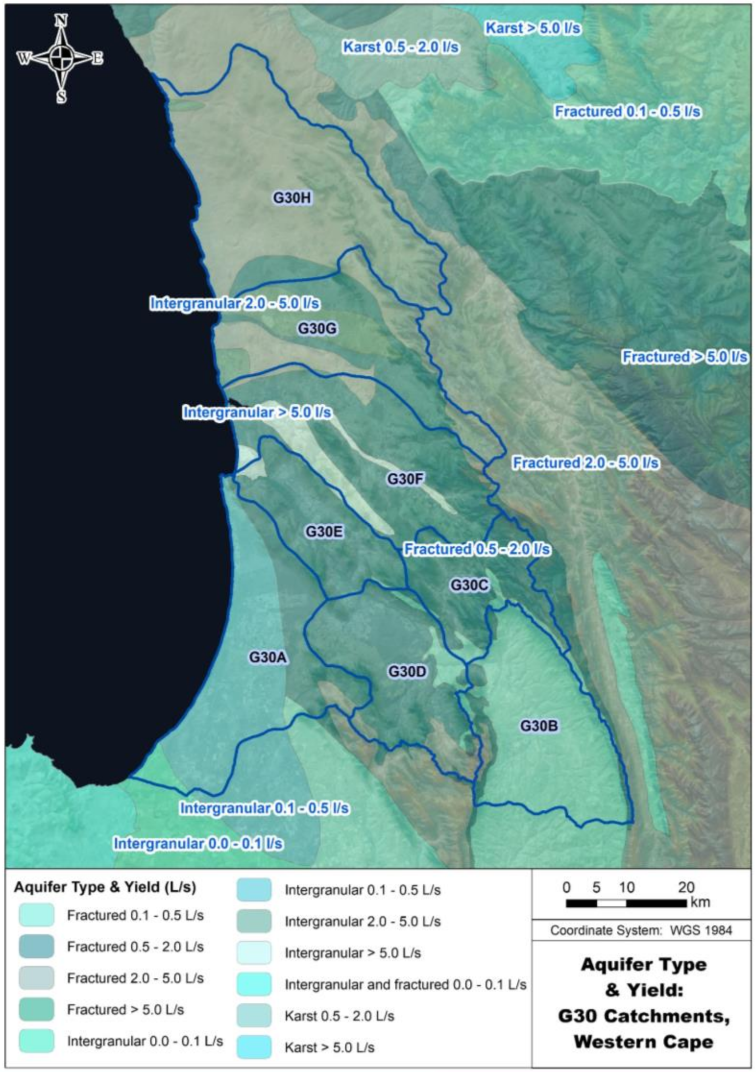
PSC 3: Groundwater

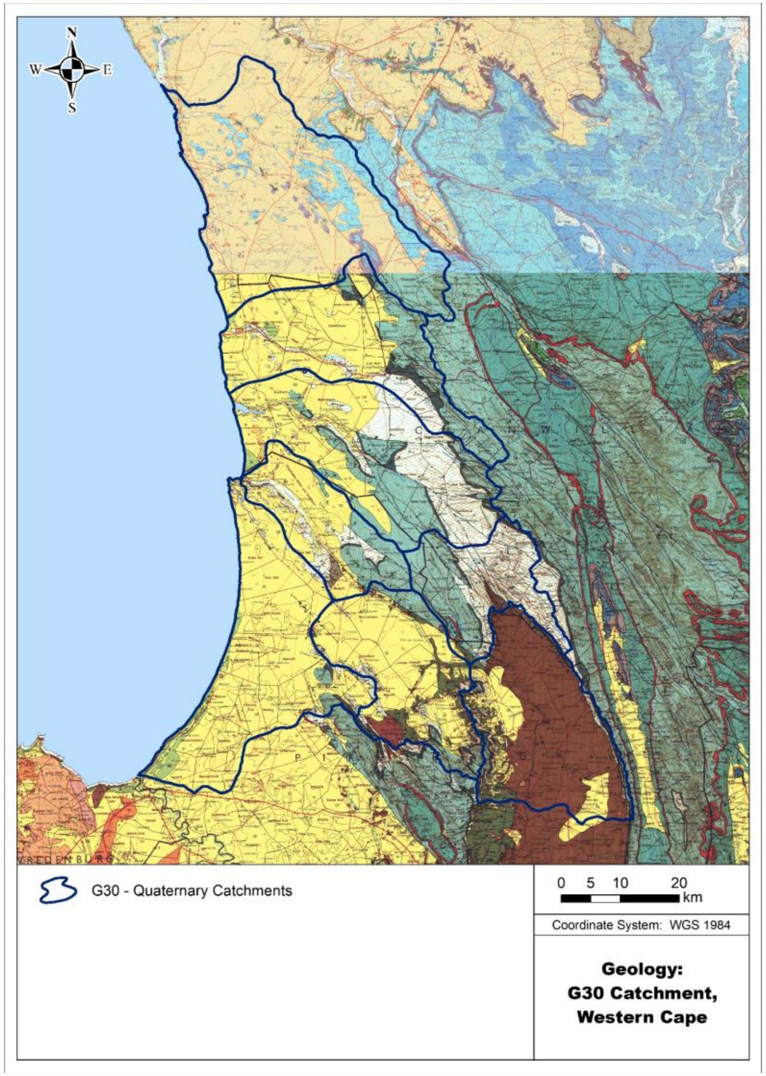
Date: 23 November 2022

WATER IS LIFE - SANITATION IS DIGNITY

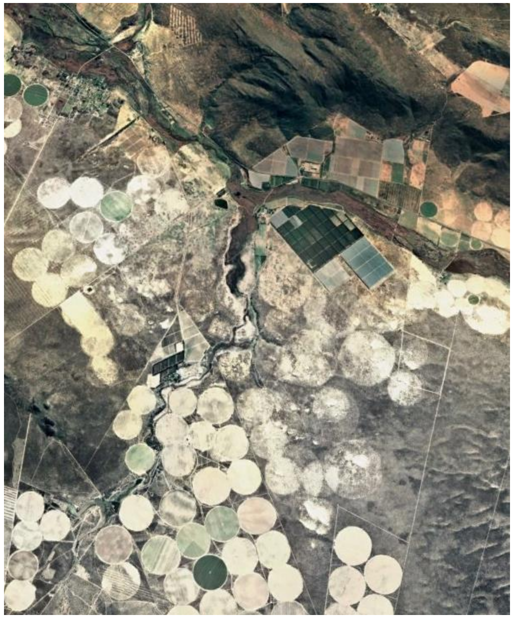

Data Collection
•GW Levels
•GW Quality
•Abstraction
•Aquifer Parameters
Delineate Resource Units
Determine Reference Conditions
Aquifer Parameters and Recharge
Baseline Study:
Groundwater Reserve
Calculate Reserve
Determine Operational Scenarios
Resource Quality Objectives
Recommendations and Monitoring Program

Baseline Studies G30

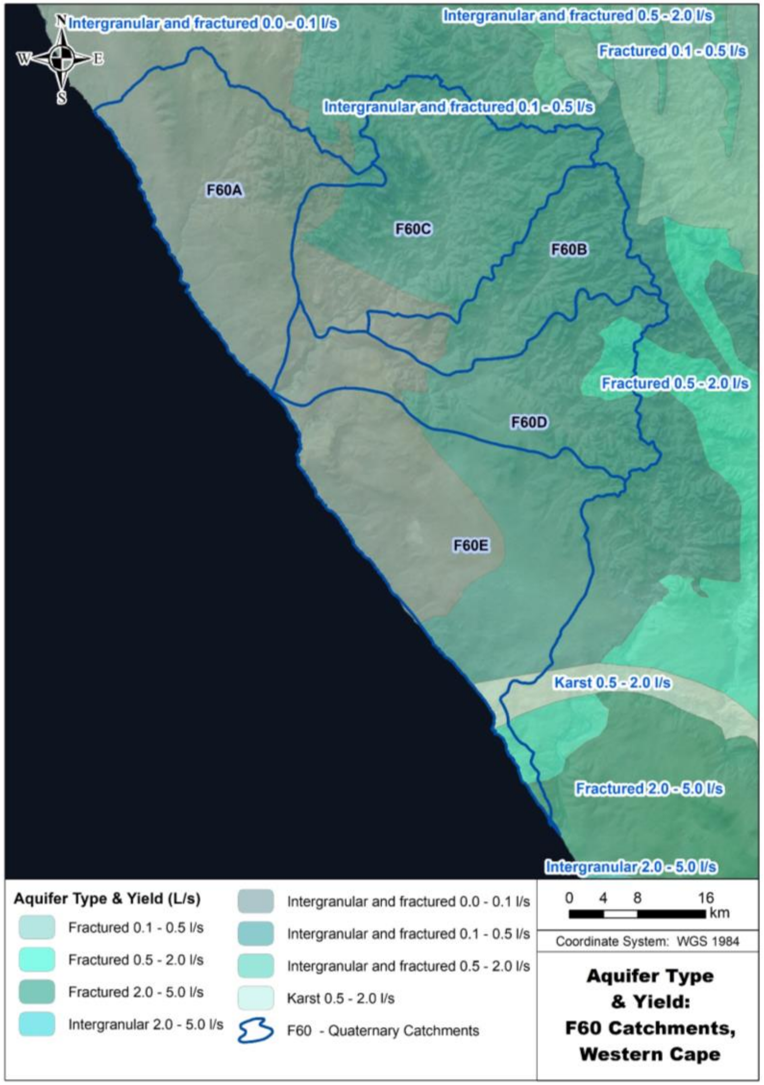


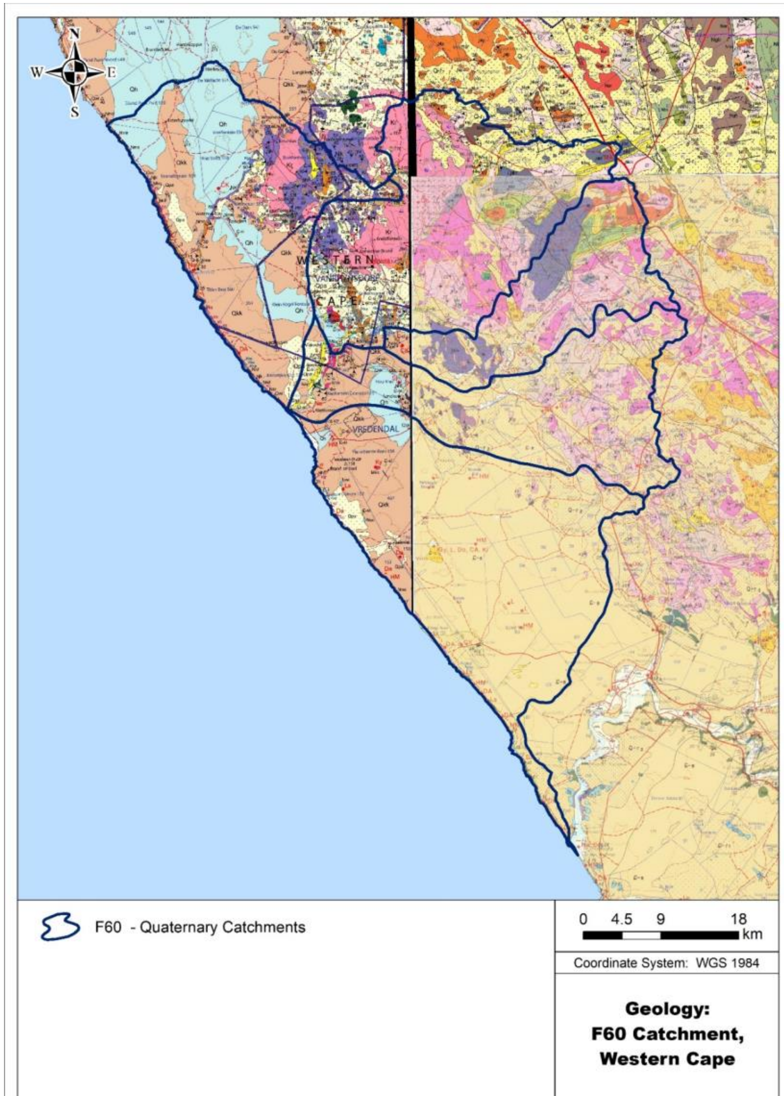


Seepage Zones in G30



Baseline Studies F60





F60 Hydrocensus

Sample Details					
SampleID	W27352	W27353			
Water Type	Irrigation Water	Irrigation Water			
Water Source	Borehole				
Sample Temperature					
Description	4127PhA_HBH1	4127PhA_SP4			
PO Number	4127PhA	4127PhA			
Date Received	2022-05-03	2022-05-03			
Condition	Good	Good			

Water - Routine									
	Unit	Method	Uncertainty	Limit	Results	Results	Results	Results	Results
pH@25C* (Water)		VIN-05-MW01	0.1%		7.39	7.83			
Conductivity@25C* (Water)	mS/m	VIN-05-MW02	^		964	1184			
Total dissolved solids (Water)	mg/L				6535.92	8027.52			
Chloride (Cl-)* - Water	mg/L	VIN-05-MW08	10%		3199.94	3930.25			
Sulphates (SO4)* - Water	mg/L	VIN-05-MW08	10%		489.46	615.94			
Alkalinity as CaCO3 (Water)	mg/L				75.10	143.60			
Carbonate as CO3 (Water)	mg/L				<1.00	<1.00			
Bicarbonate (HCO3) - Water	mg/L				75.10	143.60			
Langelier Index (Water)					-0.15	0.57			
Date Tested					2022-05-03	2022-05-03			

GROUNDWATER RESOURCE UNIT DELINEATION

- **The delineation of Groundwater Resource Units (GRUs) was done at a desktop level is based on reviewing multiple datasets. Geological, hydrological and meteorological data were combined with general knowledge of the area and comments from residents**

- **The type of groundwater and aquifer system were taken into account during the process of delineation of the GRUs within F60 and G30 catchments.**

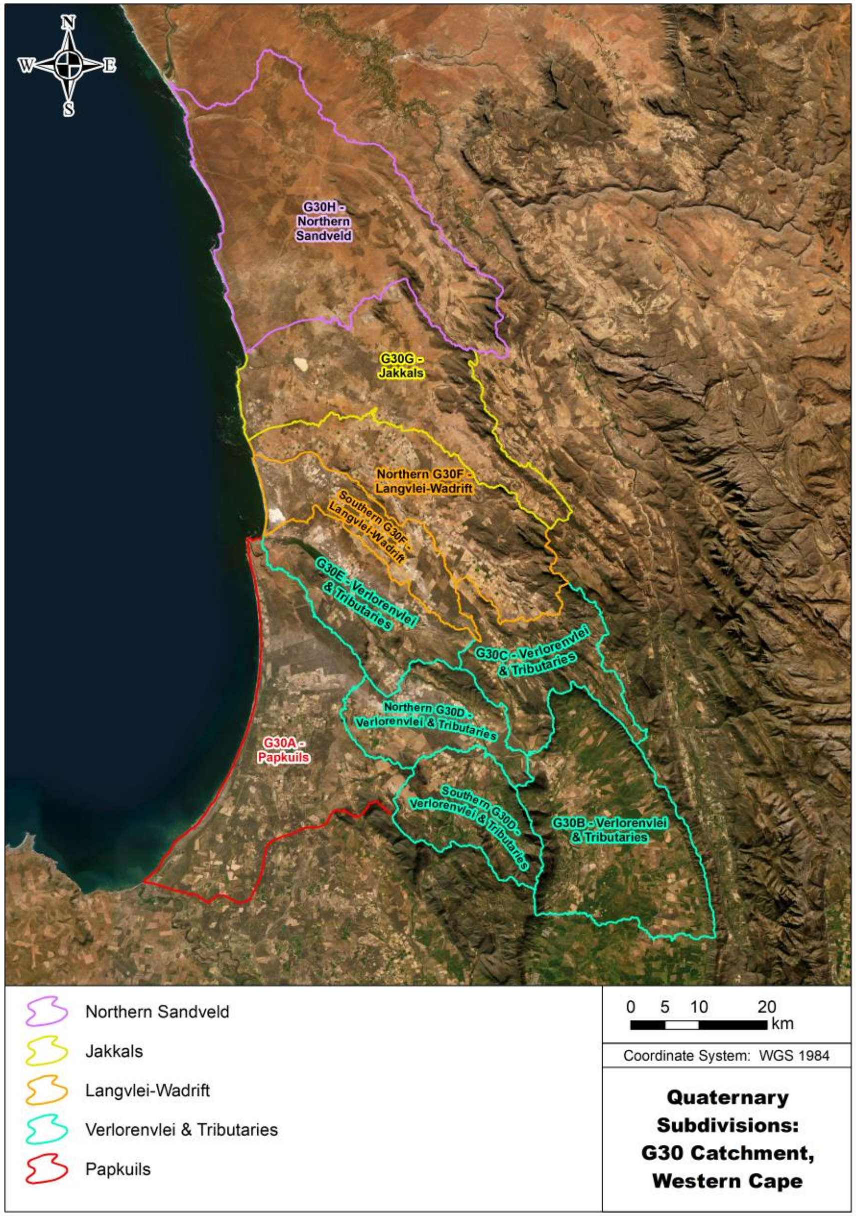
- **Because the groundwater reserves and RQOs that are linked to them will ultimately have to be linked to surface water RQOs and the quaternary catchments, it was decided to use these boundaries were possible.**

- **For the G30 catchments, the 30m DEM was used to match groundwater and surface water catchments.**

- **For the F60 catchments, the quaternary boundaries were used.**

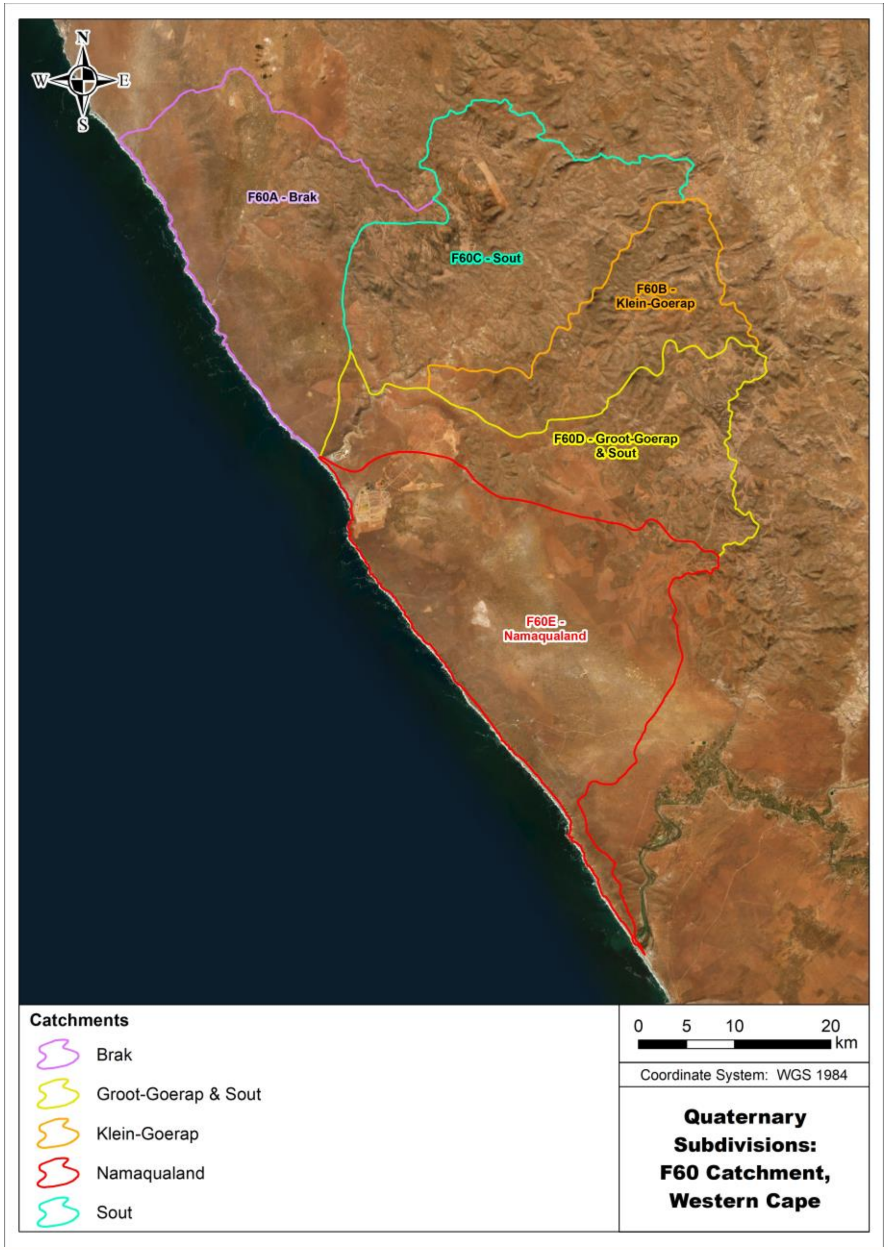
G30 GRUs

- Taking into account the nature of the groundwater system within the G30 catchments, it was decided to mostly stick to the existing quaternary boundaries as they do tend to each incorporate a single valley that relates well with perceived groundwater flow.
- G30D was split into a northern and southern GRU, as the southern portion includes much higher rainfall mountainous areas that would be linked to higher recharge.
- G30F has also been split into a northern and southern GRU as this quaternary catchment includes two valleys that each have a separate paleochannel type feature.



G30 GRUs

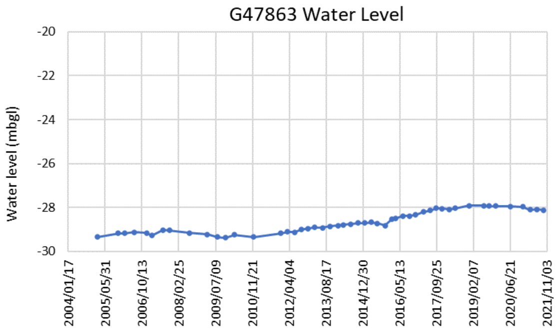
- Taking into account the nature of the groundwater system within the F60 catchments, it was decided to stick to the existing quaternary boundaries as they do tend to each incorporate a single surface water system and as the RQOs will be on that level and actual groundwater boundaries are not known, the quaternary boundaries will act as sufficient separation.

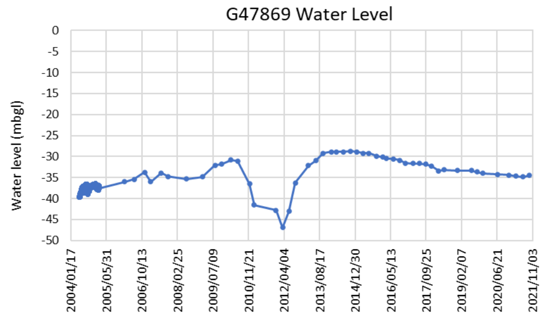


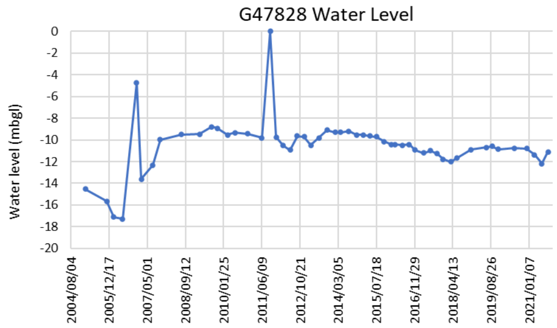
Aquifer Parameters and Recharge %

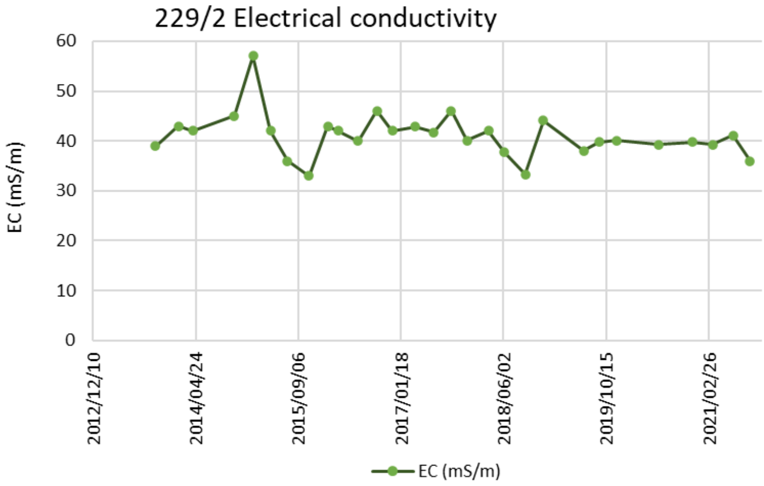
Quaternary Catchment	Recharge Percent of MAP	Source	Comments
F60A	0.7	GRAII, (AFYM, WRC, 2012)	Designed for Karoo aquifer, per Q catchment, vertical recharge. Box model
F60B	1.2	GRAII, (AFYM, WRC, 2012)	Designed for Karoo aquifer, per Q catchment, vertical recharge. Box model
F60C	1.4	GRAII, (AFYM, WRC, 2012)	Designed for Karoo aquifer, per Q catchment, vertical recharge. Box model
G10K	15.88	PSA_GEOSS (2019)	Calculated from Chloride Mass Balance (CMB) and Stable Isotope approach. Indicates higher
E10G	6.33	PSA_GEOSS (2019)	Calculated from Chloride Mass Balance (CMB) and Stable Isotope approach. Indicates higher recharge (>15%) in the mountainous areas. The
E10E	28.67	PSA_GEOSS (2019)	Calculated from Chloride Mass Balance (CMB) and Stable Isotope approach. Indicates higher
G30D	5.7	Watson et al 2020	Recharge Estimation Using CMB and Environmental Isotopes in the Verlorenvlei
G30D	13.8	Watson et al 2020	Recharge Estimation Using CMB and Environmental Isotopes in the Verlorenvlei
G30D	1.7	Watson et al 2020	Recharge Estimation Using CMB and Environmental Isotopes in the Verlorenvlei
N/A	0.2-3.5	Umvoto 2020	Refered to Recharge calculations pulled from Conrad et al. (2004); Eilers et al. (2018)
N/A	4.0-6.0	Umvoto 2020	Refered to Recharge calculations pulled from Conrad et al. (2004); Eilers et al. (2018)
N/A	22-25	Umvoto 2020	Refered to Recharge calculations pulled from Conrad et al. (2004); Eilers et al. (2018)
N/A	6.0-11	Watson et al 2018b	J2000 model
N/A	22-25	Watson et al 2018b	Modflow model
N/A	1.0-5	Watson et al 2018b	J2000 and modflow models
N/A	up to 29 (20-50 mm/year)	Miller et al 2022	Characterization of groundwater types and residence times in the Verlorenvlei catchment, South Africa to constrain recharge dynamics and
N/A	3.0-4	Miller et al 2022	Characterization of groundwater types and residence times in the Verlorenvlei catchment, South Africa to constrain recharge dynamics and
N/A	(2-8 mm/year)	Miller et al 2022	Characterization of groundwater types and residence times in the Verlorenvlei catchment, South Africa to constrain recharge dynamics and

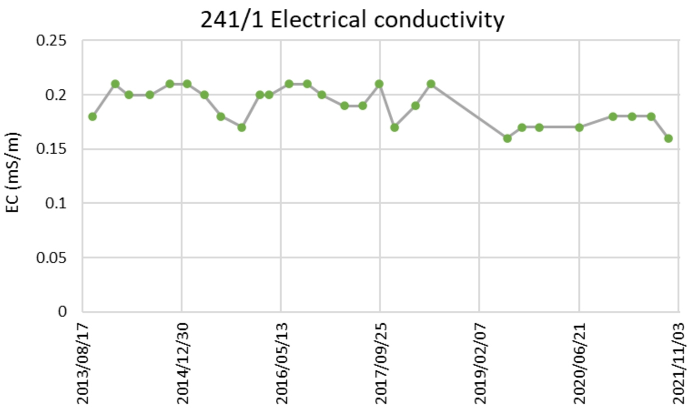
Water Level and Quality Data











Baseflow Contribution

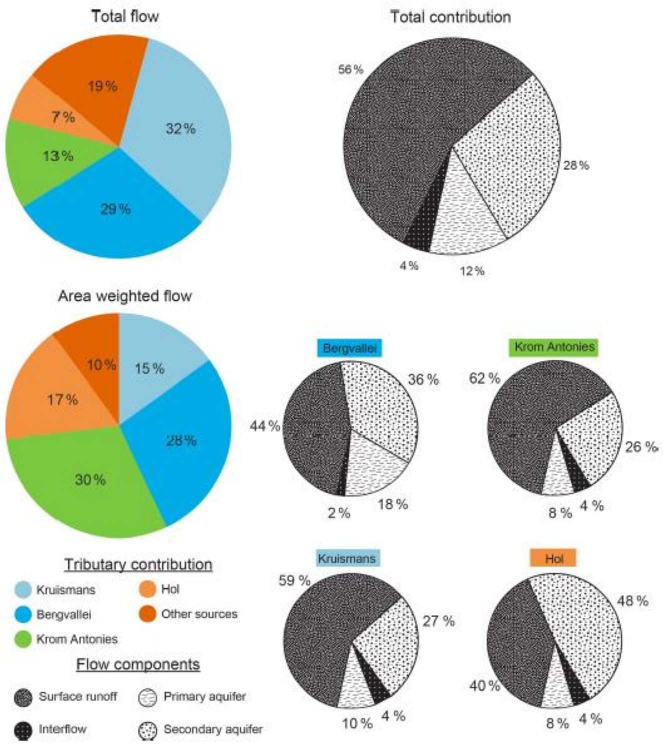


Figure 10. The Verlorenvlei reserve flow contributions (total flow and area-weighted flow) of Kruismans, Bergvallei, Krom Antonies and Hol as well as flow component separation into surface runoff (RD1), interflow (RD2), primary aquifer flow (RG1) and secondary aquifer flow (RG2).

Aquifer	Formation	Type	RG1_max (mm)	RG2_max (mm)	RG1_k (d)	RG2_k (d)	RG1_active (n/a)	Kf_geo ($mm\,d^{-1}$)	depthRG1 (cm)
Primary	Quaternary sediments	Sediments	50	700	100	431	1	2000	1750
Secondary	Mooresberg Formation	Shale greywacke	0	580	0	350	0	2000	1750
Secondary	Porterville Formation	Shale greywacke	0	560	0	335	0	2000	1750
Secondary	Piketberg Formation	Shale greywacke	0	1000	0	600	0	2000	1750
TMG	Peninsula Formation	Sandstone	0	1000	0	600	0	2000	1750
TMG	Piekenierskloof Formation	Sandstone	0	600	0	400	0	2000	1750
TMG	Klipheuwel Group	Sandstone	0	500	0	300	0	2000	1750

n/a: not applicable.

Vertical Groundwater Recharge

RU module	Catchment	Name	MAP	GW (Pitman) (mm)	GW (Pitman) Mm3/a	Area (km2)	MAP (mm)	*Dominant geology*	Estimated Recharge (Workshop)	Calculated recharge (million m3)
RU1	G30A1	Papkuils	Low			131.1	292.0	*Sand*	3.5%	1.34
RU2	G30A2	Papkuils Lower	Low			10.0	292.0	*Sand*	3.5%	0.10
RU3	G30B1	Upper Kruisman	High	5	1.422	23.7	504.9	*TMG*	23.0%	2.75
RU4	G30B1	Upper Kruisman	Low	1	1.108356	92.4	300.0	*Shale*	5.0%	1.39
RU30	G30B2	Soutkloof	High	5	1.065	17.8	415	*TMG*	23.0%	1.69
RU5	G30B2	Soutkloof	Low	1	2.333448	194.5	300	*Shale*	5.0%	2.92
RU6	G30B3	Huis tributary	High			53.8	504.9	*TMG*	23.0%	6.25
RU7	G30B3	Huis tributary	Low			288.5	300.0	*Shale*	5.0%	4.33
RU8	G30C1	Kleinvlei	Slightly higher MAP use			64.3	404.0	*TMG*	23.0%	5.98
RU9	G30C2	Jansekraal	Slightly higher MAP use			62.6	404.0	*TMG*	23.0%	5.81
RU10	G30C3	Bergvallei	Slightly low MAP relati			218.2	383.0	*Sand*	3.5%	2.92
RU11	G30D1	KA upper	High			64.8	517.0	*TMG*	23.0%	7.71
RU12	G30D1	KA lower	Low			55.1	366.0	*Shale*	5.0%	1.01
RU13	G30D2	Hol upper	High			51.7	517.0	*TMG*	23.0%	6.15
RU14	G30D2	Hol lower	Low			102.6	366.0	*Shale*	5.0%	1.88
RU15	G30D3	Matroosfontein	Low			128.2	347.0	*Sand*	3.5%	1.56
RU16	G30D4	Verlorenvlei	Low			151.8	347.0	*Sand*	3.5%	1.84
	G30E1	Kruisfontein	Low			90.4	286.0	*Sand*	3.5%	0.91
	G30E2	Verlorenvlei	Low			44.9	286.0	*Sand*	3.5%	0.45
	G30E3	Verlorenvlei	Low			35.3	286.0	*Sand*	3.5%	0.35
	G30E4	Verlorenvlei	Low			190.5	286.0	*Sand/Shale*	5.0%	2.72
	G30F1	Langvlei	Low			194.2	352.0	*Sand*	3.5%	2.39
	G30F2	Lambertshoek	Low			98.9	352.0	*TMG*	23.0%	8.01
	G30F3		Low			397.8	236.0	*Sand*	3.5%	3.29
	G30F4		Low			30.2	236.0	*Sand*	3.5%	0.25
	G30G1	Jakkals	Low			134.4	268.0	*TMG/Sand*	xx	11.15
	G30G2	Peddies	Low			49.4	268.0	*TMG*	23.0%	3.05
	G30G3		Low			317.5	208.0	*Sand*	3.5%	2.31
RU28	G30G4		Low			21.7	138.0	*Sand*	3.5%	0.10
	G30H1		Low			580.8	204.0	*Sand*	3.5%	4.15

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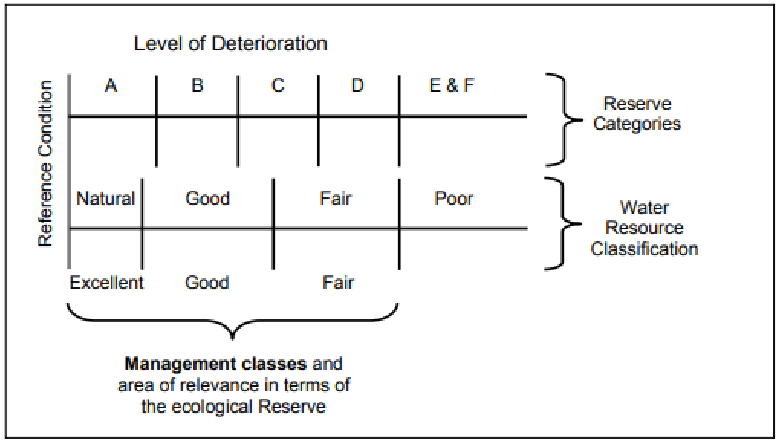
Groundwater Use: Then and Now

- Looked at Verification and Validation Groundwater Data, as well as WARMS.
- Best current actual groundwater use volumes from 2017/18 Crop Census done by the Department of Agriculture

OBJEC	CROPS	DRY_IRR	SUM_AREA_HA
1	Butternut	Irrigated	16.11
2	Cabbage/Cauliflo	Irrigated	0.6
3	Canola	Dry land	116.25
4	Citrus (unspecifie	Irrigated	5.06
5	Fallow		2576.5
6	Fallow, Potatoes	Irrigated	20.82
7	Fallow, Rooibos	Dry land	47.58
8	Lemon	Irrigated	49.09
9	Lime	Irrigated	5.68
10	Lucerne/Medics	Dry land	616.06
11	Lucerne/Medics	Irrigated	60.14
12	Naartjies	Irrigated	149.74
13	Nectarine	Irrigated	7.03
14	Old field		1767.4
15	Olives	Irrigated	80.18
16	Onions	Irrigated	101.56
17	Oranges	None	5.92
18	Oranges	Irrigated	127.24
19	Other	None	0.11
20	Other		1.6
21	Other	Irrigated	0.73
22	Planted pastures	Dry land	24.3
23	Planted pastures	Irrigated	212.45
24	Planted pastures	Dry land	1904.32
25	Planted pastures	Irrigated	12.7
26	Planted pastures	Dry land	34.05
27	Pomegranate	Irrigated	0.49
28	Potatoes	Irrigated	358.85
29	Proteas	Dry land	1.18
30	Pumpkin	Dry land	3.56
31	Rooibos	Dry land	3582.74
32	Rooibos, Potatoe	Irrigated	18.22
33	Small grain grazi	Dry land	2312.91
34	Small grain grazi	Irrigated	189.27
35	Stubble		444.9
36	Table grapes	None	55.96
37	Table grapes	Irrigated	205.48
38	Triticale	Dry land	293.83
39	Triticale	Irrigated	41.88
40	Unknown		33.81
41	Unknown vegetal	Dry land	1.34

Groundwater Reserve and Resource Classification

- After groundwater recharge, baseflow contribution and rainfall has been determined, a groundwater reserve can be determined.



- After the reserve is calculated per GRU, ecological and basic human needs are subtracted. The volume left over is what can be used for other uses.

- Comparing these volumes with current abstraction volumes as well as indicating parameters like change in water level and chemistry, a stress factor can be assigned to that catchment.

$$\text{Stress Index} = \frac{\text{Groundwater Abstraction}}{\text{Recharge} - \text{Baseflow}}$$

- Resource management strategies are then proposed to assist with the management of the groundwater for these catchments.

Thank you !