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REPUBLIC OF SOUTH AFRICA

Emergency Drought Intervention Report for Sutherland

Report no.: GH4438

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5 July 2021 Report no: 14/14/3/5/3/3/2

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1 Introduction and Aim

The ongoing drought has placed significant strain on the water resources in the Central Karoo over the past 7 years. The rainfall is erratic, and many areas recorded their lowest rainfall records in decades. In addition, recharge to the groundwater system was significantly interrupted by climatic changes. Sutherland is one of many towns in the Karoo that have been impacted negatively, resulting in a decline in water level and subsequently a decrease in borehole yields.

This report provide overview of the groundwater situation in Sutherland, the recommendations and actions executed to address the drought situation since late 2020, including a site visit on 5 May 2021. Recommendations for actions are for the short and medium-term. These recommendations enable the management and protection of the groundwater resource and inform the users of their water use impacts.

2 Background and Current Situation

The town of Sutherland lies in the Northern Cape Province, approximately 120km southwest of Fraserburg, 160km southeast of Calvinia and about 267km northeast of Cape Town. The entire study area falls within the D51A Quaternary Catchment of the Orange WMA. Sutherland is dependent on groundwater as a source of water supply to the town.

Elevations in the study area range from 1315 m above mean sea level (m amsl) in the north-south-oriented valley to the mountains to the west and east, reaching 1574 and 1530 m amsl, respectively. Drainage from the high-lying western and eastern mountainous regions is along seasonal flowing drainage channels towards the northerly flowing Dorpsrivier, which only flows after good rainfall events (Figure 2.1).

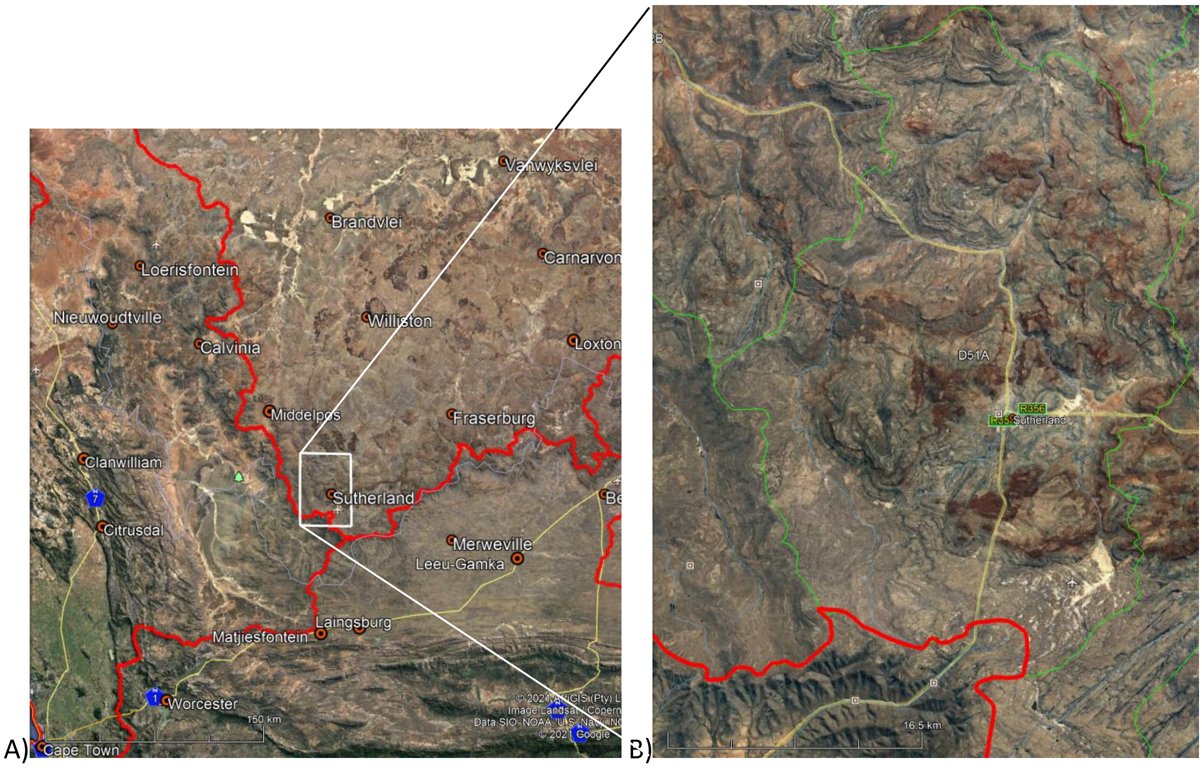

Figure 2.1 Sutherland – A)Regional Area and B)Town location, drainage and WMA

2.1 Rainfall

The region's climate is typical of the Karoo, with most of the rain falling during the very late summer months of March to May. Winter rain and snow also occur in the high-laying areas. The catchment's MAP varies from 200mm in the north to approximately 300mm in the southwest. The 'average' MAP for Sutherland is in the order of 240mm (Middleton and Bailey, 2008).

Over the last 10 rainfall seasons, Sutherland only received 4 years (2011 – 2015) of average rainfall (+20% to -20%). From 2015, Sutherland received 6 consecutive years of very low rainfall (below 20%) (Figure 2.2), of which seasons 2016-2017 and 2018-2019 were less than half the average rainfall.

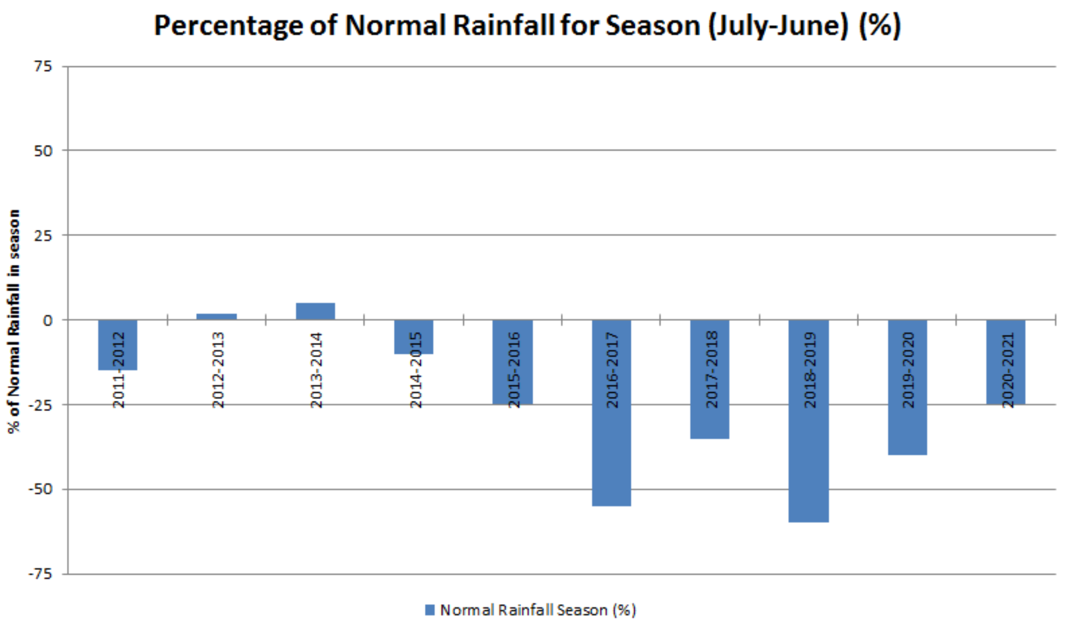

Figure 2.2 Percentage of Normal Rainfall for Season – July 2011 – June 2021

Although the rainfall was very low in the 2016-2017 season, one single event in May 2016 resulted in a downpour of 100mm that filled the town's dam. The effect on the water levels can be noted in Figure 2.4.

2.2 Wellfield

The water supply boreholes in Sutherland consist of 4 production boreholes. The 4 production boreholes were drilled before 2004, and very little is known about the lithology or water interceptions.

Up to 23 April 2021, BH1, BH3 and BH4 were operational, but on 24 April 2021, BH4 was removed from the water supply network. The pumped water levels in BH4 dropped below the Critical Water Level (CWL) during pumping, and the rest water level could not be achieved above the Pump Restart Water Level (RSWL).

The yields of BH1 and BH3 were adjusted on 24 April 2021 by choking the borehole pumps. BH1 and BH3 are now pumped at 2.3 for 10 hours and 1.2 l/s for 4 hours, respectively, per day.

The BH2 – Rebelskop borehole collapsed and was replaced with a new replacement borehole BH2a (152m deep), 5m from the original production borehole on 24 February 2021. The new borehole

BH2a is not yet pump tested but was connected to the bulk infrastructure on 9 June 2021. The pump yield was choked to 1.5 l/s, and it was recommended to pump only 2 ½ hours a day until a full pump test can be done on BH2a. On 29 June 2021, the pump duration was increased to 4 hours at 1.5 l/s after evaluating the water level monitoring data.

Water is only opened from the reservoir from 04h00-09h00 and 17h00-19h00 to the water reticulation network of the town each day.

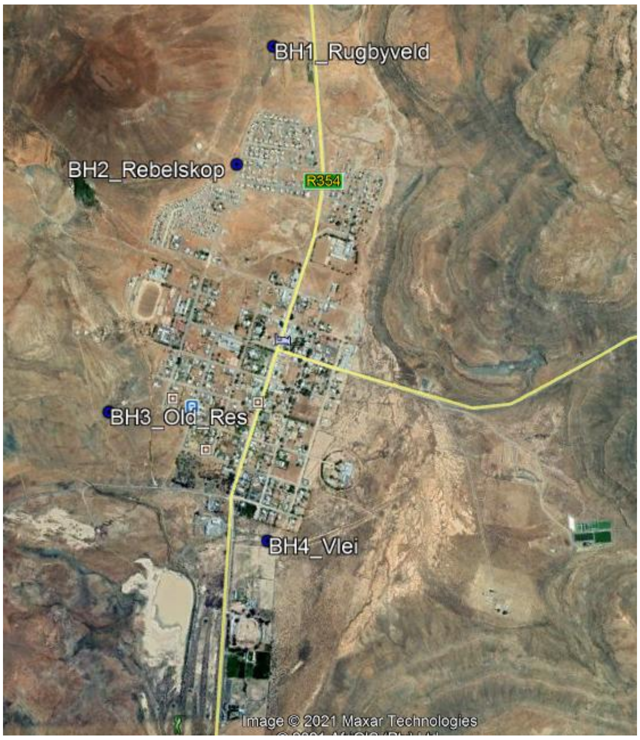

Figure 2.3 Sutherland – Location of the production boreholes

2.2.1 Aquifers and Production Boreholes

All production boreholes penetrated the upper and lower aquifers. The upper aquifer (unconfined aquifer) is located at a depth of 40m below ground level. The lower aquifer (confined aquifer) is found from 70 – 90m deep.

The upper aquifer is recharged through direct recharge events and streamflow events on the Dorps River's occasional flow. Figure 2.4 indicates that the lag recharge time from the upper (BH4) to the lower aquifer (BH2) is about 7 months.

The lower aquifer has a deep flow regime, and recharge is predominantly from snow and rainfall in the mountain regions.. More detailed borehole information is provided in Table 2.1:

Table 2-1 Sutherland – Production Borehole Information

BH Name	BH Numb	Latitude S	Longitude E	Elevation (masl)	BH Depth (original) (m)	Water Strike (m)	Pump Installation Depth (m)	Water Quality
Bh1_Rugbyveld	SUT 10	-32.38239°	20.66177°	1466	117.4 (118)	70, 90	90	Sulphur odur

Bh2_Rebelskop	SUT4	-32.38704°	20.66004°	1476	65 (122.0)			Sulphur odur
Bh2_Rebelskop New – Bh2a	New	-32.38704°	20.66004°	1476	152	98,112, 120		-
Bh3_ Ou Res	SUT9	-32.39647°	20.65387°	1478	120.7 (122)	99-106	90	Sulphur odour
Bh4_Vlei	SUT1	-32.40162°	20.66102°	1469	44.0 (87)		41	

2.2.2 Water levels

The water levels in the 3 + 1 production boreholes represent the two aquifer systems (upper and lower systems). The Vlei (BH4) borehole taps into the upper aquifer system with the fracture system at 30 – 40m, which is the same system all the private boreholes in town tap into. The Rugbyveld (BH1), Rebelskop (BH2a) and Old Reservoir (BH3) boreholes tap into the lower aquifer system with the fracture system at 70 – 90 - 106m deep.

The snow and rainfall during the winter months in 2020 are only reflected in Vlei (BH4), with a slight rise in the water level after June and July 2020.

The water levels of both aquifers dropped below the critical level from 2017, since the volume of water abstracted was not equal to or greater than the volume of water recharging the aquifer (Figures 2.4 and 2.9). The critical water levels and pump yields of all the production boreholes were adjusted after each pump test event, but the implementation of adjusted pump yields was not done.

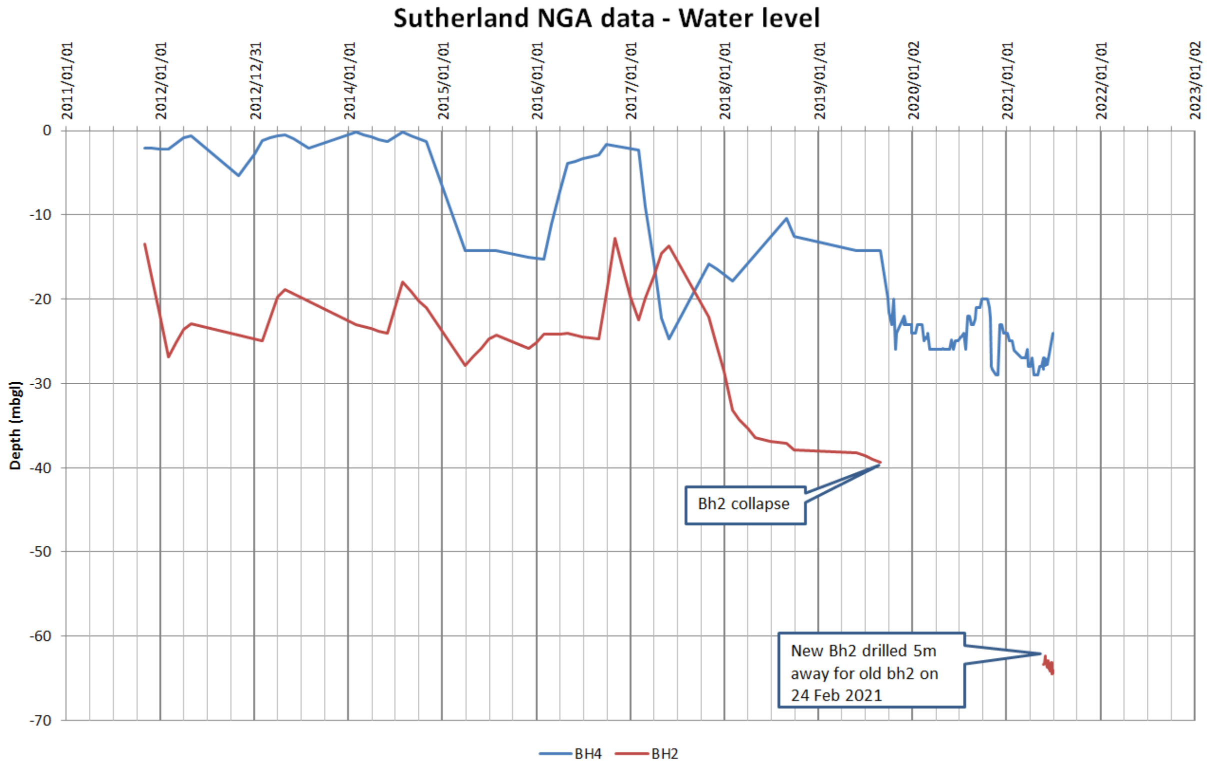

Figure 2.4 10year water level record of BH2 and BH4

2.2.2.1 Rugbyveld (BH1)

The water level in Rugbyveld (BH1) borehole varied over the last 2.5 years at 30 – 50m with a steady decline during the previous 2 years of 20m (Figure 2.5). The snow and rainfall in the winter months did not affect the water level.

This borehole is currently being pumped for 10 hours per day and yielding between 36 000 m^3/a, delivering half of what it should, since the work done in 2020 indicated the borehole yielded 121 414m^3/a.

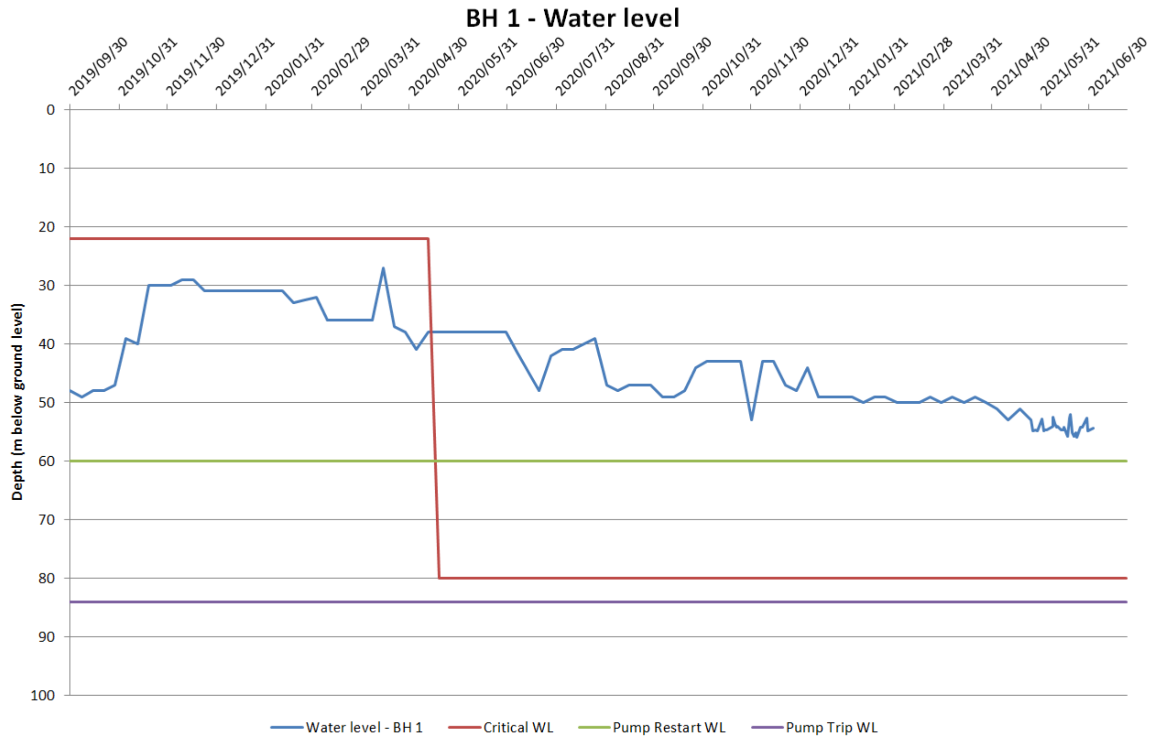

Figure 2.5 Sutherland – Pump 1 - Water level and Critical Water Level

The main water strikes are at 70 and 90m below ground level. Because the critical water level was determined to be at 80m, the collapse of Rebelskop (BH2) and the drop in water level in Old Reservoir (BH3); pump trip level needs to be placed at 75m below ground level, that is 5 m above the critical water level.

2.2.2.2 Rebelskop (BH2a)

Water levels measured after BH2a was drilled on 24 February 2021 indicate a slow decline. After equipping the borehole on 9 June 2021 and pumping of BH2a daily, the waterlevel still shows the same rate of decline as before pumping.

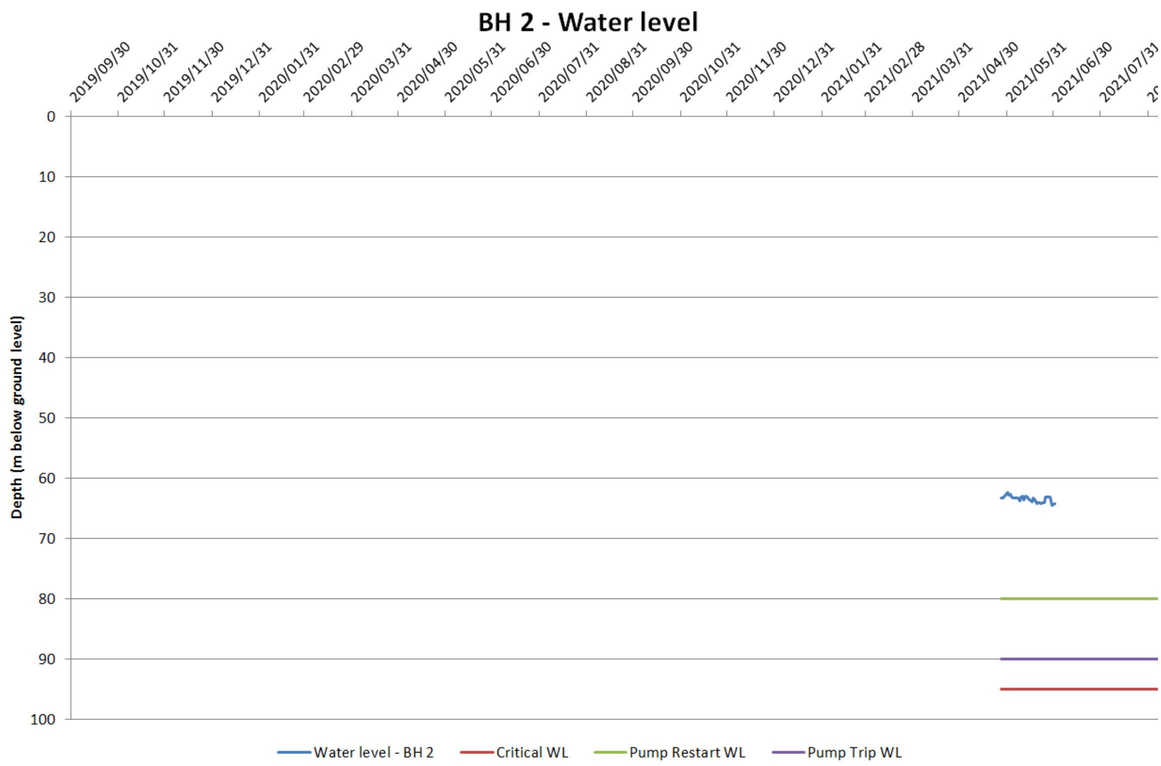

Figure 2.6 Sutherland – Pump 2a - Water level and Critical Water Level

2.2.2.3 Old Reservoir (BH3)

Water levels in Old Reservoir (BH3) borehole are stable over the last 2.5 years, with a small rise in water levels in mid-2020 when the borehole was not pumped (Lazarus, R., and Murray, K.(2020)).

The critical water level was determined at 33m in 2014, but was adjusted to 85m in mid-2020 after the water table decreased below the upper fracture system. The water levels were above the 80m level (Pump Trip Level) from March 2020 to mid-April 2021, but almost decreased to the CWL in May 2021.

Currently, borehole BH3 is only pumping at a rate of 1.2l/s for 4 hours, which can deliver 6307 m^3/a; thereafter, the pumping hours have been reduced because the borehole is under severe stress.

The water level rise is from the snow and rainfall in the winter months of 2020, and the lowering of the volume abstracted from the borehole from 52 034 m3/a to 15 768 m3/a (a reduction of 70%).

The adjustment in the pump yield on 24 April 2021 resulted in a stabilisation (82m) and an increase of water level to before the pump trip level (80m).

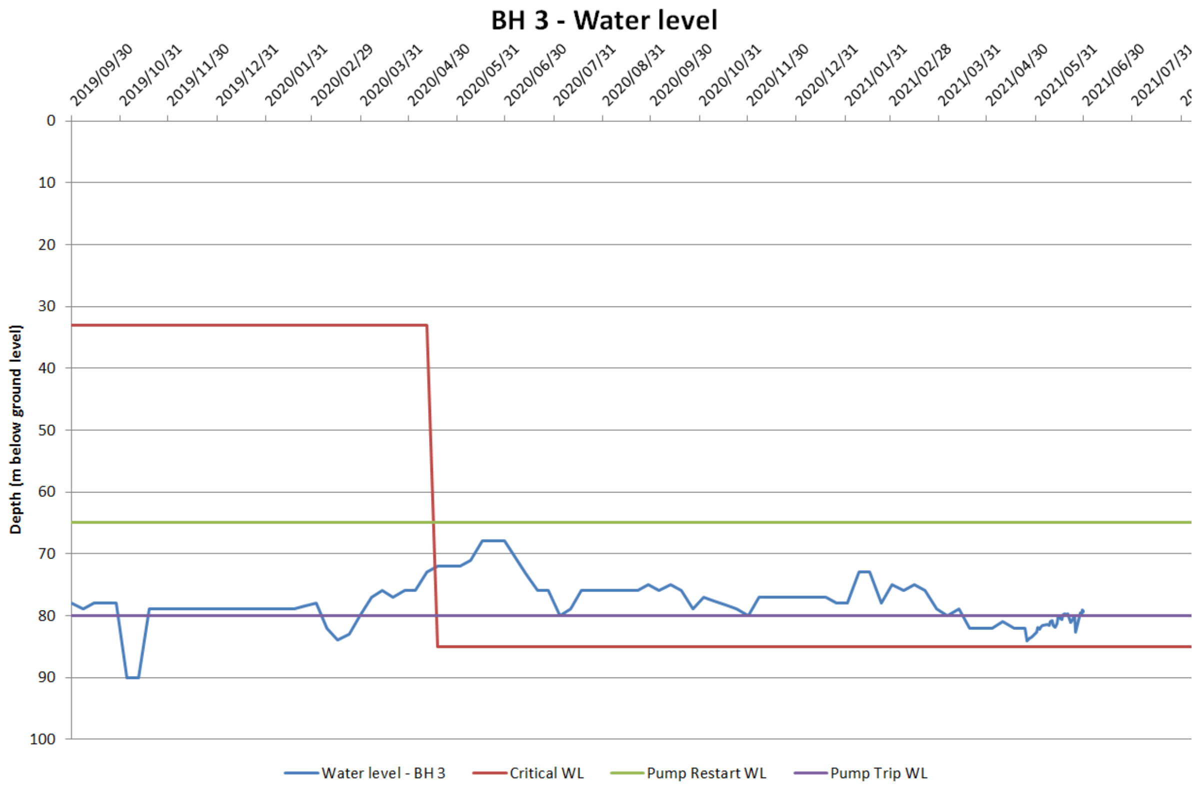

Figure 2.7 Sutherland – Pump 3 - Water level and Critical Water Level

2.2.2.4 Vlei (BH4)

The water level stayed stable from Sept 2019 till Sept 2020, between 20 and 30m below ground level. But since October 2020, the water level has been steadily declining to 29m, which is the restart level of the pump.

The BH4 was taken off the water supply network on the 24th April 2021 and has not been pumping since. The water level has slowly increased and recovered to 24m below ground level with the recent good rains received.

In June and July, the snow and rainfall did provide a rise in water level from June to October 2020. Another contributing factor is reducing the abstraction volume in mid-2020 from 327 449 m3/a to only 75 686 m3/a (77% reduction in abstraction volume).

The Vlei (BH4) was initially drilled to 87m but collapsed to 44m between 2004 and 2014. The borehole's collapse resulted in the borehole only penetrating the upper aquifer and not both aquifers.

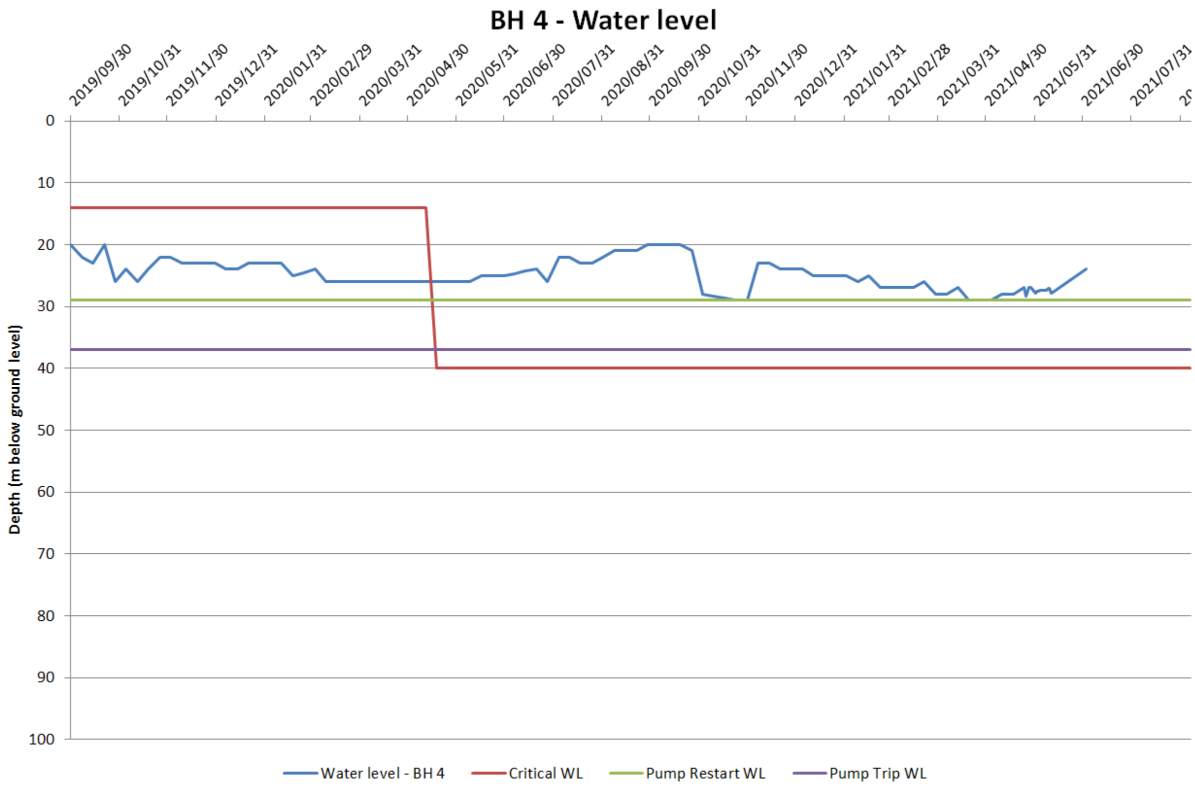

Figure 2.8 Sutherland – Pump 4 - Water level and Critical Water Level

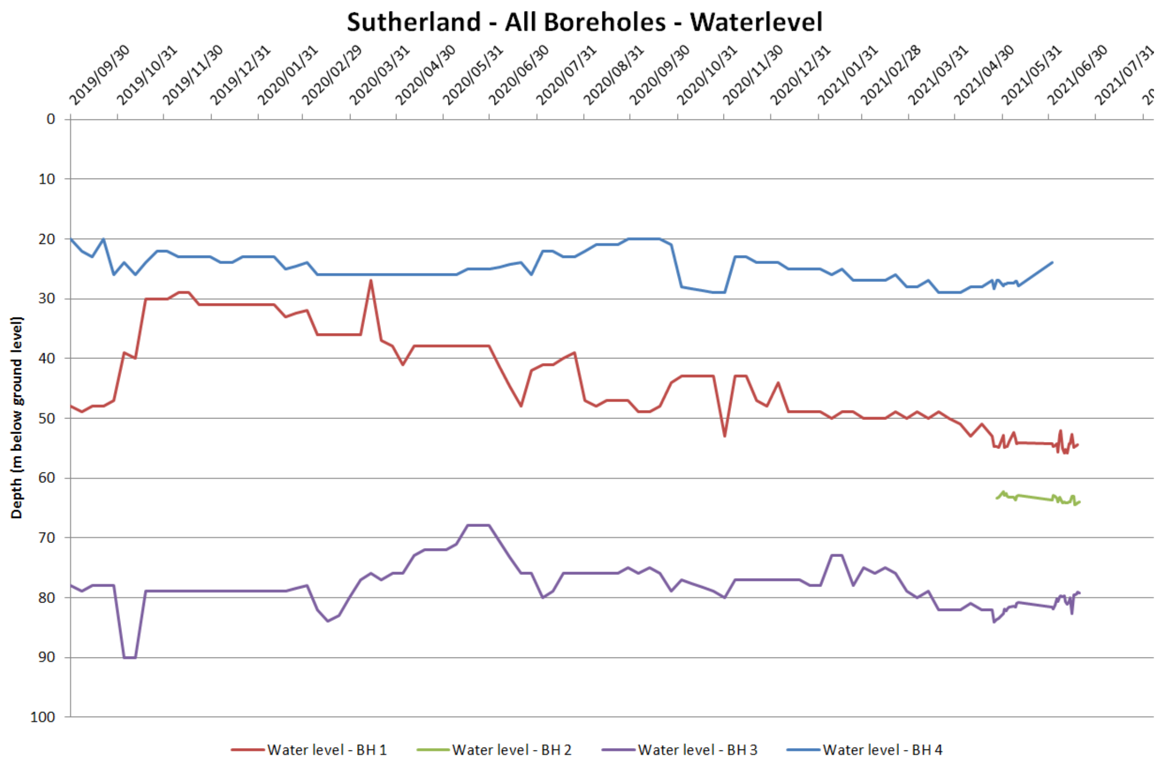

Figure 2.9 Water levels of all 4 production boreholes

2.2.3 Water Use

2.2.3.1 Annual Average Daily Demand

The current water use for the Sutherland Town Area is estimated at 0.274 million m^3/annum in 2020, and it is projected to increase to 0.287 and 0.343 million m^3/annum by 2030 and 2040, respectively (Le Roux, 2021). The Annual Average Daily Demand is currently 751 kl/day and will increase to 785 and 938 kl/day in 2030 and 2040, respectively (Table 2-2). The current peak daily demand (critical case) of 1882 kl/d is not met by the existing safe yield of 583.2 kl/d (Geoss, 2020) if all 3 boreholes are pumped.

The Peak Monthly Demand is only taken for the midsummer month demand and is linked to the tourist season. In the past few years 3 big wind farms and various solar farms were and a been build that created a full occupation of all the guest houses and numerous houses in Sutherland town. The Peak Month Demand has moved from only a month of peak demand to 8-10 months of peak month demand.

Table 2-2 The design criteria for a new water supply scheme

	Population						
Demand	**2021**	**2030**	**2040**	**Factor**	**2020**	**2030**	**2040**
High Income	679	811	970	0.350 kl/p/d	237.6	283.8	339.5
Low Income	2651	1857	2220	0.125 kl/p/d	331.3	232.1	277.5
New Housing	0	1312	1568	0.060 kl/p/d	0	78.7	94.1
Other					114	119	142
				Sub-Total (kl/d)	683	714	853
				Water Losses (kl/d)	68	71	85
Annual Average Daily Demand			**kl/d**		**751**	**785**	**938**
			Ml/a		**274 235**	**286 549**	**342 512**
Demand				**Factor**	**2020**	**2030**	**2040**
Peak Monthly Demand			kl/d	1.67	1 255	1 311	1 567
Peak Daily Demand			kl/d	1.25	1 568	1 639	1 959
Peak Hourly Demand			kl/d	4.00	6 274	6 555	7 836
Resource				**Factor**	**2020**	**2030**	**2040**
Annual Average Source Demand			kl/d	365	274 235	286 549	342 512
Peak Daily Source Demand			kl/d	1.20	1 882	1 967	2 351

2.2.3.2 Private borehole water use

The private boreholes in town are tapping into the upper as well as the lower aquifer Figure 2.10). All newly drilled private boreholes are drilled into the lower aquifer up to 180m deep, and blow yields up to 8.3 l/s or 30 000 l/h. These private boreholes are predominantly equipped with wind pumps, but in recent years, submersible pumps have exceeded the use of windpumps. The private boreholes' primary water use is for gardening, with only 5 of the total 117 boreholes used for domestic use in 2014, but the number has increased tremendously over the last few years.

The effect of the private borehole use can be seen in BH4 with a decline in the water level even when the pump was switched off on 24 April 2021 (Figure 2.10). The water level fluctuates quite vastly after pumping was stopped, and the water level only started to rise after the dam received some water.

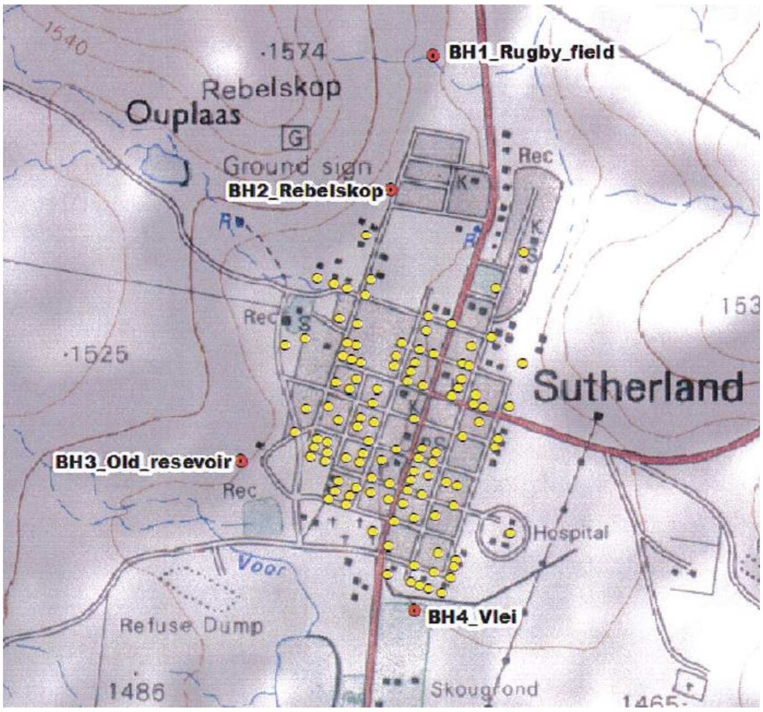

Figure 2.10 Sutherland – Location of private boreholes

2.2.4 Borehole Yields

The abstraction between 2011 and 2020 near the Rugbyveld (BH1), Rebelskop (BH2), and Old Reservoir (BH3)resulted in the water-level being drained to below the shallow fracture system. In the case of the Rebelskop (BH2) borehole, the borehole collapsed and was destroyed. The new critical levels are now linked to the lower aquifer at 70 – 90m.

No iron bacteria or bio-fouling (*Thiobacillus ferrooxidans* and *Leptospirillum ferrooxidans*) clogging is present in the boreholes to reduce the yield; thus, no mechanical or acid treatment will increase the yield.

There were three pump test events in the last 15 years (Table 2.3). The recommendations differ between the years, which is evidence of the complex geological, climatic, and geohydrological system in the study area.

The maximum volume to be abstracted in 2004 was as 791m^3/d or 0.289 million m^3/year for the 4 boreholes. In 2011 the maximum volume to be abstracted was updated to 1577 m^3/d or 0.575 million m^3/year for the 4 boreholes after pumptests were done. In 2020 only 3 boreholes were tested and the maximum volume to be abstracted was updated to 583 m^3/d or 0.212 million m^3/year. The yield recommendation of 2020 was never implemented in 2020 but only in April 2021. In 2021 (24 April), the pumps' yield was adjusted to lower yields as recommended in 2020. The maximum volume to be abstracted in 2021 was adjusted to 126/139/200m^3/d (different flowmeters).

The recommendation differences between 2011 and 2020 is directly linked to the volume of water in the aquifers. The contributing fracture system in the upper aquifer was drained near BH1, BH2 and BH3 and thus not available in 2020.

The sustainable yield of 583 m^3/d was restricted with 79% to an operational yield of 126m^3/d.

Table 2-3 Sutherland – Borehole yield and Maximum Recommendation Volume

Year Pump Tested	Description	Unit	Bh1 Rugbyveld	Bh2 Rebelskop		Bh3 Ou Res	Bh4 Vlei
			SUT 10[1]	SUT4[1]	New*	SUT9[1]	SUT1[1]
2004[1]	Depth	mbgl	118	122		122	87
	Recom Yield	l/s		8			8.04
	Max Recom Vol	m^3/d		191.8			183.6
	Pump Duration	hr/d		6.66			6.34
	Max Recom Vol	m^3/d	**791.8**				
		m^3/a	68000	70000		84000	67000
			289000				
	Pump depth	mbgl					
	Max pump WL	mbgl	34	29		30	18
2011[2]	Depth	mbgl	118	120		120	44
	Recom Yield	l/s	6.93	5.5		3.3	12.46
	Max Recom Vol	m^3/d	299.4	237.6		142.6	897.1
			1577				
	Pump Duration	hr/d	12	12		12	20
	Max Recom Vol	m^3/a	109272	86724		52034	327449
			575480				
	Pump depth	mbgl	30	30		45	20
	Max pump WL	mbgl	22	26		33	14
2020[3]	Depth	mbgl	117.4	65	152	120.7	44
	Recom Yield	l/s	4.2			3	3.6
	Max Recom Vol	m^3/d	332.64	0		43.2	207.36
			583.2				
	Pump Duration	hr/d	22			4	16
	Max Recom Vol	m^3/a	121414			15768	75686
			212868				
	Pump depth	mbgl	90			90	41
	Max pump WL	mbgl	80			85	40
2021**	Pumping Yield	l/s	3			2.5	
	Adjusted Pumping Yield	l/s	2.4		1.5	1.25	
	Pump Duration	hr/d	10		4	4	
	Max Recom Vol:	m^3/d	86.4		21.6	18	
	BH1 and BH3		**104.4**				
	BH1, BH2a, BH3		**126**				

[1]) SRK, 2004; [2]) GEOSS, 2014; and [3]) GEOSS, 2020

* New BH2 drilled on 24 February 2021 and equipped on 9 June 2021

** Municipality adjusted the borehole yield on 24 April 2021

2.2.5 New and exploration borehole

The Rebelskop (BH2) borehole was replaced with a new borehole (BH2a) 5m away from the existing production borehole. During the drilling, water strikes were encounter at 98m, 112m and 120m. A pump test was conducted, but the recommendation is still outstanding. The yield recommendation is expected to be in the order of 1.5 l/s.

Additional borehole locations were investigated by DWS to be drilled in future when funding is made available. A Structure Analysis was done to locate a potential new exploration borehole in and around Sutherland. The University of the Free State did a geophysics survey (magnetic) on 22-23 May 2021 to locate new drilling sites south of town near the shooting range (Exp BH3b) and oval track (Exp BH3 and Exp BH3a) (Figure 2.11).

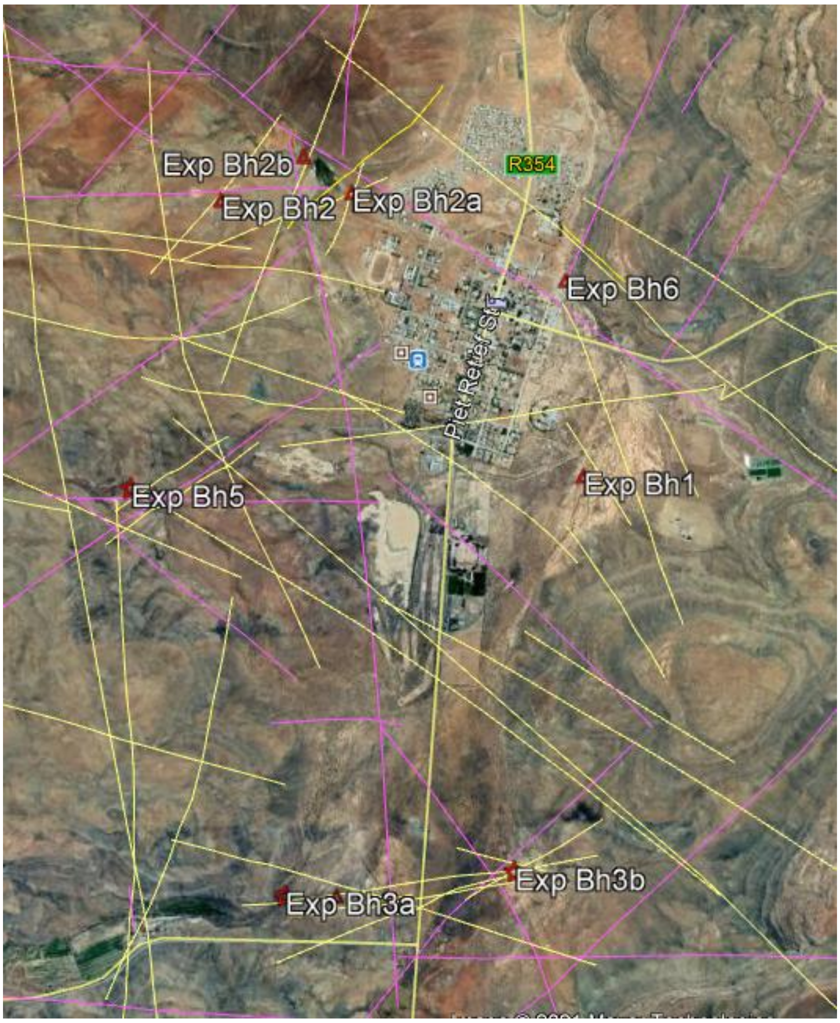

Figure 2.11 Sutherland – Geological structure Analysis around town with potential Exploration boreholes.

2.2.6 Day Zero and D-Day

The definition of Day Zero is the day the municipality turns the water supply off to the reticulation network, and water will only be provided at various central points throughout the town or as the municipality prefers, the implementation of "water-shedding" by shutting the reticulation off and only opening the water network twice a day for a few hours.

The definition of D-Day (or Disaster Day) for the author is the day the municipality switches off the borehole pump, and no water is available from the borehole or aquifer. The static water level has passed the Critical Water Level (CWL) level and reached the pump inlet. In layman's terms, the borehole has dried up.

D-Day (or Disaster Day) for **BH4** was on 24 April when the rest water level in BH4 dropped to a restart level (Figure 2.8), and the pumped level reached the pump trip level. The water level did not recover, although the pump was operated manually and the pump yield was adjusted to 1.2 l/s. BH4 was taken out of commission and switched off.

BH1 is pumping at 2.4 l/s for 10 hours per day, resulting in 86.4 m3/day. The water level in BH1 decreased after 24 April, when BH4 was taken out of the network, although the pump yield was adjusted. If the water level continues to decline, the Day Zero level (60m) would have been reached on 18 June 2021 (as calculated in the 10 May 2021 water levels). The Restart Level of 60m, which is the Day Zero level, is where the pumps need to be operated manually.

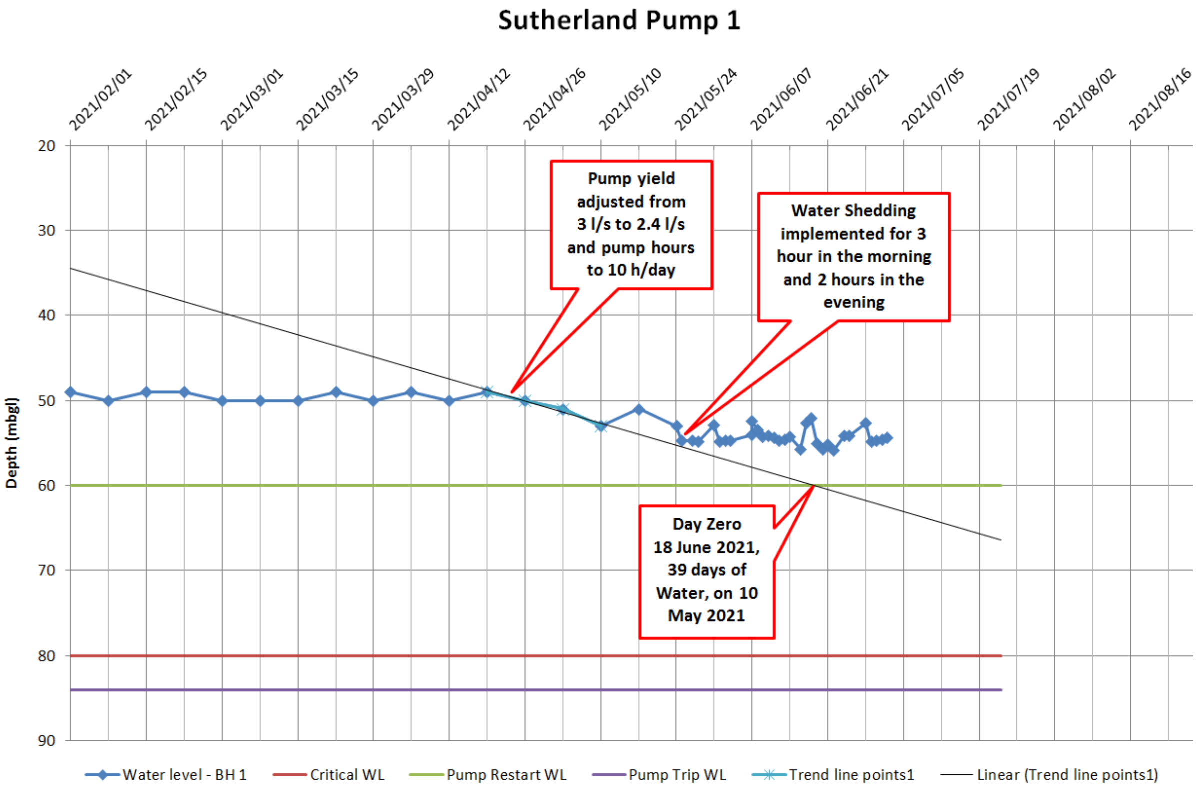

Figure 2.12 Day Zero on BH1

The water levels stabilised in BH1 after water shedding of 5 hours a day was implemented on 25 May 2021.

BH3 is pumping at 1.25 l/s for 4 hours per day, resulting in 18m^3/day. When the 65m level (the critical or Day Zero level) was reached, the borehole did not restart automatically and was turned on and off manually. For this reason, the water could be dropped below the Pump Trip Sensor level from 2 April 2021.

D-Day was almost reached on the 30th May 2021, as the water level would have reached the water strike and the borehole would not have yielded any water anymore (Figure 2.13).

The water levels had stabilised in BH3 after the pump yield was adjusted to 1.25 l/s for 4 hours per day on 24 April 2021, and started to increase above the Pump Trip level (80m) after water shedding was implemented on 25 May 2021.

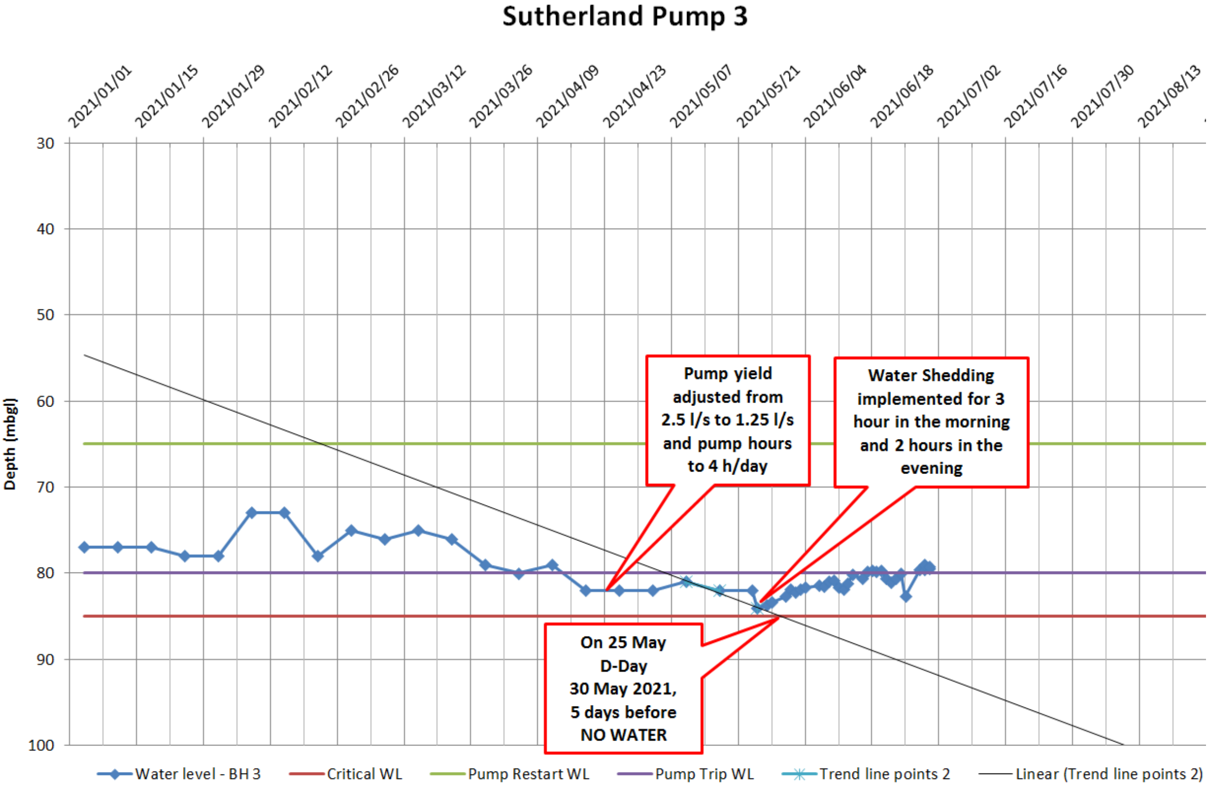

Figure 2.13 D-Day on BH3

2.2.7 Chemistry

In Sutherland, BH1 - BH3 and BH2-BH4 are pumped together to the Water Treatment Plant, where the water mix and chemicals are added to ensure good water quality to the users.

The data of BH1 and BH3 are reflected on the piper (Figure 2.14), and stiff (Figure 2.15) reflects data as captured during a pump test (2011) for the WULA (Conrard and Engelbrecht, 2014); DWS sampling (2019); and pump testing (2020)(Lazarus and Murray, 2020).

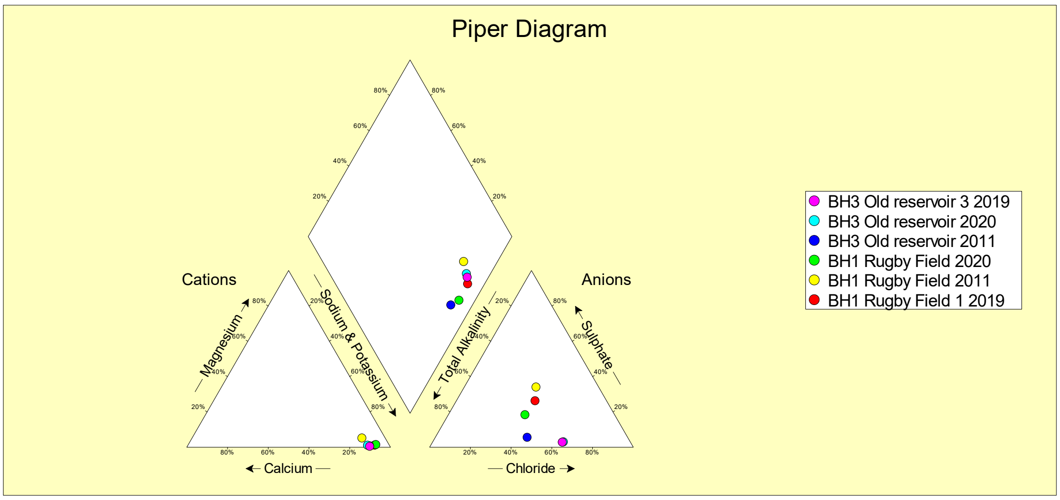

Figure 2.14 Piper diagram: BH1 and BH3

A higher concentration of NA+K was seen in BH1 in 2011, with a decrease in 2019 and 2020. An increase in alkalinity, however, can be detected. For BH3 Na+K increased from 2011, a sharp increase in chloride can also be noticed for 2019 and 2020.

Trace metals: This was not conducted in 2011. In 2020 only Cadmium was indicated as problematic in 2019 as well as in BH2. Fluoride was over the SANS 241 limit (3 - 6.62mg/l) in BH1-3 in 2019; this can be because the water is located in the deeper aquifer where the shale is found. In 2020 F decreased to 1.4 and 1.5mg/l for BH1 and BH3.

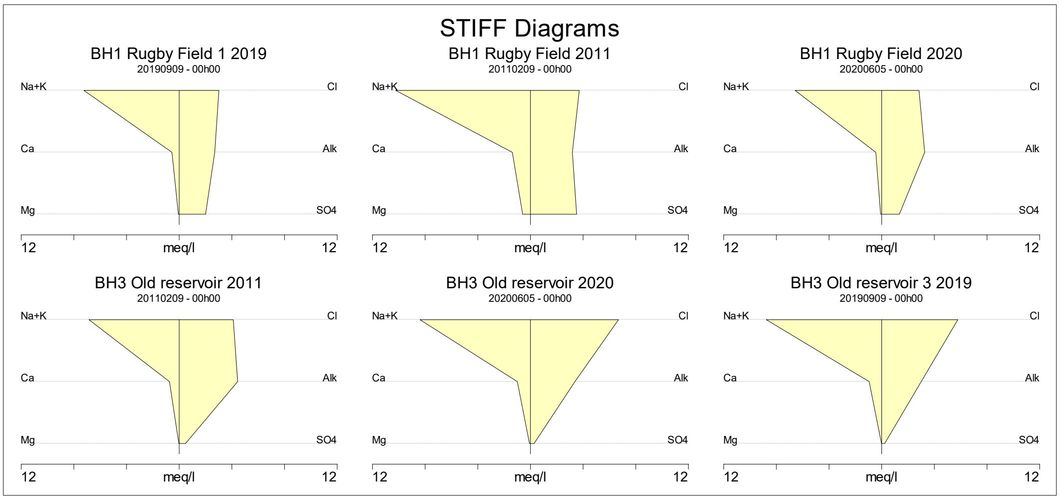

Figure 2.15 Stiff Diagram: BH1 and BH3

The data of BH2 (and BH2a) and BH4 are reflected on the piper (Figure 2.16), and stiff (Figure 2.17) reflects data as captured during a pump test (2011) for the WULA (Conrard and Engelbrecht, 2014); DWS sampling (2019); pump testing (2020)(Lazarus and Murry, 2020); and IGS sampling (2021).

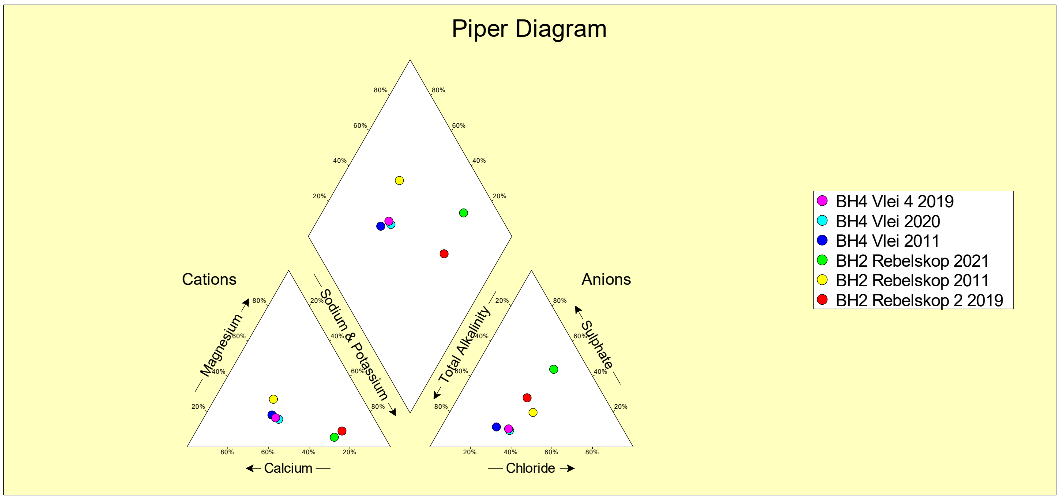

Figure 2.16 Piper Diadram: BH2 and BH4

For BH2, a higher concentration of Chloride, Calcium, Alkalinity and Magnesium was noticed in 2011, a signature of shallow water (Murray et al., 2015), which indicates the upper aquifer water (Figure 2.17). With a decrease in 2019 in Ca, Mg, alkalinity and Cl. And an increase in Na+K and SO4 in 2019 and 2020, a signature of deep water aquifers (Murray et al. 2015). For BH4, water quality stayed constant from 2011-2020. The signature of shallow aquifers and water level readings confirms this.

Trace metals: This was not conducted in 2011. In 2020, only Cadmium and CaCO3 were indicated as problematic in 2020 in BH4. In 2019 Arsenic was over the SANS241 limit in BH2. Then it collapsed. In 2021, BH2 was re-drilled, and As and Pb were over the SANS241 limit.

Fluoride was over the limit (4.64mg/l) in BH2 in 2019 because the water is located in the deeper aquifer where the shale is located. In 2021, F was again over the SANS 241 limit in BH2.

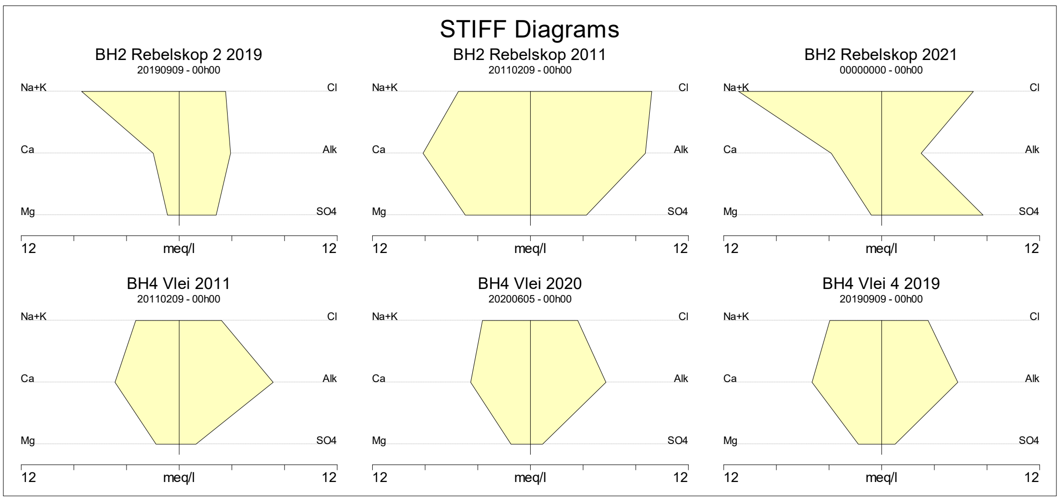

Figure 2.17 Stiff Diagram: BH2 and BH4

Recommendations:

Water from these boreholes should be tested again to ensure the correct borehole mix with each other and also to make sure As and F are not over the SANS 241 limit.

The increase in trace metals occurs because of drought conditions and water not recharging in the shales.

3 Interventions

The interventions can be divided into three categories: the source (groundwater – aquifer), municipality, and the community.

The interventions are recommendations to manage the groundwater better and to assist in the reduction of water use. The implementation of the interventions is for the municipality, community and DWS.

3.1 The source

We need to acknowledge there is a drought, and we cannot say for certain that it is a seven-year drought or a new normal rainfall we need to adapt to. The source needs to be managed as if the new normal is here to stay.

3.1.1 New Operating Rules

After each pump test conducted in the past (2011 and 2020), a recommendation was provided. The recommendation includes a yield of abstraction, duration of abstraction, and the total volume that can be abstracted during a day or month. The critical water level (CWL) is one of the levels that allows the user to manage the borehole yield abstracted. The pump test recommendation do not provide any guidance if the water level drops to the CWL. Various factors influence the water level, such as the amount of rainfall and the volume abstracted. Over the last 7 years, the rainfall has reduced the recharge tremendously, and the normal inputs from rainfall events have not been observed. Pumping tests include a drought factor, but not a severe decline in rainfall of 7 years.

A borehole deployable output curve provides no single volume yield for the whole borehole column, but the yield decreases as the water level decreases. Figure 3.1 provides an example of such a borehole deployable output curve in chalk, but a fractured rock aquifer like Sutherland will be a step curve.

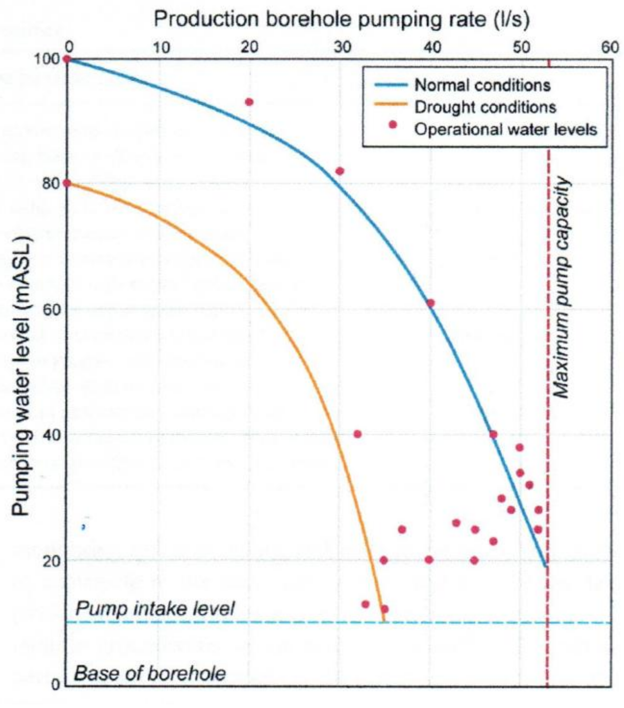

Figure 3.1 An Example of a Borehole Deployable Output Curves

Recommendation: *On the current boreholes in use a Re-evaluation should be conducted on pump test recommendation on the current boreholes in use that was done in previous years. Determine each water strike with different critical water level and pumping rate to prolong the lifespan of the borehole during periods of drought. A Borehole Deployable Output for each borehole need to develop.

*All newly drilled boreholes need to have a borehole deployable output curve.

3.1.2 Borehole construction

BH2 and BH4 collapsed and are now only 65 and 44m, deep respectively. The collapse of a borehole can be prevented by casing the borehole from surface to bottom of the borehole to prevent caving in sedimentary rocks like shale/mudstone/siltstone. The casing will prevent the loss of pumping equipment in future due to rocks fall in the borehole.

DWS (Kimberley Office) drilled a borehole (BH G for now) in the early 2000's 45m southeast of BH4 to a depth of 120m (Figure 3.2). The yield and quality were in the same order as the yield and quality of BH4 and was recommended as a replacement for BH4. The borehole collapsed and is closed up till 29m.

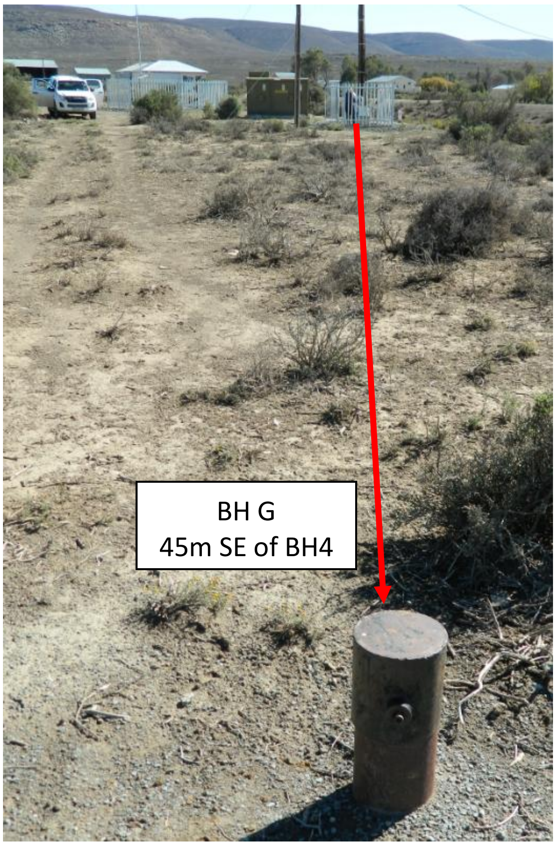

Figure 3.2 BH G borehole near BH4

Recommendation: *Re-drill BH4 to the original depth of 88 or to 150m; case borehole from top to below last water strike with uPVC casing. Additional yield from fracture of the original depth (88m) and new water strike will be obtained, but to obtain the additional yield volume, a pump test needs to be conducted.

*Re-drill the DWS borehole near BH4 to 120m and case the borehole from top to below last water strike with uPVC casing. Conduct a pump test in the borehole. BH4 and BH G's yield recommendations need to be assessed together as both boreholes are in the same fracture system and cone of depression.

3.1.3 New wellfield

Any additional borehole might provide a higher yield to the network, but the aquifer yield will not increase if drilling is conducted near the town. Sites outside of town need to be located to limit impact on the town wellfield.

The University of the Free State did geophysics (magnetic) in beginning of June 2021. But because of the high occurrence of carbonatite and scrap metal in the area, the magnetic survey did not provide the concrete results.

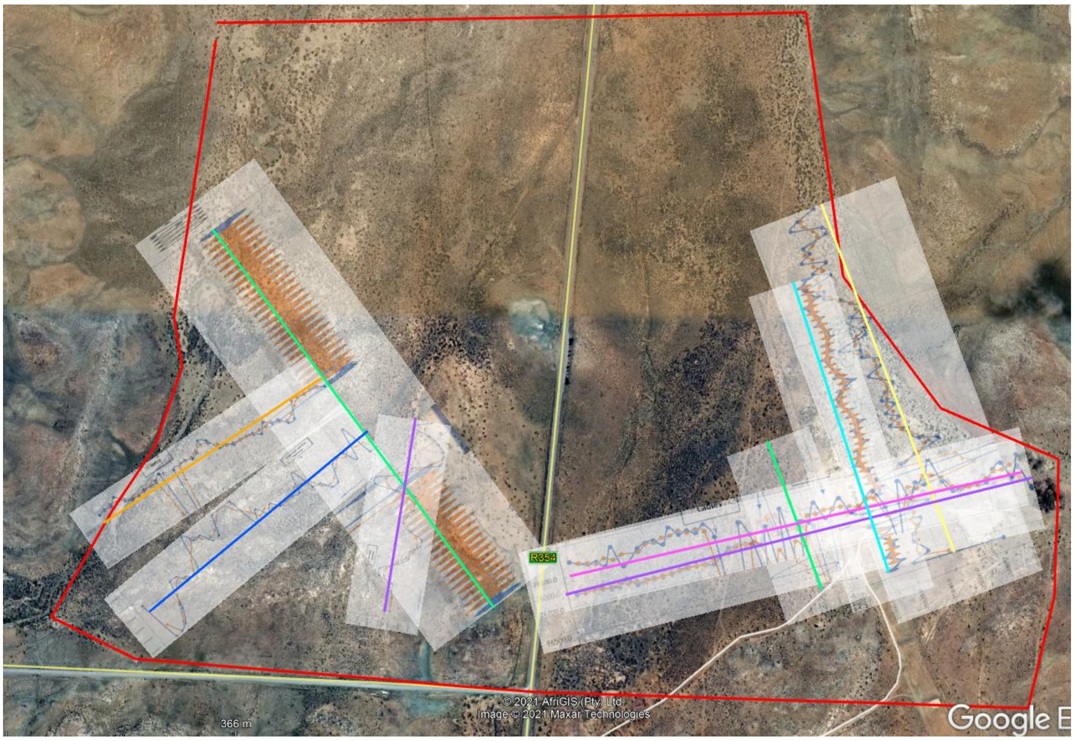

Figure 3.1 Geophysics done by IGS

Recommendation: *Drill exploration boreholes south of town near the shooting range (Exp BH3b) and oval track (Exp BH3 and Exp BH3a) (Figure 3.4). The exploration in one direction will reduce the pipeline cost as it can share the same infrastructure.

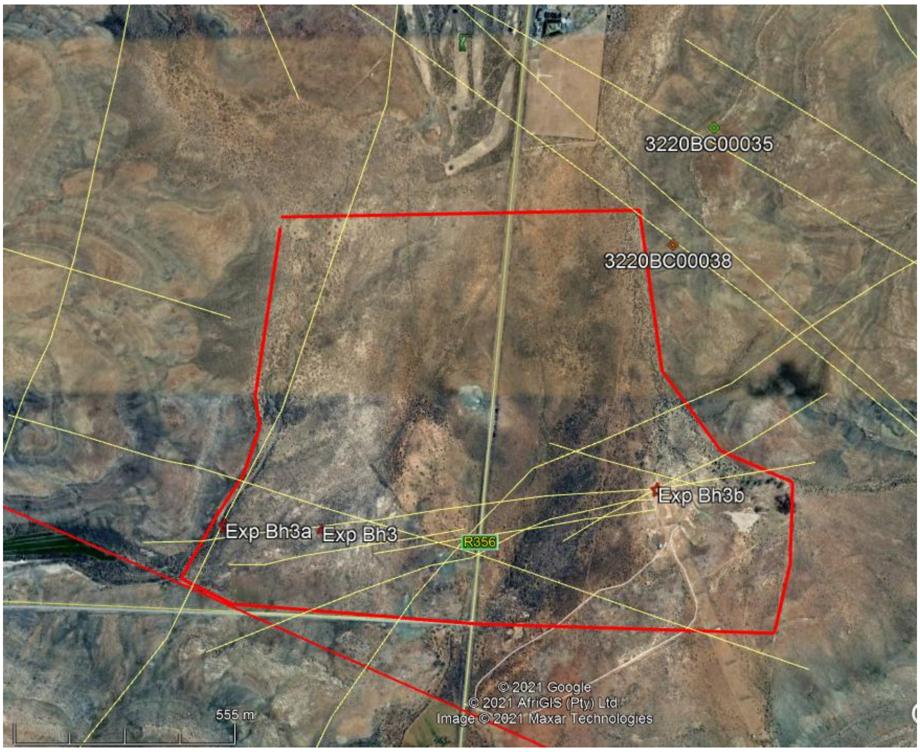

Figure 3.2 Exploration area south of town

3.1.4 Aquifer Recharge Enhancement Schemes (ARES)

The water level in the upper aquifer decreased in all the boreholes to the level that the fracture system collapsed around 3 of the production boreholes as the fracture system requires water to remain open. The low rainfall and snow resulted in no or low water infiltration into the subsurface. Through various methods, the infiltration can be enhanced to recharge these systems quicker and on a regular basis. Recharge occurs only during high rainfall events (25mm+) and runoff, but the ARES will happen with low rainfall events (10mm) and little or no runoff.

3.1.4.1 Method

Various methods can be utilised to enhance the recharge to the aquifer when water is available. Low cost with low maintenance and no mechanical treatment of water is the preferable option to as natural as possible (Nature-Based Solutions approach).

The proposed methods include trenches, infiltration pods and weirs.

3.1.4.2 Locations

Various sites in Sutherland are under-investigated for Aquifer Recharge Enhancement Schemes (ARES) (Figure 3.5), focusing now on the production boreholes as quick win.

Figure 3.3 Sutherland – Locations under investigation

The sites at the Town's dam (green locations in Figure 3.5) can be implemented in phases with the drilling of the infiltration island boreholes and sand box implemented in the last phase.

Sites near BH1 and BH2 (red locations in Figure 3.5) can easily be transform into infiltration pond and weirs.

New potential production site (light blue locations in Figure 3.5) are also listed for investigation but can be implementd only when the new production borehole are drilled.

Recommendation: *The 2 sites around the Vlei (BH4) borehole (green locations in Figure 3.5) were identified as the most important sites to do preliminary designs, namely Below the dam and in the dam. Implementation of these is require funding as boreholes needed to be drilled in the 2nd phase of the ARES. The 1st phase requires only digging of trenches and can be implemented immediately.

*The two sites near BH2 and BH1 (red locations in Figure 3.5) involve infiltration ponds and weirs and can be implemented immediately.

*An number of other sites were identified but are links to potential future exploration borehole sites and to be implemented after exploration drilling phase.

3.1.5 Groundwater Management Plan

The groundwater can only be managed if all 12 principles of groundwater management are addressed. Groundwater management doe not only relates to the operation of the boreholes also aspects that influence the way groundwater is been managed.

The 12 Groundwater management principles can be grouped into two broad categories. The first category is the quantity and quality science side, including planning, assessment, protection, monitoring, conservation, operation, use, and infrastructure principles. The second category consists of the softer principles side, including regulation, institutional arrangements, capacity and skills, awareness, information sharing, and stakeholder participation.

A groundwater management plan incorporates all of the 12 principles into one plan with actions, responsibilities and time frames to achieve sustainable groundwater management.

Recommendation: *Develop a groundwater management plan for Sutherland.

3.1.6 Implementation of pump recommendations

The pump test recommendations need to be followed to prevent the water level decline or increase costs like electricity, pump failure, or pollution risks. The collapsing of the boreholes and higher cost with no water to show for it results from not managing a borehole according to the recommendations. Now, very little water can be pumped to safeguard the borehole and the source. The restart and trip level are manually overridden in BH3 as the water level is now below the trip level. The trip level of BH1 is below the Critical Water Level and will damage the fracture system at 80m.

Recommendation: *Adjusted the Pump Restart and Pump Trip levels to the recommendations of the pump test report of 2020.

3.1.7 Pump rate assessment

Pumping rates recommendations from the pump test report in 2020 need to be adhered to. The pump rates were only adjusted on the 24th of April 2021, almost a year after the pump test recommendation was given to the municipality. BH3 and BH4 were reduced to only 70-77% of the 2011 recommendation. The over abstraction for almost a year contributed to the decline in the water levels.

Recommendation: *A quarterly assessment of the pumping rates for each borehole in the Karoo Hoogland Municipality to ensure over abstraction is not taking place and safeguarding the boreholes.

3.1.8 Bylaws and Gazette Drought Restrictions the Karoo

The current drought is not just impacting Sutherland but the whole Hantam, Central Karoo and as far as Victoria West and VanWyksvlei. Groundwater restriction may be implemented through bylaws by the municipalities and drought restrictions by the Department through the gazetting the restructions.

Recommendation: *Departement of Water and Sanitation need to investigate the prosibility to develop and Gazette groundwater restriction to manage the use of groundwater.

*Karoo Hoogland Municipality needs to investigate the possibility of developing, approving, and implementing bylaws to manage the use of private borehole water and the return of the groundwatder as waste water to municipal wastewater system.

3.2 The municipality

3.2.1 Block Water Tariff

Every house is equipped with a water meter, and they are buying water. A block tariff should be encouraged that works on a log sliding scale. For example, when you use your first 10 kiloliters of water, you pay R10.00, your second block 20 kiloliters of water R30.00, then 40 kiloliters of R70.00 and the more you use, the higher the amount you pay in scale. Figure 3.6 illustrate the water use charges of Overberg Municipality in the Western Cape.

The Non-Revenue-Water balance could provide areas/locations where water is wasted, or income is not generated. A WC/WDM strategy can be developed as a medium-term intervention to summarise the actions to conserve water and managing the water requirement.

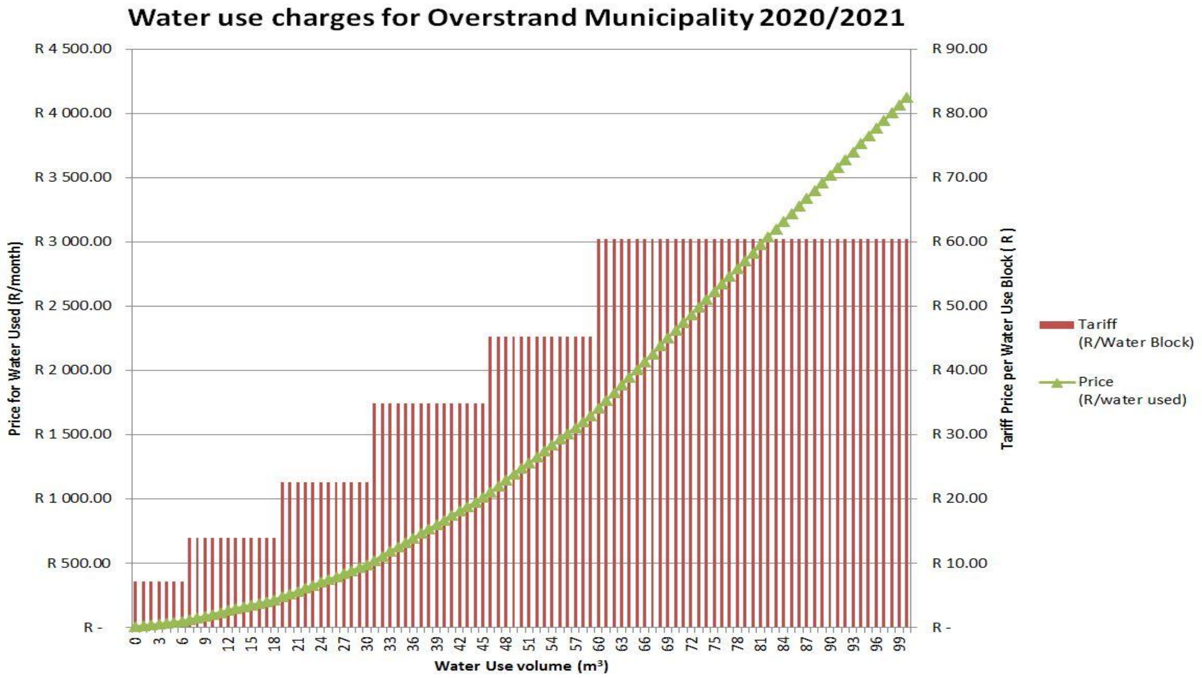

Figure 3.4 Example of a Block Tariff for Water Use from Overberg Municipality

Recommendation: *A log scale block tariff for water needs to be implemented.

*Calculate the NRW balance and develop a WC/WDM strategy.

3.2.2 Groundwater Development Budget

The drilling of high yielding boreholes has a normal success rate of 30-50%. The limitation of only drilling 4 borehole will result in only 1 or in the best case scenario 2 high yielding boreholes to pump test. When a new project is being planned, it should be planned in phases. Phase 1: For groundwater, the source must first be found and developed on its own budget and then in Phase 2, infrastructure can be determined and on another budget.

Recommendation: *A split budget approach needs to be adopted.

3.2.3 Income from groundwater to groundwater

In the last few years, water use in Sutherland has increased with the higher number of visitors. If the public then constantly uses more water, the municipality's income would increase and this money that is then generated must be used for the management of the water or to increase the supply.

Recommendation: *Redirect additional income to groundwater resource management like the development of additional boreholes, obtain electronic water level data loggers, etc.

3.2.4 Peak population period

The water supply system is planned to absorb a 1-3 month peak influx of visitors to a town. The Peak Monthly Demand is only taken for the midsummer month demand and is linked to the tourist season. In the past few years, 3 big wind farms and various solar farms have been built that created full occupation of all the guest houses and numerous houses in Sutherland town. The Peak Month Demand has moved from only a month of peak demand to 8-10 months of peak month demand. Previous years the town had seasonal peaks, winter was high peak and summer low peak, now it is almost all year high peak. The high peak period does not represent the peak anymore, it is the normal trend based on the housing infrastructure developed

Recommendation: *Calculate the population, the tourist peaks and how many people are staying in town from the wind farms.

*** Determine the socio-economic impact of lack of water supply to the tourism sector, which affects people's livelihoods.**

3.2.5 Water supply network balance

The water loss in the reticulation network can be picked up with a standard water balance reconciliation table. Measure the flow meter at borehole need to be equal to the flow meter at the reservoir and equal to water sell in simple terms.
A Water Datasheet (Appendix A) was implemented to capture water levels, pump yields, flow meter volumes and water treated at the WTW.

Recommendation: *Develop a standard water balance reconciliation table for Sutherland; calculate the system losses and act on the losses.

3.2.6 Private water discharge to Waste Water Network

The private borehole use in town increase tremendously over the last few years. The water use was mostly for garden purposes but has moved to domestic use. The wastewater component on the municipal bill is calculated as a portion of the water use. Therefore, the volume of water used by the user will decrease if a user uses his/her private borehole for domestic use, BUT the volume of wastewater will still stay the same. The income from the water provided, in this case, will decrease because of the less water sold but the expenses to treat the wastewater will remain the same.

Recommendation: *Assess the volume or percentage change of the years in the water and wastewater

*Register and bill users with a private borehole that return wastewater to the wastewater system (See section 3.1.8 - Bylaws).

3.2.7 Reed bed

The higher volume of people creates more sewage, leading to problems at the oxidation dams like larger oxidation ponds needed. A reed bed system could be an option to treat and purify wastewater to increase the possible uses for the water from the watering of the rugby field to include a recharge scheme at the boreholes. Great results are obtained from the reed bed at Calvinia.

Recommendation: *Assess the oxidation ponds' capacity
*Investigate the possibility of developing a reed bed

3.2.8 Water treatment works

It was mentioned that the new water treatment works (WTW) must run on a certain volume of water. If this is true, the system might have been developed on data from a geohydrological report from 2011, when there was still a large amount of water available.

Recommendation: *Future treatment works must be developed to run on different volumes of water to include periods of drought and the volumes that the boreholes can deliver to ensure that boreholes are not over abstracted to run the treatment works. A possible solution can be to create more storage capacity at the WTW to be used as a balancing dam.

3.3 Awareness Municipality and Community

Informing the town residence, visitors and workers of the current water situation is very important.

3.3.1 Information Signboard

The municipality must create signboards to indicate that the area is experiencing a drought and that people need to be cautious about water use. These boards must be placed outside of town as you enter the town. They can do it for all the towns. Create a status for each town like, today we are in the green safe zone, tomorrow we are in the red zone, meaning danger running low on water.

Recommendation: *Develop an information billboard sign and place it at the 3 roads entering Sutherland.

3.3.2 Information Account

Each household receives a municipal account each month. The water unit used is indicated normally in numbers. The municipality can create graphs for each household. Showing the use of water and comparing it with the average use of the town, etc. The visual display of usage and the historical use will create a healthy competition between houses to lower their water usage.

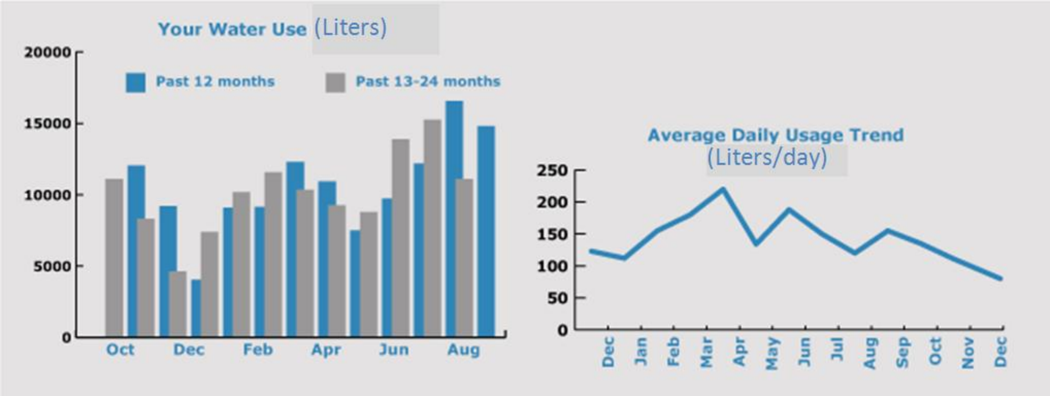

Figure 3.5 Example of a graph on Municipal account: Water Usage of household

Recommendation: *Develop graphs like figure 3.7 for a municipality account and add the graphs to each indivual account.

3.3.3 Awareness notices

Visitors to the town are not always aware of the water situation in the town. The guesthouses can put up signage or notices indicating that it is a dry area and people must use water sparingly.

Recommendation: *Request the Guesthouse section to promote the saving of water with their guests.

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SANS241 2015

Appendix A

Sutherland Water Balance

Date: ______________

	Morning					Afternoon				
Borehole Number	Time	Waterlevel	Flowmeter	Pump Switch ON time	Pump yield	Time	Waterlevel	Pump Switch OFF time	Flowmeter	Total time pumped
	hh:mm	m	m^3	hh:mm	l/s	hh:mm	m	hh:mm	m^3	hh:mm
BH1										
BH2a										
BH3										
BH4										

	Morning		Afternoon	
Plant	Time	Flowmeter	Time	Flowmeter
	hh:mm	m^3	hh:mm	m^3
Scada				
Blou				