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Institution where Information is held: TOENS & PARTNERS

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SUSTAINABLE YIELD OF THE TABANKULU - EMBANGWENI SPRINGS

(T&P Report No. 99021)
990210

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August 1999

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SUSTAINABLE YIELD OF THE TABANKULU - EMBANGWENI SPRINGS

1.0 INTRODUCTION

Toens & Partners were requested by Mr. W. Ketteringham of Uhlmann, Witthaus & Prins (UWP) Engineers, East London, to estimate the sustainable yield of a group of three springs, currently being used for community water supply in the Tabankulu and Embangweni areas.

2.0 BACKGROUND INFORMATION

2.1 Location of Study Area

The village of Thabankulu is located in the Eastern Cape, formerly the Transkei, midway between the towns of Flagstaff, Mount Ayliff and Mount Frere, some 86 kilometers NNE of Umtata (**Figure 1**).

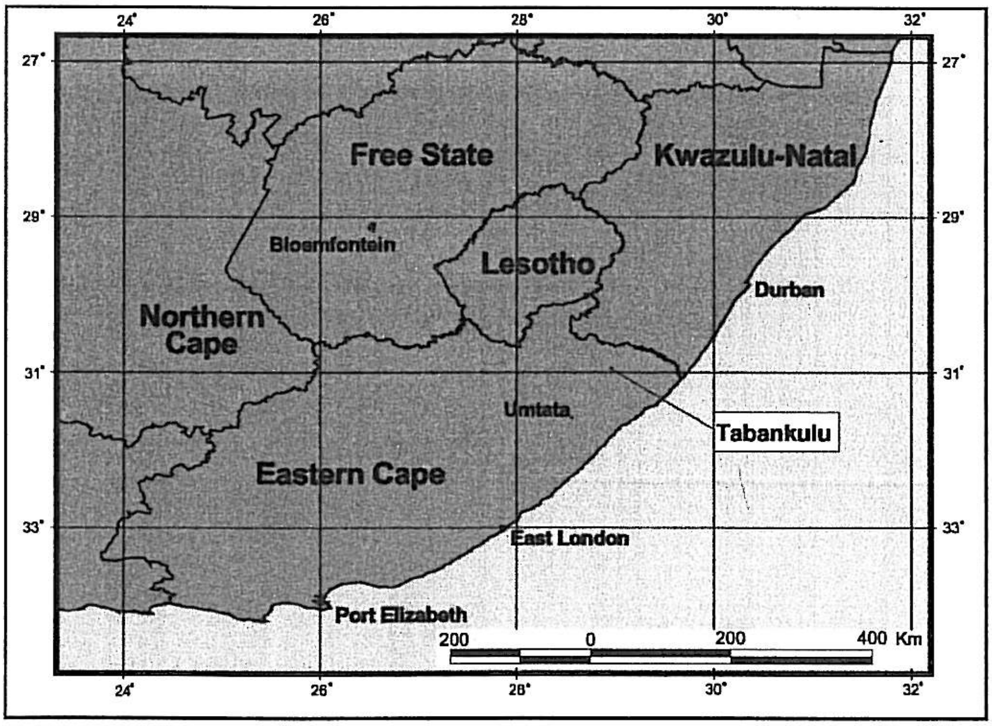

Figure 1: Location of the Tabankulu Study Area in the Eastern Cape.

2.2 Physiography and Rainfall

The study area falls within the *inland plateau* region, which has an uneven surface and is dominated by several high mountain ranges, such as the Ngele (2268m), Ntsizwa (1924m) and Mount Currie (2224m). These mountains are invariably capped by massive dolerite sills.

The village of Tabankulu is situated on a hill (elevation 1120 m.amsl), at the foothills of the NTabankulu Mountain range (1592 m.amsl) and alongside the north-westerly draining, perennial Mngcipongweni River (**Figure 2)**. The 25x25m raster Digital Elevation Model (DEM) in Figure 2 was interpolated from the 20m-contour information obtained from 1/50,000 scale topocadastral mapsheets, 3129AB and 3029CD).

Tabankulu village receives between 800 – 1000 mm of rainfall per year, most of which falls in the late summer months (January). The mean annual precipitation (MAP) of the springs "catchment" varies between 1000 – 1200 mm, enhanced by the orographic effects of the NTabankulu Mountain, (**Figure 2)**. The rainfall information was interpolated from the CCWR 1x1' raster MAP data.

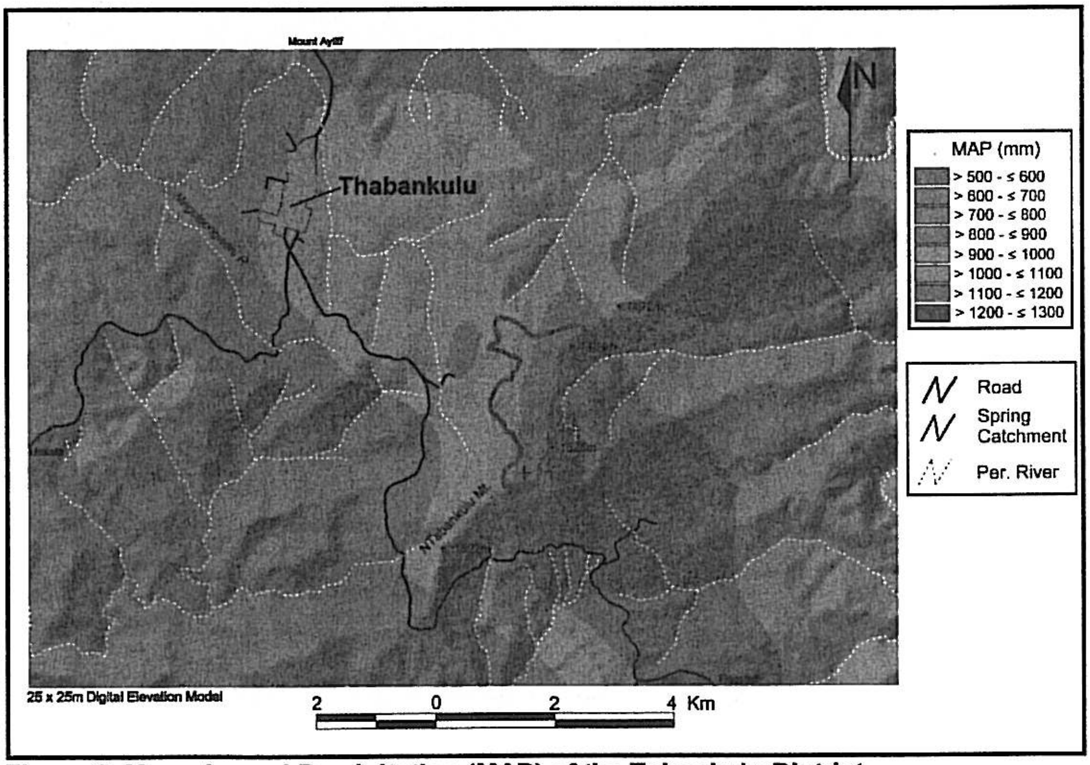

Figure 2: Mean Annual Precipitation (MAP) of the Tabankulu District

2.3 Geology

The Tabankulu area is underlain by greenish-grey, bluish-grey to grey-maroon mudstone, alternating with subordinate grey, fine-grained sandstones of the Adelaide Subgroup of the Beaufort Group. The total thickness of these sediments is in the order of 700m (Coertze and Johnson, 1978).

The Adelaide rocks have been intensively intruded by Jurassic-aged dolerite sills and, unlike the underlying Ecca shales, by dykes as well.

On the regional scale, the sediments dip at between 2° and 5° towards the north-west, although locally the dips may vary considerably, mainly as a result of disturbance by dolerite intrusions (Coertze and Johnson, 1978).

The thick dolerite sill from which the springs emanate forms part of the extensive "*Insizwa-Ingeli-Tabankulu-Tonti-Embangweni*" intrusive complex (Coertze and Johnson, 1978). The Tonti-Tabankulu sill complex extends from Mount Ayliff to Thabankulu. These dolerite sills are extremely thick, i.e. the Insizwa complex is in excess of 900m thick.

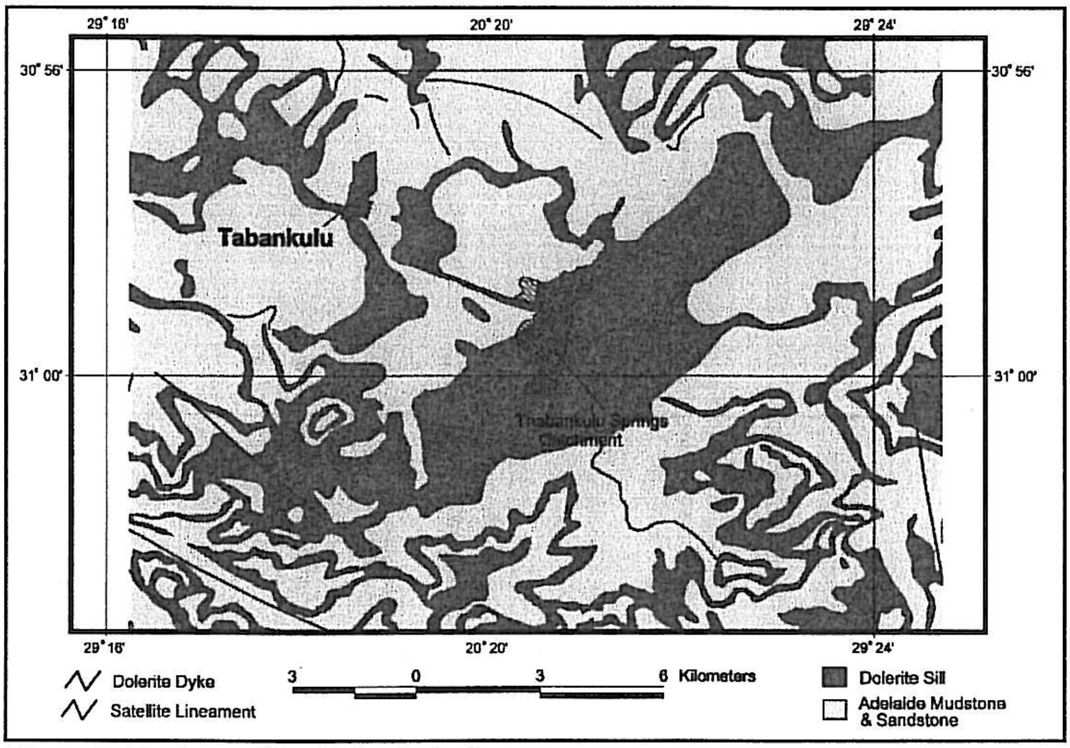

Figure 3: Geology of the Tabankulu Area

2.4 Springs and Seeps

Seeps represent the attenuated discharge of infiltrated rainwater from the vadose zone or from a locally "perched"-aquifer, before it actually reaches the main groundwater body (**Figure 4**). They tend to show marked seasonal fluctuations in yield (i.e. directly correlated to the local rainfall variability), and their water chemistry is similar to that of rainwater (i.e. electrical conductivity or EC < 20 mS/m).

The springs in the area tend to emanate in the lower-lying areas, especially in the deeply incised valleys, along bedding-planes, intrusive contacts and other structural features – where the groundwater phreatic- or piezometric-level intersects the surface (**Figure 4**). The chemistry of the spring-water therefore reflects that of the local shallow aquifer (EC > 70 mS/m) or in more rare cases a deeper-seated aquifer. The yield of a spring is more regular than that of a seep, i.e. seasonal fluctuations in flow are not as marked, because the spring is linked to a relatively large groundwater storage reservoir. Springs are therefore more favourable for development as community water supplies.

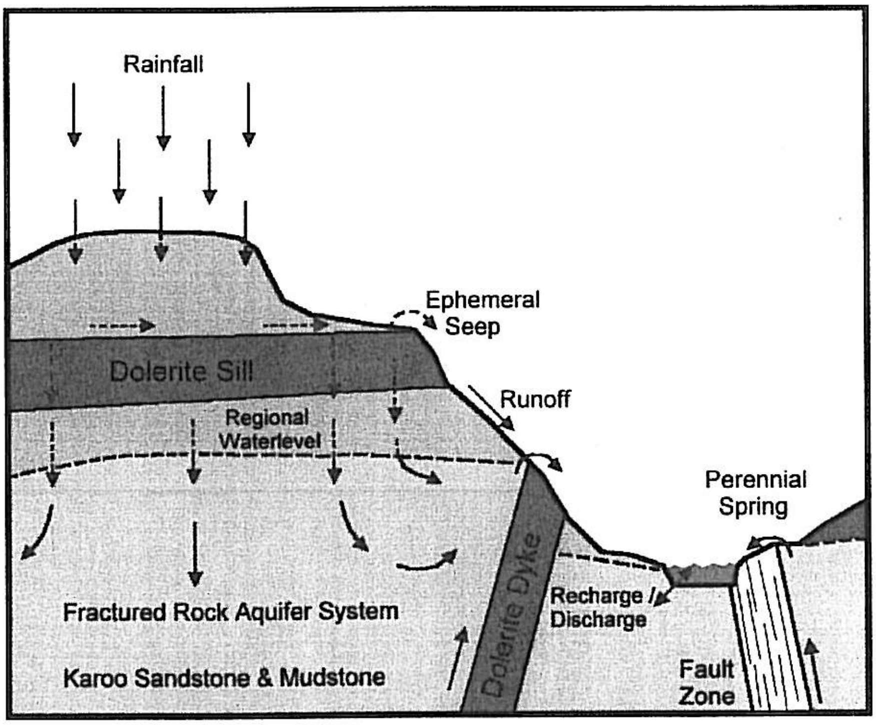

Figure 4: Schematic Conceptual Diagram indicating the occurrence and hydrological significance of springs and seeps in the study area.

It is the author's opinion that the electrical conductivity, as well as other macro-chemical and isotopic constituents, of this water may be used as a first-order approximation of the sustainability of the resource (i.e. spring versus seep). The nature and degree of correlation between the rate of flow (l/s) and local rainfall (mm) will provide a more reliable definition between the two types, as well as quantitative estimates of the long-term sustainable yield of the supply. Such applied research would greatly enhance our understanding and selection of 'true' springs suitable for community water supply - especially in this area where they form an important freshwater resource for cost-effective, small-scale development, but have the stigma of being 'unreliable'.

3.0 FIELDWORK

Mr. Booi Malghas of Kei Water Solutions, Umtata, visited the site on the 15th March 1999 with the aim of ascertaining:

- the source and origin of the springs,
- the immediate yield, and
- general quality of the springwater.

4.0 GEOHYDROLGY OF THE SPRINGS

The springs emanate from fractured sediments at the base of an extensive dolerite sill complex, at 1280 m.amsl (TU-Sp 2+3) and 1240 m.amsl (TU-Sp1) (**Figure 5**). The dolerite sill forms part of the NTabankulu -Tonti Mountain range.

The spring-water is extremely fresh, with an electrical conductivity of 20 mS/m (i.e. similar to that of rainwater). At present, springs TU-Sp 1 and 3 are piped directly from source for village water supply, while TU-Sp 2 flows into an earth-lined dam which is utilised by Tabankulu.

The immediate yield of springs TU-Sp 2 and 3 were estimated to be in the order of 2 and 5 *l*/s, respectively. According to the local inhabitants there were no heavy rainfall events prior to our field-visit, which may have influenced the strong flows measured. They also stated that the springs are perennial.

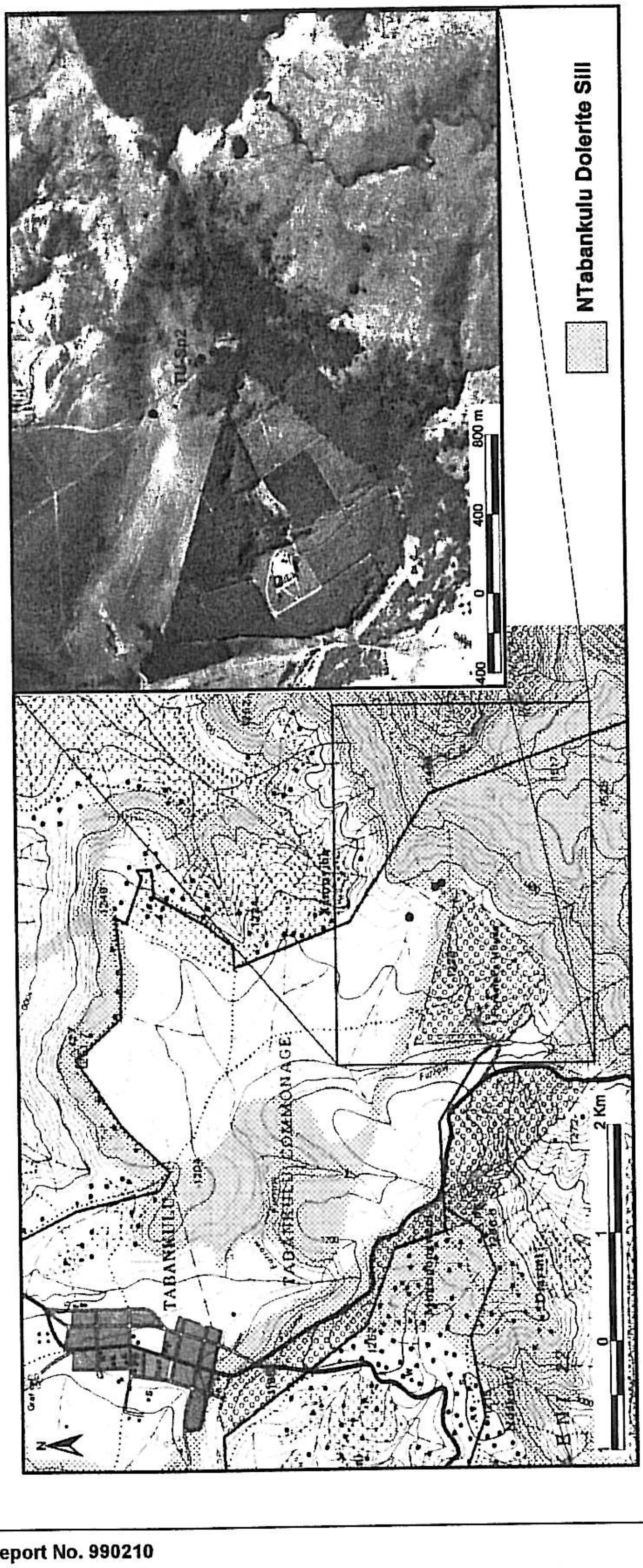

Figure 5: Air-photo and Topocadastral map showing Location of the Tabankulu – Embangweni

4.1 Catchment Area

The surface catchment for infiltrating water likely to recharge the Tabankulu springs were defined (**Figure 6,** also 2 and 3), using the following information:

- Geology (i.e. outcrop of the Tabankulu dolerite sill complex), obtained from the 1/250 000 geological mapsheets (3028 Kokstad and 3128 Umtata), as well as interpretation of the 1/50 000 scale panchromatic air-photographs.
- A 25x25m digital elevation model (DEM) of the area, derived from the 20m contour elevation vector data for the 1/50,000 scale topocadastral 3029CD (Mount Ayliff) and 3129AB (Flagstaff).
- Perennial and ephemeral river vector data from the above 1/50 000 scale topocadastral maps.

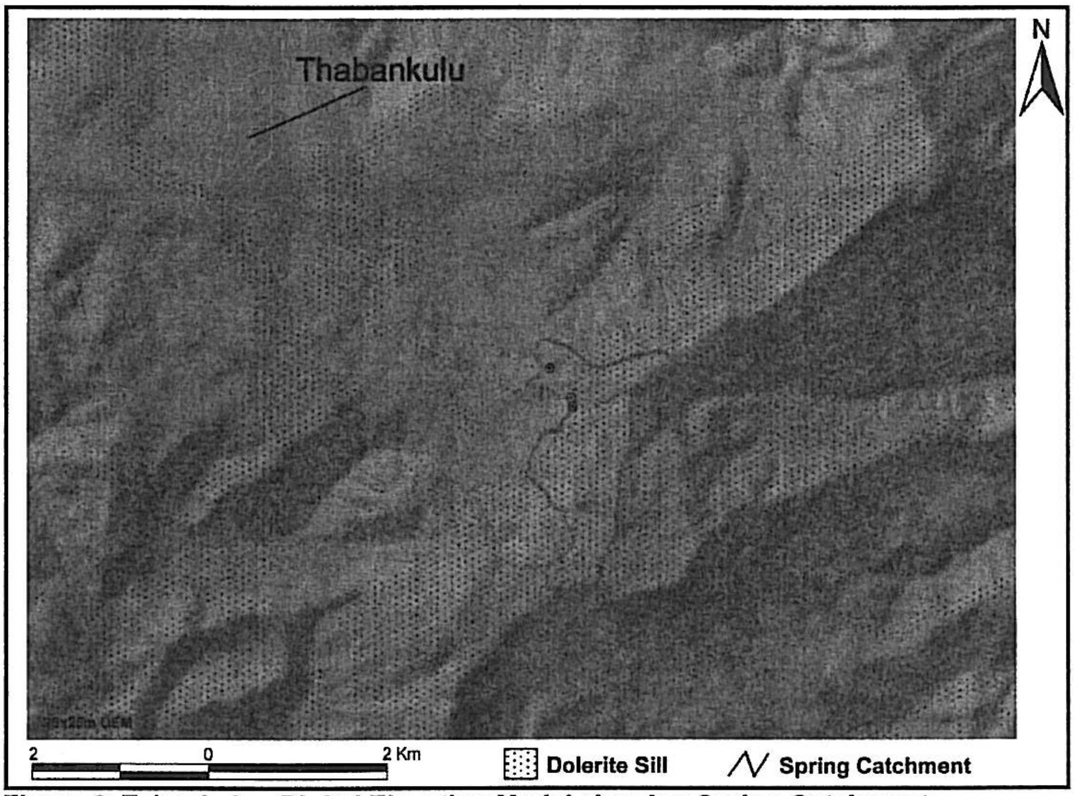

Figure 6: Tabankulu - Digital Elevation Model showing Spring Catchment.

The surface catchment of the springs covers an area of ±2.23 km^2.

4.2 Sustainable Yield

The springs are recharged directly by rainwater infiltrating into the fractured dolerite sill and Beaufort sediments, which then discharges in a relatively short space of time at the springs or, according to our earlier definition (**Section 2.4**), 'seeps'. This assertion is based purely on the low electrical conductivity (20 mS/m) of the water, which is more typical of rainfall. Groundwater issuing from a typical Beaufort fractured-rock aquifer in the area would have an EC in excess of 70 mS/m. The yield of the 'springs' are therefore likely to fluctuate according to the rainfall variability and the mean annual sustainable yield of the springs will be equal to the rate of recharge from precipitation only.

A number of spatially-weighted and empirical rainfall-recharge formulae were therefore used to estimate the sustainable yield of the Tabankulu springs (**Table 1 and 2**). **Figure 7** illustrates the results of a GIS simulation of mean annual recharge, where MAP variability, percentage slope and recharge rate are taken into account.

Table 1: Sustainable Yield of the Tabankulu-Embangweni Springs – Spatially Weighted Estimates.

Spring Catchment Area (km^2)	Mean Annual Precipitation (mm)		Recharge Rate (% of MAP)		Volume Recharge (m^3/yr)	Mean Annual Spring Flow (l/s)
	Min	Max	Min	Max		
2.23	914	1200	9.1	12.0	272978	**8.7**
	"	"	"	"	232183*	**7.4***
	914	1200	5.0	5.0	122831	**4.0**
	"	"	"	"	104474*	**3.3***
	* Weighted by the inverse of percentage slope grid.					

Estimates of the average annual volumes of precipitation recharging the Tabankulu springs (**Table 1 and 2**), varies between 67 000 and 273 000 m^3 (i.e. resulting in an average combined spring-flow of between 2.1 and 8.7 l/s). According to Schultze et al (1997), the MAP in this area may vary by approximately 25%, which equates to a spring-flow varying between 1.6 and 8.9 l/s.

The lower spring-flow estimate of 2.1 l/s (i.e. 3% of MAP) is considered to be very conservative and such recharge-rates are more realistic in the drier western portions of the Karoo (De Aar to Calvinia). In our opinion, the sustainable yield of the Tabankulu springs are in the order of 3.5 to 5.5 l/s or 110 000m^3 to 170 000 m^3 per annum.

Table 2: Sustainable Yield of the Tabankulu-Embangweni Springs - Empirical Formulae Estimates.

Mean Annual Precipitation (mm)	Recharge Rate (% of MAP)	MAP Coefficient of Variation [A] (%)	Volume Recharge (m^3/yr)	Mean Annual Spring Flow (l/s)	Upper[A] Spring Flow (l/s)	Lower[A] Spring Flow (l/s)
1000	10	25	223351	**7.1**	8.9	5.3
1000	7	25	156346	**5.0**	6.2	3.7
1000	5	25	111676	**3.5**	4.4	2.7
1000	3	25	67005	**2.1**	2.7	1.6
-	-	-	178681[B] (80 mm/a)	**5.7**	7.1	4.3
900			156346[C] (70 mm/a)	**5.0**	6.3	3.8
1000	-	-	178681[C] (80 mm/a)	**5.7**	7.1	4.3
900	10[D]	-	201016	**6.4**	8.0	4.8
1000	12.5[D]	-	259828	**8.2**	10.3	6.2

Note: Spring Catchment Area = 2.23 km^2

[A] Derived from map of '*Coefficient of Variation (%) of Annual Precipitation*' (Schultze et al. 1997)

[B] Derived from map of '*Mean Annual Recharge of Soil Water (mm) into the Vadose Zone*' (Schultze et al. 1997)

[C] After Kok's rainfall-recharge spring-flow based regression equation (in Bredenkamp et al, 1995, p262).

[D] After Enslin's rainfall-recharge regression equation for summer rainfall regions (in Bredenkamp et al, 1995, p258).

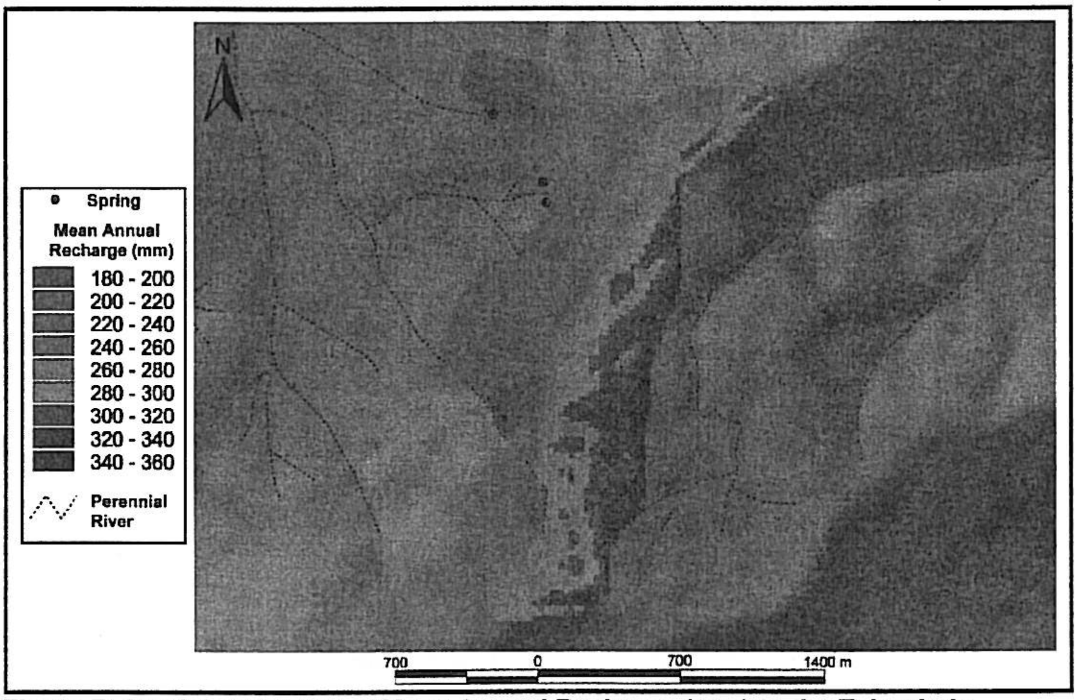

Figure 7: Spatial estimates of Mean Annual Recharge (mm) to the Tabankulu -Embagweni Springs.

The anticipated direct relationship between rainfall and spring-discharge would imply considerable seasonal variations in the rates of flow, which may result in dry-season, peak demand water supply shortfalls. Conservative estimates of possible combined monthly spring-flow variations are presented in **Table 3**.

Table 3: Anticipated Seasonal variation in Spring-flow

Month	Median [A] Monthly Rainfall (mm)	Median Monthly Spring-Flow (l/s)
Jan	150	12.5
Feb	150	12.5
Mar	113	7.5
Apr	63	2.6
May	25	0.8
Jun	13	0.4
July	13	0.4
Aug	25	0.8
Sep	50	1.7
Oct	100	5.0
Nov	138	11.5
Dec	150	12.5

[A] Estimates from maps showing '*Median Monthly Rainfall*'' (Schultze et al. 1997).

5.0 CONCLUSIONS AND RECOMMENDATIONS

The three springs emanate from the base of an extensive, thick dolerite sill in the Tabankulu – Embangweni area. The present combined yield (15/03/99) of the Tabankulu-Embangweni springs are in excess of 7 l/s and the water quality is excellent (i.e. electrical conductivity of 20 mS/m).

The yield of the springs are directly related to the volumes of rainwater infiltrating a 2.2 km^2 catchment area on the slopes of the Ntabankulu Mountain. The combined sustainable yield of the Tabankulu-Embangweni springs are in the order of 3.5 to 5.5 l/s or 110 000m^3 to 170 000 m^3 per annum. It is likely that the yield of the springs will show marked seasonal variability.

It is recommended that:

- The spring water should be tested for full chemical and bacteriological constituents to ensure that it meets the required drinking standards. This process should be repeated annually.
- Additional water supplies be developed to overcome seasonal and drought low spring-flow periods.
- The source of the springs should be protected (fenced-off) to ensure that they are not polluted, especially by animal activity. This would require collecting and piping of the springs from their source.
- The combined yield of the springs should measured on a monthly basis using a 90° V-notch flume. These measurements, along with local monthly rainfall information, will result in a more reliable estimate of their long-term sustainable yield.

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