3.7 Piezometric Head

3.7.1 Kalahari Aquifer

1) Present Rest Water Level

Rest water level in the Kalahari Aquifer is shown in Fig. 3.7-1. The figure shows the elevation of rest groundwater level above sea level. Groundwater of the Kalahari Aquifer is flowing from the northwest to the southeast harmonizing with geological conditions. A gradient of groundwater table becomes steeper in Aranos or Gochas area but it is inclined gently toward the Salt Block.

2) Long-term Variation of Rest Water Level

The variation of groundwater level in the Kalahari Aquifer at Olifantswater West and Tugela is shown in Fig.3.7-4 to Fig.3.7-6. It is clear that the water levels have been decreasing constantly while showing periodic fluctuation by 5.8 cm/year in Olifantswater West or 4.2 cm/year in Tugela on average since 1986 as shown in Table 3.7-1.

On the other hand, they were suddenly changed after the heavy rain in the rainy season from 1999 to 2000. (hereinafter referred to as 99-00 rainy season)

Table 3.7-1 Results of Water Level Monitoring in Kalahari Aquifer

Area	Well No.	WW No.	*Decreasing Rate (cm/yr)	Increasing Value in 99-00 Rainy Season (cm)	Note
Olifantswater West	DWA-7K(1)	21814	5.5	38	Weak Withdrawal Pattern
	DWA-7K(2)	21815	6.6	46	Withdrawal Pattern
	DWA-5K(1)	22545	5.5	69	Withdrawal Pattern
	DWA-5K(2)	22545	5.5	62	Withdrawal Pattern
	DWA-4K(1)	22546	5.5	46	Weak Withdrawal Pattern
	DWA-4K(2)	22546	6.1	46	Weak Withdrawal Pattern
	Average	-	**5.8**	**51**	-
Tugela	DWA-8K	21814	4.0	192	Weak Withdrawal Pattern
	DWA-10K	21815	4.4	215	Weak Withdrawal Pattern
	DWA-12K	22545	4.3	354	Weak Withdrawal Pattern
	Average	-	**4.2**	**254**	-

*During 1986 to 1999

3.7.2 Auob Aquifer

1) Present Piezometric Head

Groundwater flow of the Auob Aquifer as a whole is similar to the Kalahari Aquifer. A concentric circle at J-8 seems to be attributed to its peculiar circumstance that the observation borehole for Auob Aquifer at J-8 targeted merely the A1 bed situated in the lowest of the Auob Member so that this borehole doesn't represent the whole Auob Aquifer. (Refer to Fig.3.7-2)

2) Long-term Variation of Piezometric Head

Piezometric head of the Auob Aquifer has been recorded at DWA-4A, 5A, 6A and 7A in Olifantswater West, Boomplaas (DWA-2A) and Spes Bona (DWA-3A) although they are strongly affected by withdrawal for irrigation. The monitoring results of piezometric head of the Auob Aquifer are shown in Table 3.7-2.

DWA-6A typically reveals that the piezometric head of the Auob Aquifer had been declining by 5.4cm/year same as the Kalahari Aquifer and slightly risen after heavy rain in 1999 to 2000 rainy season.

Table 3.7-2 Monitoring Results of Piezometric Head in Auob Aquifer

Well No.	WW No.	Area	*Decreasing Rate (cm/yr)	Increasing Value in 99-00 Rainy	Riedmond Member	Note
DWA-2A	10120	Boomplaas	Recognition of tendency	Recognition of tendency	Exist	Strongly effected by irrigation withdrawal
DWA-7A	21784	Olifantswater West	3.6	0	Exist	-
DWA-6A	22544	Olifantswater West	6.2	Slightly	Exist	-
DWA-5A	22545	Olifantswater West	5.9	200	None	-
DWA-4A	22546	Olifantswater West	6.5	Slightly	Exist	Almost same as DWA-7A
DWA-3A	32457	Spes Bona (Stampriet)	Recognition of tendency	Recognition of tendency	Exist	Strongly effected by irrigation withdrawal
DWA-8A	22838	Tugela	5.8	172	?	Same as DWA-8K
DWA-10A	22839	Tugela	5.8	200	?	Same as DWA-10K
DWA-11A	22556	Tugela	4.5	118	?	Same as DWA-8A,10A

*During 1986 to 1999

3.7.3 Nossob Aquifer

1) Present Rest Water Level

General direction of groundwater flow is also from the northwest to the southeast. The gradient of groundwater piezometric head becomes steep locally near the west of Aranos. The average of piezometric head in the Nossob Aquifer is gentle as 1/1000.

This value does not largely change among three aquifers. Although the Nossob Aquifer is located at the lowest altitude, its piezometric head is the highest in the southeastern part of the basin. (Refer to Fig.3.7-3)

2) Long-term Variation of Piezometric Head

There are four observation boreholes for monitoring piezometric head of the Nossob Aquifer by DWA at Gomchanas (DWA-1N) and Tugela (DWA-8N, 9N and 10N) as shown in Fig.3.7-10, 11. Fluctuations of piezometric head of the Nossob Aquifer at DWA-8N and 10N except for DWA-1N or 9N, which are recorded extraordinary data, are very similar to the Kalahari Aquifer. It seems that these boreholes are affected by leakage. Groundwater of the Nossob Aquifer probably can be regarded as fossil water. Whether it is true or not, the analysis of monitoring data from JICA test boreholes is indispensable

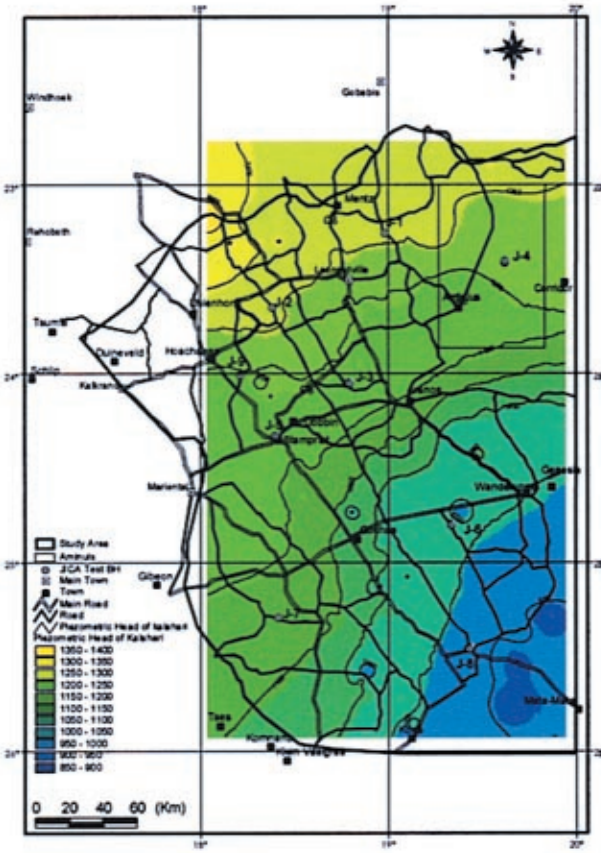

Fig. 3.7-1 Piezometric Head of Kalahari Aquifer

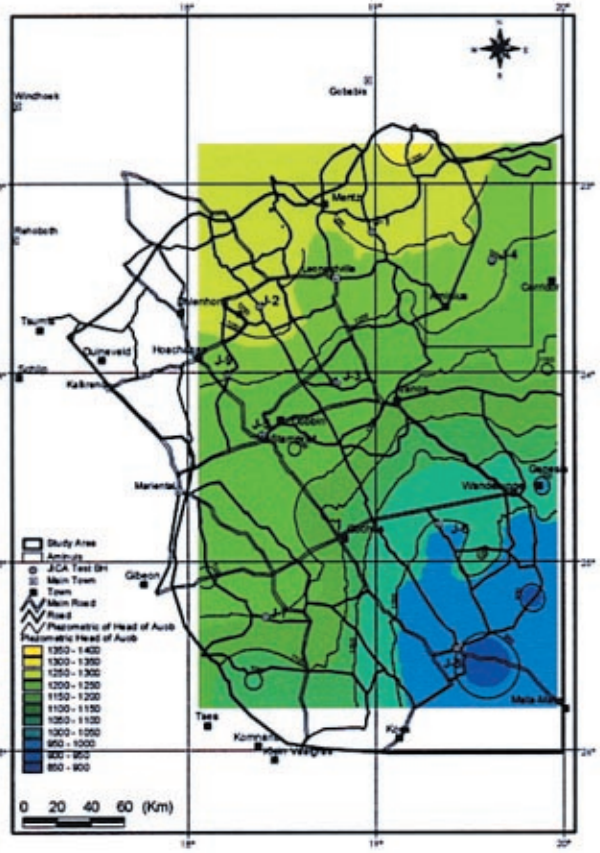

Fig. 3.7-2 Piezometric Head of Auob Aquifer

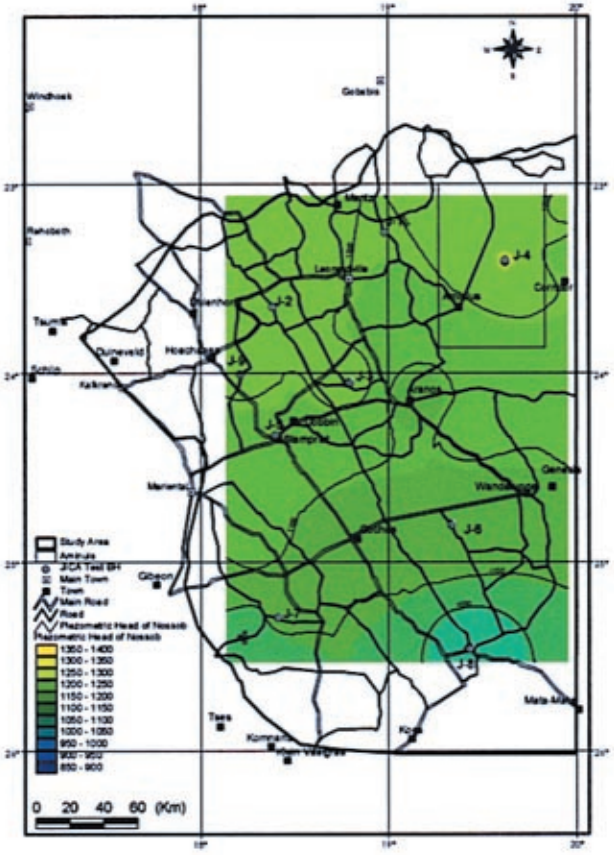

Fig. 3.7-3 Piezometric Head of Nossob Aquifer

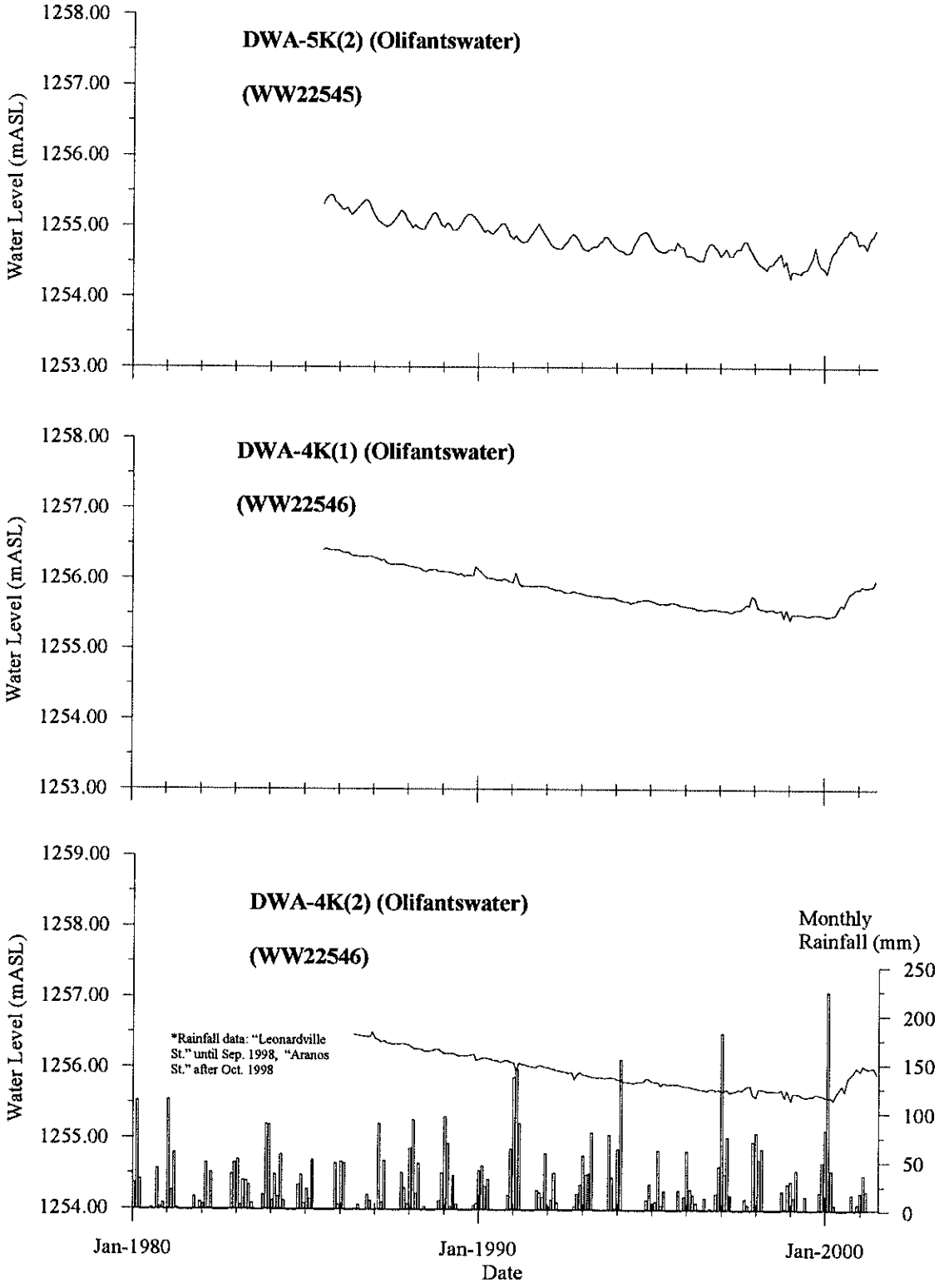

Fig.3.7-4 (1) Variation of Piezometric Head in Kalahari Aquifer

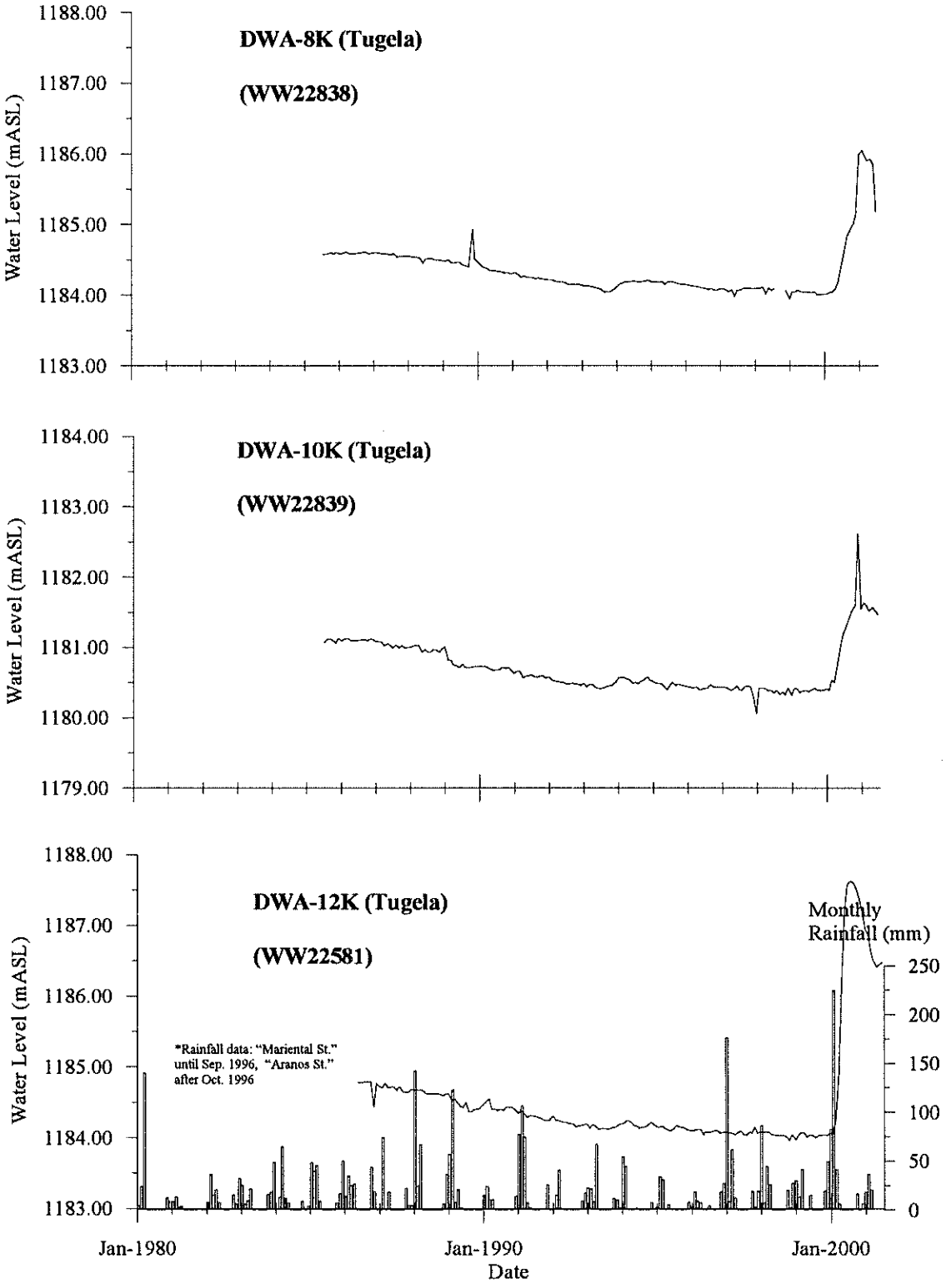

Fig.3.7-4 (2) Variation of Piezometric Head in Kalahari Aquifer

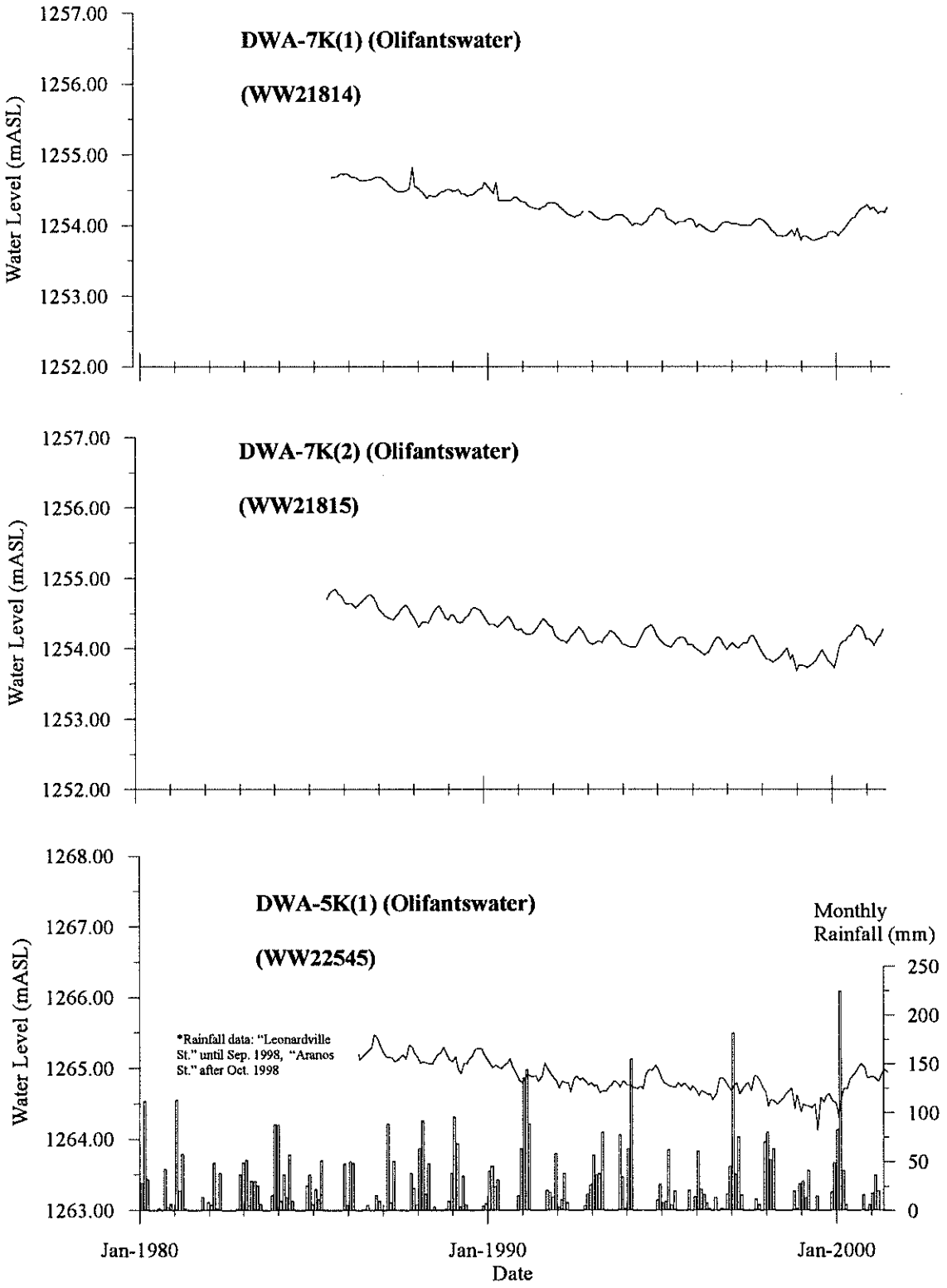

Fig.3.7-4 (3) Variation of Piezometric Head in Kalahari Aquifer

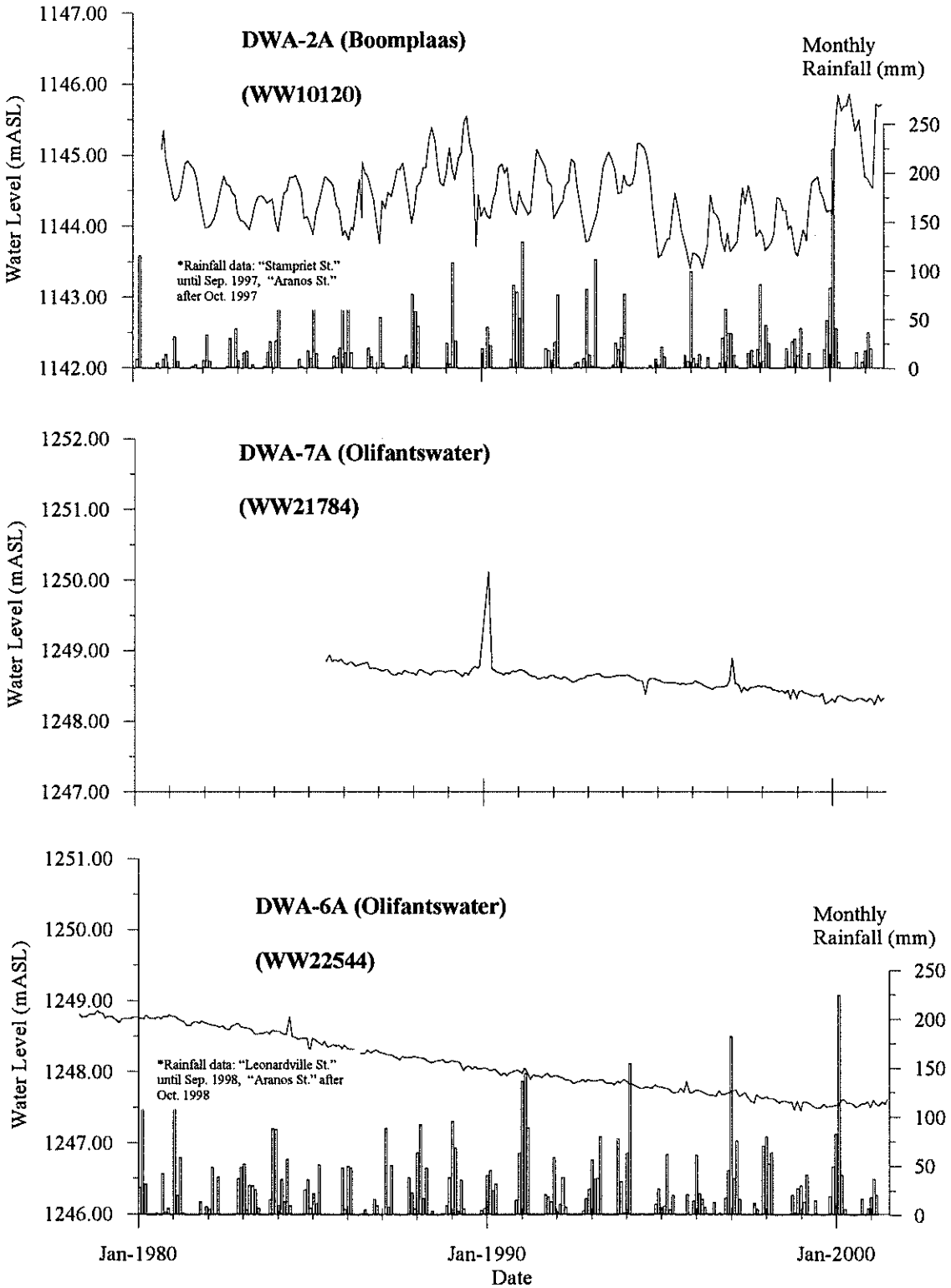

Fig.3.7-5 (1) Variation of Piezometric Head in Auob Aquifer

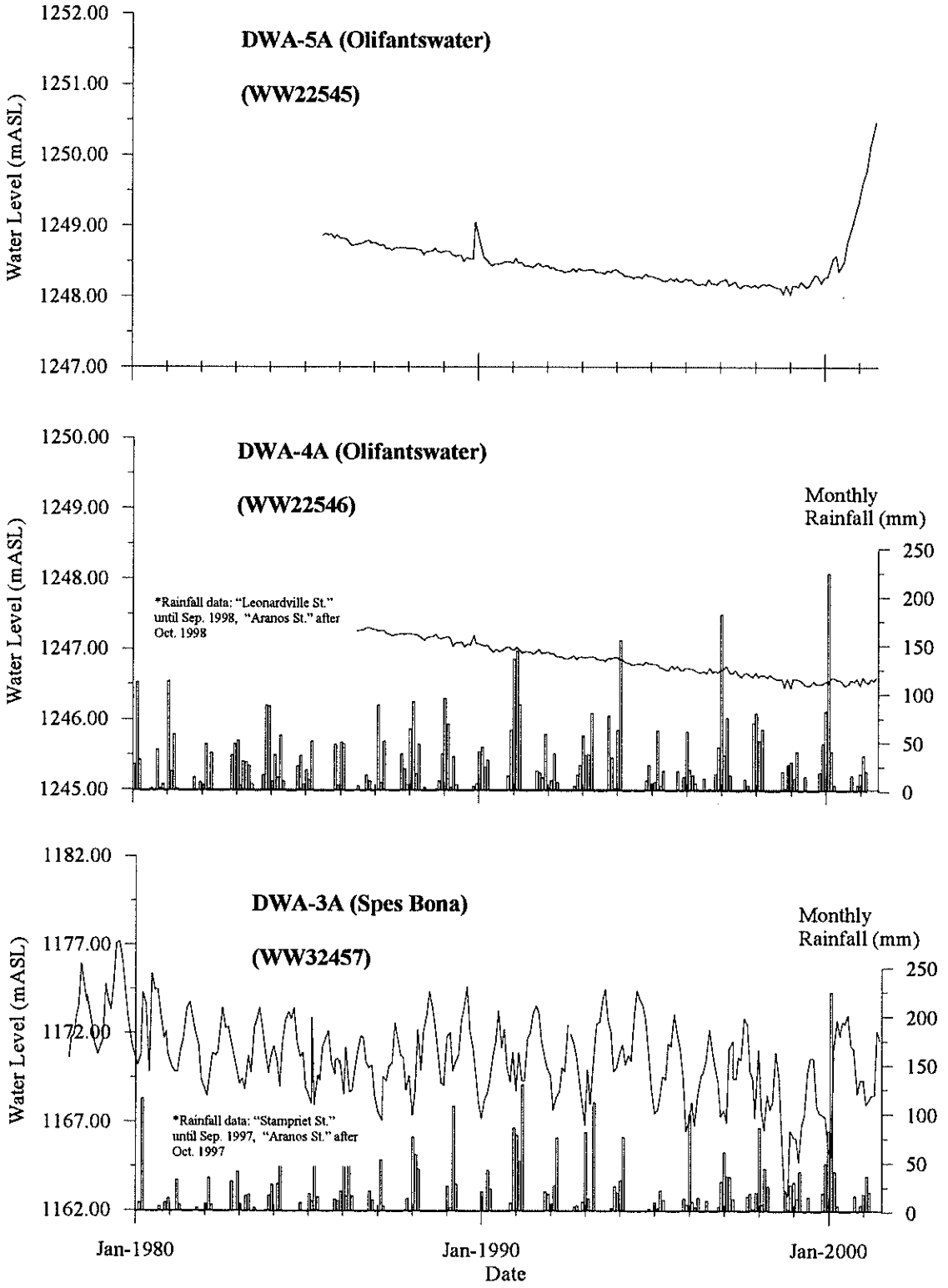

Fig.3.7-5 (2) Variation of Piezometric Head in Auob Aquifer

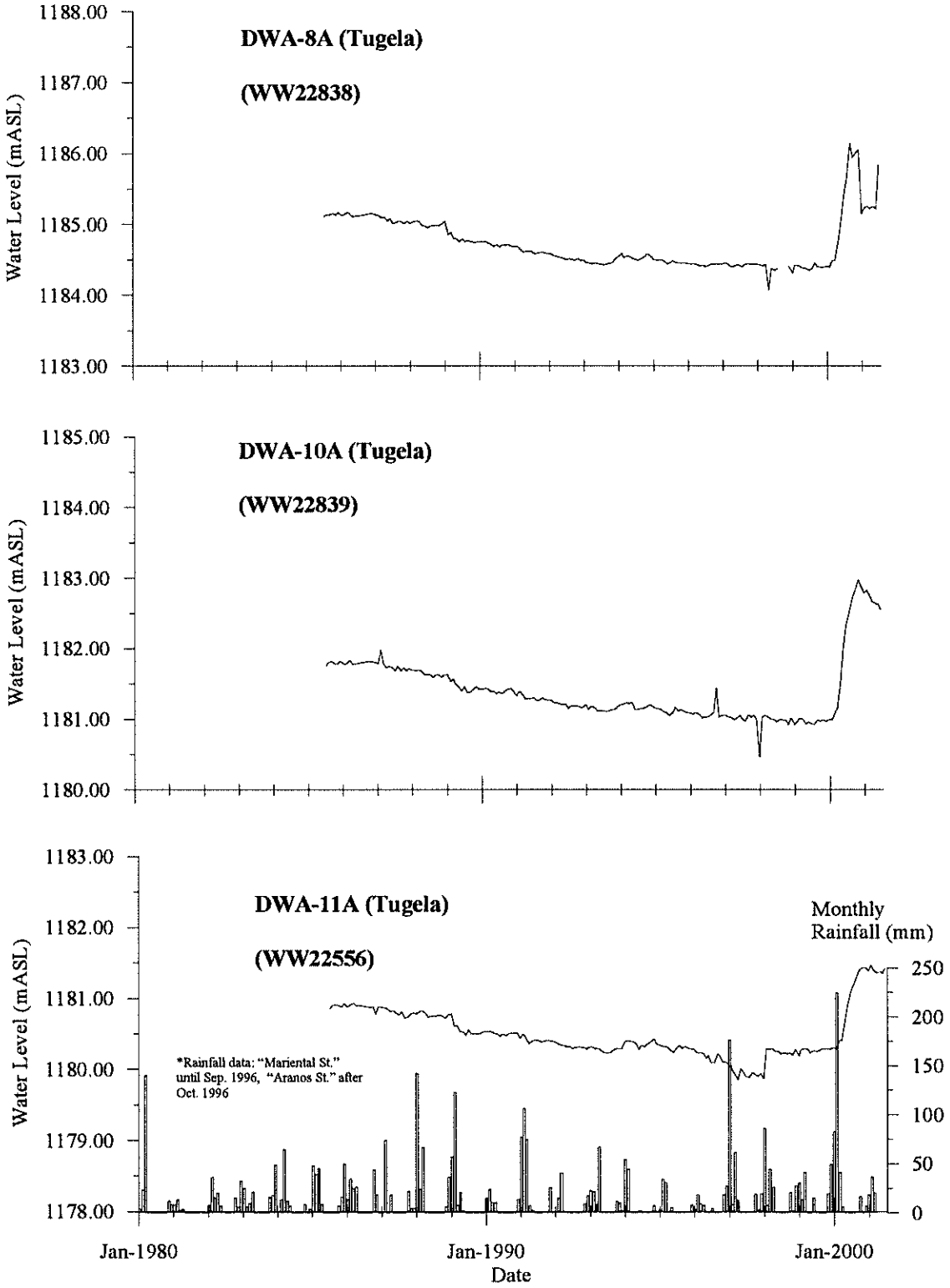

Fig.3.7-5 (3) Variation of Piezometric Head in Auob Aquifer

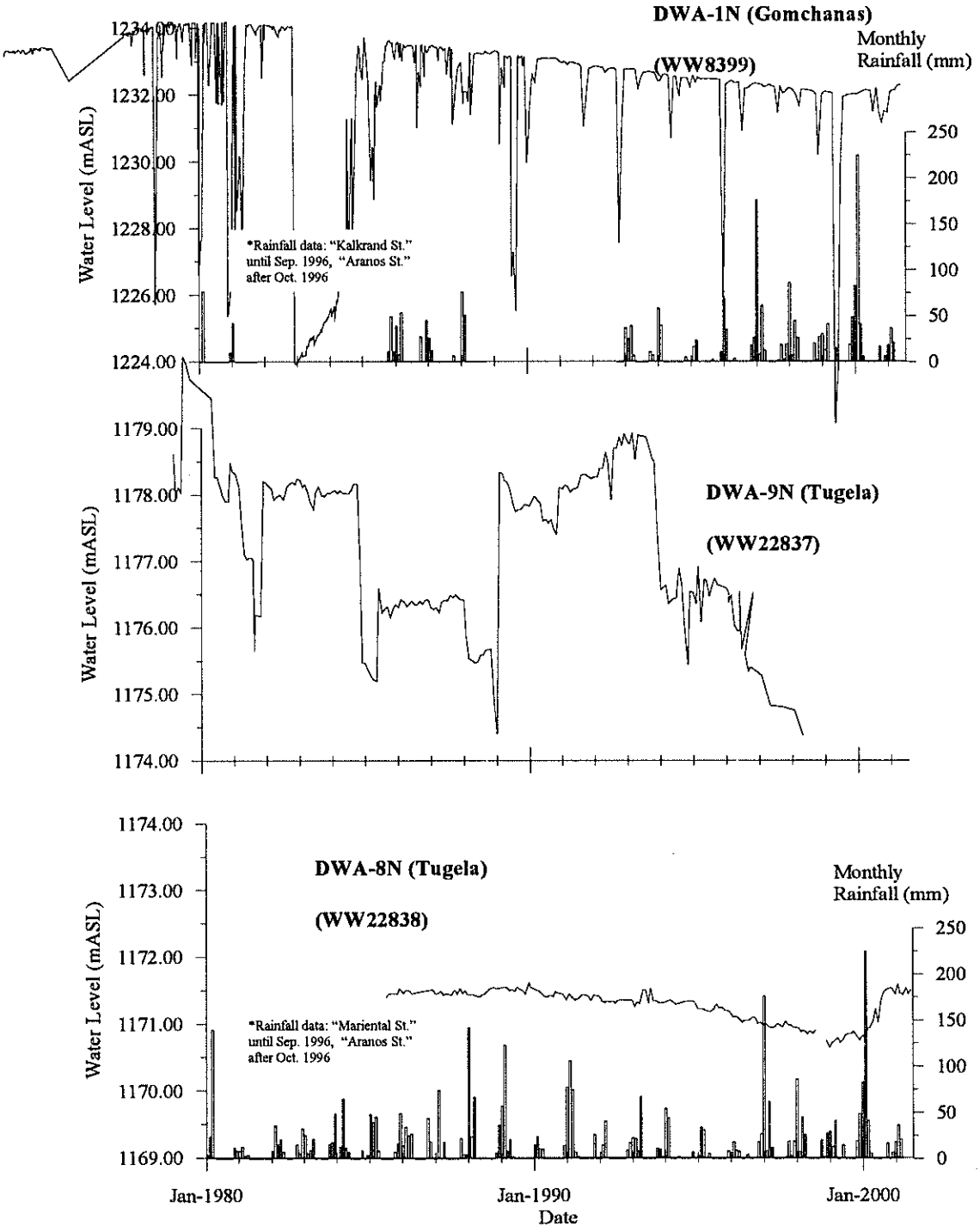

Fig.3.7-6 (1) Variation of Piezometric Head in Nossob Aquifer

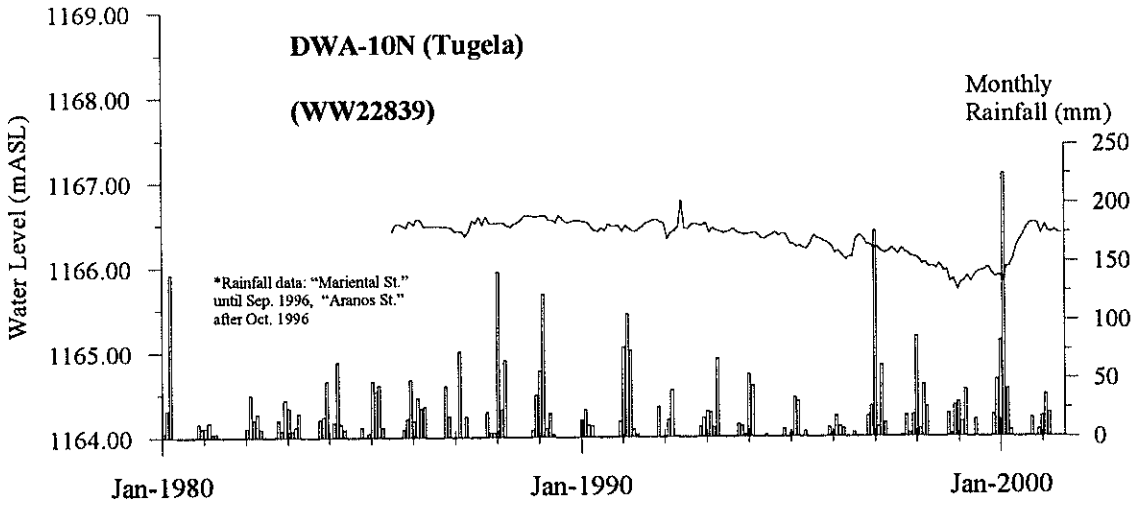

Fig.3.7-6 (2) Variation of Piezometric Head in Nossob Aquifer

3.8 Groundwater Quality

TDS data was obained during this study from JICA test boreholes and selected existing boreholes representing each aquifer. A distribution of TDS concentration of each aquifer is shown in Fig.3.8-1 to Fig.3.8-3.

1) Kalahari Aquifer

It is obvious that the high concentration areas are located in the southeastern part of the study area, especially around J-6. This area mostly coincides with the Pre-Kalahari Valley or “Salt Block”. The maximum concentration of TDS 14,874 mg/l was recorded at J-6.

According to WHO’s Standards for Drinking Water, TDS should be less than 1,000 mg/l. However, its value in the southeastern area from Aranos exceeds the standard.

2) Auob Aquifer

High concentrations of TDS are observed around J-8. The existence of the Salt Block is not so much conspicuous as vague. The maximum value of it is 6,754 mg/l at J-8. Water quality in the northeastern half of the study area is better than the standard as well as that of the Kalahari Aquifer.

3) Nossob Aquifer

High concentration area of TDS in the Nossob Aquifer is also distributed around J-8. Due to a lack of sufficient data and the deep existence of the aquifer, quality evaluation of the data is no possible. A available data seems to indicate that water quality of Nossob Aquifer is the worst among the three aquifers. TDS in most of distribution area of the Nossob aquifer do not satisfied the standard.

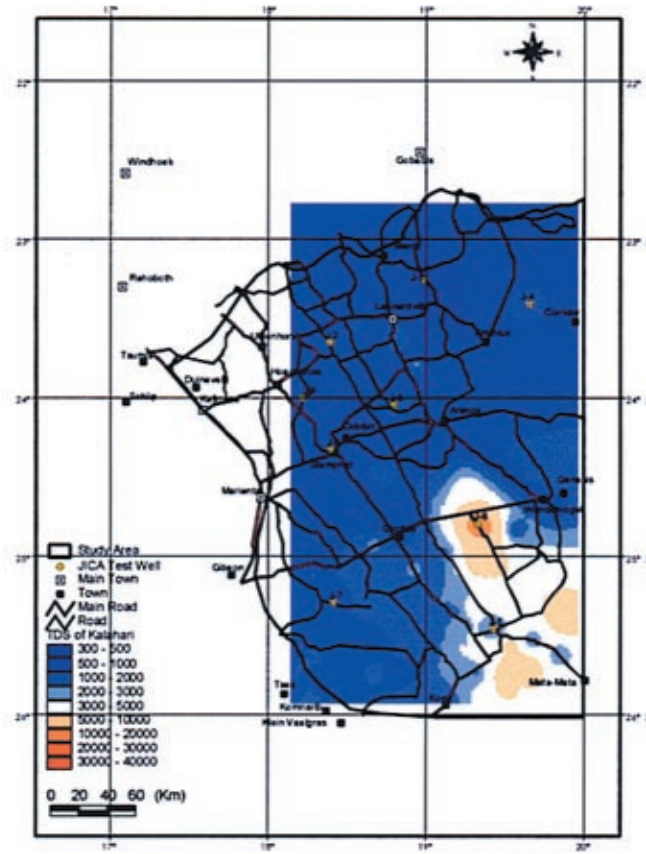

Fig. 3.8-1 TDS of Groundwater in Kalahari Aquifer

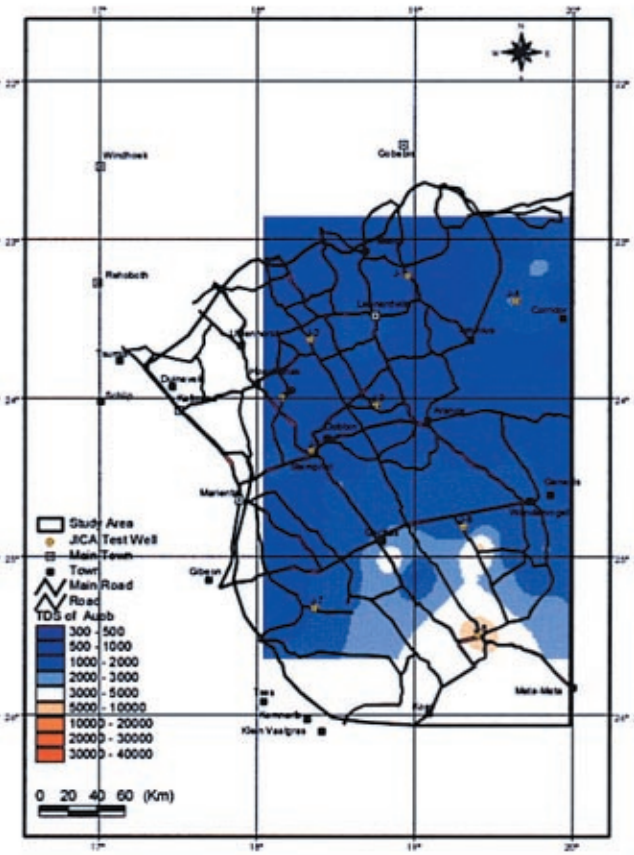

Fig. 3.8-2 TDS of Groundwater in Auob Aquifer

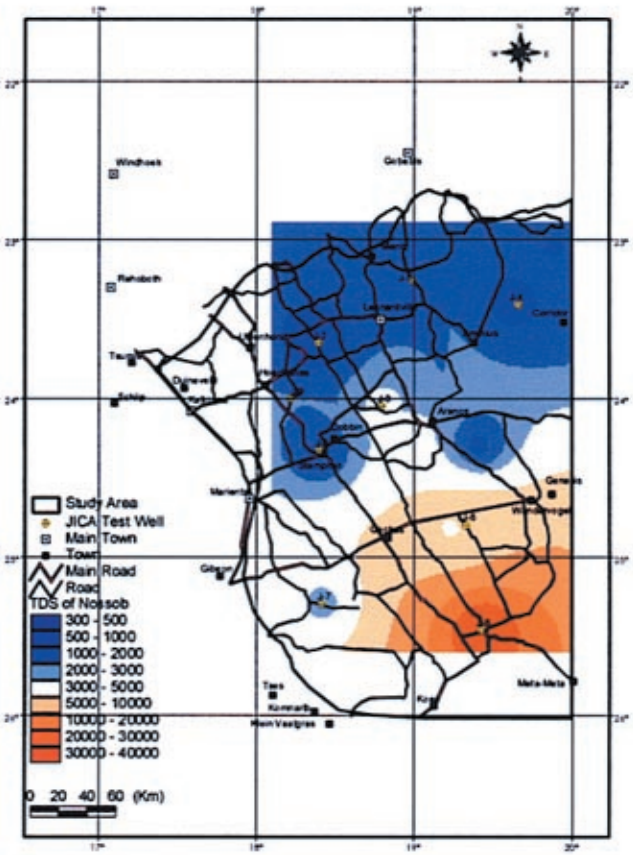

Fig. 3.8-3 TDS of Groundwater in Nossob Aquifer