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Variations in some groundwater characteristics, Belawai Water Supply, Sarikei Division, Sarawak.

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Abstract : A systematic monitoring programme has been carried out on the water supply in the Belawai catchment area since August 1987 to gather information and data on the quality and quantity of the water as well as the trend of domestic water demand; the information is essential for the proper development and management of the groundwater system of the Belawai water supply.

The aquifer in the Belawai Catchment Area is shallow and underlain by beach sand and marine sand.

The groundwater in general flows from southern part of the catchment area to the north. However, the water flow changes according to the recharge-discharge relationship of the catchment area. Recharge of the groundwater in the catchment area is mainly from precipitation and groundwater in flow. The response time is short where the rainwater available reached the water table almost immediately. Discharge is mainly by the abstraction of water from the production wells, evapotranspiration, groundwater outflow and surface drainage. During the dry season, the total discharge is more than the total recharge resulting in the water supply being supplemented by the aquifer storage. The effect of water use in the catchment area aquifer changes according to the pattern of abstraction and this groundwater table at the beginning.

The quality of water changes with every well and at different months. There appears to be relationship between chloride contents with the total rainfall. From the trilinear diagram, water quality changes becoming less satisfactory when the total recharge decreases.

Abstrak : Kajian pemonitoran yang bersistematik telah dijalankan semenjak Ogos 1987 keatas Kawasan Tadahan Punca Air Tanah Belawai untuk memperolehi dan mengumpul data-data kuantiti dan kualiti air, juga jumlah permintaan penduduk; maklumat ini sangat diperlukan untuk pembangunan dan pengurusan yang berkesan kepada Punca Air Tanah Belawai.

Akuifer di Kawasan Tadahan Belawai adalah jenis terdedah yang cetek di mana ianya terdiri dari pasir pantai dan pasir laut.

Air tanah pada amnya mengalir dari selatan ke utara Kawasan Tadahan. Walau bagaimanapun aliran air akan berubah bergantung kepada pertalian antara imbuhan dan luahan air kawasan tadahan. Punca imbuhan adalah dari penyerapan air hujan dan larian air tanah. Masa sambutan adalah pendek dimana air hujan didapati sampai ke paras air tanah dengan kadar yang segera. Punca luahan adalah dari pemampaan perigi pengeluaran, evapotranpirasi, larian air tanah dan larian permukaan menerusi parit. Semasa musim kemarau, jumlah luahan adalah melebihi jumlah imbuhan yang mengakibatkan punca air terpaksa di ambil dari simpanan akuifer. Kesan kegunaan air dalam akuifer Kawasan Tadahan didapati berubahan mengikut corak pemampaan dan keadaan paras air tanah pada peringkat awal.

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Kualiti air berubah pada setiap perigi dan pada bulan yang berlainan. Didapati ada pertalian antara kandungan klorida dengan jumlah hujan yang turun. Dari rajah triliner, kualiti air berubah menjadi kurang memuaskan apabila jumlah imbuhan berkurangan.

INTRODUCTION

A systematic monitoring programme has been implemented at the Belawai Water Supply since August 1987 to gather information on the seasonal variation in the groundwater quantity, quality and trend of domestic water demand; the information is essential for the proper development and management of the groundwater system of the Belawai Water Supply (Hatta, 1988; Yogeswaran, 1984). It would allow for immediate action to be taken for problems, such as saline water encroachment, pollution of aquifer and reduction in well performance, that may be encountered during the present and future stages of the development of the groundwater resource. As the groundwater source of the Belawai Supply is from a shallow coastal sand aquifer, this monitoring programme will also help to improve the understanding of groundwater resources in shallow coastal sand aquifers elsewhere in Sarawak.

BACKGROUND OF THE BELAWAI WATER SUPPLY

The Belawai Water Supply is located at Kampong Jerijeh Baru, and is about 35 km west of Sarikei (Fig. 1). Three villages namely Kampong Belawai, Kampong Jerijeh Baru and Kampong Rajang, having a total population of 8000 people, are depending on this water supply scheme for their domestic water requirement.

Preliminary investigation of the Belawai groundwater potential was carried out from 1977 to 1979. This was followed by the construction of 12 arrays of wells during 1979 and 1980. In 1982, 20 more wells were constructed. At present there are 12 arrays of production wells which are represented by a seven - well array (PW1), a five - well array (PW2), and and 10 three - well arrays (PW3 - PW12). Figure 2 shows the layout of these well arrays.

The Belawai Water Supply Scheme, which is fully treated by aeration, sedimentation, flocculation, filtration and chlorination, was commissioned in 1982. The wells are all located within an area of 900,000 m^2 which has been assigned as the water catchment area for the scheme. The production wells are located in the northern part of the catchment area. The general layout of the wells and the ground contour of the northern part of the catchment area is shown in Figure 3. The production wells are located approximately 200 m from each other.

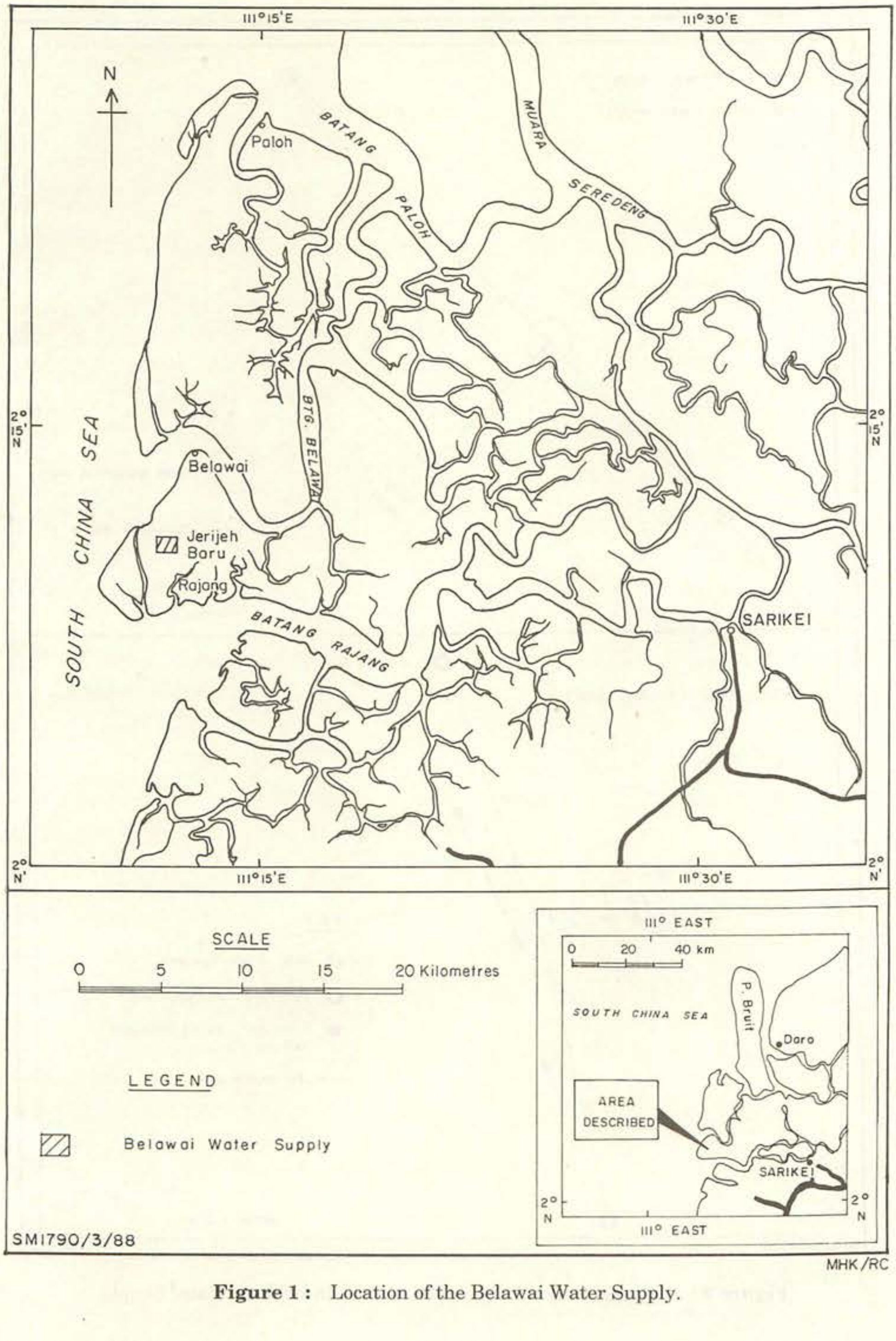

Figure 1 : Location of the Belawai Water Supply.

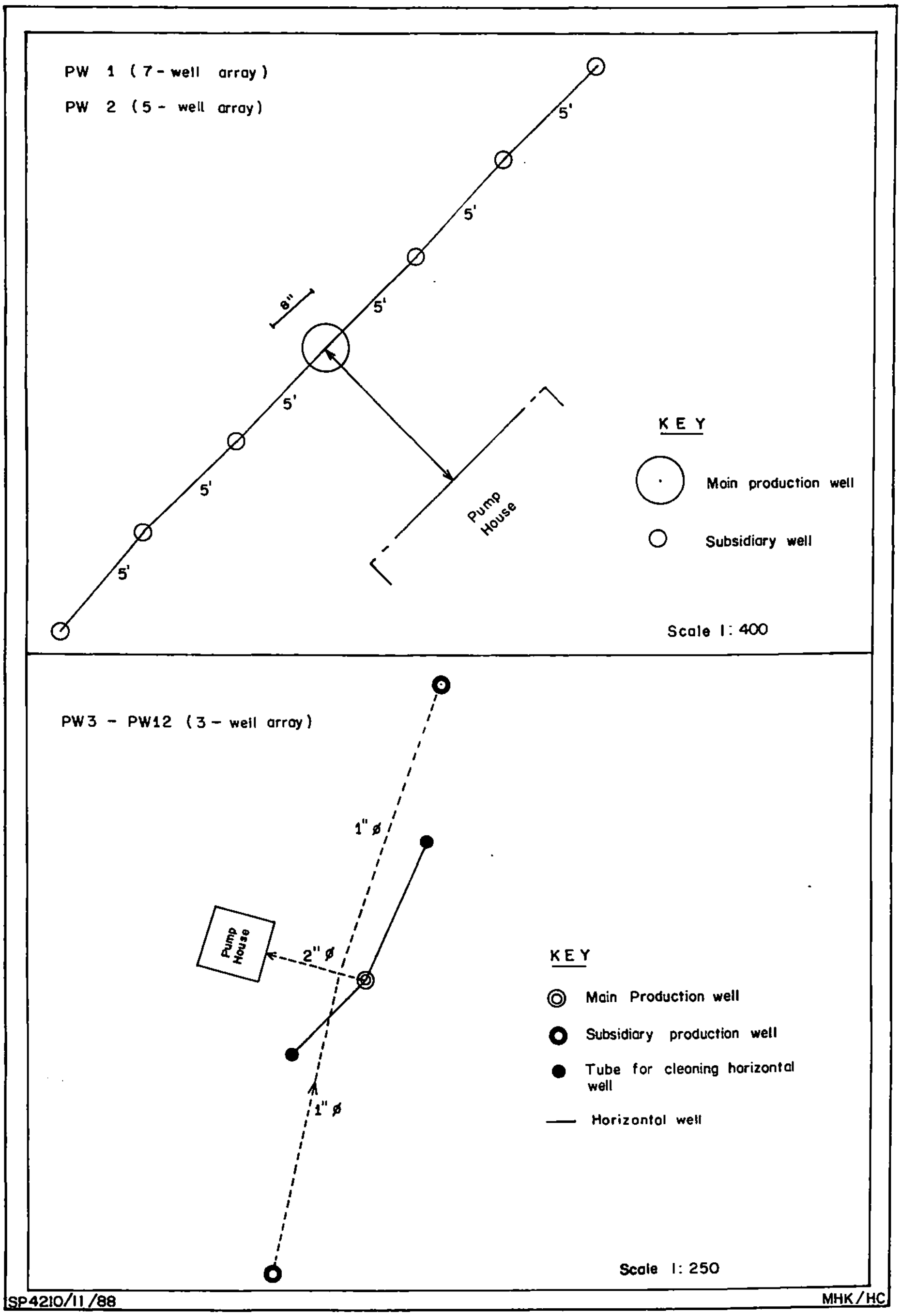

Figure 2 : Schematic layout of production wells in Belawai Water Supply.

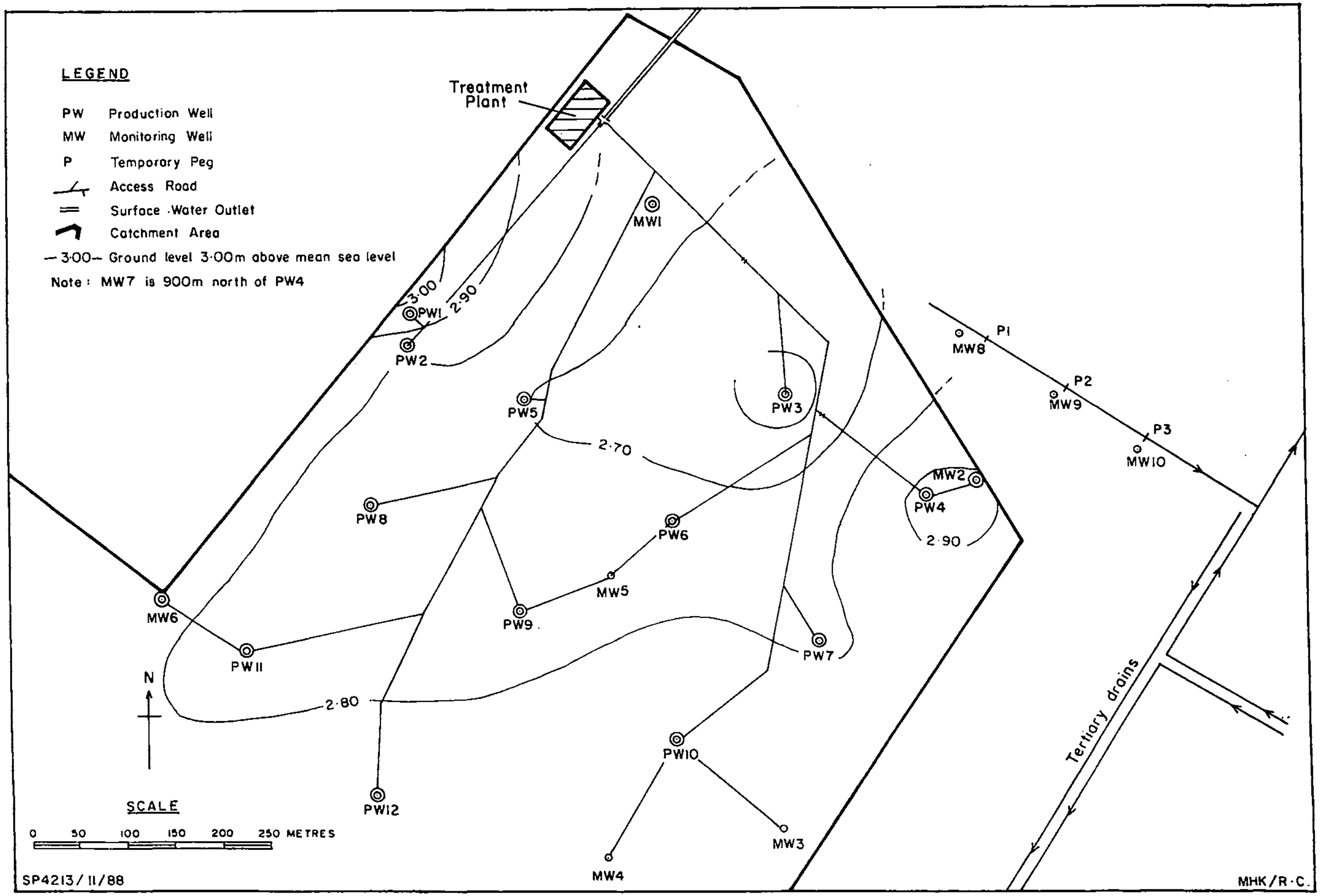

Figure 3 : General layout and ground contour of the Belawai Water Supply Catchment Area.

GEOLOGY AND HYDROGEOLOGY

The Belawai area is underlain by Quaternary sediments which comprise of beach sand and other shallow marine sands rich in shells and broken wood fragments. These deposits, which form the unconfined aquifer system of the area, are underlain by estuarine silty sand, clay and gravelly clay.

The beach sand and the shallow marine sands offered the most promising prospect for the development of groundwater in the area.

Figure 4 shows the cross-section of the Belawai area and its general groundwater movement. The detail lithology of the catchment area is shown in isometric fence diagram of Figure 5.

THE REGIONAL HYDROLOGICAL SYSTEM

The groundwater generally flows from the groundwater-mound at the southern part of the catchment area to the north and also to the northeast into the nearby Drainage and Irrigation Department (DID) drain (Fig. 6).

The flow directions of the groundwater in the catchment area very according to the height of the water-level. Variations of water-level are dependant on the recharge - discharge relationship of the catchment area.

There are basically three distinct patterns in the flow directions of the groundwater in the catchment area. When a large groundwater - mound, with a water-table of greater than 2.7 m at monitor well MW5, develops in the southern part of the catchment area; then the groundwater flows to the north and to the drain, northeast of the area (Fig. 6). As the water-level drops, a localised groundwater - mound is found around production well PW9 and groundwater flows away in all directions expect to the south (Fig. 7). During drier periods, and when the abstraction of water from the aquifer is maintained, the groundwater flows from the surrounding area into the catchment area (Fig. 8)

The distinct patterns described above illustrate the progressive change experienced from dry period in September 1987 to the wet period in May 1988, and the intermediate situation in July 1988. From these observations, the need to monitor the groundwater levels cannot be overemphasized to avoid contaminated or poor quality water from outside the catchment area to flow into the production well areas.

GROUNDWATER RECHARGE

Recharge of the groundwater in the catchment area is mainly from precipitation and groundwater inflow. Table 1 shows, besides other details, the total available recharge throughout the monitoring period.

Table 1: Summary of the development of Groundwater Resources, Belawai Water Supply.

	Abstraction m^3/d	Tot. Available Recharge m^3/d	Total Discharge m^3/d	Diff. In Aquifer Storage m^3/d
1987				
Sep.	483	1822	3216	−1394
Oct.	471	7547	3615	3932
Nov.	505	5166	3762	1404
Dec.	400	4365	3308	6057
1988				
Jan	405	9821	2790	7031
Feb	476	3148	3384	−236
Mac	460	6833	3473	3360
Apr.	462	4512	3595	917
May.	495	6020	4761	1259
June	493	2629	3568	− 939
July	499	2999	4153	−1154
Aug.	473	5094	5106	− 12

The precipitation and water-level data were plotted to study the recharge - discharge behaviour in the catchment area. The precipitation data were collected from the rain-gauge at the treatment plant and the water-level was recorded by a Stevens Continuous Water Level Recorder installed at monitoring well MW1. From Figures 9 and 10, the magnitudes of the water-level change is not similar for different rainfall intensities, but the response time of the rise in the water-level due to the recharge from precipitation was generally short. This suggests that the rainwater reached the water-table almost immediately.

Figure 9 shows the water-level and rainfall data during the monitoring period of August and September 1987. There was occasional rain during this month. As shown in the figure the water-level dropped continuously between 29th August to 11th September 1987. This fall is generally attributed to the extraction of water from the production wells. The daily rise in the water-level during this period was at night when there was no pumping, and the effect of the inflow is reflected during such times. From the monitoring period of October and November 1987 (Fig. 10), the catchment area experienced more recharge mostly, from the rain. The rise in the water-level on the 18th and 19th of October, 1987 is due to contribution from groundwater inflow.

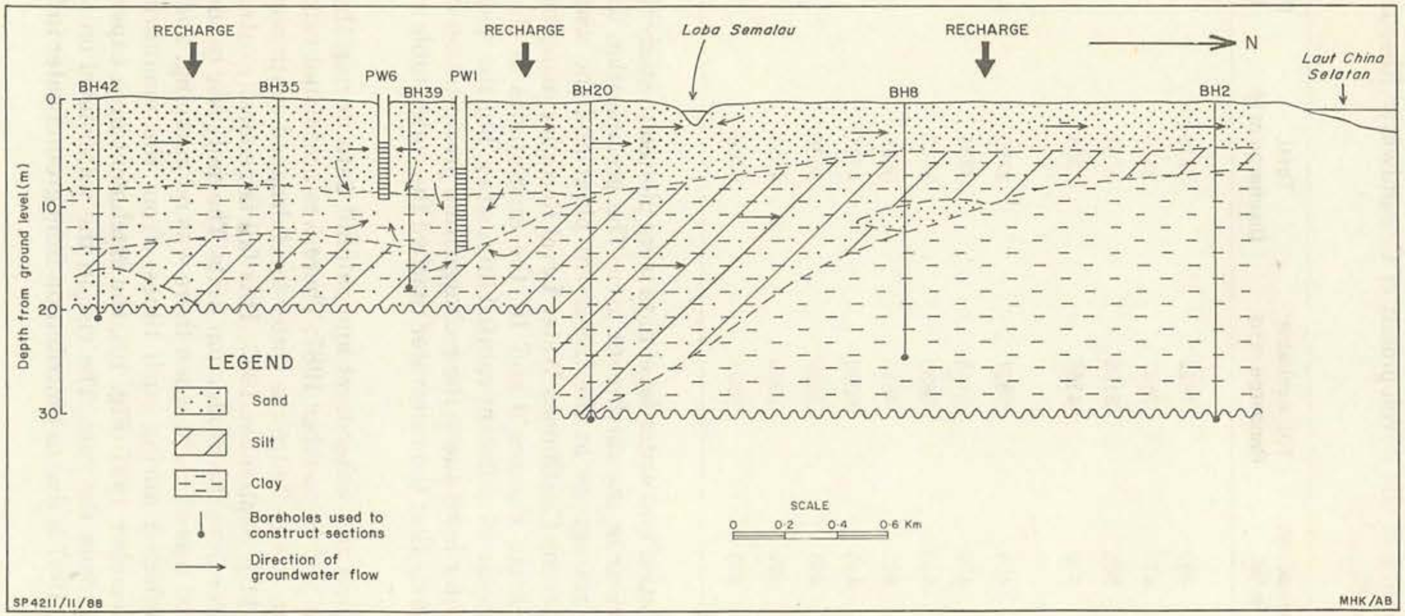

Figure 4 : Cross - section of the Belawai Area with general movement of groundwater.

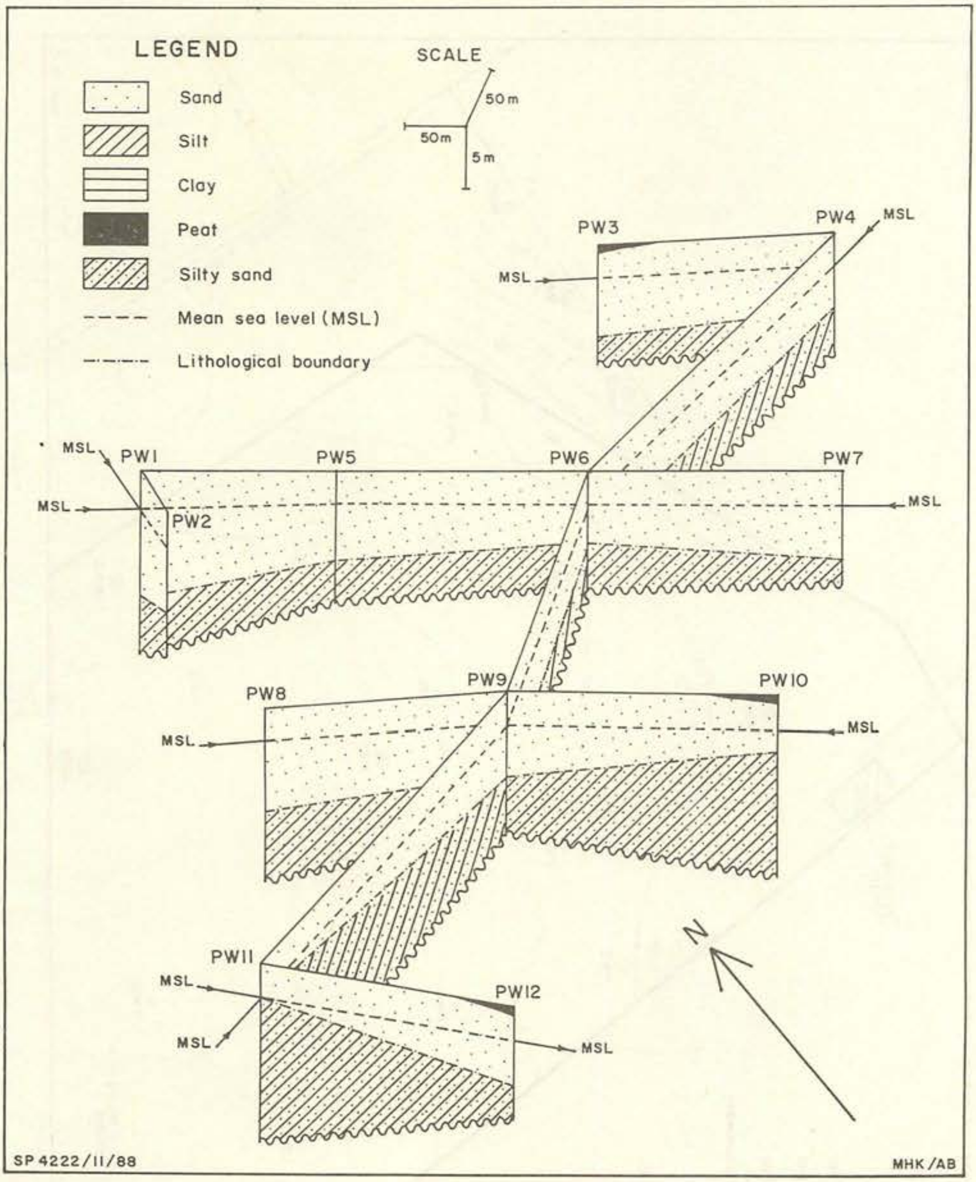

Figure 5 : Isometric fence diagram showing the subsurface geology of the Belawai Water Supply Catchment Area.

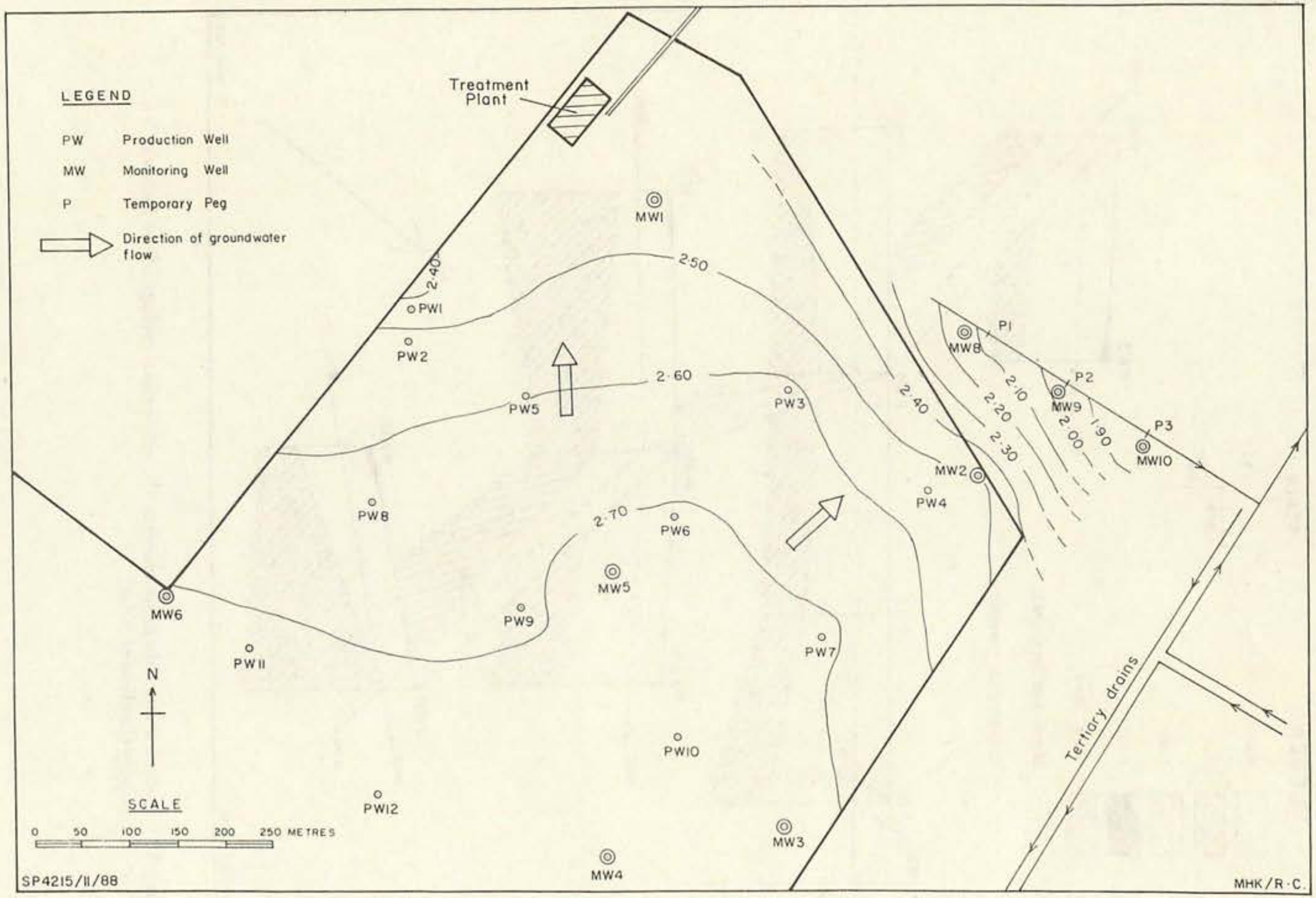

Figure 6 : Belawai Water Supply static groundwater level as on 14.5.1988.

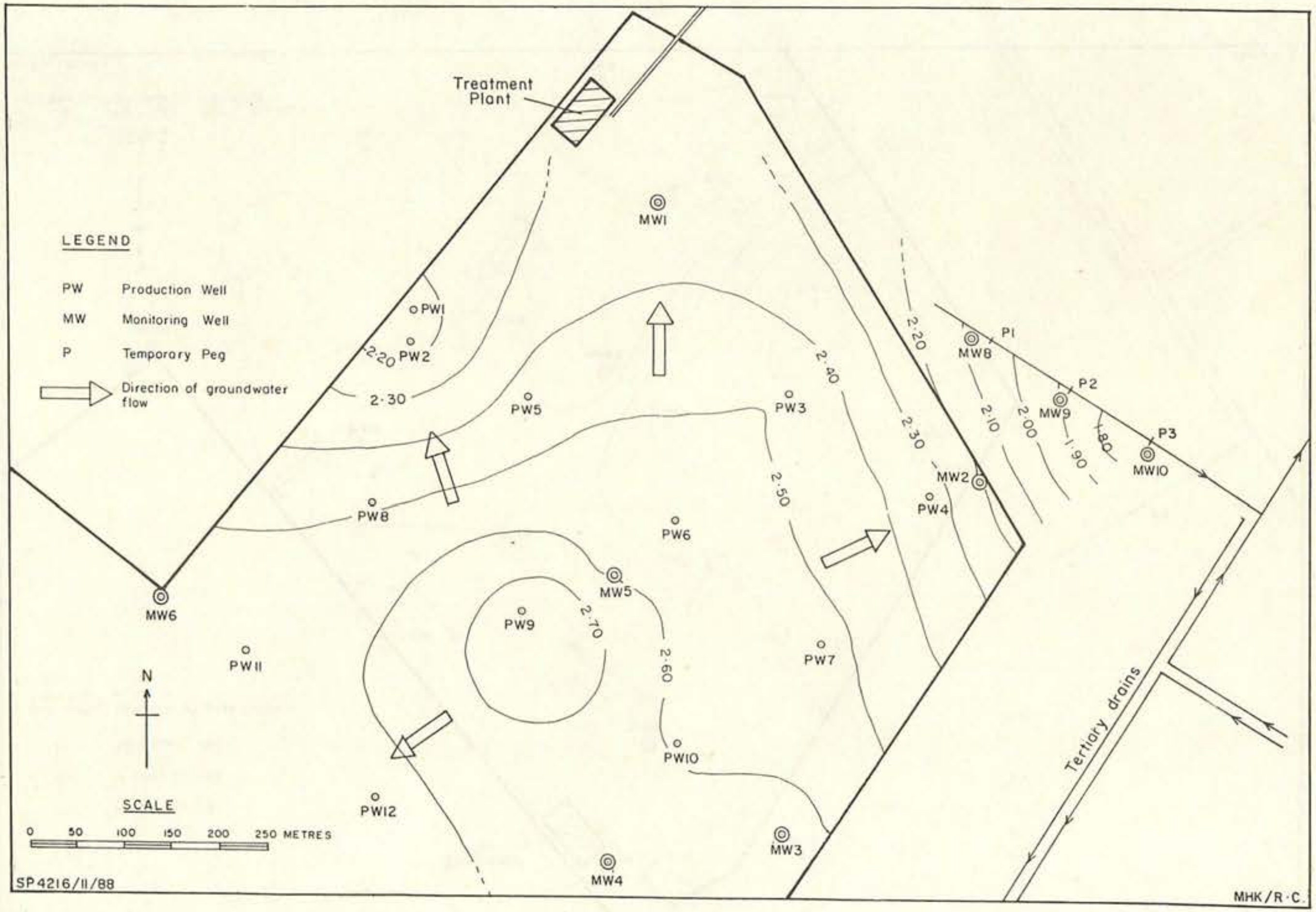

Figure 7 : Belawai Water Supply static groundwater level as on 15.7.1988.

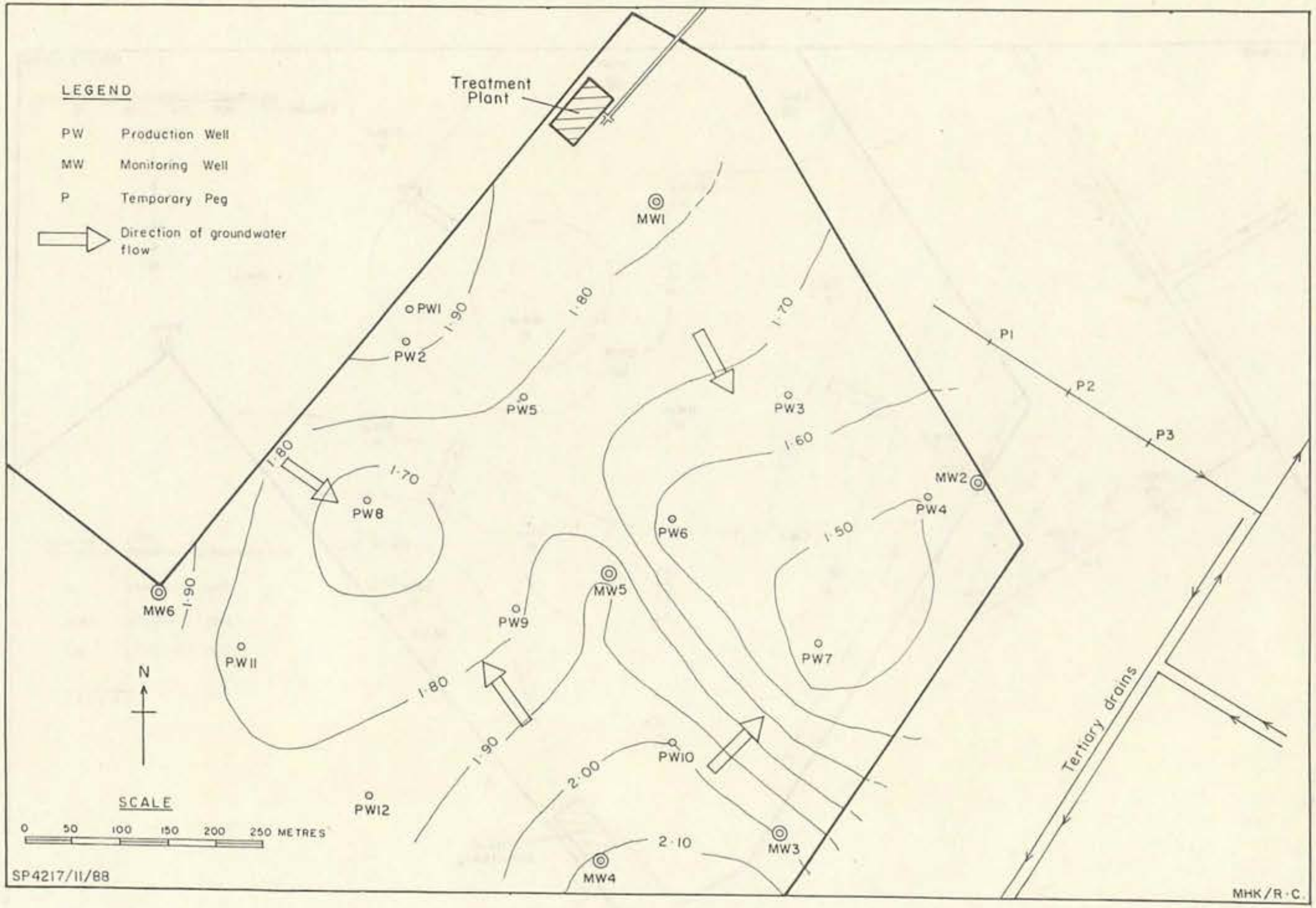

Figure 8 : Belawai Water Supply static groundwater level as on 18.9.1987.

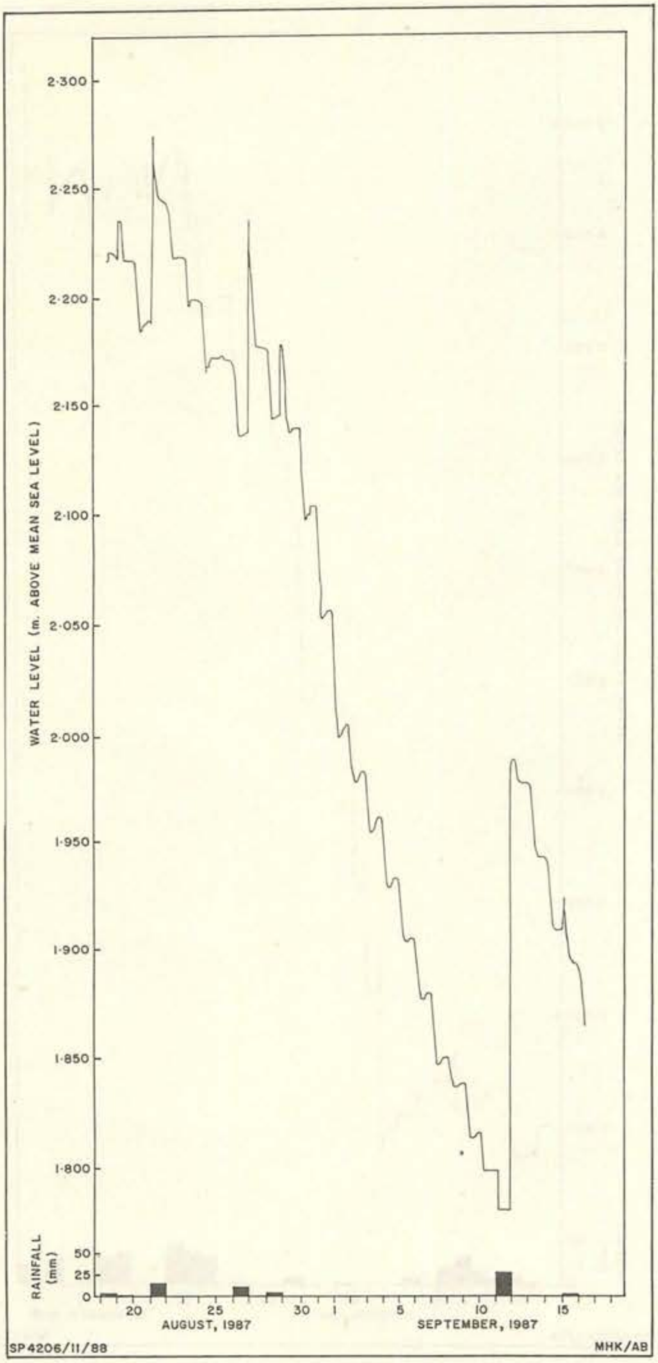

Figure 9 : Relationship between rainfall data and water-level record during August-September 1987 monitoring period.

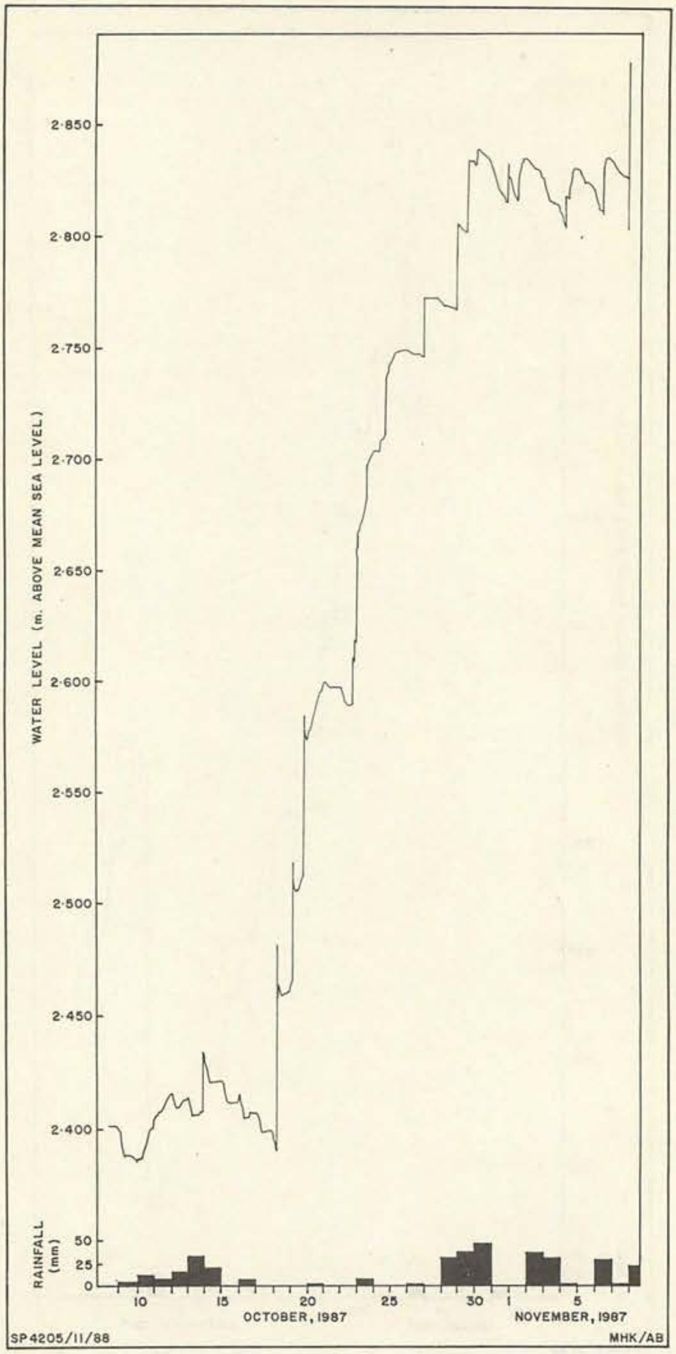

Figure 10 : Relationship between rainfall data and water-level record during October-November 1987 monitoring period.

GROUNDWATER DISCHARGE

Groundwater in the catchment area is discharged mainly by the abstraction of water from the production wells, evapotranspiration, groundwater outflow and surface drainage.

Table 1 shows the rate of abstraction of the groundwater during the monitoring months. The abstraction rates were quite similar except during drier months and during festive seasons when more water was needed. The average abstraction rate was $469m^3/d$. The relationship between the monthly total available recharge and the total discharge is shown in Figure 11. For five months the amount of discharge was more than the available recharge, especially during the drier months of August 1987, January, May, June and July 1988.

The relationship between the water level measured at monitor well MW5 and the abstraction rate is shown in Figure 12. The water level showed a prominent inverse relationship with the abstraction rate during the dry season, but this relation is masked by high recharge during the wet season.

VARIATION IN AQUIFER QUANTITY AND QUALITY

From the contours of the difference in the water-levels between two consecutive months, it was observed that there are some variations as pumping pattern changes. These variations depend not only on the amount of water being pumped from individual wells but also on the initial groundwater level of the catchment area.

From the contours of the difference in water-level for June and May 1988 (Fig. 13), it is clear that substantial amount of water was taken out at the eastern and western corner of the catchment area. This this was due to the large volume of water being abstracted from wells PW2, PW8, PW11, PW10 and PW7. By plotting the difference in water-levels, the management was able to react immediately and wells PW6 and PW9 were pumped in order to distribute the impact of pumping to the whole of the catchment area.

Due to the initial existing low water-level around PW9 and PW10, the difference in water-levels for April and March 1988 (Fig. 14) showed a depression around these two wells even though all wells were pumped uniformly.

Figure 15 shows the contours of the difference in water-level for January 1988 and December 1987, where only the wells on the northern half of this sector of the catchment area had been utilised to extract large volume of water. The effect of the DID drain can also be seen by the steep gradient of the water-table in that area of the catchment area.

From the contours of the difference in water-level for May and April 1988 (Fig. 16), it can be seen that the water held in storage has increased as there

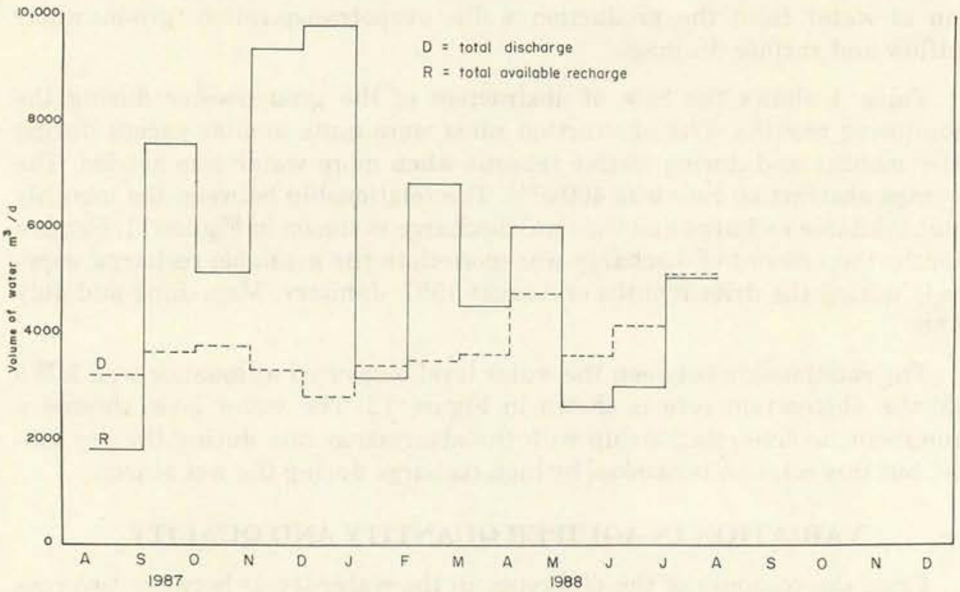

Figure 11 : Discharge - recharge relationship of Belawai Water Supply.

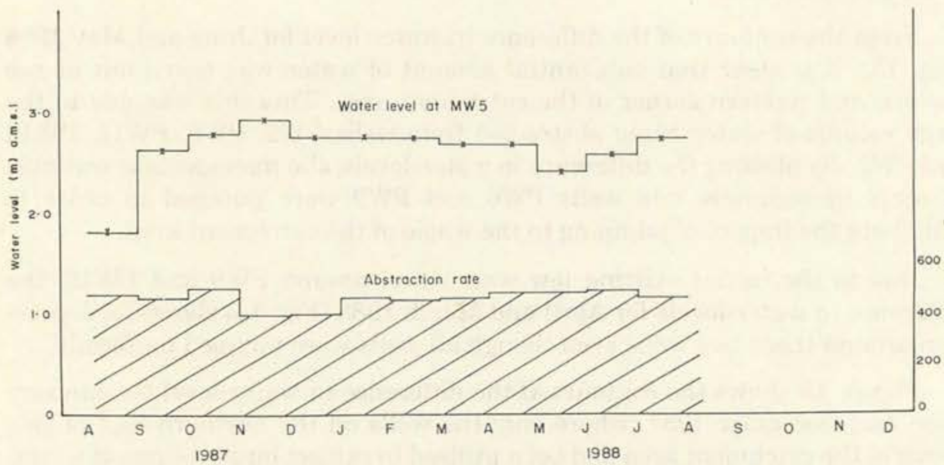

Figure 12 : Abstraction rate and water-level at MW5 in Belawai Water Supply Scheme.

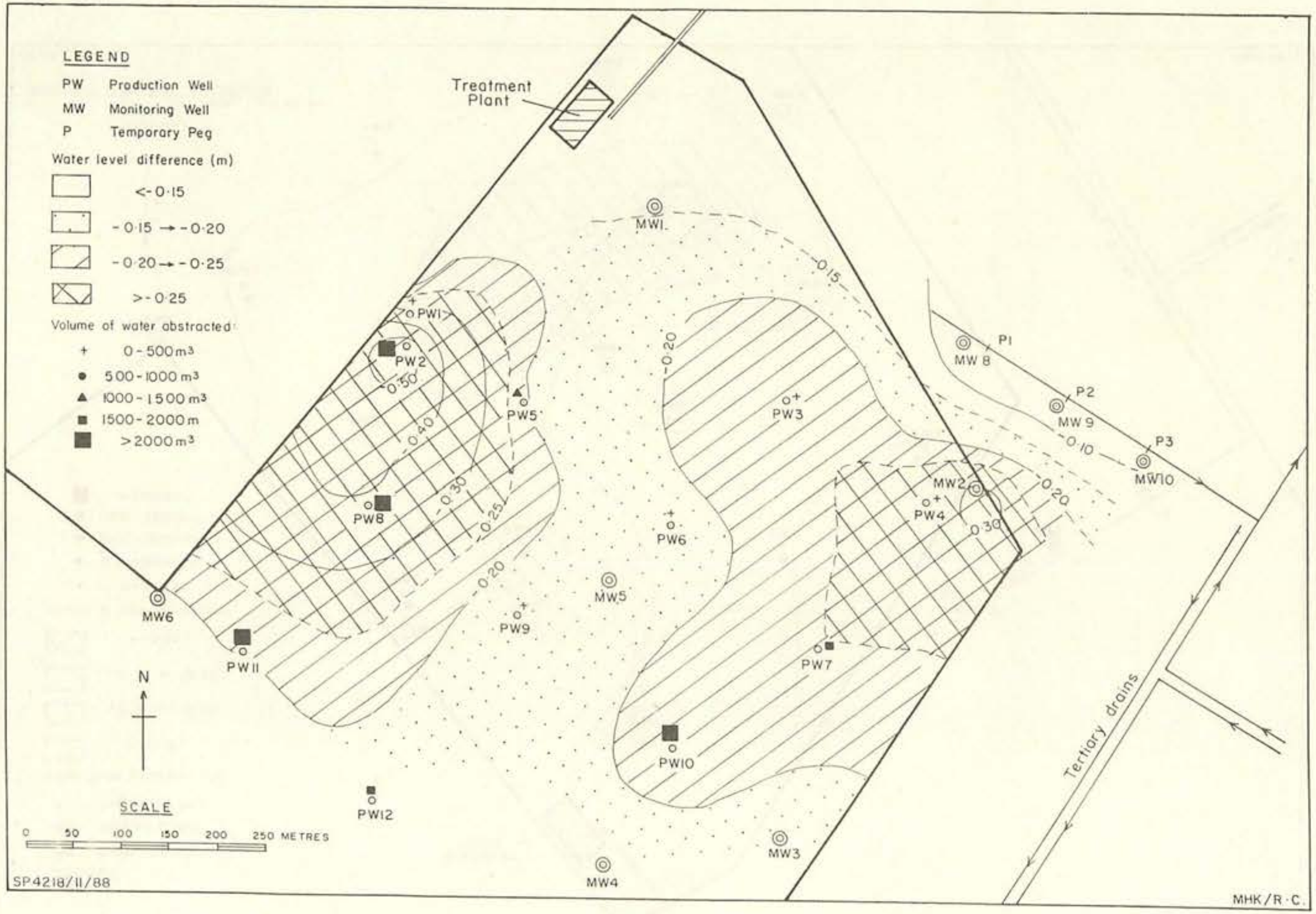

Figure 13 : Belawai Water Supply: Water-level difference June - May 1988.

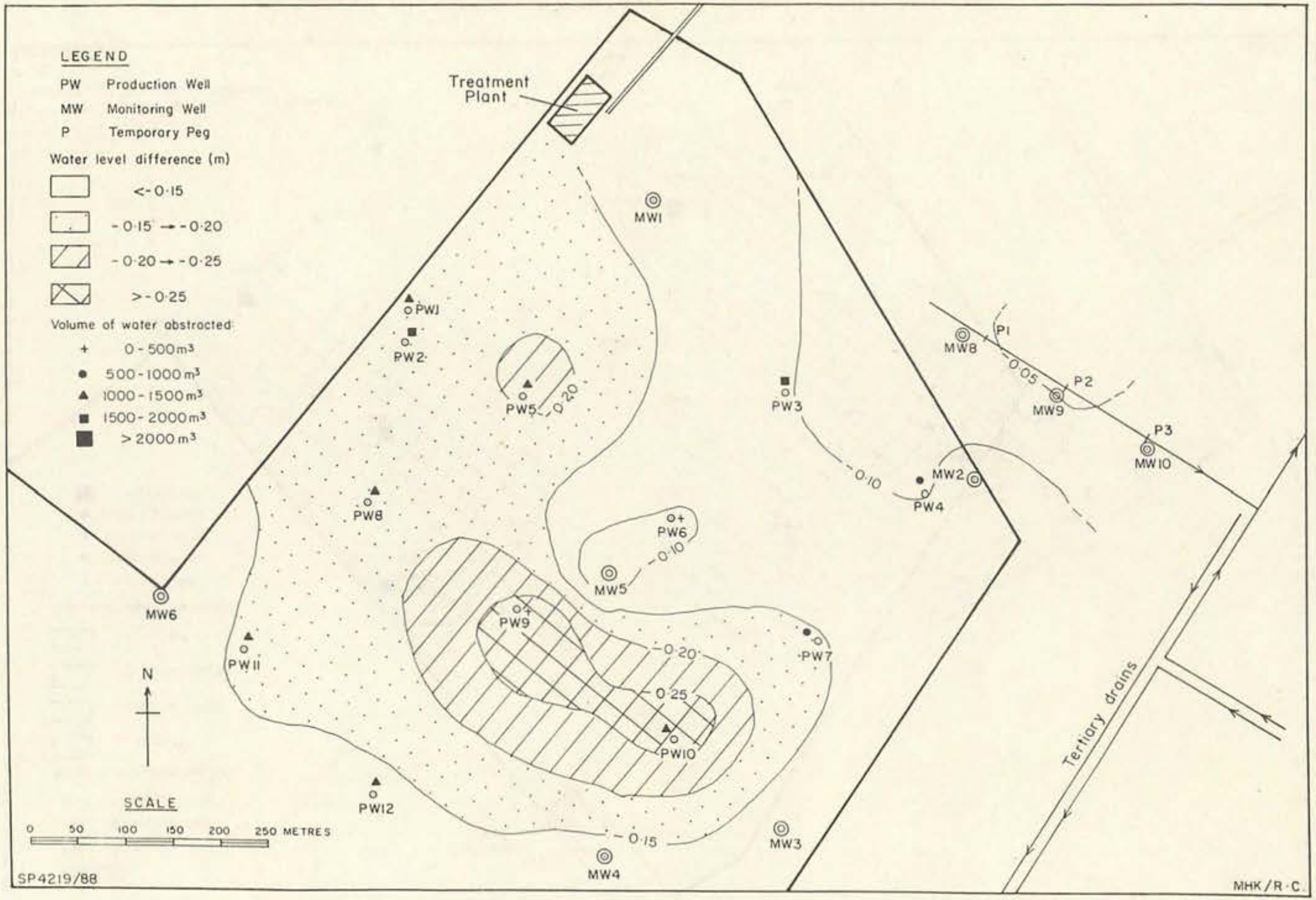

Figure 14 : Belawai Water Supply: Water-level difference April - March 1988.

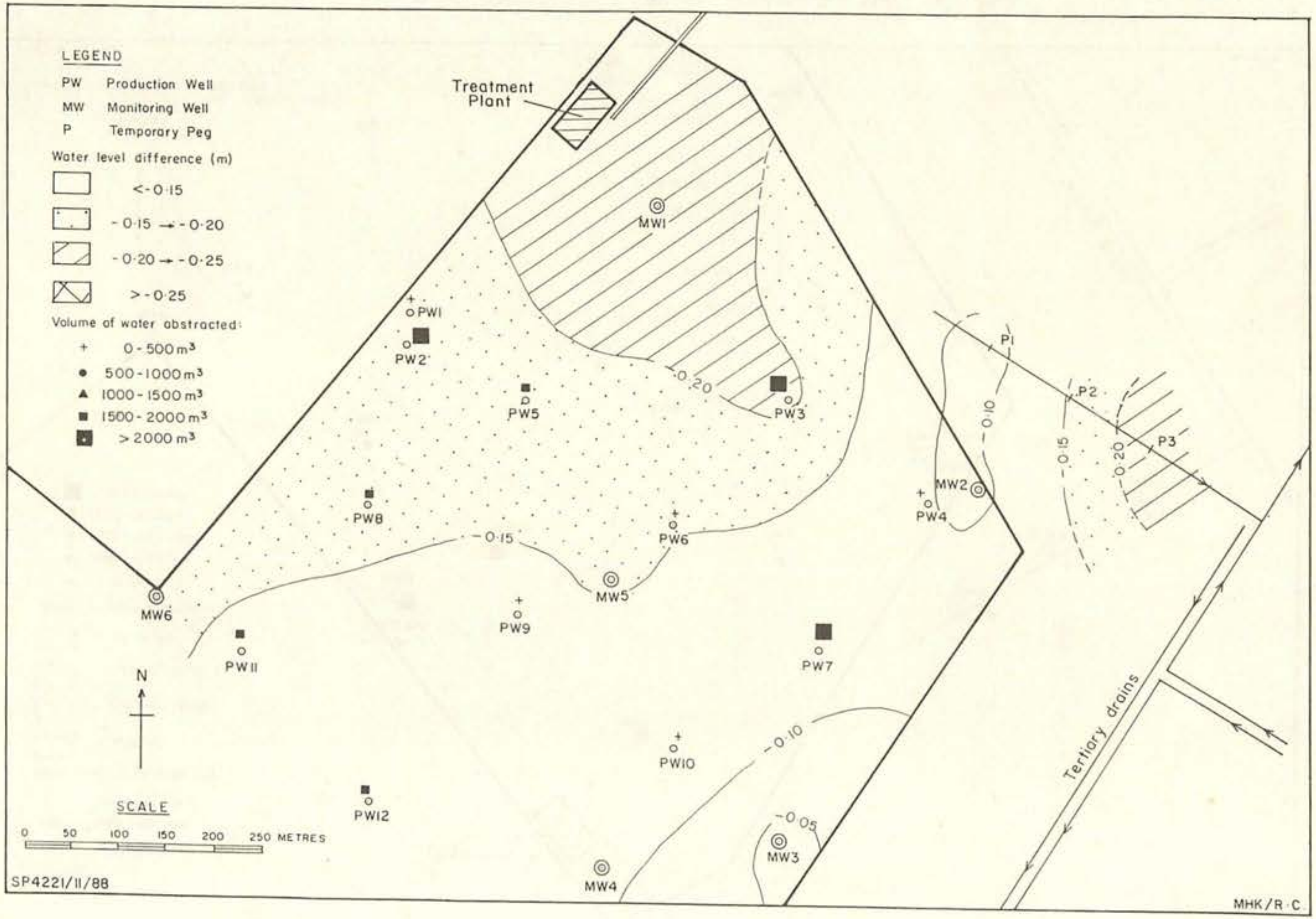

Figure 15 : Belawai Water Supply: Water-level difference December 87 - January 88.

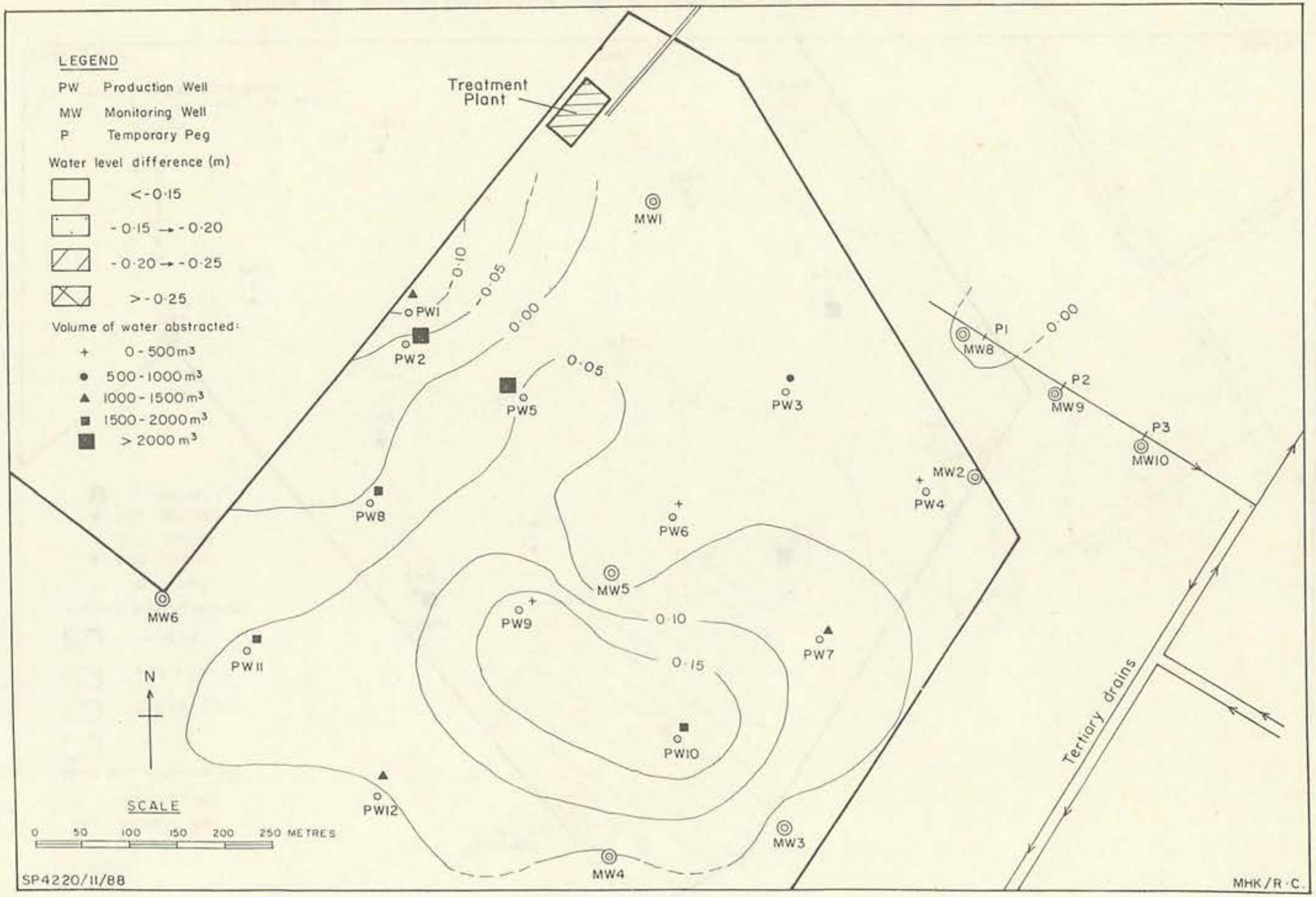

Figure 16 : Belawai Water Supply: Water-level difference May - April 1988.

was a rise in the water-levels. The only exception was the area surrounding production wells PW1 and PW2. where more water was pumped. Similar results would be obtained for those months which have rainfalls higher than the rainfalls of the preceeding months.

The quality of water from the aquifer varies at every well as well as at different months. Figure 17 shows the variation of the chloride content at well PW2 with respect to the average amount of the rainfall for the period of August 1987 to July 1988. The value of the chloride content varied from 2 to 75 ppm. It shows that there is an inverse relationship between rainfall and chloride values of the groundwater from the aquifer. Generally the value of chloride content varied from <1 ppm to 680 ppm. Well MW6 and occasionally wells PW1 and MW7 had chloride values greater than 200 ppm. The higher chloride values are due to the presence of connate water around these wells.

The values of the total iron of all the wells vary from 3.1 to 26 ppm. Wells PW11, PW12 and MW4 were having values between 22 to 26 ppm.

The range of total solids is from 62 to 1734 mg/1. Wells MW6 and MW7 had total solids greater than 1000mg/1, whereas wells PW1, PW11, MW4 and MW7 had value for total solids ranging from 600 to 1000 mg/1.

Using a trilinear diagram plot, the variation of the overall quality of groundwater in the Belawai Water Supply area can be demonstrated quite effectively. Generally, the quality drifted from 'not satisfactory' to 'good' as the amount of available recharge was increased. Figure 18 shows the general behaviour of the groundwater quality based on information obtained from two months having a large difference of total available recharge. The total available recharge was the lowest in September 1987 (1822 m^3/d), and was the highest in January 1988 (9821 m^3/d). The groundwater in September 1987 may be classified as a calcium - sodium - chloride - bicarbonate water but, as available recharge was increased as in January 1988, the groundwater becomes a calcium - sodium - bicarbonate water.

CONCLUSION

From the systematic monitoring programme of the Belawai Water Supply Scheme, variations of some groundwater characteristics were observed.

The shallow unconfined aquifer of the Belawai Water Supply catchment area is sensitive to its recharge - discharge behaviour. During dry period, continuous monitoring is necessary so as to avoid problems such as saline water encroachment and pollution of the aquifer. The pumping pattern has to be monitored to avoid excessive pumping in certain areas of the catchment area.

The monthly abstraction rates are quite similar and are sufficient for the

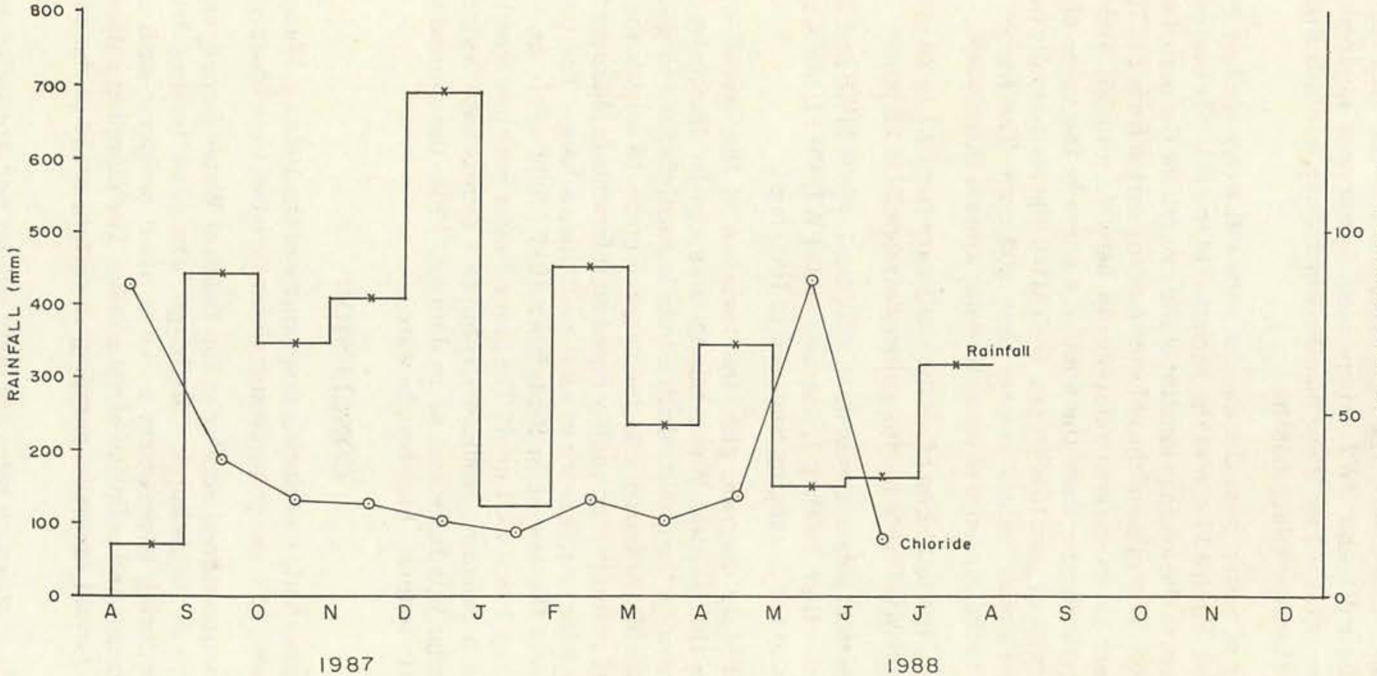

Figure 17 : Relationship between rainfall and chloride content at PW2.

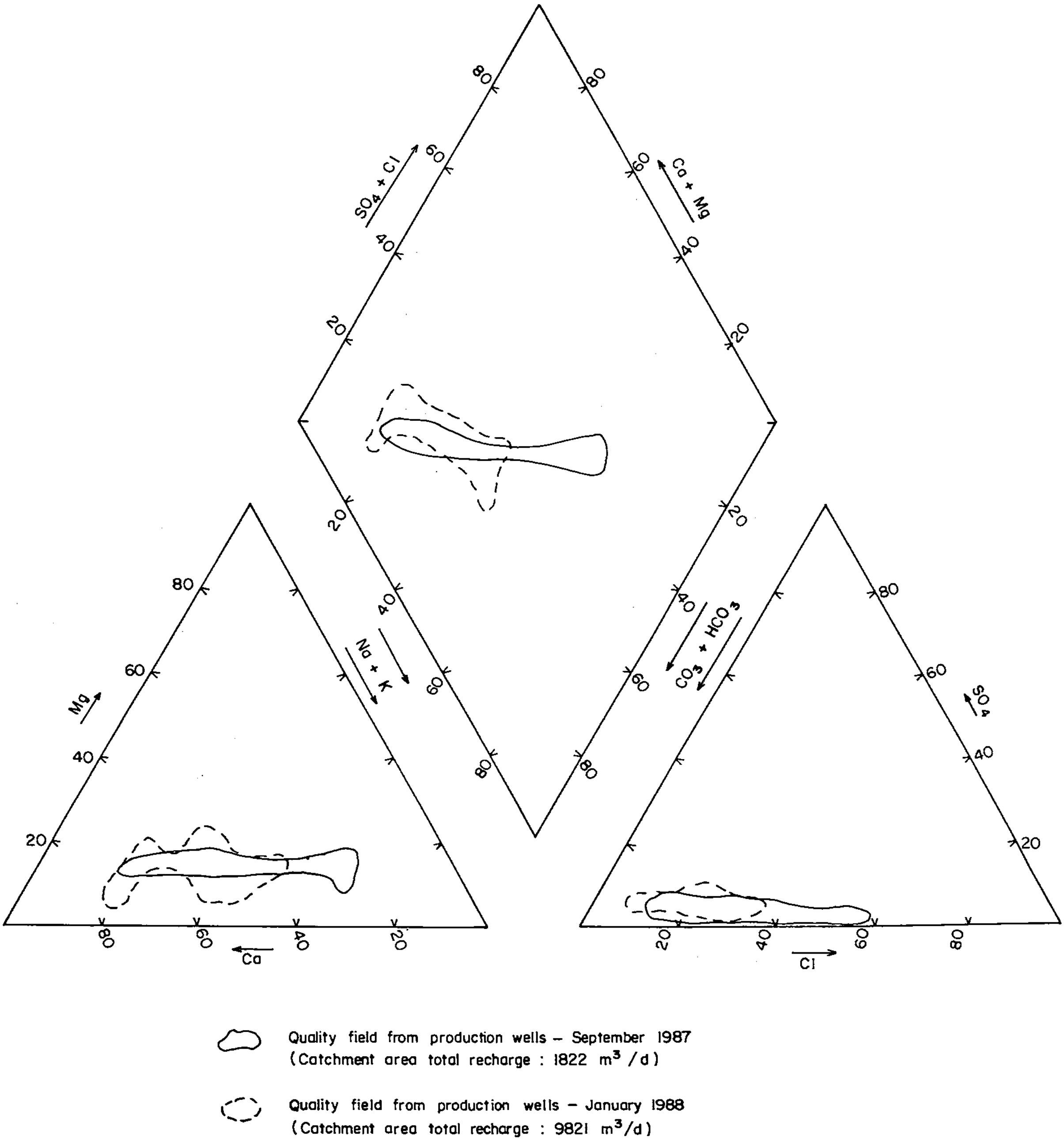

Figure 18 : Trilinear plot of hydrochemical data for two extreme conditions in Belawai Water Supply Catchment Area

present domestic needs. Though the quality of the groundwater varies with the seasons, it still is suitable for the domestic use.

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