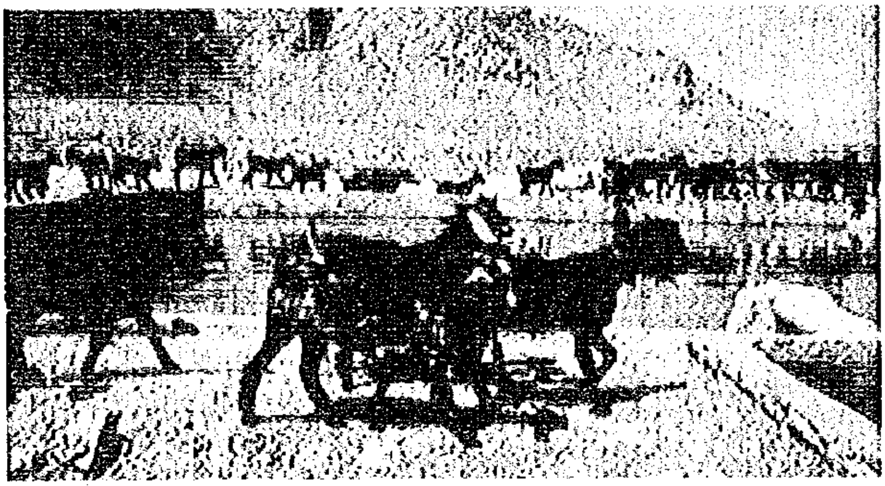
Annex C
Groundwater



ANNEX C

GROUNDWATER

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ANNEX C GROUNDWATER

C.1 GENERAL

The groundwater levels in Pishin Lora Basin are going down year by year due to increased utilization of water for urban and agriculture water supply so that the resource may have become a potential threat to these valleys.

Groundwater monitoring had been carried out occasionally at some existing dug-wells and tubewells from the 1970s in Pishin Lora Basin from the view point of groundwater mining. However, because excessive pumping up made it rapid drawdown, the government of Balochistan and its relating organization have done the measure relatively in detail and systematically from the end of the 1980s to grasp the tendency of the groundwater level change in the following important Sub-Basins in view of groundwater conservation.

Quetta Northern Sub-Basin

Mastung Sub-Basin

Mangocher Sub-Basin

Main monitoring sites were situated at total 15 locations, out of which 10 in Quetta Northern, 4 in Mastung, and 1 in Mangocher Sub-Basin. The observation data of monthly basis and/or daily basis from 1989 at these 15 locations are available. Seasonal-basis data are also available during these periods at the other observation points continually.

According to those data, the fluctuation of the groundwater level in the respective sub-basins shows the respective characteristics. Even in one sub-basin, It can be distinguished and classified into some patterns. Respective situations of the sub-basin regarding Pishin, Quetta (Northern) and Mastung are as mentioned under.

In the other sub-basins, the groundwater monitoring has not been carried out well.

C.2 TENDENCY OF GROUNDWATER LEVEL CHANGE IN THE RESPECTIVE SUB-BASIN

To ascertain the tendency of groundwater level changes in respective Sub-Basins, first dividing respective Sub-Basins into some areas according to some features such as topography, hydrogeology, location of aquifers, and the groundwater using condition, etc., the graphs of groundwater level changes expressed in each divided area.

Fig.C.1 to Fig.C.3 show the general tendencies of the groundwater level change making the monitored data smooth by moving average method, out of which Fig.C.1 shows the tendency of the groundwater level change in Pishin Sub-Basin, Fig.C.2 Quetta Northern, Fig.C.3 Mastung.

(1) Pishin Sub-Basin

Groundwater table in the zone along the Pishin Lora and its tributaries is usually shallow. In the case it is in deeper aquifers in the valley floor, however, piezometric heads are semi-artesian conditions. The zone in the foot hill areas of right flank of the valley is usually deep in water table condition. This zone is main recharging area to the groundwater reservoir through direct infiltration. The sub-surface inflow is restricted to the left flank of the valley. The reservoir is recharged from Kuchlagh area through two gaps in the Ajram Ghar range.

As shown in the Fig.C.1, it is classified approximately into the following four regions.

i) Western Foot Slopes and Piedmont

ii) Northern and North-Eastern Piedmont

iii) South-Eastern Piedmont

iv) Center of Valley Floor

In the case i), Western Foot Slopes and Piedmont mean the area along the foot slopes of mountain chains from Killi Habib of south Qila Abdullah to south-west side of Gulistan Town. The monitoring data show the continual declining of groundwater level uniformly in this region. The rate of drawdown during six years from 1987/88 to 1993/94 is 2 to 6 meters.

One monitoring datum shows 10 meter's drawdown during the first two years.

This area has the Loe Darra and Roghanai Manda, etc. which flow from the western side to Gulistan area. However the scale of piedmont formed by these river-flow is small and groundwater may not be recharged so much.

However, water may utilized for irrigation, drinking, etc. in its own way rather more than the recharging ratio by some villages and towns scattering around.

In the area of Northern and North-Eastern Piedmont (case ii)), groundwater level was falling down a little less than 5 meters during 14 years from 1976 to 1990, though it can't be mentioned accurately because of the lack of the data between 1977/78 and 87/88. After that, however, groundwater levels turn into rising, and show about 10 to 13 meters up during 3 years between 1990 and 1993, and then their fluctuation settled relatively.

It is considered there are so many cases around observation wells, showing recovered groundwater level temporarily and partially because the pumping up from wells had been stopped in some reasons. To avoid these kind of temporal and partial water level change caused by stopping pumping up not showing actual wide-range groundwater level change, we picked up the data during 2 years from 1992/93 to 94/95 and analyzes them. Though partly they show the area (Northern piedmont) groundwater level rising, groundwater level change per annum shows not so large comparing to the case during 6 years from 1988/89 to 94/95. The area groundwater level rising may be influenced by Delay Action Dams and so on.

This area is located in the wide and large scale of piedmont slopes made of outflow by Pishin Lora and Barshora Lora at the outlet of mountains or by the right flank branch such as Togha Manda, and in the area of the upstream of K.K.Bund. The area is usually highly permeable so that the groundwater may be recharged easily through them. This may be due to groundwater is recharged by some effective method.

South-Eastern Piedmont is located around Pishin Town (case iii)), and geologically Subrecent deposits are extent widely. The groundwater level change in this area has the relatively same tendency as Northern and North-Eastern Piedmont, however, the ratio of rising and falling are small. From 1976 up to 1990, it didn't change so much, and raised as the same manner of the area mentioned at ii) about few meters during 1 to 3 years, and then stabilized. It may be caused the same reason as the area ii, however its influence may little.

The area of Center of Valley Floor (case iv)) shows very little groundwater change which is only around 1 meter fluctuation during 20 years from 1977 up to date. Aquifer is existing very few in this area, then groundwater have not been exploited so much. Even if the aquifer existed, it may be confined and not influenced so much by the change ratio of the other areas.

(2) Quetta Northern Sub-Basin

Fig.C.2 shows the monitoring result after 1988 in the Quetta Northern Sub-Basin. According to this result, the sub-basin can be divided into Southern, North to North-Eastern, and Mid-area, and further following seven areas.

i) Landi ~ Mian Ghundi ~ Western Piedmont

ii) Landi ~ Mian Ghundi ~ Eastern Piedmont

iii) Lower Karez (Eastern Piedmont)

iv) Western Piedmont ~ Sariab Lora

v) Hanna River ~ Baleli Gap

vi) River Side in Valley Floor

vii) Mountain Side in Valley Floor

Southern Piedmont is from Landi ~ Mian Ghundi to east or west piedmont, which is composed of highly permeable wide aquifer. Though the tendency is a little different from each other, the groundwater level is declining continually, and the ratio of drawdown may be gradually increasing year by year. Total drawdown is 7~8 meters to ten and few meters during 8 years from 1988 to 1996. (case i) - iv)).

In North and North-East Piedmont along Hanna-Urak River, highly permeable alluvial fan deposits extent very widely, and like the area i) continual drawdown of groundwater level is recognized. Total drawdown during 8 years from 1988 to 1996 is ten and few meters. (case v)).

In the area of from i) to v), the excellent aquifers exist, and groundwater may have been exploited actively. Remarkable drawdown in these areas reflects of this result, because much higher quantity may have been pumped up from ground than recharge.

While, vi) to vii) show very little groundwater change, and it is rather said that groundwater is rising, though its ratio is very little. The scale of aquifer in this area is small, so that groundwater would not exploit so much. Due to aquifer in this area is usually confined, fluctuation may be reduced remarkably. Rising of groundwater level may be caused by the result of infiltration through the area by irrigation water or domestic sewage water, etc.

(3) Mastung Sub-Basin

Fig.C.3 shows the monitoring result in the Mastung Sub-Basin from 1988. The classification of the tendency of groundwater level change in the Mastung Sub-Basin is according to the depth of aquifer and divided into the following two.

i) Kad Kocha Area

ii) Around Pringabad Town

iii) Northward of, Southward of, and Around Mastung Town

The monitoring result shown in the graph of Kad Kocha Area (case i)) is confined deeper aquifer. Their depth to piezometric level is between 30 and 60 meters. Totally Groundwater level declines relatively in large ratio which reaches 10 or ten and few meters during 8 years from 1988 up to date.

The monitoring result shown in other four graphs may be shallower unconfined aquifer of which depth to water level is between 10 and 20 meters. The most of all has same tendency. Water level of the shallower aquifer shows also generally continual declining, however their drawdown is in the small range of between one to few meters during 8 years from 1988 to 1966.

C.3 GROUNDWATER ANALYSES ACCORDING TO THE GROUNDWATER MONITORING

Monitoring studies of Quetta, Mastung, and Mangocher Sub-Basins carried out by WAPDA and UNDP in the early stages have been succeeded to Balochistan Bureau of Water Resources (so-called Water Bureau) which was established as a section of Irrigation Department, so far. Monitoring is now going on adjusted and computerized as data-base by them including Pishin Sub-Basin.

In the study of Irrigation Water Resources Development with Delay Action Dams, Quetta Northern, Mastung and Pishin Sub-Basins are the most concerned.

In this section, according to these data-bases cooperated by courtesy of Water Bureau, it is tried to compute the deficit rate from recharge into to discharge from the respective groundwater basin in the most concerned Sub-Basins to this study.

--- Change of Groundwater Level in Pishin, Quetta Northern, and Mastung Sub-Basin

Monitoring locations of Pishin, Quetta Northern, and Mastung Sub-Basin are shown in Figs. C.5, C.10, and C.16 respectively. Applied groundwater levels at the same times at respective sites calculated from the moving average fluctuation (taking the moving average of one year) and the respective changes of groundwater level are shown in Tables C.1 to 3. However, because of the shortage of data, the standard dates are extracted from groundwater contour maps existing in the appropriate report or publication issued by WAPDA {1975/76 fiscal year for Pishin Sub-Basin (this is the latest one available as the standard), 1985/86 fiscal year for Quetta Northern Sub-Basin, and 1977/78 fiscal year for Mastung Sub-Basin}. The standard elevation of or depth to the groundwater level has been read from the above contour maps at respective observation locations. As far as Mastung Sub-Basin concerned, after securing the enough duration to a certain extent, and comparing the changes between 1977/78 and 1985/86 fiscal year, the data of 1985/86 have been taken as the standard groundwater level to get higher reliability.

The elevation and the change of groundwater level are shown in Figs.C.6 to 8 for Pishin Sub-Basin, C.11 to 15 for Quetta Sub-Basin, and C.17 to 21for Mastung Sub-Basin from the above analyses.

C.4 REGIONAL CHARACTERISTICS OF THE CHANGE OF GROUNDWATER LEVEL

(1) Pishin Sub-Basin

i) Altitude of Groundwater Level at 1994/95

Altitude contour map of groundwater level at 1994/95 is shown in Fig. C.6.

Groundwater elevation is gradually going down from East to West or South-West generally. Among their tendencies, some remarkable characteristics can be described as under.

First, the hill range and its extension composed mainly of Bostan Formation divide the groundwater basin largely into the upstream and the downstream side.

Bostan Formation is composed mainly of impervious material so that it may shape the barrier to groundwater flow like as underground dam.

In the upstream side, though the hydraulic gradient is relatively steep around the piedmont, it is rapidly reduced near side of this hill range. Hydraulic gradient becomes again steep, after that it becomes gentle again along the hill range. The further proceeding to the downstream side, the more gentle the groundwater level.

Second, groundwater in the downstream side is not flowing along exactly same direction as Pishin Lora, but first flowing to western piedmont ward and then bending its flow direction into the main stream of Pishin Lora. This is why the drawdown rates in the western piedmont are very large comparing to the eastward.

ii) Change of Groundwater Level

--- Characteristics

It can be mentioned as under as shown in Fig. C.1.

The groundwater level in the western piedmont and their down-reaches is going on drawing down consistently from 1975/76 resulting around 10 meter's drawdown in the piedmont and 17 to 18 meter's drawdown in the down-reaches during 19 years.

In the northern and the north-eastern piedmont, those have been rapidly drawing down during the first 13 years resulting the observed maximum value is almost 13 meters. After that however, the groundwater level turns to rising resulting the observed maximum value is almost 13 meters during 6 years by 1994/95.

Though the tendency in the south-eastern piedmont is same as the northern and the north-eastern piedmont, their rate is much lower than them, namely, the observed maximum drawing down during first 13 years is 4.5 meters, on the contrary 1.3 meters rising during 6 years after that.

From the down reaches of valley floor to hill range of Bostan Formation, the groundwater level changes very little.

--- Change during 13 years from 1975/76 to 88/89

The contour map of groundwater level change during 13 years from 1975/76 to 88/89 is shown in Fig. C.7. The nearer to the piedmont slope from the central area of valley floor, the larger drawdown the groundwater level. The maximum observed drawdown is almost 13 meters in the northern piedmont, 7 meters around the way out of Pishin Lora from mountain to piedmont, and a little less than 5 meters in the western piedmont.

--- Change during 6 years from 1988/89 to 94/95

The contour map of groundwater level change during 6 years from 1988/89 to 94/95 is shown in Fig. C.8. In the westward from the central area, those show the same tendency as before. On the contrary, those in the northern to the north-eastern piedmont turn to rising resulting more than 6 meters rising generally in the piedmont. In the case of the south-eastern area, those are very little drawdown of less than 1 meter during 6 years.

--- Change during 2 years from 1992/93 to 94/95

The contour map of groundwater level change during 2 years from 1992/93 to 94/95 is shown in Fig. C.9. This analysis was carried out to avoid temporal and partial water level change caused by stopping pumping up not showing actual wide-range groundwater level change. Though partly they show the area (Northern piedmont) groundwater level rising, groundwater level change per annum shows not so large comparing to the case during 6 years from 1988/89 to 94/95. The area groundwater level rising may be influenced by Delay Action Dams and so on.

(2) Quetta Northern Sub-Basin

i) Altitude of Groundwater Level at 1994/95

Altitude contour map of groundwater level at 1994/95 is shown in the Fig. C.11.

All groundwater flow in this Sub-Basin, part of which is from South to North (along Sariab Lora) and from East to West (along Hanna-Urak River) is absolutely drained to Baleli Gap.

It is largely divided into the following three areas according to the gradient of the groundwater level.

First, the area from the southern to Quetta city, groundwater is flowing to Sariab Lora at first, and then directing to the northward. Generally their hydraulic gradient is very gentle due to much discharge causing great drawdown in the upper stream. On the contrary, those in the downstream side are not so significant. As a result, the hydraulic gradients become more gentle relatively year by year.

Second, the area from Baleli Gap up to 7 to 8 km upstream side, the hydraulic gradient is also very gentle. Generally this area is recharged from Hanna River abundantly, and simultaneously actively pumped up. Permeability in this area may be very good so that the influence of pumping up at some location may reach to large extent resulting groundwater level is keeping relatively even at any places. Active pumping up at many places cause the relatively rapid but even drawdown of groundwater level.

Third, the area between the above two areas, the hydraulic gradient is relatively steep due to rapid drawdown in the downstream, on the contrary not so much in the upstream side. As a result, the hydraulic gradient is going to steeper gradually.

ii) Change of Groundwater Level

--- Characteristics

It can be mentioned as under as shown in Fig. C.2.

Around the southernmost part of Sub-Basin (both eastern and western piedmont and Landi ~ Mian Ghundi), the drawdown ratio of the groundwater level is relatively large showing average approximately 1 meter along the western piedmont, and 0.5 to 1 meter along the eastern piedmont per annum.

That of the area around Hanna River to Baleli Gap is more remarkable showing approximately average 2 meters per annum.

While in the central part of the sub basin, generally the changes are very little, though partly showing the relatively large drawdown of groundwater level.

--- Change during 9 years from 1985/86 to 94/95

The contour map of groundwater level change during 9 years from 1985/86 to 94/95 is shown in Fig. C.12. Around the southernmost part (Landi ~ Mian Ghundi and both piedmonts), total drawdown during 9 years is more than 10 meters (the maximum nearly 13 meters). In the northward of Mian Ghundi, partly the drawdown is remarkable where may be closely connected with the pumping ratio in the area.

The drawdown around the area of Hanna River to Baleli Gap is very remarkable showing total 15 meters. Abundant groundwater is existing in this area and it has been pumped up actively from the early days resulting great drawdown.

The drawdown in the central part of the Sub-Basin is relatively small, though partly large where may be closely connected with the pumping ratio in the area.

--- Average Change during Respective 3 years of 1985/86 to 88/89, 88/89 to 91/92 and 91/92 to 94/95

Comparing to the above mentioned long-term change of groundwater level during 9 years, the tendency of relatively short-term change was checked dividing them into each 3-years. The results are shown in Fig. C.13 to 15. According to these results, it is said that they show the approximately same tendency each other, that is, the actively pumped up areas in the Sub-Basin are generally around both the northern and the southern areas, and in the area between them, the groundwater is scarcely existing, and difficult to be pumped up easily.

Drawdown ratio is generally high in the southernmost area, and the most remarkable area has been shifting gradually from both the eastern and the western piedmont to the area between Landi and Mian Ghundi. In the area toward North, remarkable drawdown area shift from some place to the other place where may be closely connected with of pumping up ratio. Drawdown ratio is gradually increasing year by year.

In the area around Hanna River to Baleli Gap, the drawdown during first three years was the maximum 4 meters, however, it increases more than 6 meters per three years recently. The largest drawdown area is shifting gradually from the upstream side to the downstream side which may be closely connected with the pumping up ratio.

(3) Mastung Sub-Basin

i) Altitude of Groundwater Table at 1994/95

Altitude contour map of groundwater level at 1994/95 is shown in the Fig. C.17.

All groundwater flow in this Sub-Basin is heading for the Gap between Mastung and Shirinab Sub-Basin. The hydraulic gradient in the southern area is very gentle due to probably the large drawdown around Kad Kocha caused by a lot of pumping up. That the contour lines go into the mountain side is also due to the result of the large drawdown especially in Kad Kocha area.

Except the above mentioned area, the contour lines of groundwater level are generally following with the surface topography. That the groundwater gradient from Sakhol and Amach area to the Gap is relatively steep suggest that this area may be composed of relatively impervious material.

ii) Change of Groundwater Level

--- Characteristics

It can be mentioned as under as shown in Fig. C.3.

The drawdown around the alluvial fan area distributing in the downstream of the Kad Kocha and the northernmost is remarkable.

That around the Pringabad Town is also considerable partly.

--- Change during 9 years from 1985/86 to 94/95

The contour map of groundwater level change during 9 years from 1985/86 to 94/95 is shown in Fig. C.18. The area showing the most remarkable groundwater drawdown is the alluvial fan area of Kad Kocha, the observed maximum drawdown is 16 meters during 9 years.

The drawdown around Pringabad Town is the maximum 10 meters during 9 years. And that around Mastung Town is the maximum 7 meters.

In the other area, the drawdown is characterised like as followings; it is usually large along the piedmont, and become smaller gradually as proceeding to the downstream side. The maximum drawdown is approximately 10 meters which is observed around the piedmont of the northernmost area of the Sub-Basin. That around Amach and Sakhol situating in the eastern piedmont is approximately 6 meters. While around the Gap, it is only around 1 meter.

--- Average Change during Respective 3 years of 1985/86 to 88/89, 88/89 to 91/92 and 91/92 to 94/95

Comparing to the above mentioned long-term change of groundwater level during 9 years, the tendency of relatively short-term change was checked dividing them into each 3-years. The results are shown in Figs. C.19 to 21.

Even during every 3-years, specially mentioned the above three areas in the alluvial fan of Kad Kocha, around Pringabad Town, and around Mastung Town show the relatively remarkable drawdown, though around Mastung Town shows a little different characteristic from the other two due to water in this area mainly supplied from a lot of Karezes. Kareze is a system to intake water widely from the elevation around the groundwater table, then the drawdown caused by this system is not so significant.

The drawdown around Mastung Town during every 3-years remains 1 or 2 meters. While that around Pringabad Town and in the alluvial fan of Kad Kocha is relatively large showing 4 to 5 meters during first and second 3 years, and during recent 3 years, though in the case around Pringabad Town remain a little over than 3 meters, in the case of the alluvial fan of Kad Kocha, it becomes very large showing the observed drawdown being the maximum 10 meters, that is, average 3 to 4 meters per annum. The drawdown during recent 3 years in the northernmost piedmont area becomes also large around twice as much as the before.

C.5 ANNUAL DEFICIT OF GROUNDWATER IN PISHIN, QUETTA NORTHERN, AND MASTUNG SUB-BASIN

To calculate the deficit of groundwater recharge to discharge in the respective Sub-Basins from the Monitoring data, first dividing the alluvial area of each Sub-Basin into some elements (unit area in Pishin Sub-Basin is 2km*2km=4km2, Quetta Northern and Mastung Sub-Basin 1km*1km=1km2), and second the representative values of Specific Yield are shown in every element as shown in Table C.4.

Values shown in Table C.4 are decided from Figs. A.2, A.7, and A.9, ANNEX A showing the location of existing wells utilized for hydrogeological analyses in Pishin, Quetta Northern, and Mastung Sub-Basins. In these Figs, contour maps of Specific Yield extracted from Tables A.1 to A.2, ANNEX A are also shown.

Likewise from Figs. C.7 to 8, Figs. C.13 to 15, and Figs. C.19 to 21 the representative values of drawdown in every element are shown on Table C.5 in the case of Pishin Sub-Basin, on Table C.6(1) Quetta Northern Sub-Basin, and on Table C.7(1) Mastung Sub-Basin.

The volume change stored in elements of groundwater basin have been calculated as the multiplication of Specific Yield by Groundwater Level Change, and shown on Tables C.5, C.6(2), and C.7(2). The summarization of all values in every element is the total volume change in the respective Sub-Basins, namely the deficit or the surplus of total recharge to total discharge.

(1) Pishin Sub-Basin

During 13 years from 1975/76 to 1988/89, the deficit of groundwater volume reserved in the basin is total 574 MCM, namely, discharge is average 44 MCM surplus per annum over recharge.

While, during 6 years from 1988/89 to 1994/95, the groundwater volume reserved in the basin turns into the surplus of 316 MCM, that is, average 53 MCM surplus per annum.

However because it is considered there are so many cases showing temporary and partial groundwater level change around observation wells, we picked up the data during 2 years from 1992/93 to 94/95 and analyzes them. As a result, the groundwater volume reserved in the basin show the deficit of 26 MCM during 2 years, that is, average 13 MCM deficit per annum.The area groundwater level rising may be influenced by Delay Action Dams and so on.

A cause of this result is not decided yet. As a possible reason, so many delay action dams have been constructed in Pishin Sub-basin so far and their distribution is fit with the area groundwater level rising as shown in Fig. C.1 where locates in the northern and the north-eastern. Provided that the discharge in this basin is not changing, it is said that the average surplus of recharge 44+53=97MCM per annum has been taken place comparing to the before. Recent rising ratio of the groundwater level becomes lower or some are said to be drawing down again as shown Fig. C.1 due to probably reducing recharging ratio from delay action dams or increasing pumping up ratio. However, the time every groundwater level beginning to rise is almost same, then it is difficult to say the groundwater rising has been caused by delay action dams completely because every dam wasn't constructed at the same time.

(2) Quetta Northern Sub-Basin

During every 3-years from 1985/86 to 1988/89, 1988/89 to 1991/92, and 1991/92 to 1994/95, the deficit in the groundwater reservoir of recharge under discharge is 57 MCM, 63 MCM, and 51 MCM respectively, that is, average 19 MCM, 21 MCM, and 17 MCM per annum respectively.

The deficit ratio increases a little during the second 3 years comparing to first 3 years. However during recent 3 years it is reduced 4 MCM average per annum due to probably pumping up control or groundwater mining limit, etc.

(3) Mastung Sub-Basin

During every 3-years from 1985/86 to 1988/89, 1988/89 to 1991/92, and 1991/92 to 1994/95, the deficit in the groundwater reservoir of recharge under discharge is 43 MCM, 39 MCM, and 65 MCM respectively, that is, average 14 MCM, 13 MCM, and 22 MCM per annum respectively.

During the first and the following 3 years, the deficit ratio of recharge under discharge is almost same, however it is increasing remarkably during recent 3 years. Especially, the drawdown around the downstream area of Kad Kocha is distinct as shown in Fig. C.21.

C.6 SIMULATION FOR AVAILABLE GROUNDWATER RECHARGE BY DAD

Groundwater recharge contributed by delay action dam is categorized into two types. One is a recharge from reservoir bed and the another is downstream recharge in the fan, for the later water is supplied through conduit installed under the dam body. Each recharge volume of water is subject to hydrogeologic characteristic of related groundwater layer, scale of reservoir, dam facilities, rainfall pattern, and reservoir stage. In order to estimate the available quantity of water for groundwater recharge, a dam operation simulation is required to be conducted.

The dam operation simulation was done to calculate reservoir stage monthly for the duration of 30 years, by input of runoff into reservoir, and outputs of evaporation from reservoir water surface, recharge from reservoir bed, and releasing water for downstream recharge. Runoff from catchment of the DAD was estimated by actual rainfall from 1966 to 1995 multiplied by runoff factor varying from 8 % in summer to 15 % in winter, which was deduced from observed data of Chapper Lift station. Evaporation calculated by Penman method attached in the ANNEX H as Table H.2.1.

Recharge from reservoir bed was estimated in consideration with characteristics of dam foundation layer for permeability and stage of reservoir using results of F.E.M. seepage analysis which was attached in the Section of I.3.2 of the ANNEX I. Seepage into reservoir bed was obtained through the seepage analysis in the some typical cases of permeability of reservoir bed, thickness of the reservoir bed, and water depth in the reservoir. Prior to the dam operation simulation, maximum seepage into reservoir bed of each proposed dam was calculated as shown in Table 6.6.1 in the Main report applying a regression equation derived from the seepage analysis in the some typical cases.

(Seepage into reservoir bed; cu.m/day) = $0.982 \times 10^{(26.937K)} \times H^{(0.345\log K+1.556)} \times B$

Here, K: Permeability of reservoir bed (cm/sec.)

H: Maximum water depth in reservoir (m)

B: dam length (m)

Recharge from reservoir bed is estimated through the dam operation simulation on the basis of the maximum seepage giving water depth in reservoir with time, and decreasing permeability with year.

Downstream recharge was estimated in consideration with the area spread and its characteristic of permeability. Prior to the dam operation simulation, maximum releasable water by each proposed dam was calculated as shown in Table 6.6.1 in the Main report, which was the lower of the rechargeable water during flowing down on alluvial fan and flowing capacity of aquifer. Downstream recharge is estimated through the dam operation simulation on the basis of the maximum releasable water giving releasing water from reservoir corresponding with water depth in reservoir with time.

Annual rechargeable water of the delay action dam is an annual average of the results of the reservoir bed recharge and downstream recharge obtained through the dam operation simulation.

Table C.1 Applied Groundwater Level at Each Observation Point in Pishin Sub-Basin

No. of Observation Well		1	2	3	4	6	7	8	9	11	12	13	14	15	16	17	18
Ground Height (m)		1483	1680	1640	1550	1550	1530	1535	1530	1605	1562	1563	1555	1509	1497	1475	1415
Depth to Water Level (GL.-m)	1975/76	50.00	10.60	34.50	16.00	45.50	36.00	29.00	17.00	65.00	29.00	29.00	16.00	40.00	47.50	11.00	6.00
	1985/86	52.72	10.12	41.35	19.12	49.63	36.25	29.22	16.23	68.00	32.00	33.48	19.56	56.78	56.01	14.23	6.02
	1988/89	54.64	9.64	41.47	20.04	50.59	36.54	29.22	16.60	68.65	32.50	32.96	20.28	51.40	60.21	18.35	5.78
	1991/92	56.60	9.18	36.37	13.46	47.21	34.47	29.20	17.31	61.00	23.40	24.14	13.87	46.04	51.69	26.98	5.51
	1992/93	57.98	9.37	34.88	9.37	44.17	33.26	28.82	17.46	57.75	21.24	20.18	11.76	43.75	49.45	27.90	5.62
	1994/95	60.08	9.84	40.34	9.37	38.60	31.25	28.21	17.70	56.06	20.18	20.02	11.93	42.08	51.85	28.39	5.88
Elevation (m)		1423	1670	1600	1541	1511	1499	1507	1512	1549	1542	1543	1543	1467	1445	1447	1409
Change of Water Level (m)	75/76~88/89	-4.64	0.96	-6.97	-4.04	-5.09	-0.54	-0.22	0.40	-3.65	-3.50	-3.96	-4.28	-11.40	-12.71	-7.85	0.22
	88/89~91/92	-1.96	0.46	5.10	6.59	3.38	2.07	0.03	-0.71	7.65	9.10	8.82	6.41	5.36	8.52	-8.14	0.27
	91/92~94/95	-3.48	-0.67	-3.97	4.09	8.61	3.22	0.99	-0.39	4.94	3.22	4.12	1.94	3.96	-0.16	-1.40	-0.37
	92/93~94/95	-2.10	-0.47	-5.46	0.00	5.57	2.01	0.61	-0.24	1.69	1.06	0.16	-0.17	1.67	-2.40	-0.49	-0.26
	88/89~94/95	-5.44	-0.21	1.13	10.67	11.99	5.29	1.01	-1.10	12.59	12.32	12.94	8.35	9.32	8.36	-9.54	-0.11

No. of Observation Well		19	20	21	22	23	24	26	27	29	30	32	33
Ground Height (m)		1505	1450	1460	1450	1530	1449	1536	1526	508	1460	1430	1469
Depth to Water Level (GL.-m)	1975/76	10.00	15.00	13.50	7.00	6.00	7.00	17.50	2.00	10.00	9.00	10.00	15.00
	1985/86	8.32	13.82	14.00	8.55	6.84	7.33	20.97	4.88	10.57	8.95	12.35	14.80
	1988/89	7.69	13.12	14.15	8.78	7.06	7.62	22.00	5.85	10.04	8.66	13.97	14.20
	1991/92	7.27	11.86	9.38	6.15	6.86	8.49	22.13	4.37	9.64	8.52	15.89	13.15
	1992/93	7.10	10.83	9.38	5.19	6.57	9.37	21.61	4.01	9.70	8.84	16.51	12.61
	1994/95	7.50	9.71	10.72	6.63	6.42	10.71	22.80	4.55	9.90	9.39	18.88	12.82
Elevation (m)		1497	1440	1449	1443	1524	1438	1513	1521	498	1451	1411	1456
Change of Water Level (m)	75/76~88/89	2.31	1.88	-0.65	-1.78	-1.06	-0.62	-4.50	-3.85	-0.04	0.34	-3.97	0.80
	88/89~91/92	0.42	1.26	4.77	2.63	0.20	-0.87	-0.13	1.48	0.40	0.14	-1.91	1.04
	91/92~94/95	-0.23	2.15	-1.34	-0.48	0.44	-2.21	-0.67	-0.18	-0.26	-0.87	-2.99	0.34
	92/93~94/95	-0.40	1.12	-1.34	-1.44	0.15	-1.34	-1.19	-0.54	-0.20	-0.55	-2.37	-0.21
	88/89~94/95	0.19	3.41	3.42	2.14	0.64	-3.08	-0.80	1.30	0.14	-0.73	-4.90	1.38

Table C.2 Applied Groundwater Level at Each Observation Point in Quetta Northern Sub-Basin

No. of Observation Well		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ground Height (m)		1594	1680	1652	1682	1601	1647	1684	1671	1633	1615		1680	1704	1743	1719
Depth to Water Level (GL.-m)	1985/86	11.00	14.50	56.00	13.00	16.00	6.50	4.00	7.00	3.00	5.00	14.00	9.50	10.00	35.00	20.00
	1988/89	14.23	14.73	59.53	17.08	15.18	8.35	5.94	7.83	3.28	5.11	15.44	9.09	8.02	34.71	21.15
	1991/92	17.86	14.71	65.98	21.66	14.90	8.21	5.22	5.79	2.49	7.64	16.78	6.87	8.94	34.26	20.29
	1994/95	24.04	15.20	66.91	27.22	12.66	6.99	7.59	6.38	1.66	5.49		8.08	13.72	34.79	19.42
Elevation (m)		1570	1665	1585	1655	1588	1640	1676	1665	1631	1610		1672	1690	1708	1700
Change of Water Level (m)	85/86~88/89	-3.23	-0.23	-3.53	-4.08	0.82	-1.85	-1.94	-0.83	-0.28	-0.11	-1.44	0.41	1.98	0.29	-1.15
	88/89~91/92	-3.62	0.02	-6.46	-4.58	0.28	0.15	0.72	2.04	0.79	-2.53	-1.33	2.22	-0.92	0.44	0.86
	91/92~94/95	-6.19	-0.48	-0.92	-5.56	2.25	1.22	-2.38	-0.59	0.83	2.15		-1.21	-4.78	-0.52	0.87
	85/86~94/95	-13.04	-0.70	-10.91	-14.22	3.34	-0.49	-3.59	0.62	1.34	-0.49		1.42	-3.72	0.21	0.58

No. of Observation Well		16	18	19	20	21	22	23	24	25	26	28	29	30	31	32
Ground Height (m)		1738	1737	1749	1720	1766	1678	1730	1693	1611	1685	1723	1739	1757	1775	1762
Depth to Water Level (GL.-m)	1985-86	35.00	30.00	59.00	36.00	70.00	7.00	35.00	20.00	19.00	9.00	38.00	44.00	55.50	76.50	69.00
	1988-89	35.85	29.46	60.29	39.11	73.08	7.04	36.37	20.25	21.71	8.32	37.80	46.18	55.67	78.92	71.99
	1991-92	36.39	34.89	62.63	41.80	76.17	8.06	38.82	20.28	25.21	8.85	38.75	47.28	56.18	81.75	75.52
	1994-95	36.10	36.68	64.94	43.29	83.88	8.07	43.46	20.61	29.50	8.80	42.93	48.55	62.04	89.16	79.95
Elevation (m)		1702	1700	1684	1677	1682	1670	1687	1672	1582	1676	1680	1690	1695	1686	1682
Change of Water Level (m)	85/86~88/89	-0.85	0.54	-1.29	-3.11	-3.08	-0.04	-1.37	-0.25	-2.71	0.68	0.20	-2.18	-0.17	-2.42	-2.99
	88/89~91/92	-0.54	-5.43	-2.33	-2.69	-3.10	-1.02	-2.44	-0.04	-3.50	-0.53	-0.95	-1.10	-0.51	-2.83	-3.53
	91/92~94/95	0.29	-1.80	-2.31	-1.49	-7.71	-0.01	-4.64	-0.33	-4.29	0.05	-4.18	-1.27	-5.86	-7.41	-4.43
	85/86~94/95	-1.10	-6.68	-5.94	-7.29	-13.88	-1.07	-8.46	-0.61	-10.50	0.20	-4.93	-4.55	-6.54	-12.66	-10.95

Table C.3 Applied Groundwater Level at Each Observation Point in Mastung Sub-Basin

No. of Observation Well		24	21	20	30	1	31	33	19	29	28	25	5	6	2	7	9	10
Ground Height (m)		1742	1734	1731	1728	1737	1725	1716	1719	1722	1724	1698	1692	1689	1692	1686	1707	1708
Depth to Water Level (GL.-m)	1977/78	21.93	24.31	29.26	26.22	27.36	18.17	20.00	16.07	16.12	10.64	17.74	18.64	18.59	11.64	5.54	12.88	11.40
	1985/86	33.25	31.94	40.86	39.90	46.26	24.49	20.08	17.00	17.14	12.42	18.54	21.55	20.20	13.27	6.71	13.28	13.10
	1988/89	37.93	33.99	40.41	40.91	49.05	27.17	20.63	17.94	19.09	13.64	18.88	23.15	21.92	15.85	10.14	15.88	14.41
	1991/92	42.39	38.09	40.66	37.78	51.40	28.73	20.88	18.99	20.70	13.55	20.17	24.75	23.28	18.80	13.82	17.25	15.23
	1994/95	49.28	40.81	48.64	43.14	56.36	30.65	21.24	20.31	22.32	14.28	20.80	26.11	24.61	20.34	16.88	17.62	16.47
Elevation (m)		1693	1693	1682	1685	1681	1694	1695	1699	1700	1710	1677	1666	1664	1672	1669	1689	1692
Change of Water Level (m)	77/78~85/86	-11.32	-7.63	-11.60	-13.68	-18.90	-6.32	-0.08	-0.92	-1.02	-1.78	-0.81	-2.91	-1.61	-1.63	-1.16	-0.40	-1.70
	85/86~88/89	-4.67	-2.05	0.46	-1.01	-2.79	-2.68	-0.55	-0.95	-1.95	-1.22	-0.34	-1.60	-1.72	-2.58	-3.44	-2.61	-1.31
	88/89~91/92	-4.46	-4.10	-0.25	3.13	-2.35	-1.56	-0.25	-1.05	-1.61	0.09	-1.28	-1.60	-1.36	-2.95	-3.68	-1.37	-0.82
	91/92~94/95	-6.89	-2.73	-7.98	-5.36	-4.96	-1.93	-0.36	-1.32	-1.62	-0.73	-0.63	-1.36	-1.33	-1.54	-3.06	-0.37	-1.25
	85/86~94/95	-16.03	-8.87	-7.77	-3.24	-10.10	-6.16	-1.15	-3.32	-5.19	-1.86	-2.25	-4.56	-4.40	-7.07	-10.17	-4.35	-3.37

No. of Observation Well		40	39	17	16	15	11	12	13	14	18	41
Ground Height (m)		1655	1631	1655	1646	1646	1667	1693	1701	1707	1676	1664
Depth to Water Level (GL.-m)	1977/78	10.06	3.68	12.06	12.42	13.92	17.26	15.16	17.78	15.88	8.40	4.00
	1985/86	10.10	3.90	14.29	12.84	14.07	19.44	17.24	17.20	17.84	12.88	11.95
	1988/89	10.26	3.86	15.14	12.58	14.03	19.15	17.32	18.60	18.90	14.83	12.90
	1991/92	9.15	4.34	15.79	12.60	12.49	21.52	18.00	18.72	19.70	16.30	10.47
	1994/95	10.16	5.26	16.43	12.72	13.77	23.92	19.00	19.56	20.60	17.59	18.59
Elevation (m)		1645	1626	1639	1633	1632	1643	1674	1681	1686	1658	1645
Change of Water Level (m)	77/78~85/86	-0.04	-0.22	-2.23	-0.42	-0.15	-2.18	-2.07	0.59	-1.96	-4.48	-7.95
	85/86~88/89	-0.16	0.04	-0.85	0.26	0.04	0.29	-0.09	-1.40	-1.06	-1.94	-0.95
	88/89~91/92	1.11	-0.48	-0.65	-0.02	1.55	-2.37	-0.68	-0.12	-0.80	-1.48	2.43
	91/92~94/95	-1.01	-0.92	-0.65	-0.12	-1.28	-2.41	-1.00	-0.84	-0.91	-1.28	-8.12
	85/86~94/95	-0.06	-1.36	-2.14	0.12	0.30	-4.49	-1.76	-2.36	-2.76	-4.70	-6.63

Table C.4 Inferred Distribution of Specific Yield in Each Element

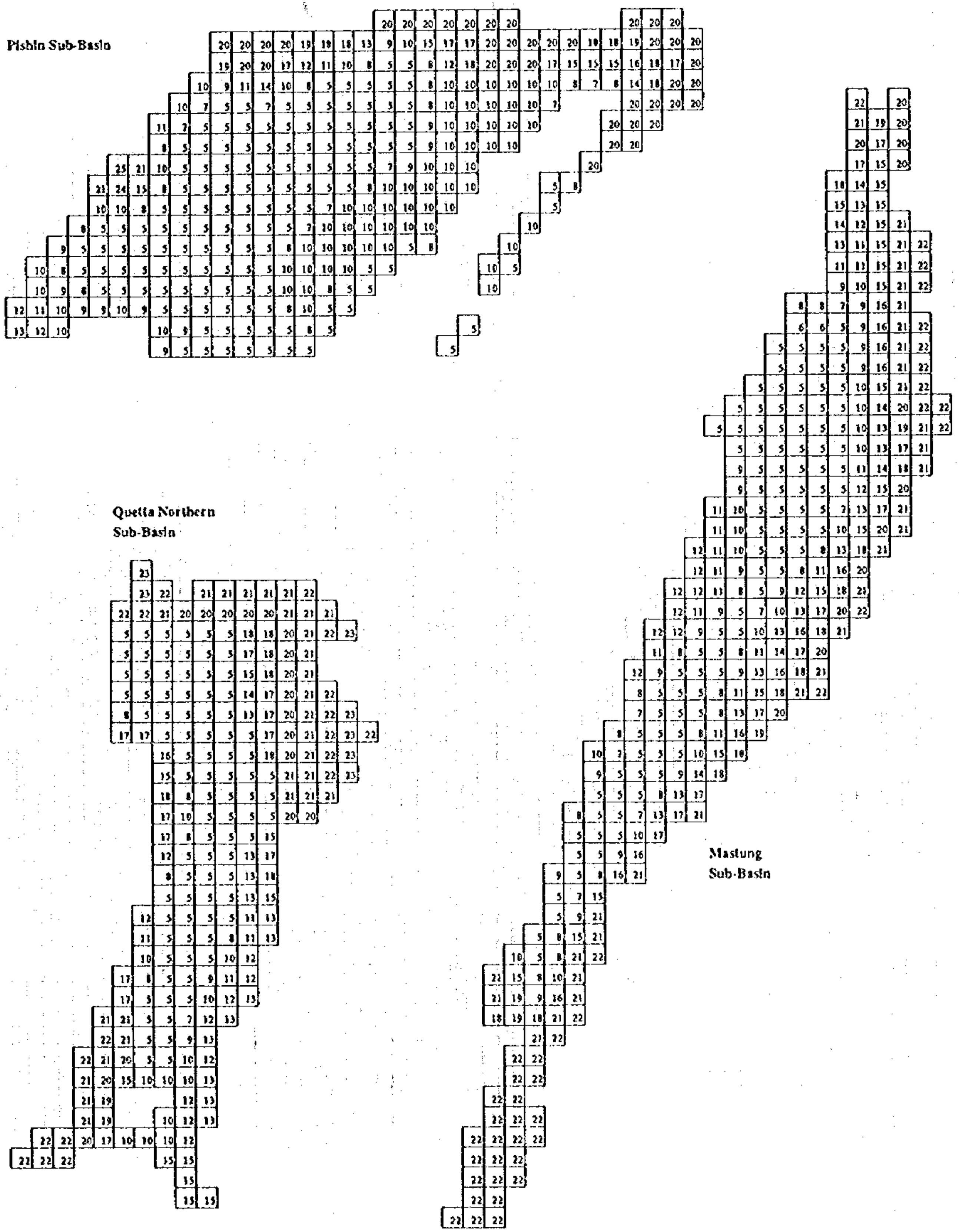
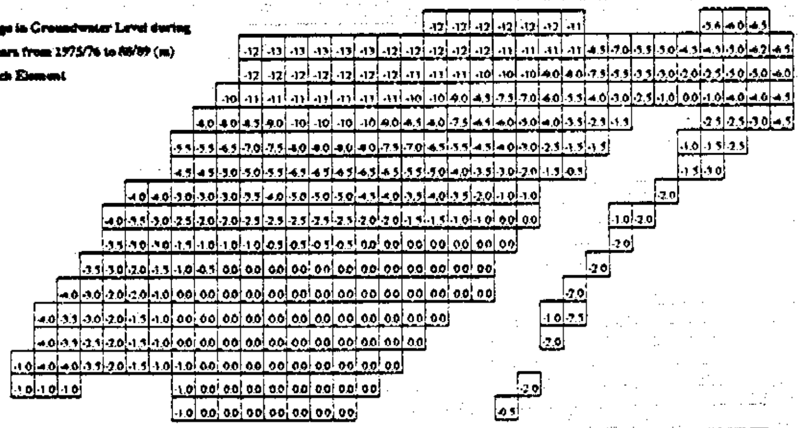
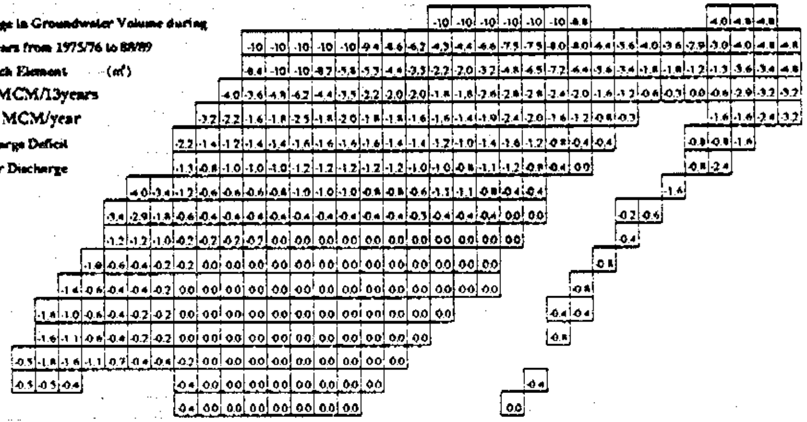


Table C.5 Change in Groundwater Level and Volume of Each Element in Pishin Sub-Basin

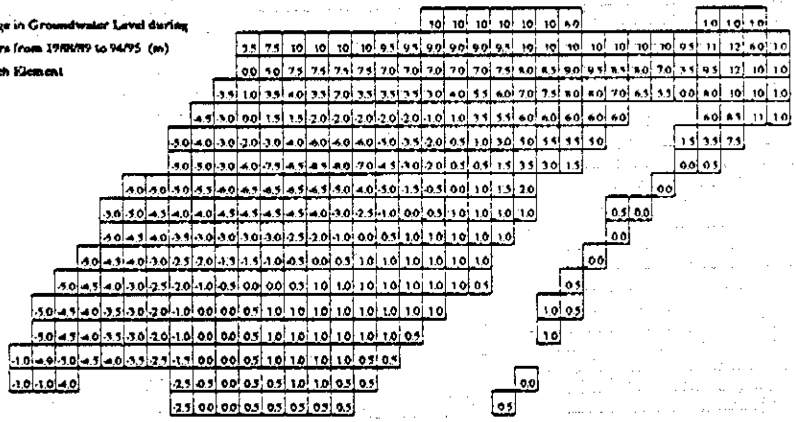
Change in Groundwater Level during
13 Years from 1975/76 to 88/89 (m)
of Each Element



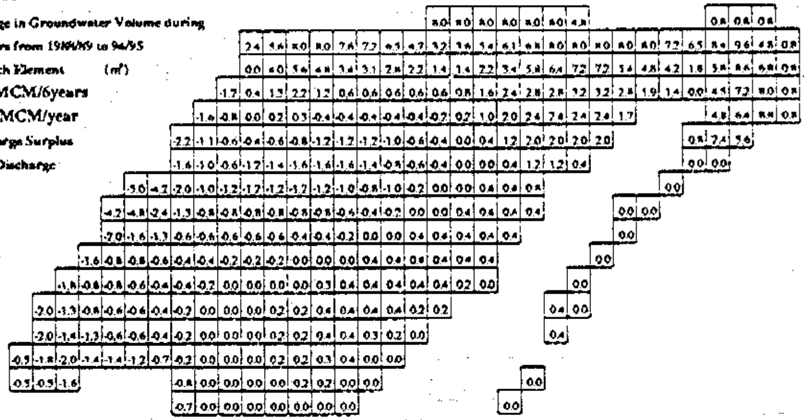
Change in Groundwater Volume during
13 Years from 1975/76 to 88/89
of Each Element (m^3)
574 MCM/13years
= 44 MCM/year
Recharge Deficit
under Discharge



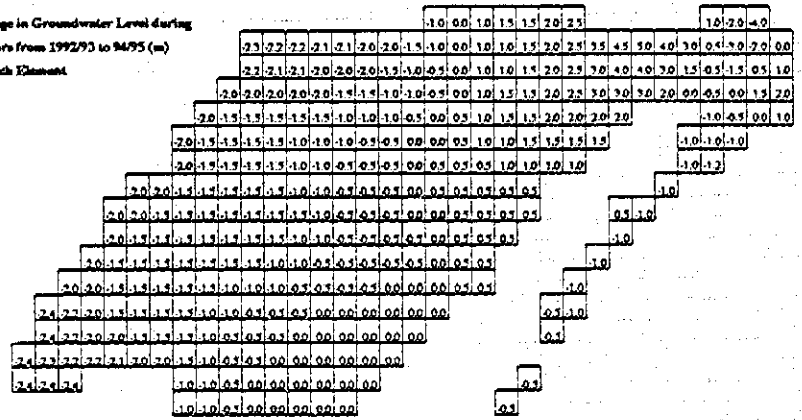
Change in Groundwater Level during
6 Years from 1988/89 to 94/95 (m)
of Each Element



Change in Groundwater Volume during
6 Years from 1988/89 to 94/95
of Each Element (m^3)
316 MCM/6years
= 53 MCM/year
Recharge Surplus
over Discharge



Change in Groundwater Level during
2 Years from 1992/93 to 94/95 (m)
of Each Element



Change in Groundwater Volume during
2 Years from 1992/93 to 94/95
of Each Element (m^3)
26 MCM/2years
= 13 MCM/year
Recharge Deficit
under Discharge

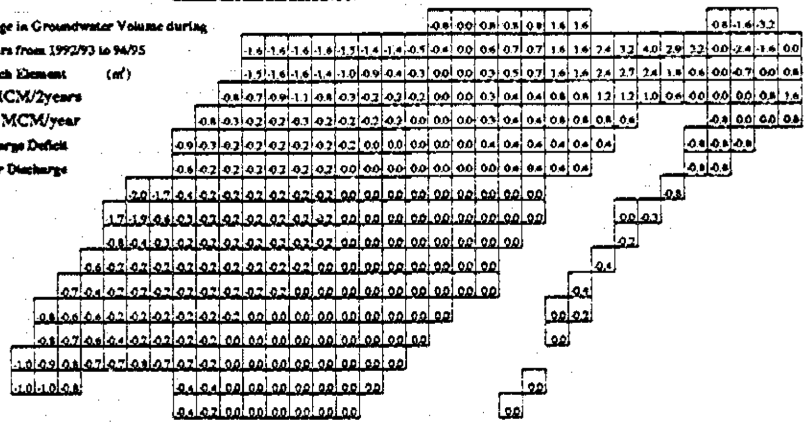


Table C.6(1) Change in Groundwater Level and Volume of Each Element in Quetta Northern Sub-Basin

Change in Groundwater Level during
3 Years from 1985/86 to 88/89 (m)
of Each Element

						-1.0											
						-3.0	-2.9		-2.8	-3.0	-3.1	-3.1	-2.6	-2.0			
					-3.5	-3.5	-3.6	-3.6	-3.5	-3.5	-3.5	-3.3	-3.1	-2.8	-2.3		
					-4.0	-4.2	-4.2	-4.2	-4.1	-3.8	-3.7	-3.5	-3.3	-3.1	-2.8	-2.0	
					-4.1	-4.2	-4.1	-4.1	-4.1	-4.0	-3.9	-3.7	-3.5	-3.2			
					-3.7	-3.6	-3.5	-3.4	-3.5	-3.7	-3.8	-3.7	-3.4	-3.2			
					-3.0	-3.2	-2.5	-2.0	-2.7	-3.1	-3.5	-3.3	-3.3	-3.2	-3.1		
					-2.0	-2.8	-1.5	0.0	-1.2	-2.3	-3.2	-3.2	-3.2	-3.2	-3.1	-2.5	
					-1.0	-1.5	-1.5	0.0	-1.0	-2.3	-2.8	-3.1	-3.2	-3.1	-3.0	-2.0	-1.0
							-0.8	0.0	-1.5	-2.0	-2.5	-2.8	-3.0	-2.8	-2.5	-2.0	
							-0.6	-0.3	0.0	-1.5	-2.1	-2.5	-2.6	-2.2	-2.0	-1.0	
							-0.5	-0.4	0.0	-1.0	-2.1	-2.3	-2.2	-2.0	-1.0		
							-0.5	-0.5	0.0	-0.5	-2.1	-2.3	-2.0	-1.0			
							-0.5	-0.3	0.0	-1.0	-2.2	-2.1					
							-0.5	-0.1	0.0	-1.0	-2.0	-1.4					
							-0.5	0.0	0.0	-0.5	-1.0	-0.7					
							-0.3	0.0	0.0	-0.3	-0.5	-0.5					
						-1.0	-0.5	0.0	-0.2	-0.2	-0.2	-0.2					
						-0.3	-0.5	0.0	0.0	0.0	0.0	0.0					
						0.0	0.0	0.0	0.0	0.0	-0.2						
					0.0	0.0	0.0	0.0	0.0	0.0	-0.2						
					-1.7	-1.0	0.0	0.0	0.0	-0.2	-0.4						
				-2.6	-3.0	-1.1	0.0	0.0	-1.8	-0.9							
				-3.0	-3.0	-1.5	-0.5	-1.0	-2.0								
			-2.9	-3.0	-2.5	-1.4	-1.4	-1.4	-1.1								
			-3.0	-3.1	-1.7	-1.5	-1.5	-1.3	-0.5								
			-3.0	-2.7				-1.0	-0.2								
			-3.1	-3.0			-1.7	-1.7	-1.5								
	-3.0	-3.1	-3.2	-3.2	-3.1	-2.3	-2.2	-2.5									
-2.8	-3.1	-3.0					-2.7	-3.0									
								-3.0									
								-2.9	-3.0								

Change in Groundwater Level during
3 Years from 1988/89 to 91/92 (m)
of Each Element

						-1.0											
						-3.0	-2.5		-2.6	-2.7	-2.7	-2.4	-2.3	-2.0			
					-3.5	-3.5	-3.3	-3.2	-3.4	-3.6	-4.0	-4.1	-4.0	-3.5	-2.5		
					-4.0	-4.0	-4.0	-4.0	-4.3	-4.9	-5.1	-5.3	-5.0	-4.5	-3.5	-2.5	
					-4.6	-4.7	-5.0	-5.1	-5.2	-6.0	-6.1	-6.0	-5.7	-5.1			
					-4.0	-4.0	-4.3	-4.9	-5.2	-6.1	-6.3	-6.3	-6.1	-5.7			
					-3.3	-3.5	-3.1	-3.0	-4.5	-5.5	-6.1	-6.5	-6.5	-6.0	-5.0		
					-2.8	-3.1	-2.6	0.0	-2.0	-4.5	-5.6	-6.5	-6.3	-5.8	-4.5	-3.0	
					-2.2	-2.8	-2.8	0.0	0.0	-2.7	-4.6	-5.3	-5.2	-4.5	-3.0	-2.5	-2.0
							-2.6	-1.0	0.0	-0.8	-2.6	-3.1	-3.0	-2.6	-2.2	-1.8	
							-2.3	-1.0	0.0	0.0	-0.7	-1.4	-1.7	-1.5	-1.3	-1.0	
							-2.0	-1.5	0.0	0.0	0.0	0.0	-0.1	-0.4	-0.5		
							-2.0	-2.0	0.0	0.0	0.0	0.0	0.0	0.0			
							-2.0	-2.0	0.0	0.0	0.0	0.0					
							-1.7	-1.0	0.0	0.0	0.0	0.0					
							-1.8	0.0	0.0	-0.1	-0.2	0.0					
							-0.9	0.0	0.0	-0.3	-0.5	-0.1					
						-0.5	0.0	0.0	-0.4	-0.9	-0.7	0.0					
						0.0	0.0	0.0	-0.7	-1.5	0.0	0.0					
						-0.8	-0.2	-0.2	-0.8	-2.3	-2.0						
					-0.8	-1.5	0.0	-0.3	-1.2	-5.0	-5.0						
					-2.5	-1.5	0.0	-0.4	-1.8	-3.2	-3.2						
				-2.8	-3.5	-1.5	-0.2	-0.8	-1.2	-0.8							
				-3.3	-3.2	-1.5	-1.0	-2.0	-1.6								
			-3.0	-3.1	-2.5	-1.6	-2.0	-2.4	-1.2								
			-3.1	-3.0	-2.4	-2.3	-2.5	-1.7	-0.8								
			-3.1	-2.9				-1.0	-0.5								
			-3.1	-3.0			-2.2	-1.8	-1.5								
	-3.0	-3.1	-3.1	-3.1	-2.7	-2.6	-3.0	-3.1									
-2.9	-3.0	-3.0					-3.0	-3.5									
								-3.1									
								-3.0	-3.3								

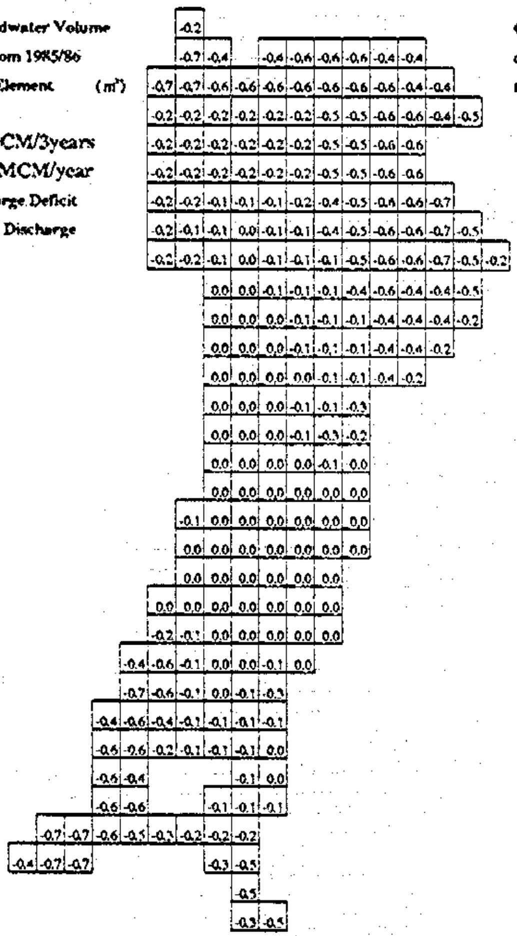
Change in Groundwater Level during
3 Years from 1991/92 to 94/95 (m)
of Each Element

						-1.0											
						-2.0	-1.0		-1.0	-2.0	-2.0	-2.0	-2.0	-2.0			
					-3.0	-3.0	-3.0	-3.5	-3.9	-3.9	-3.0	-3.5	-3.0	-3.0	-3.0		
					-4.5	-5.0	-5.1	-5.3	-5.0	-4.6	-4.3	-3.8	-3.6	-3.3	-3.1	-2.8	
					-6.0	-6.2	-6.2	-6.0	-4.8	-4.2	-3.9	-3.8	-3.6	-3.3			
					-5.6	-6.2	-5.3	-4.0	-3.0	-3.1	-3.2	-3.3	-3.3	-3.2			
					-4.5	-5.0	-3.0	-0.4	-0.8	-1.4	-1.9	-2.3	-2.6	-2.8	-2.7		
					-3.4	-4.0	-2.0	0.0	0.0	-0.5	-0.8	-1.2	-1.8	-2.3	-2.5	-2.3	
					-2.7	-3.2	-2.0	0.0	0.0	-0.1	-0.4	-0.6	-0.9	-1.3	-2.0	-2.0	-2.0
							-2.0	0.0	0.0	0.0	-0.1	-0.3	-0.6	-0.8	-1.1	-1.5	
							-2.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.4	-0.8	-1.2	
							-2.0	-1.5	0.0	0.0	0.0	0.0	0.0	-0.2	-0.5		
							-1.5	-1.5	0.0	0.0	0.0	0.0	0.0	0.0			
							-1.2	-1.0	0.0	-1.5	-0.3	0.0					
							-1.2	-0.5	-0.3	-2.2	-1.0	0.0					
							-1.1	0.0	-0.8	-2.7	-1.5	-0.1					
							-0.5	0.0	-1.0	-3.6	-2.0	-0.5					
						-0.5	-0.1	-0.1	-2.0	-4.0	-2.8	-0.6					
						-0.5	0.0	-0.3	-3.0	-3.0	-1.0	-0.1					
						0.0	0.0	-0.5	-1.5	-1.0	-0.1						
					-0.2	0.0	0.0	-0.8	-2.0	-2.1	-0.7						
					-2.5	-1.5	-0.4	-1.5	-2.4	-1.5	-0.3						
				-3.5	-4.2	-3.0	-1.0	-3.8	-2.7	-2.0							
				-4.2	-4.0	-2.5	-2.5	-4.0	-1.8								
			-4.9	-4.1	-2.0	-2.0	-2.5	-4.0	-2.5								
			-4.7	-2.0	-0.5	-0.5	-0.8	-3.0	-4.8								
			-5.0	-3.0				-3.0	-6.1								
			-6.0	-5.0			-1.5	-6.0	-6.4								
	-4.5	-5.8	-6.5	-7.3	-4.0	-3.0	-4.0	-6.1									
-4.3	-5.2	-4.5					-4.0	-6.8									
								-7.4									
								-7.4	-7.1								

Table C.6(2) Change in Groundwater Volume and Volume of Each Element in Quetta Northern Sub-Basin

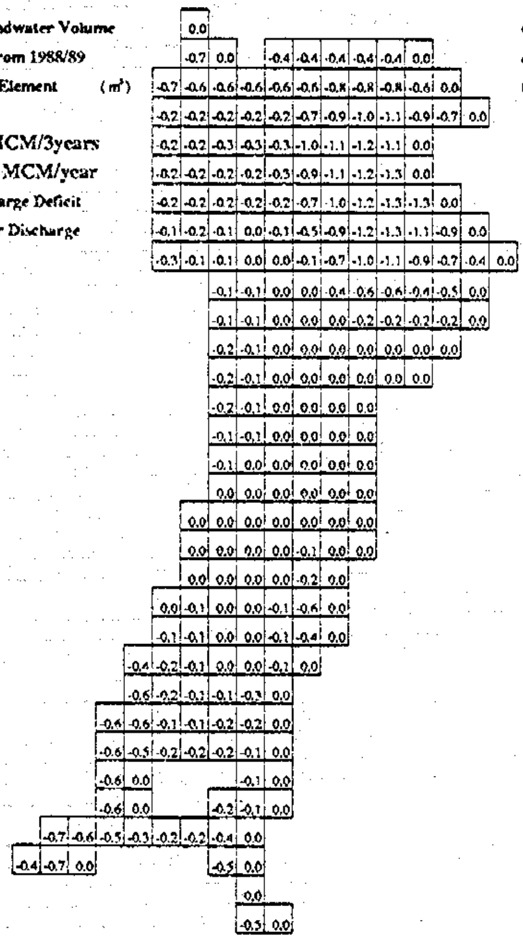
Change in Groundwater Volume during 3 Years from 1985/86 to 88/89 of Each Element (m^3)

57 MCM/3years
= 19 MCM/year
Recharge Deficit
under Discharge



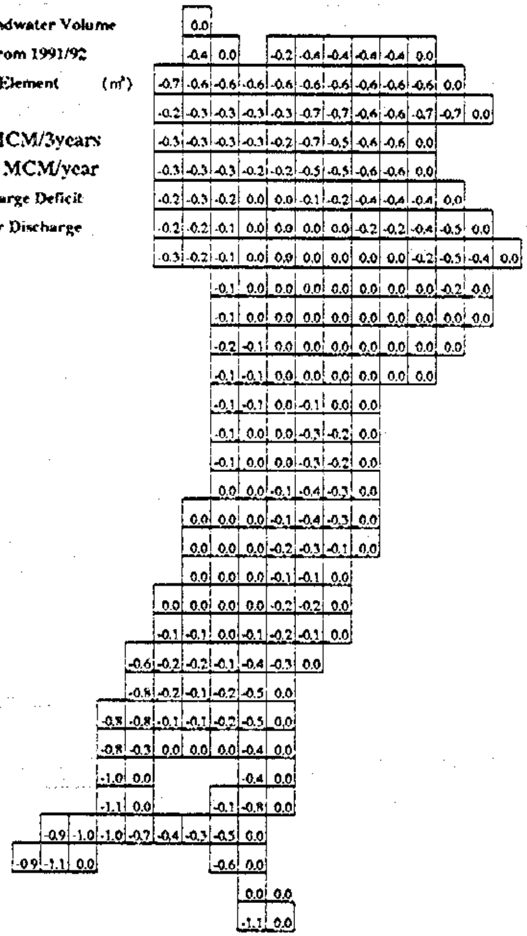
Change in Groundwater Volume during 3 Years from 1988/89 to 91/92 of Each Element (m^3)

63 MCM/3years
= 21 MCM/year
Recharge Deficit
under Discharge

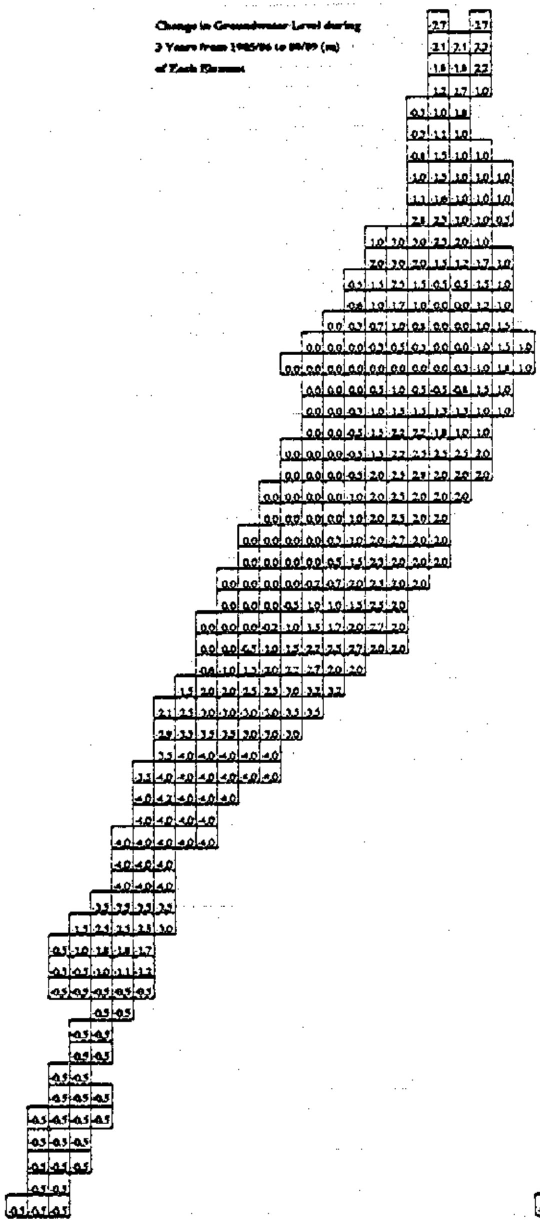


Change in Groundwater Volume during 3 Years from 1991/92 to 94/95 of Each Element (m^3)

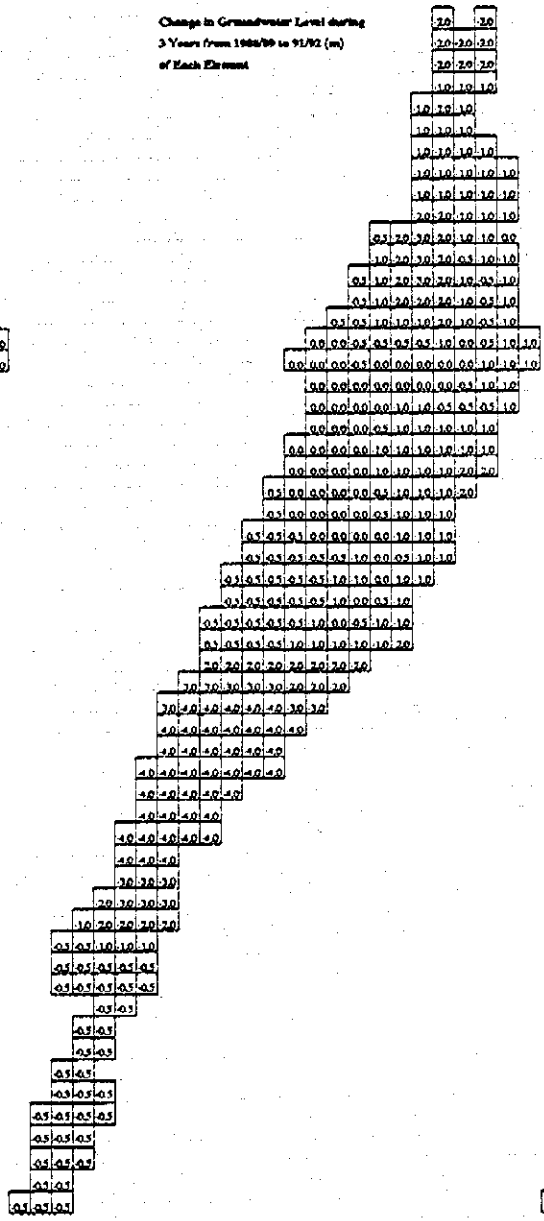
51 MCM/3years
= 17 MCM/year
Recharge Deficit
under Discharge



Change in Groundwater Level during
3 Years from 1985/86 to 88/89 (m)
of Each Element



Change in Groundwater Level during
3 Years from 1988/89 to 91/92 (m)
of Each Element



Change in Groundwater Level during
3 Years from 1991/92 to 94/95 (m)
of Each Element

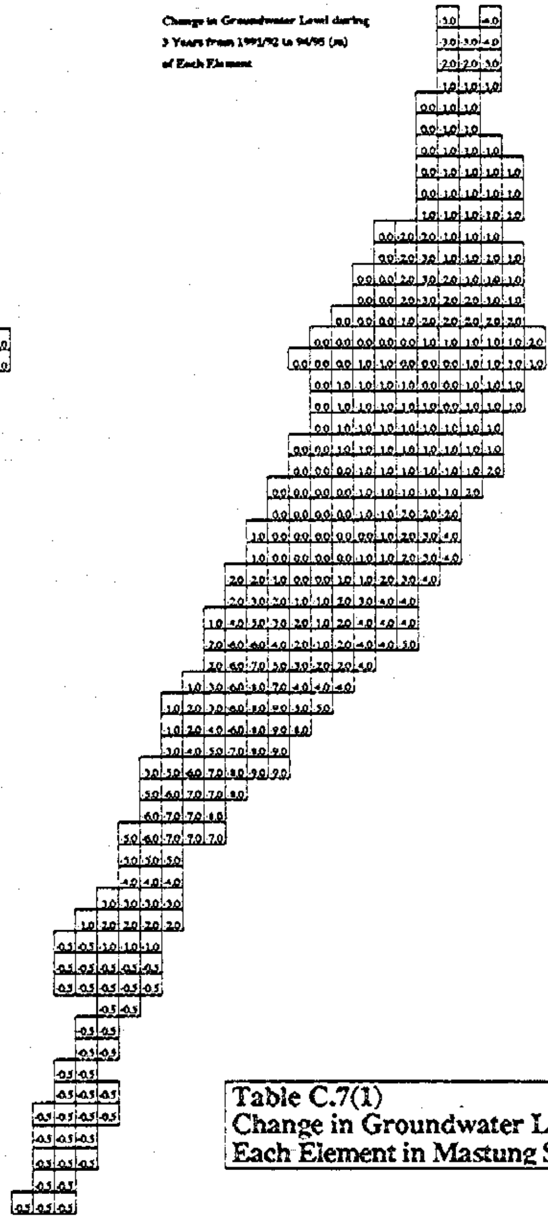
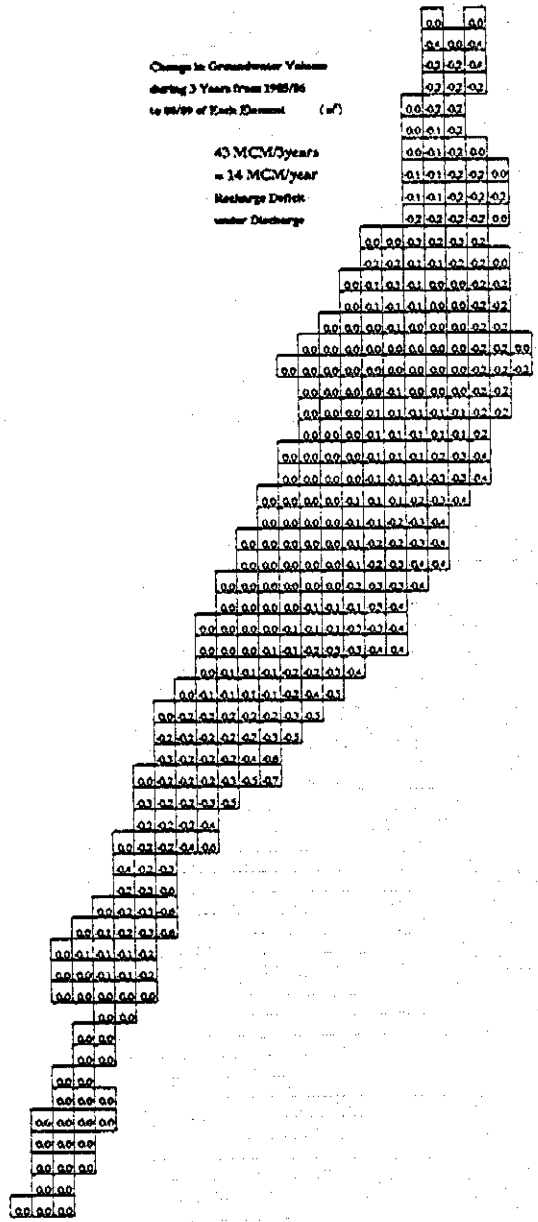
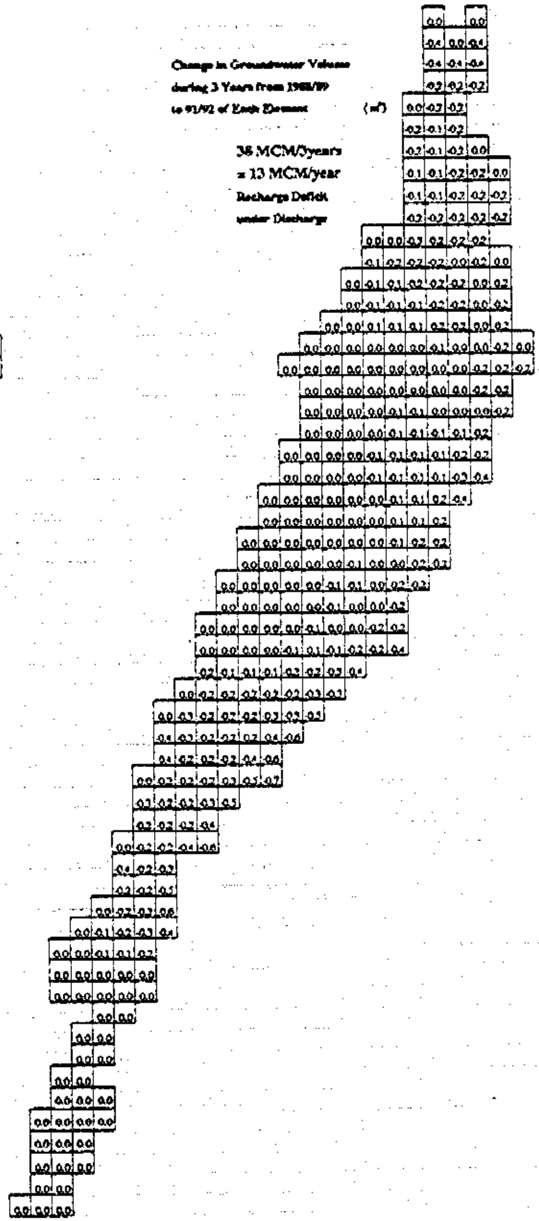


Table C.7(1)
Change in Groundwater Level and Volume of
Each Element in Mastung Sub-Basin





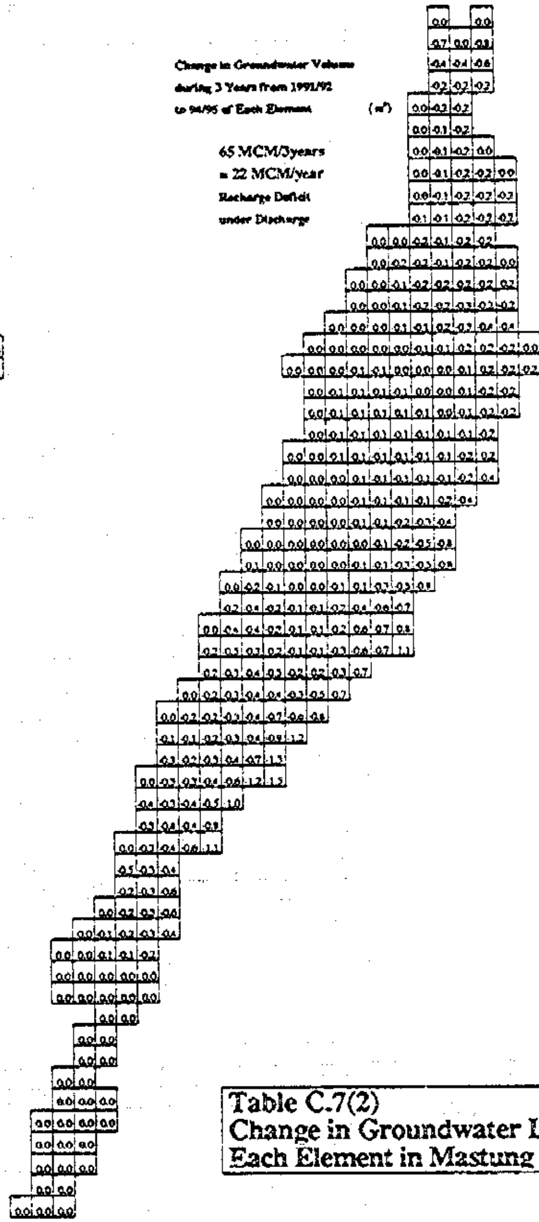


Table C.7(2)
Change in Groundwater Level and Volume
Each Element in Mastung Sub-Basin

Note;Numbers affixed to respective curves show location of observation wells refer to Fig.C.5

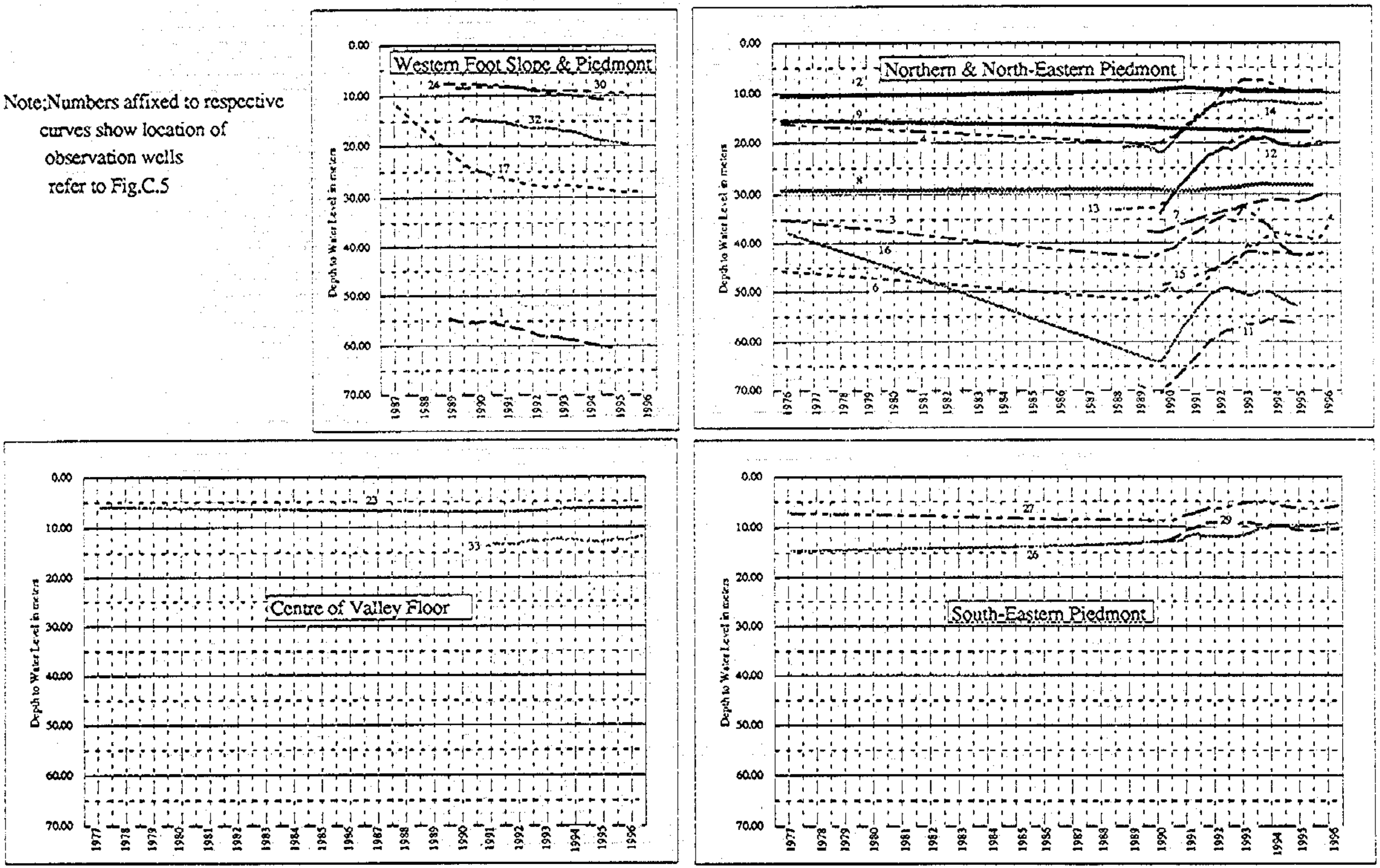
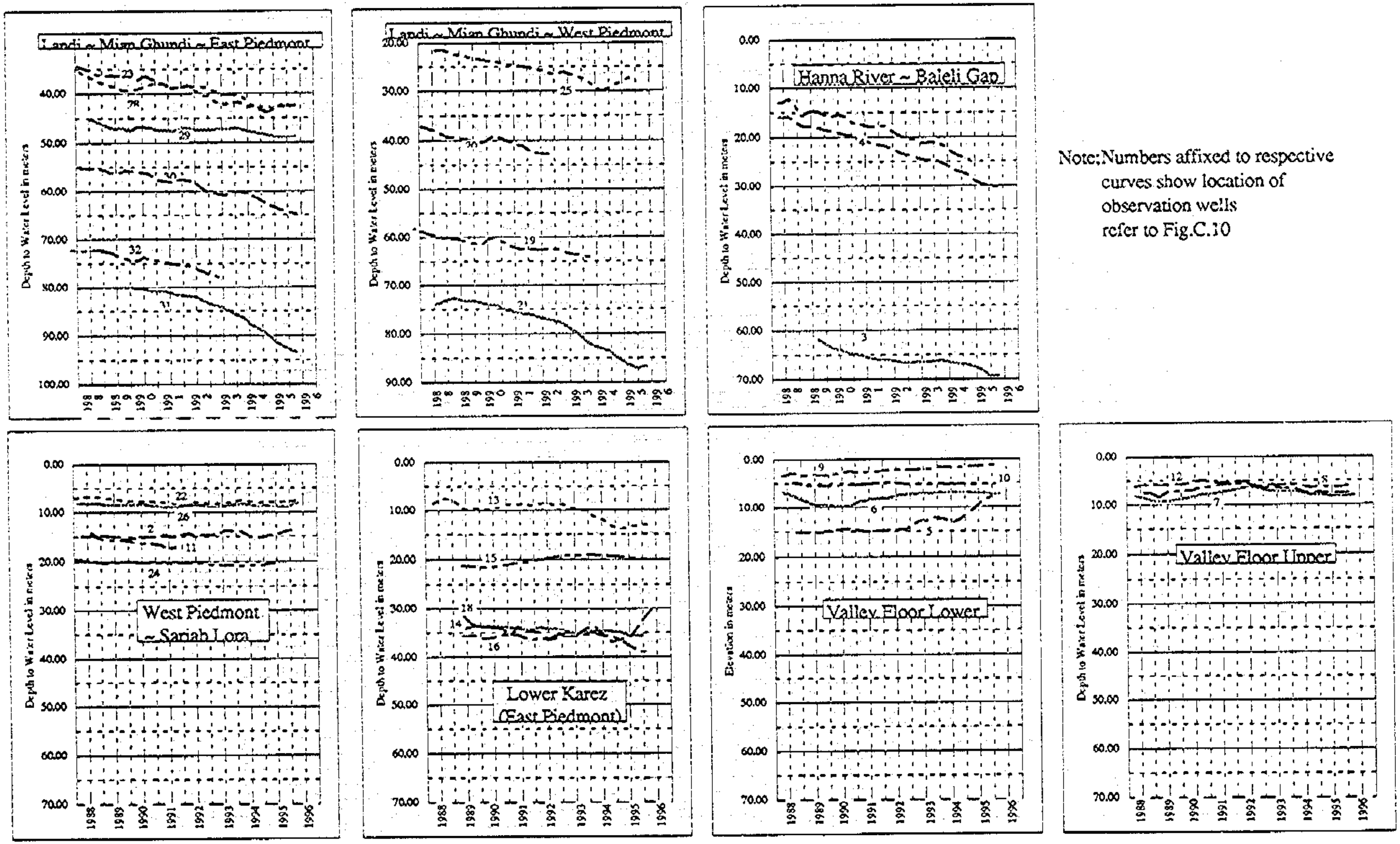


Fig.C.1 Change of Groundwater Level (Moving Average) in Pishin Sub-Basin



Note:Numbers affixed to respective curves show location of observation wells refer to Fig.C.10

Fig. C.2 Change of Groundwater Level (Moving Average) in Quetta Northern Sub-Basin

Note;Numbers affixed to respective
curves show location of
observation wells
refer to Fig.C.16

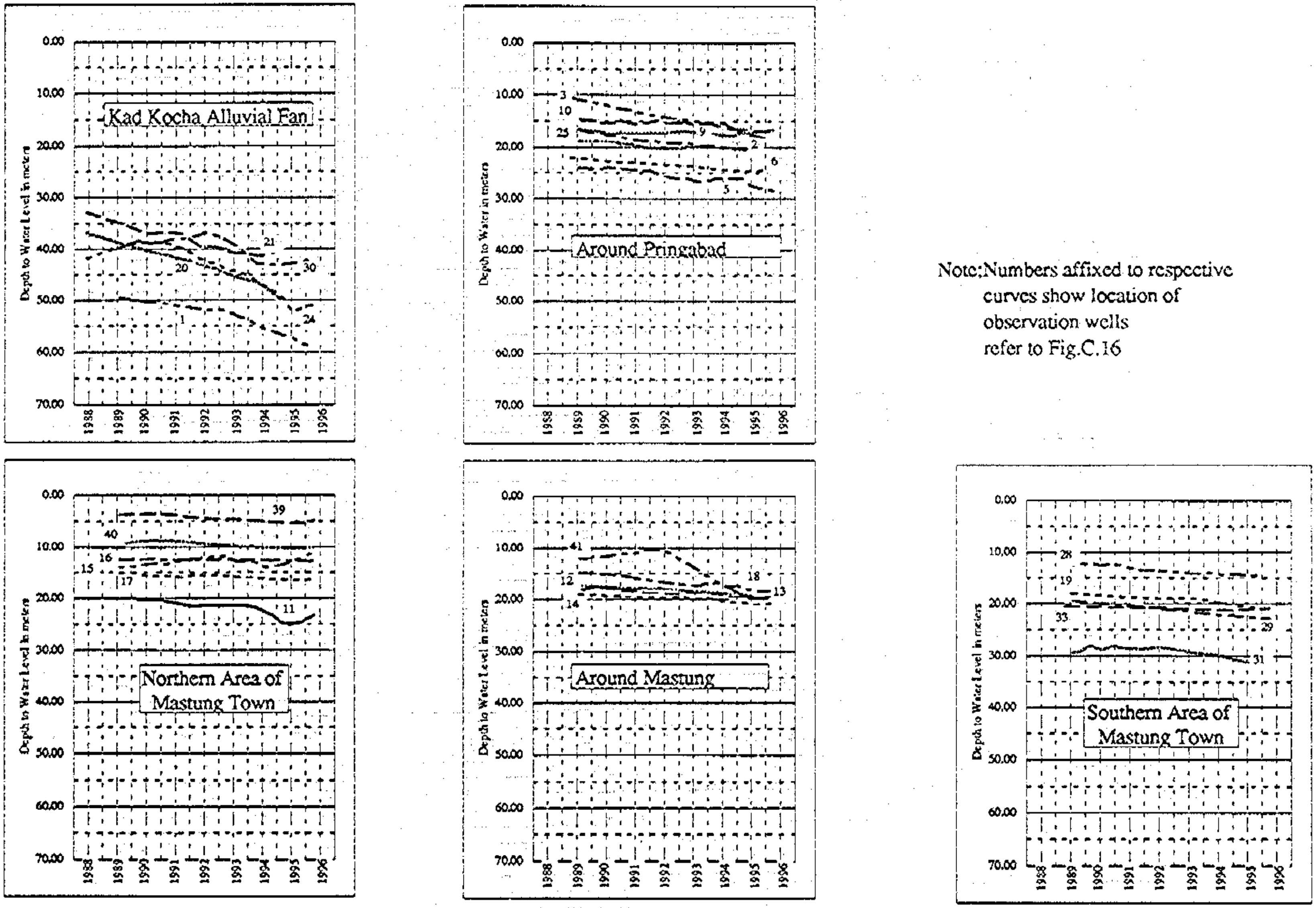


Fig.C.3 Change of Groundwater Level (Moving Average) in Mastung Sub-Basin

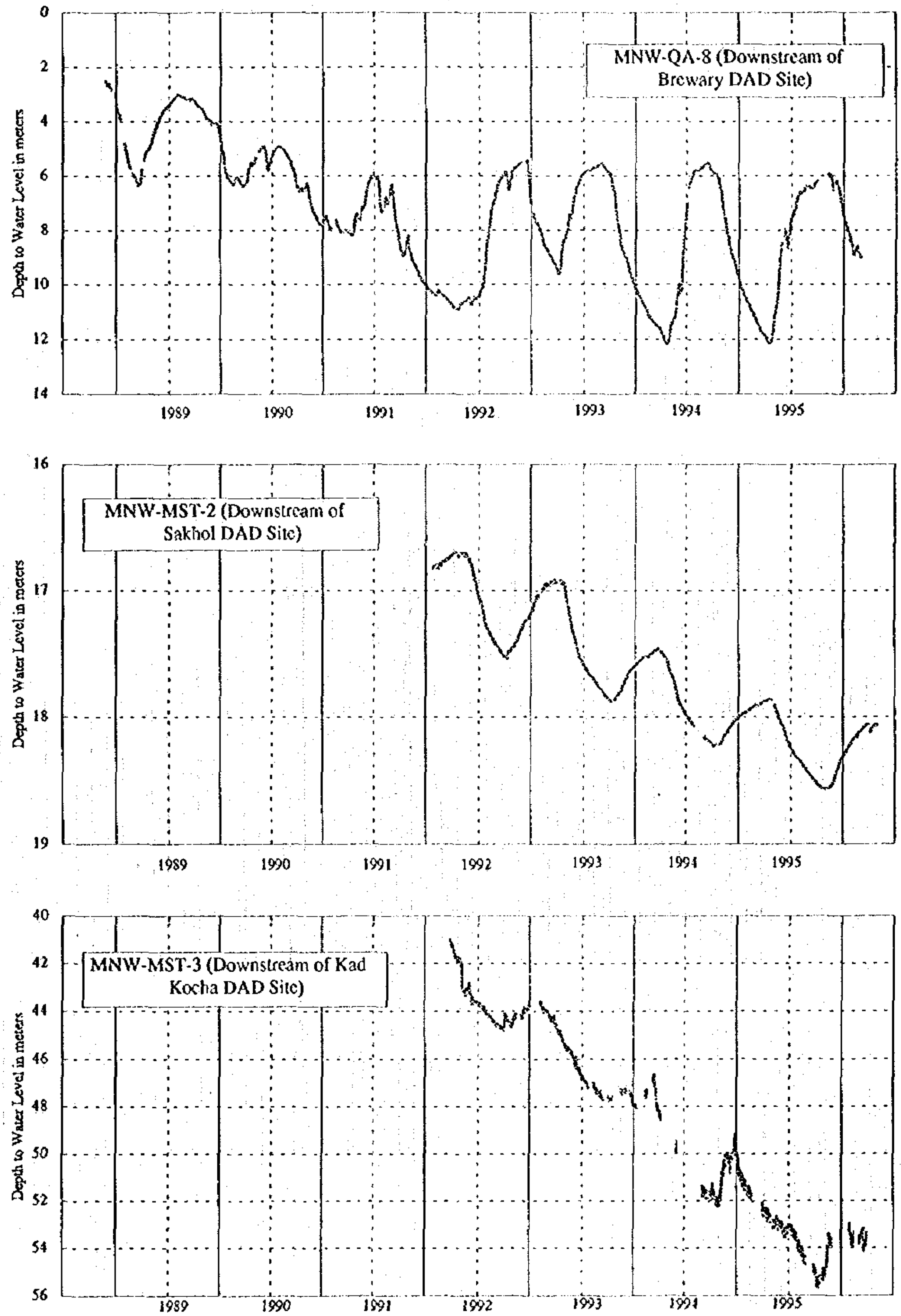


Fig.C.4 Recent Change in Groundwater Level at the Downstream of Brewary, Sakhol and Kad Kocha DAD Sites

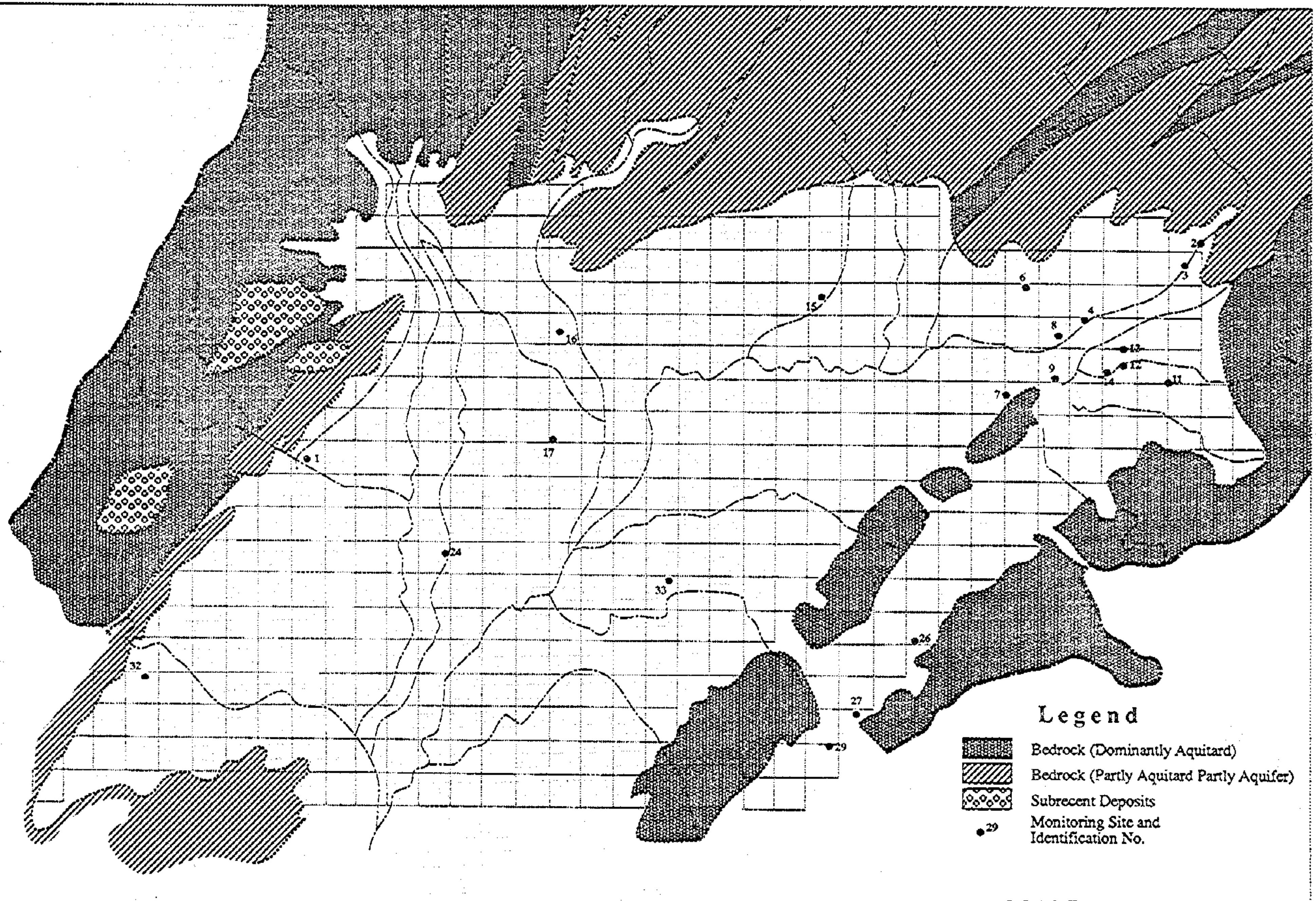


Fig.C.5 Groundwater Monitoring Sites in Pishin Sub-Basin

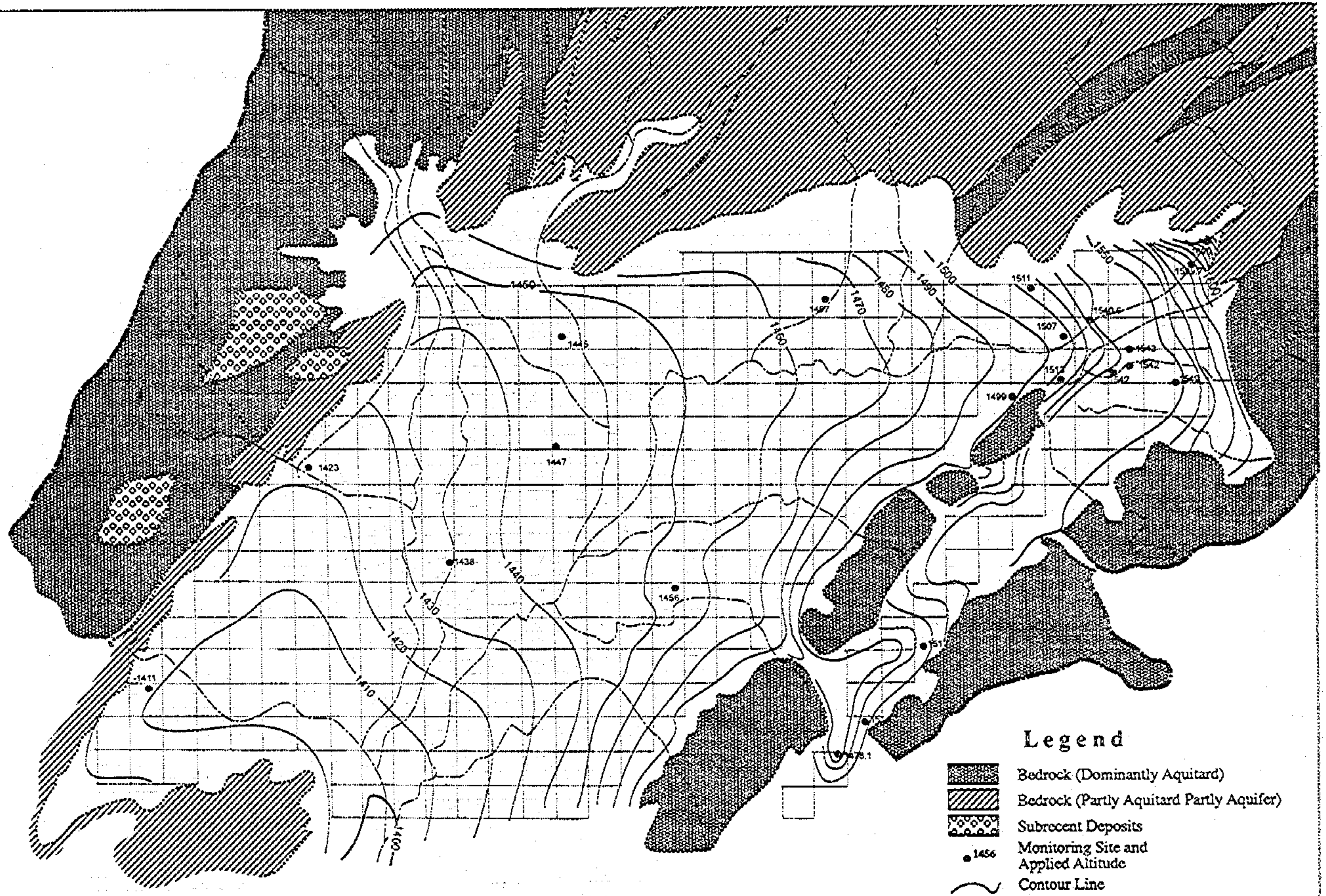


Fig.C.6 Groundwater Level in Pishin Sub-Basin
Altitude in Meters at 1994/95

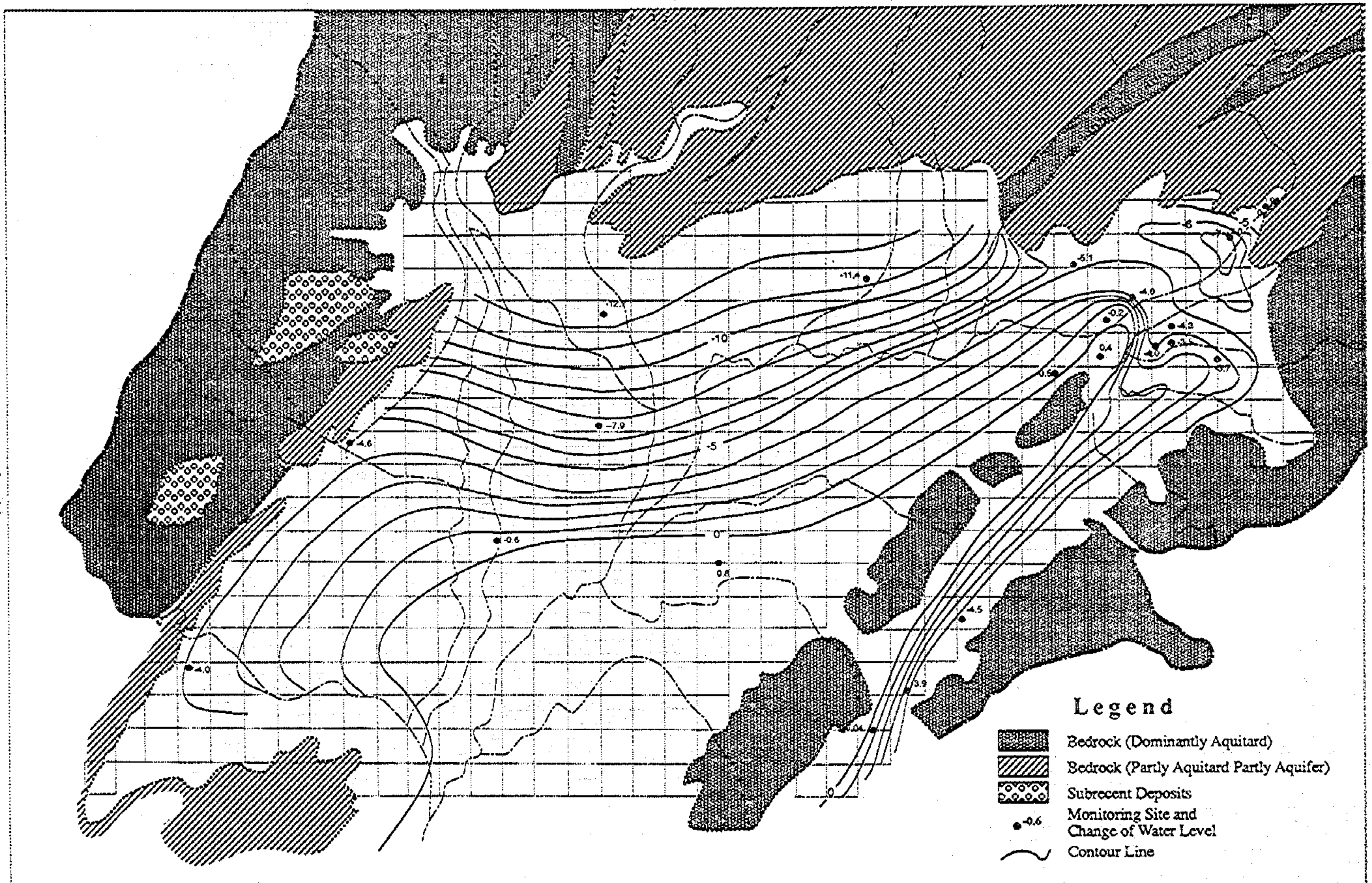


Fig.C.7 Change in Groundwater Level in Pishin Sub-Basin during 1975/76 - 88/89 (13 years)

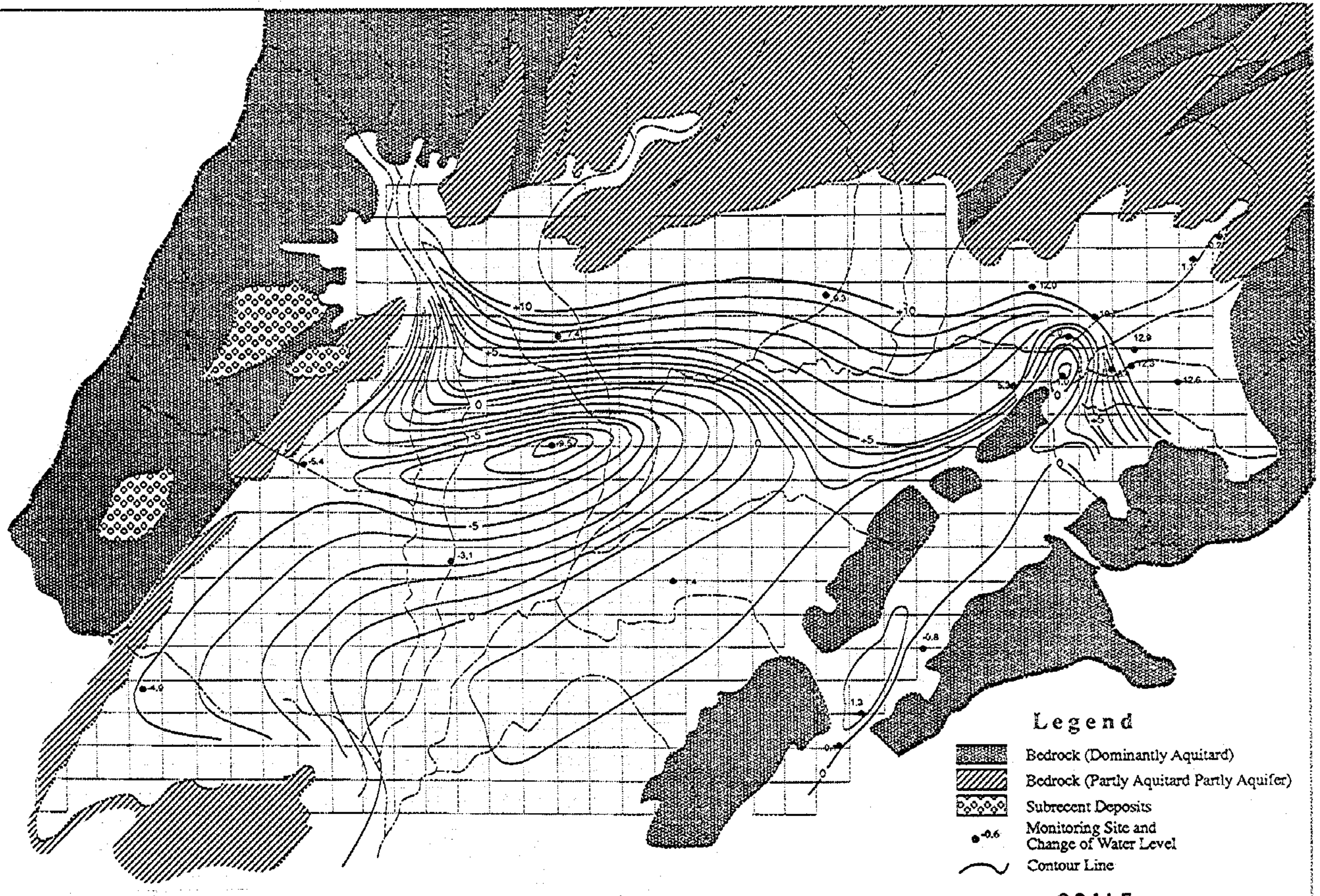


Fig.C.8 Change in Groundwater Level in Pishin Sub-Basin during 1988/89 - 94/95 (6 years)

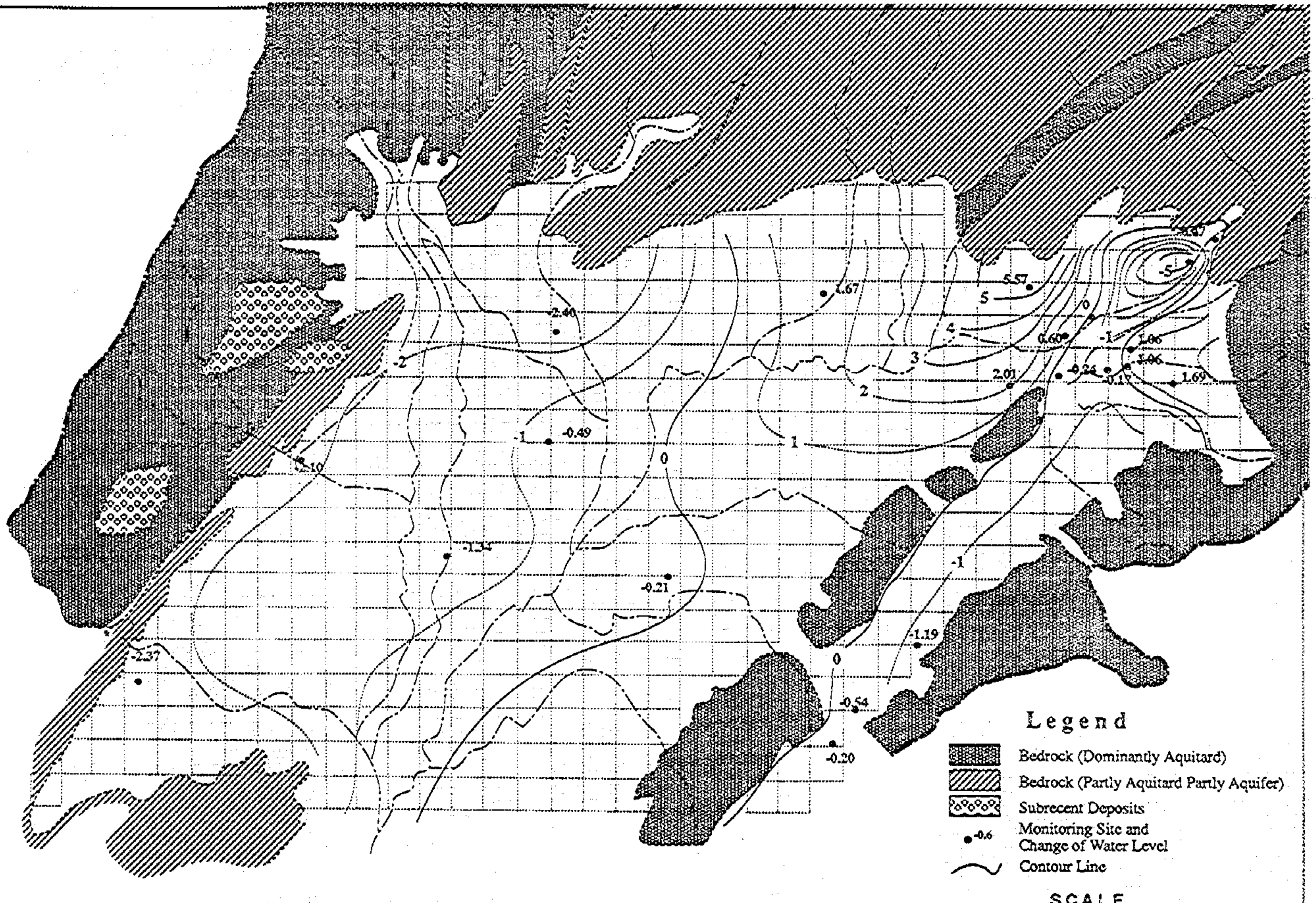


Fig. C.9 Change in Groundwater Level in Pishin Sub-basin during 1992/93 - 94/95 (2Years)

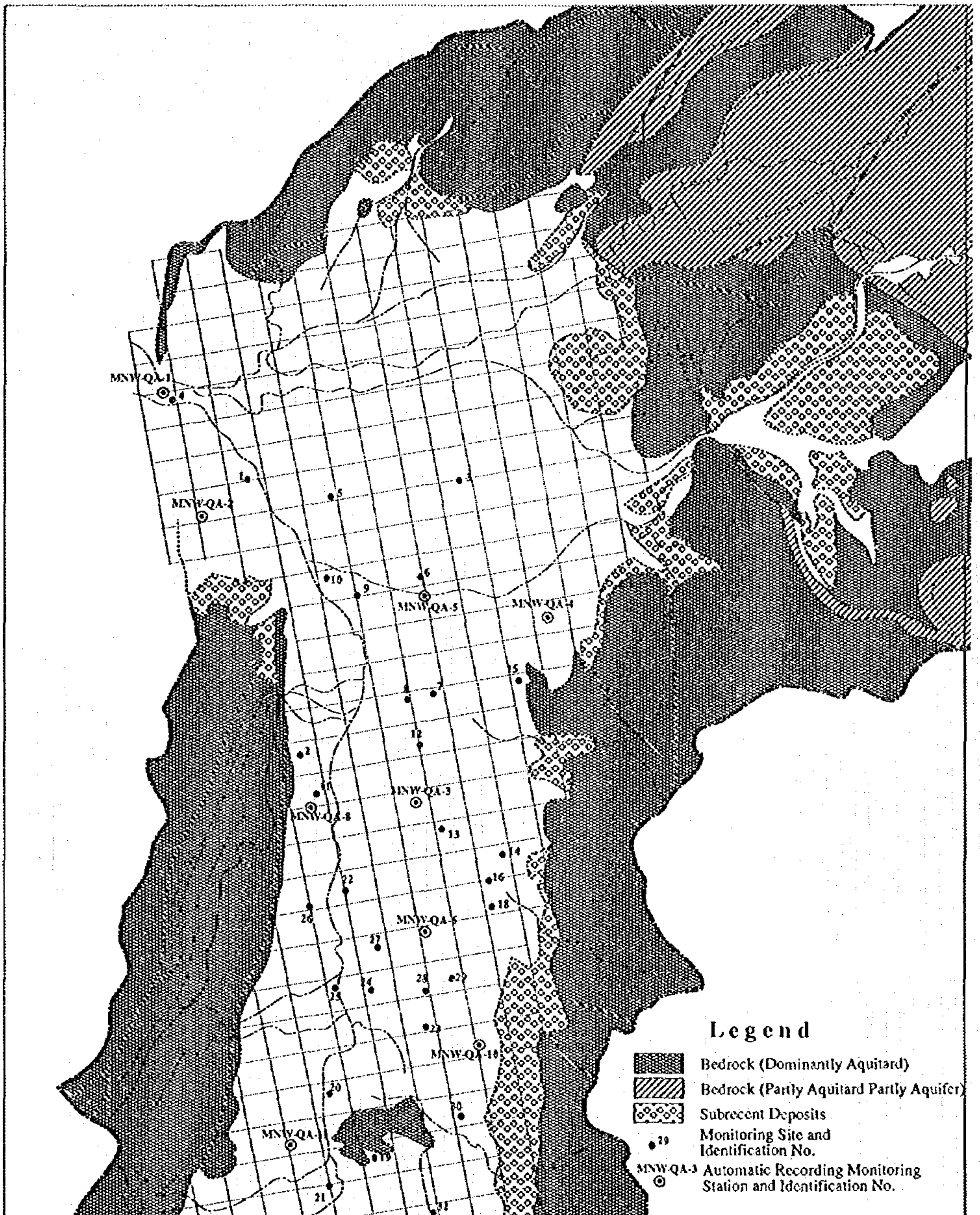


Fig.C.10 Groundwater Monitoring Sites in Quetta Northern Sub-Basin

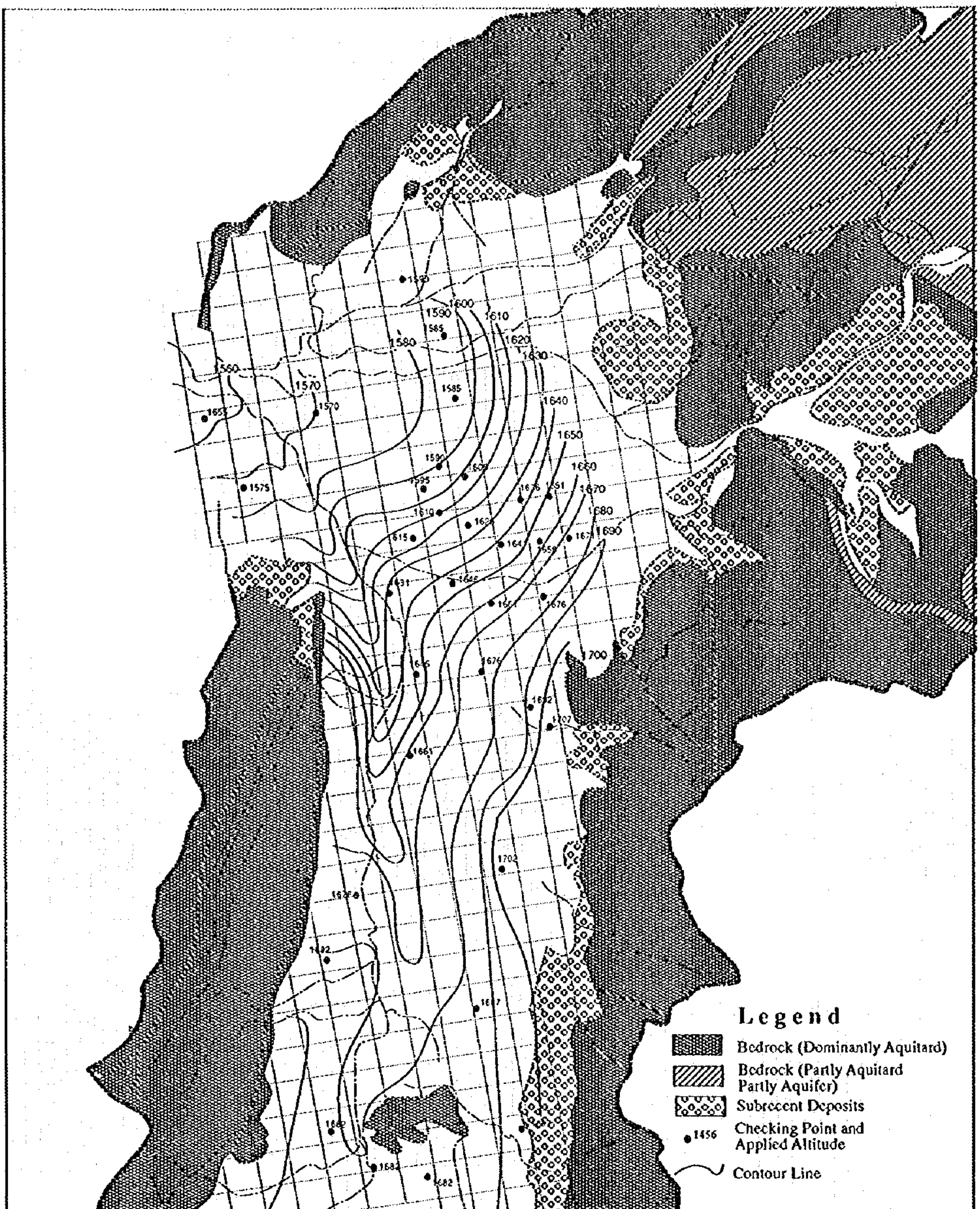


Fig.C.11

Groundwater Level in Quetta Northern Sub-Basin

Altitude in Meters at 1994/95

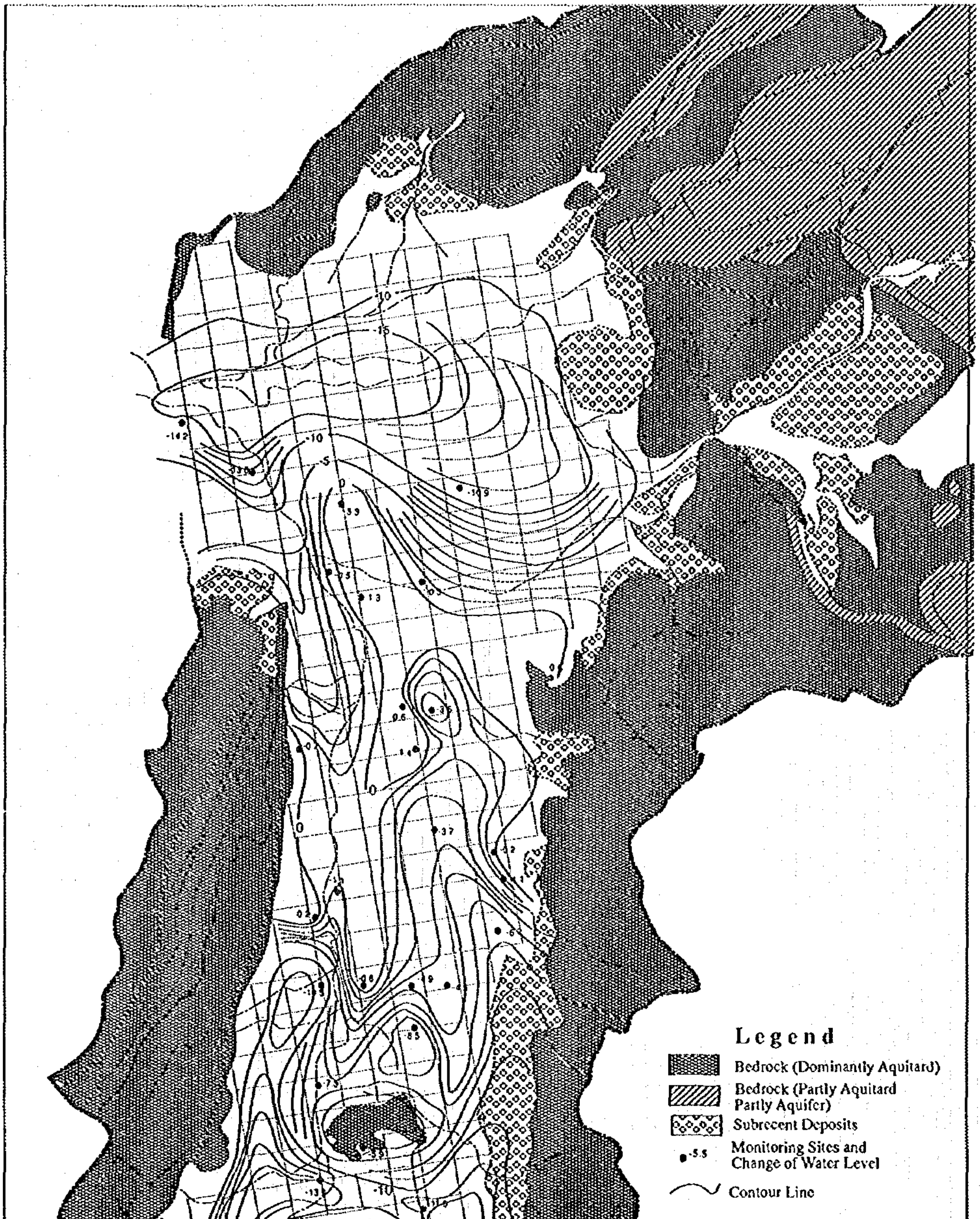


Fig.C.12

Change in Groundwater Levels in Quetta Northern Sub-Basin during 1985/1986 - 94/95 (9 years)

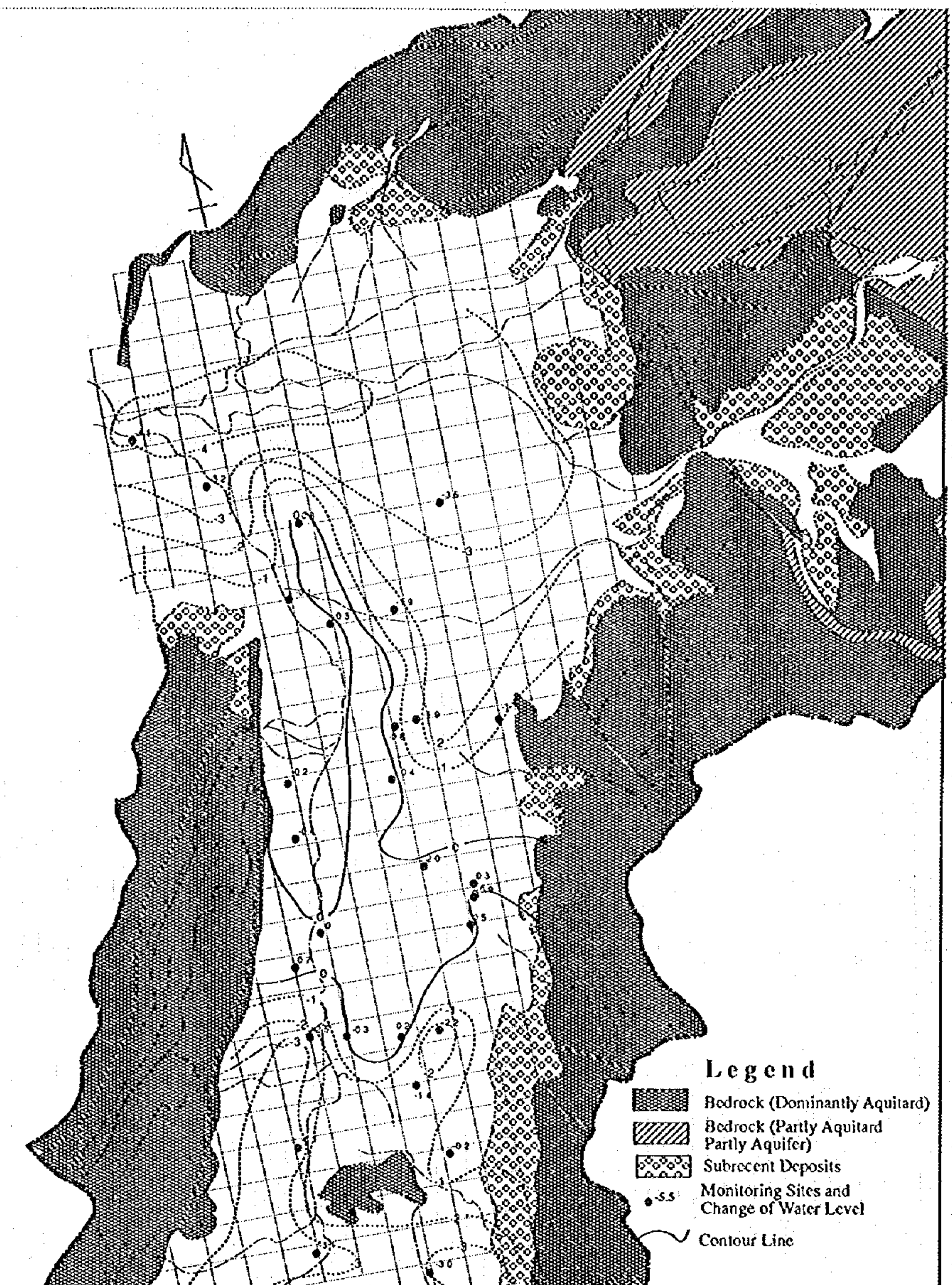


Fig.C.13

Change in Groundwater Levels in Quetta Northern Sub- Basin during 1985/86 - 88/89 (3 years)

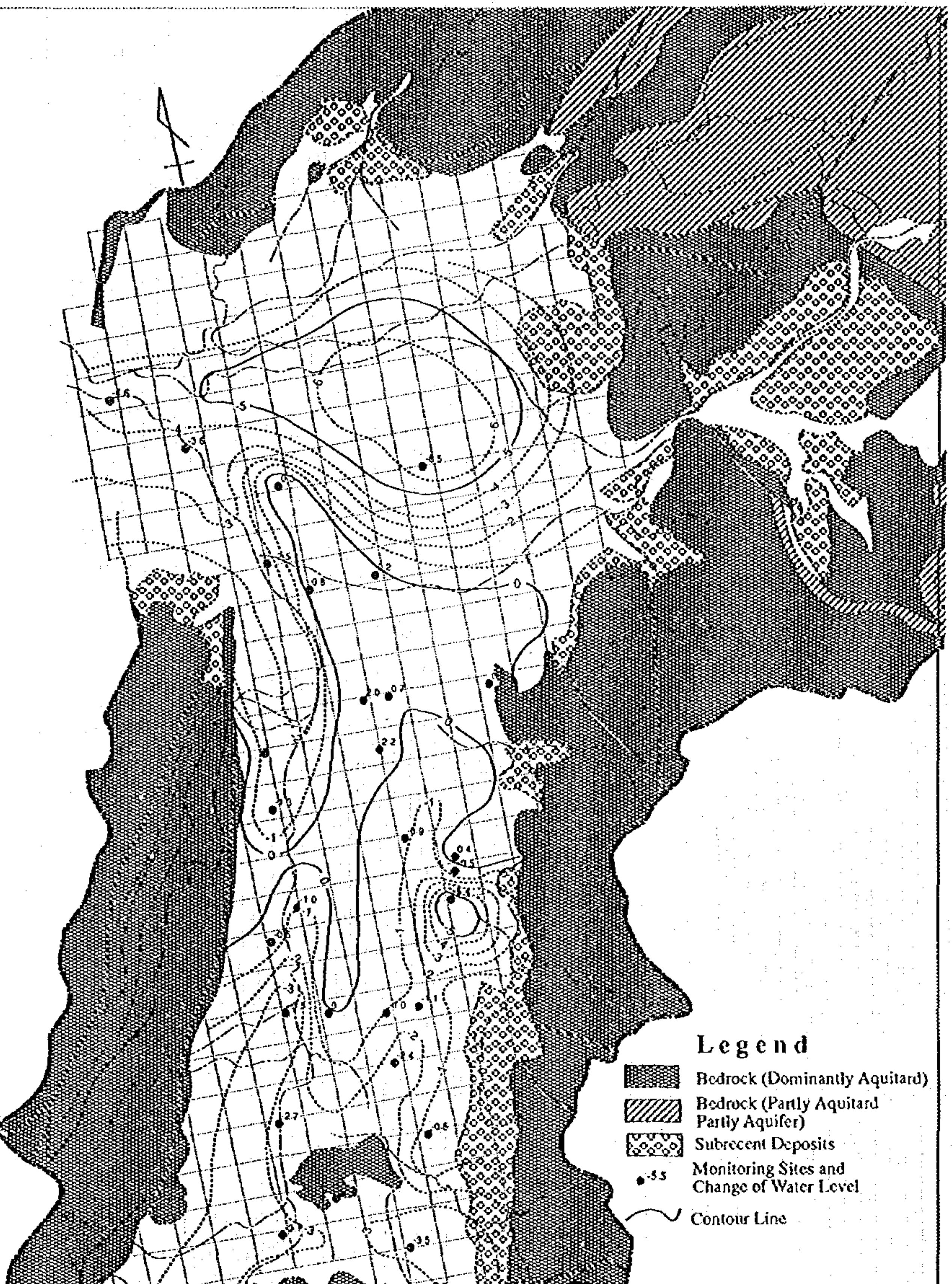


Fig.C.14

Change in Groundwater Levels in Quetta Northern Sub-Basin during 1988/89 - 91/92 (3 years)

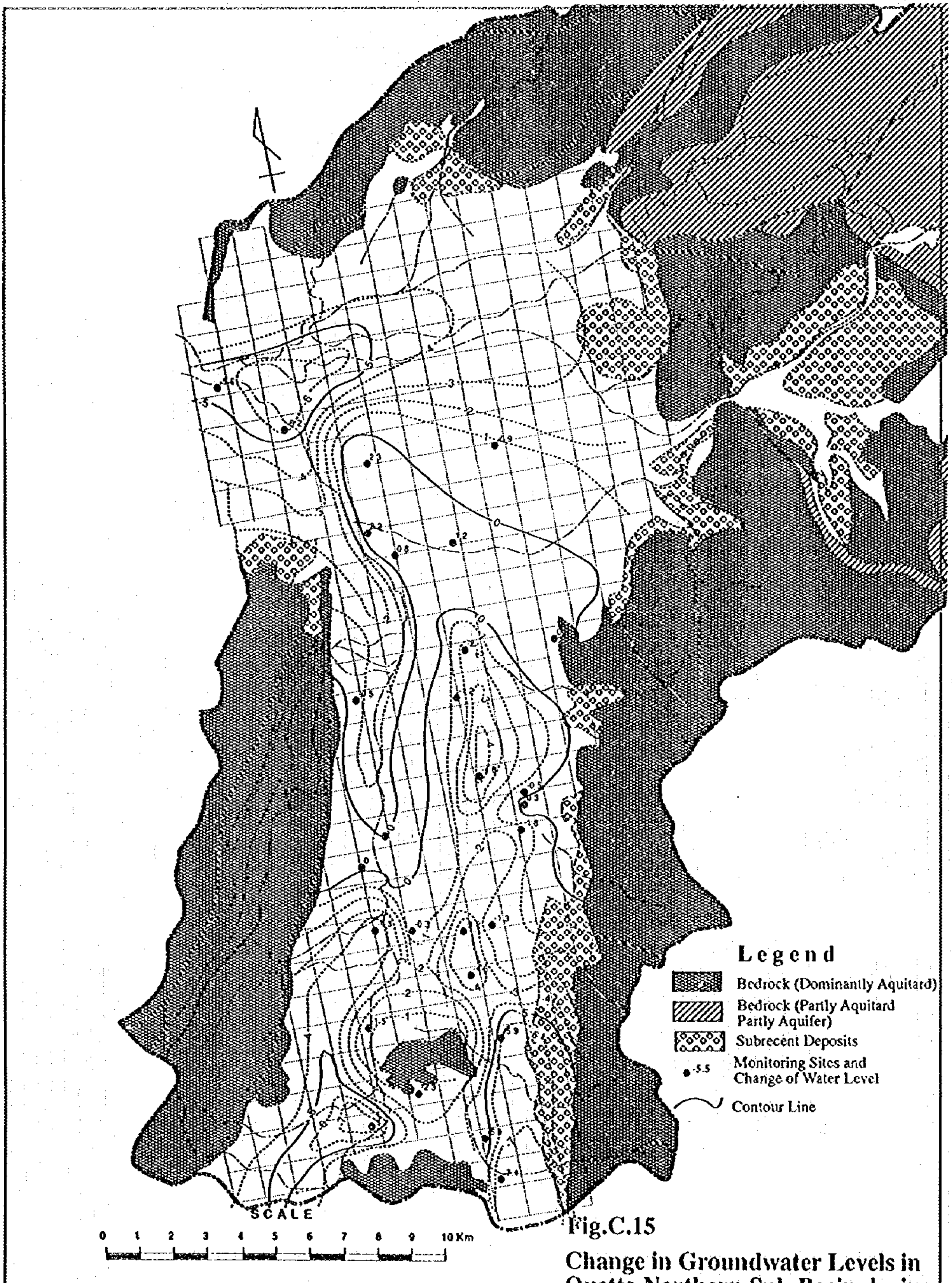


Fig.C.15

Change in Groundwater Levels in Quetta Northern Sub-Basin during 1991/92 - 94/95 (3 years)

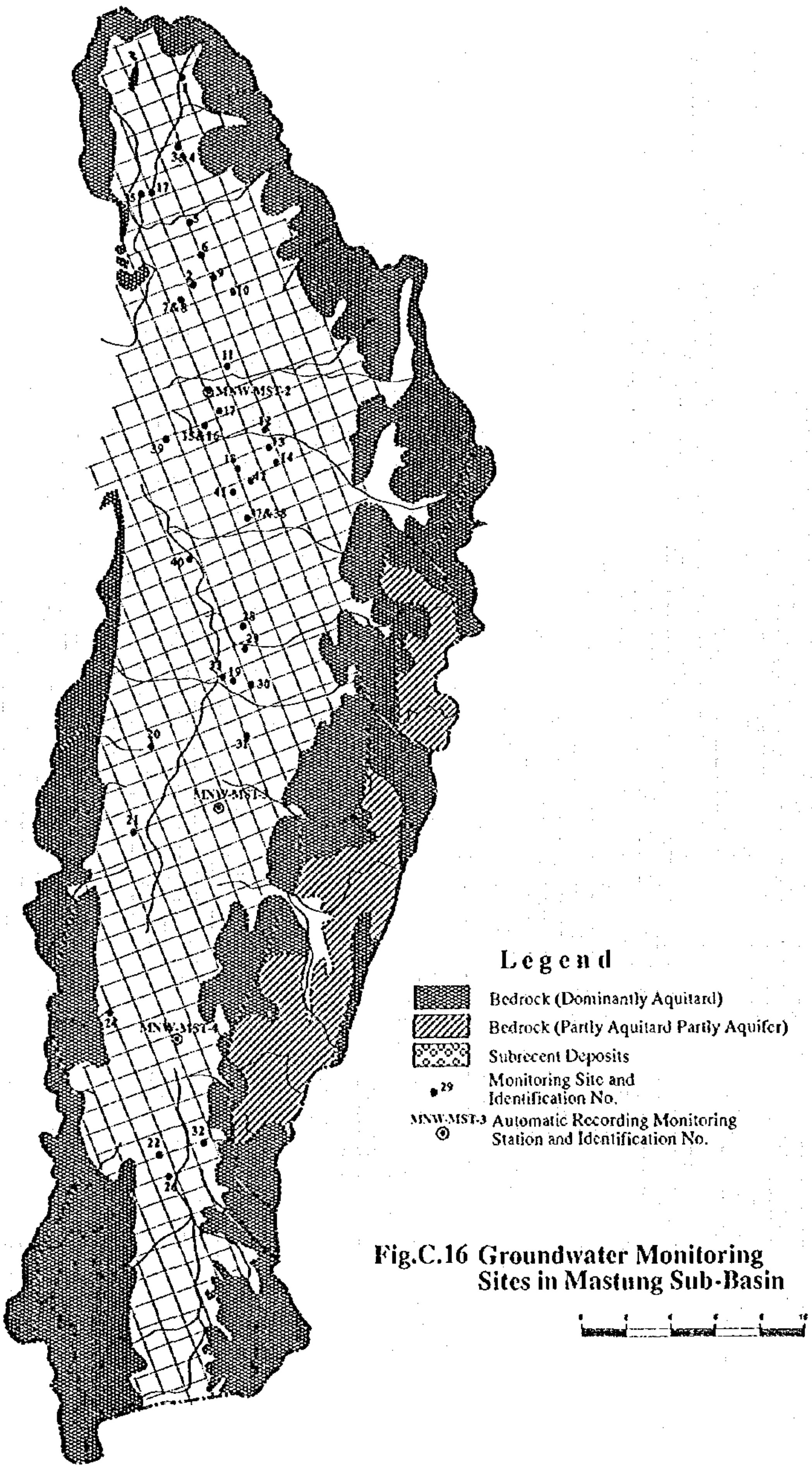


Fig.C.16 Groundwater Monitoring Sites in Mastung Sub-Basin

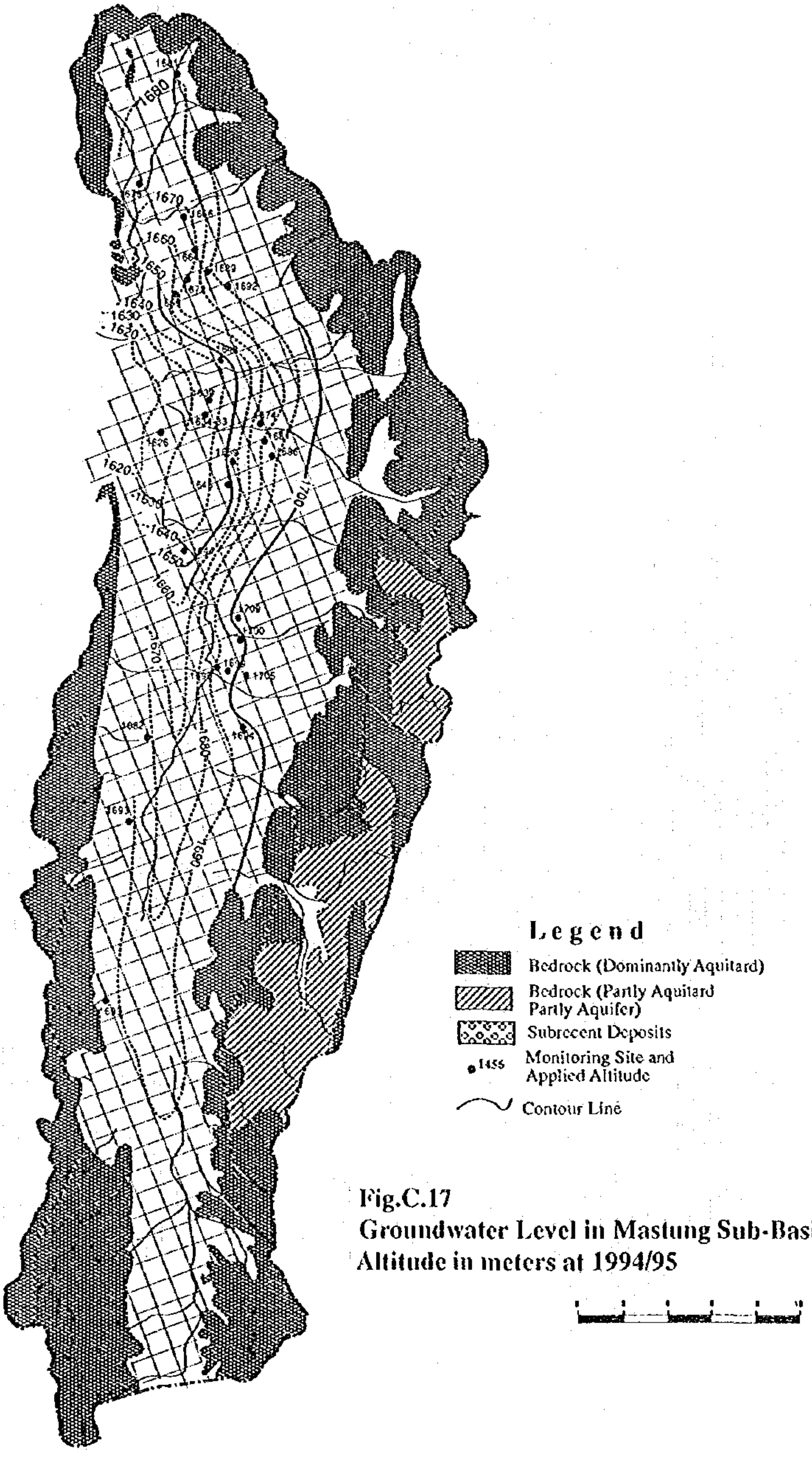


Fig.C.17
Groundwater Level in Mastung Sub-Basin
Altitude in meters at 1994/95

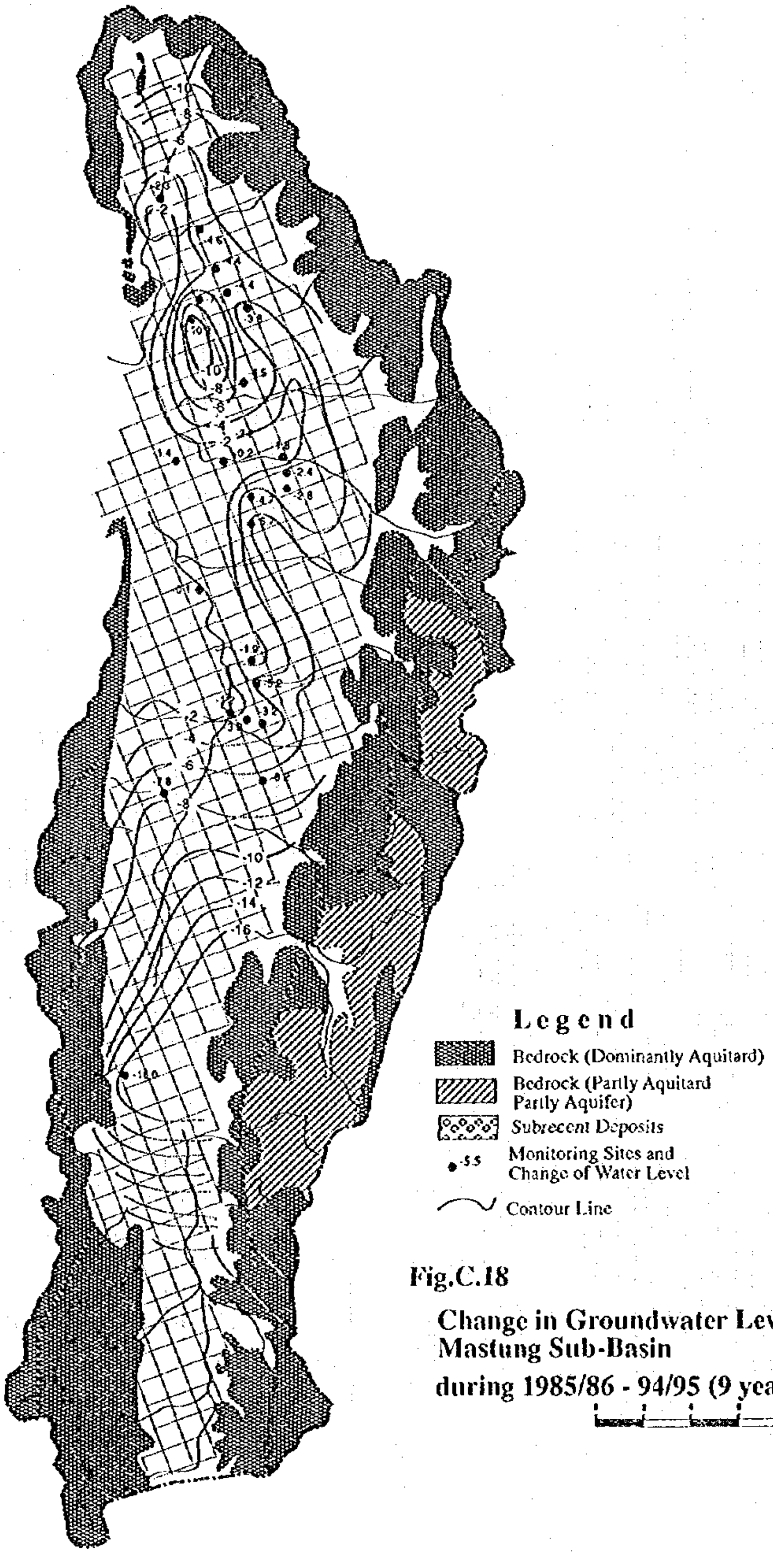


Fig.C.18

Change in Groundwater Level in Mastung Sub-Basin during 1985/86 - 94/95 (9 years)

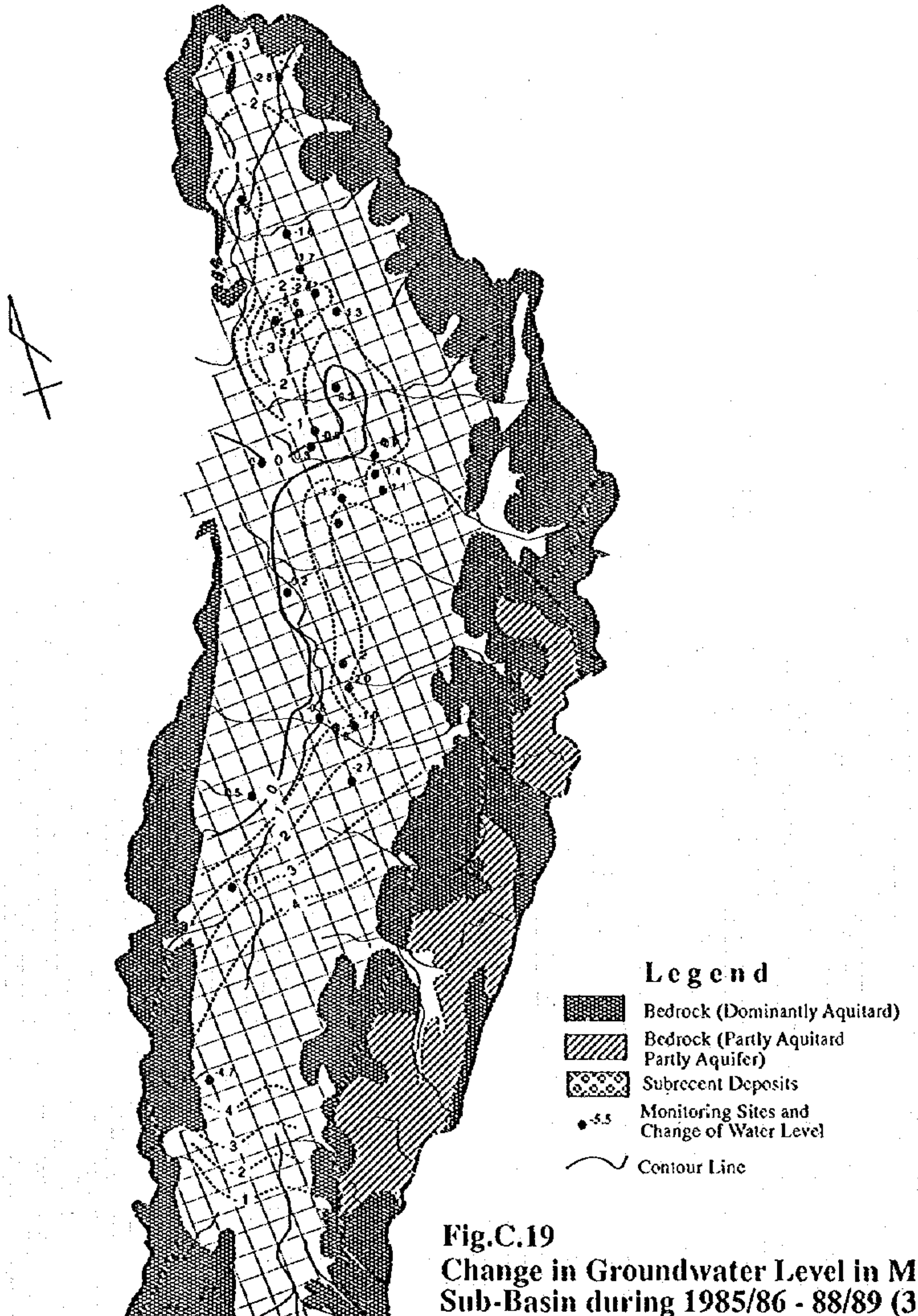


Fig.C.19
Change in Groundwater Level in Mastung Sub-Basin during 1985/86 - 88/89 (3 Years)

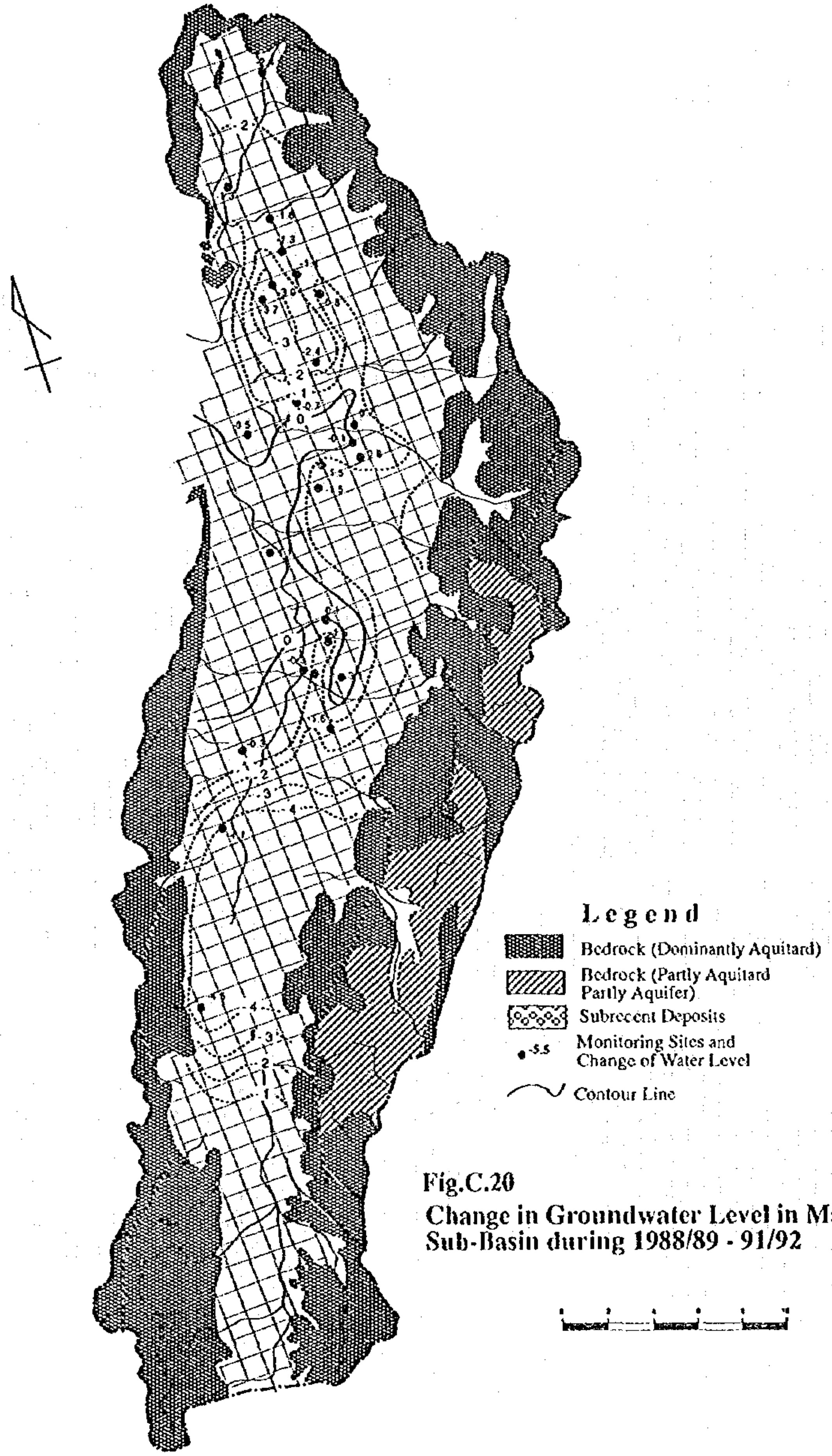


Fig.C.20
Change in Groundwater Level in Mastung Sub-Basin during 1988/89 - 91/92

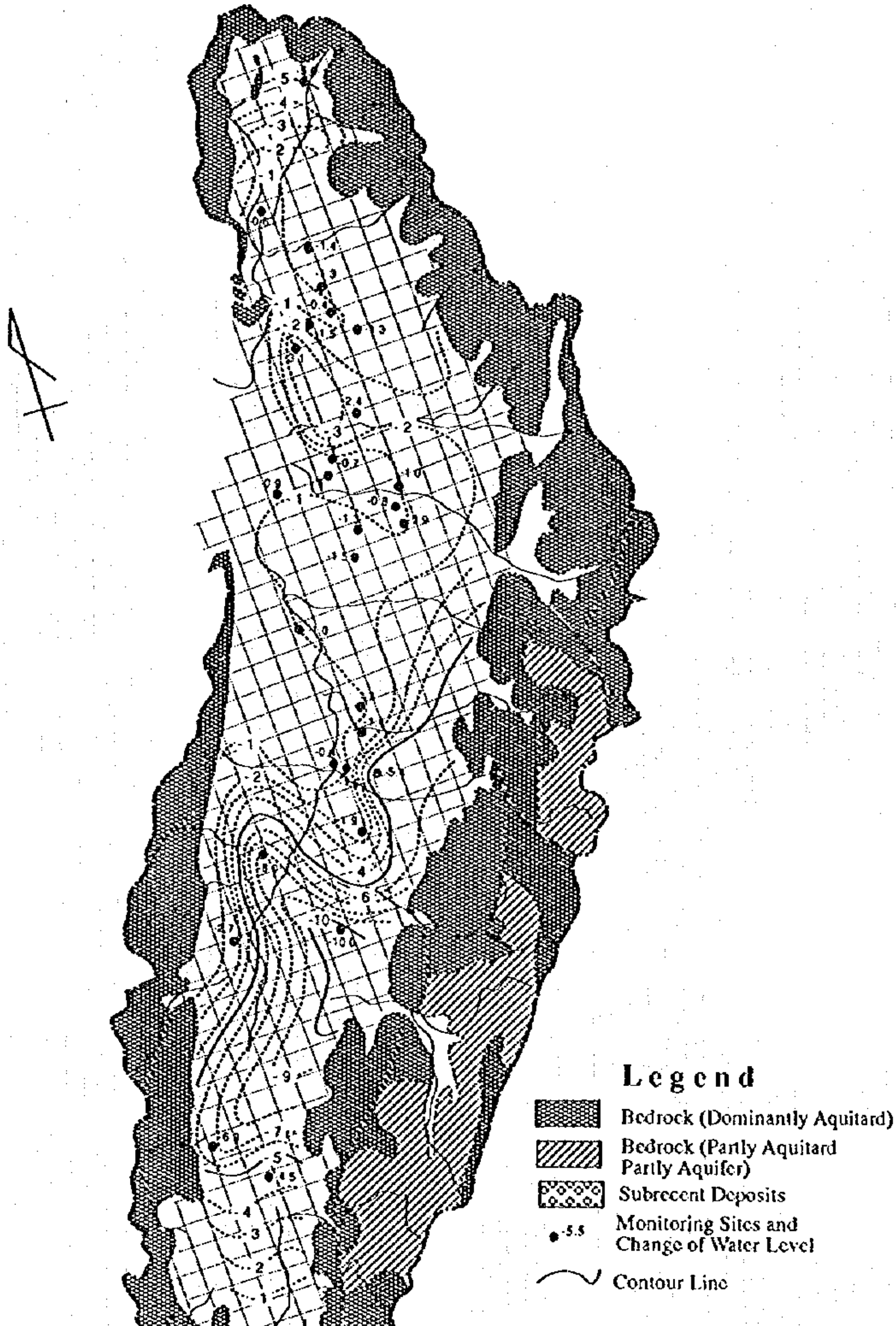


Fig.C.21
Change in Groundwater Level in Mastung Sub-Basin during 1991/92 - 94/95