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Evaluating groundwater resources in Shahrood region

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Abstract

Shahrood County is the largest county in the Semnan province and the second largest county in the Iran. In this region, there are considerable restrictions regarding to supply water for different consumptions. In order to evaluate the groundwater resources in this vast region, the available long-period groundwater levels for six large plains were collected and their unit hydrographs prepared. Applying the unit hydrographs provide, the groundwater draft was calculated for above-mentined plains. On the basis of obtained results, it is obvious that the values of groundwater draft for all plains (exception for one plain i.e Chah-Jam plain) is too much. For instance, in Mayamey plain the groundwater draft is about 332 M m^3. In Chah-Jam, the groundwater discharge is relatively so small and mostly is discharged for animal husbandries. Therefore, the insignificant annual groundwater discharge in this plain results in little groundwater draft. The groundwater quality in the study area varies from one place to another. In most plains in Shahrood County the quality of groundwater depends mainly upon lithology of the materials in the aquifer or surrounding the aquifer. The value of electrical conductivity as a representative for total dissolved solids, in Bastam and Shahrood plains is relatively less than that in other plains.

Keywords: Shahrood County, groundwater draft, unit hydrograph, discharge

1-Introduction

Groundwater is an important water resource particularly in arid and semi-arid region (Karami 2009). In fact, groundwater includes almost all water supplies in most arid and semi-arid region. Groundwater is widely used for domestic, agricultural, and industrial consumptions over the world. For instance, groundwater is the main water resources in Iran (Abbasnia et al. 2019, Ghazi et al. 2021), Japan (Amano et al. 2022), Turkey (Demiroglu e al. 2019), Africa (Sayed et al. 2020), etc.

This Groundwater constitutes a primary source of freshwater for many populations around the globe, especially regions where rainfall is scanty, surface water sources are absent, and all domestic and agricultural needs are fulfilled with groundwater. However, overexploitation of groundwater, inappropriate temporal and spatial distribution of rainfall, and lack of natural nutrition compared to the amount of harvest, the cause of groundwater salinization, and gradually lead to freshwater aquifers' pollution (Bhakar and Singh, 2019; Böhlke and Denver, 1995; Jafari et al., 2018; Michael et al., 2017; Mosaffa et al., 2021; Pacheco Castro et al., 2018; Sherwood and Klein, 1963; Jafari et al., 2018). paper is focused on the conditions of groundwater resources in

Shahrood region, Iran. Shahrood County is located in the Semnan province, 400 km in the east of Tehran. The Shahrood County has a total area of nearly 51400 square km. This county is the largest county in the Semnan province and the second largest county in the Iran.

2- Methods

There are 14 plains in Shahrood County which their details have been listed in Table 1. As can be seen from the Table 1, the largest plain in the Shahrood County is Torud plain with area of 2686 km^2 and the smallest one is Mojen plain with area of 140 km^2. In this research, the available groundwater levels for major plains (i.e plains of Shahrood, Mayamey, Bastam, Biarjomand, Chah-Jam, and Mazj and Jailan) were collected and according to Theissen's networking the unit hydrograph for each plain was prepared. Thereafter, using data from prepared unit hydrographs of above-mentioned plains, their area, and average storage coefficients, the values of groundwater draft for each plain has been separately calculated. The values of groundwater draft can be calculated using the following equation:

$$G_d = \Delta h \times A \times S \quad (1)$$

Where G_d = groundwater draft (Mm^3), Δh = difference in hydraulic head (m), A = area of plain (m^2), S = average storage coefficient of plain (dimensionless)

There are more than 1400 production wells, 329 qanats, and 289 springs in Shahrood County. The main part of production wells is located in Shahrood, Bastam, and Mayamey plains while the minimum number of production wells falls in Salamrood and Zaman Abad plains. The number of qanats in Mayamey and Forumad plains is greatest whereas the number of qanats in Ahmad Abad is least. A large number of springs are located in the Kalpoosh and Bastam plains whilst a few springs located in Shahrood, Ahmad Abad, and Salamrood plains. Table 2 illustrates the number of production wells, qanats, and spring in plains of Shahrood County.

Table 1 Plains and their area in the Shahrood County

Plain	Area (km^2)
Shahrood	472.3
Mayamey	544.0
Bastam	201.9
Biarjomand	274.8
Chah-Jam	348.55
Mazj and Jailan	385.0
Torud	3434
Abbas Abad	738
Forumad	347
Kalpoosh	204
Mojen	140
Ahmad Abad	400
Zaman Abad	350
Salamrood	580

Table 2 The number of productions well, qanats, and springs in the Shahrood County

Plain	Production well	Qanats	Spring
Shahrood	471	9	6
Mayamey	249	72	22
Bastam	386	23	54
Biarjomand	53	29	12
Chah-Jam	22	5	-
Mazj and Jailan	59	28	27
Torud	27	34	15
Abbas Abad	82	9	15
Forumad	35	56	18
Kalpoosh	60	9	61
Mojen	18	14	26
Ahmad Abad	33	4	7
Zaman	11	30	19

Abad Salamrood	5	12	7

3- Results and discussion

3-1- Groundwater discharge through wells, qanats, and springs

The total groundwater discharge in Shahrood County is almost 545 Mm^3 which is yielded by wells, qanats and springs. Table 3 shows the groundwater discharge in different plains of Shahrood County. As can be seen from the Table 2, it may be concluded that the majority of groundwater discharge is related to plains of Shahrood, Bastam, Mayamey. Table 4 gives information about the values of groundwater discharge and their percentage through wells, qanats, and spring. It can be seen from Table 4 that the main groundwater discharge yielded by wells, such that its percentage for discharging the groundwater is 67%.

Table 3 Groundwater discharge in the plains of Shahrood County

Plain	Groundwater discharge (Mm^3)
Shahrood	132.5
Mayamey	108.0
Bastam	136.2
Biarjomand	40.8
Chah-Jam	22.0
Mazj and Jailan	18.2
Torud	6.9
Abbas Abad	3.4
Forumad	26.0
Kalpoosh	16.4
Mojen	6.0
Ahmad Abad	6.3
Zaman Abad	5.9
Salamrood	16.4
Total	545

3-2- Assessing the groundwater draft in plains of Shahrood County

In order to evaluate the water budget in the plains of Shahrood County, six important plains in this county were considered. Thereafter, by using a relatively long-period unit hydrograph, the difference in groundwater level between the beginning and the end of period is calculated. Having the difference in groundwater level, area of the plain, and the average of storage coefficient, the values of groundwater draft for each plain can be determined.

Table 4 Groundwater discharge in the plains of Shahrood County

	Production well	Qanats	Spring	Total
Groundwater discharge (Mm^3)	364	103	78	545
Percentage	67	19	14	100

3-2-1- Shahrood Plain

The unit hydrograph of Shahrood plain for a 14 years period has been shown in Figure 1. As can be seen from the figure, there is a continuous decline in groundwater level in this plain which reflects a heavy pumping from this aquifer. In addition, based on this graph, the values of groundwater declie is about – 9.56 m. According to this graph, the value of groundwater draft in Shahroud plain has been calculated and shown in Table 5.

3-2-2- Mayamey Plain

Figure 2 illustrates the unit hydrograph of Mayamey plain for a 14 years period. It can be seen from the figure that, similar to Shahrood plain, there is a continuous decline in groundwater level in this plain which reflects a heavy pumping from this aquifer. The difference in groundwater level from Oct 1994 to Oct 2008 is nearly -12.2 m. According to this graph, the value of groundwater draft in Mayamey plain has been calculated and shown in Table 5.

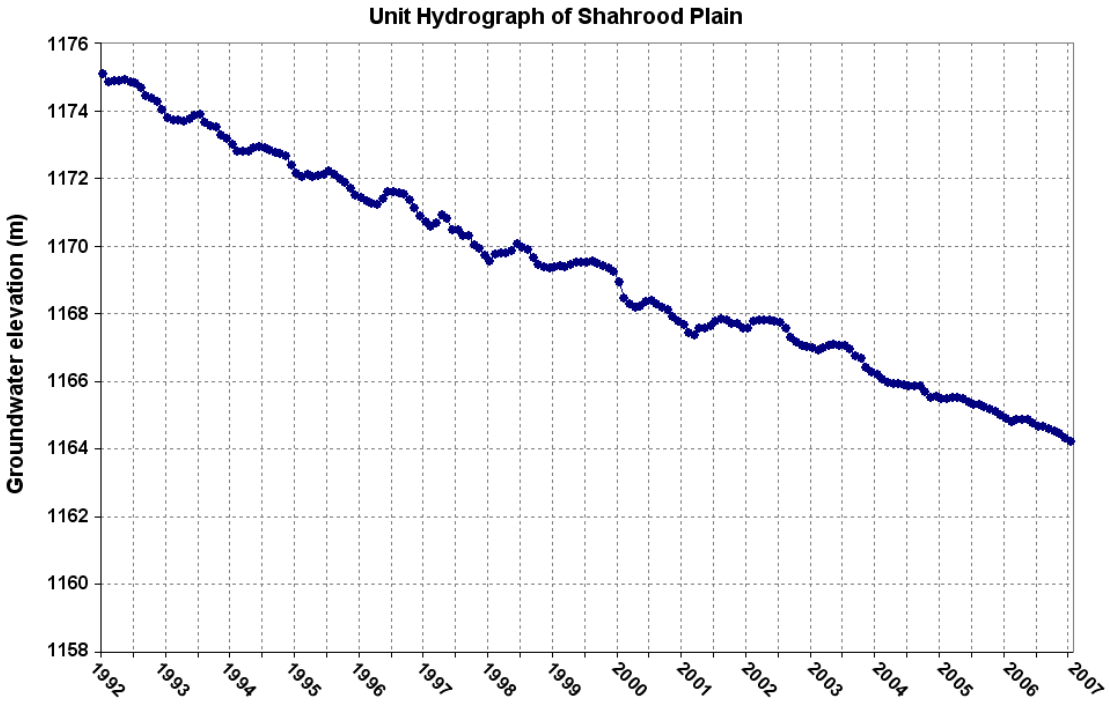

Figure 1 The unit hydrograph of 14 years period in Shahrood plain

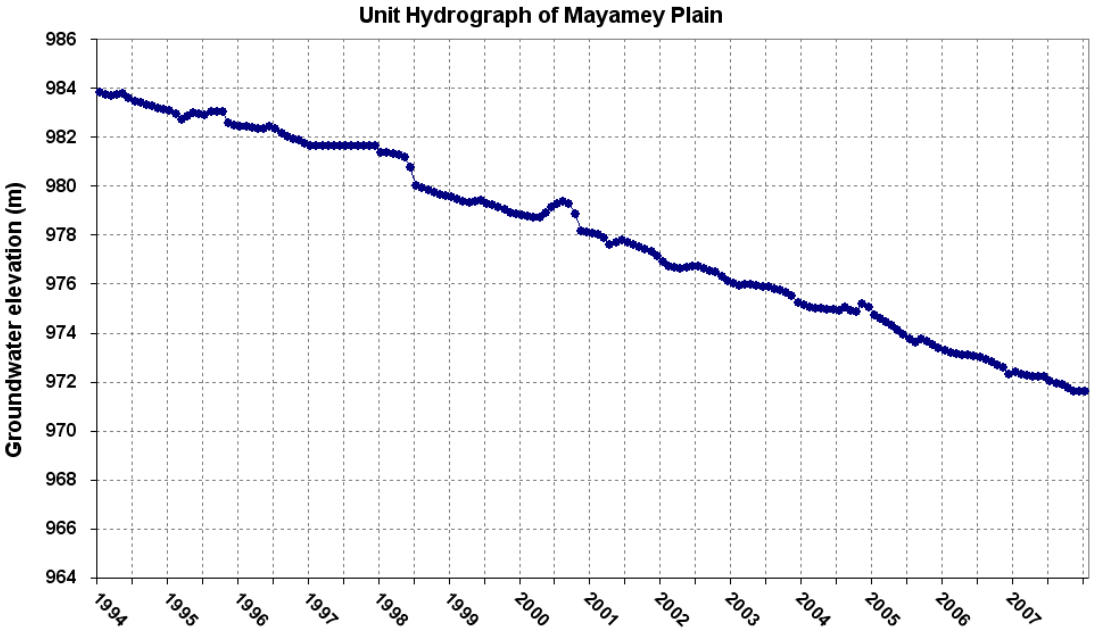

Figure 2 The unit hydrograph of 14 years period in Mayamey plain

3-2-3- Bastam Plain

The unit hydrograph of Bastam plain for eight years period has been drawn in Figure 3. As can be seen from the figure, there is a relatively uniform decline in groundwater level particularly after 2003. This plain alike other plain in Shahrood County has been faced with a heavy pumping from the aquifer. According to the Figure 3, the groundwater decline between Oct 2000 and Oct 2008 is about – 8.00 m. Using this graph, the value of groundwater draft in Bastam plain has been calculated and shown in Table 5.

3-2-4- Biarjomand Plain

The unit hydrograph of Biarjomand

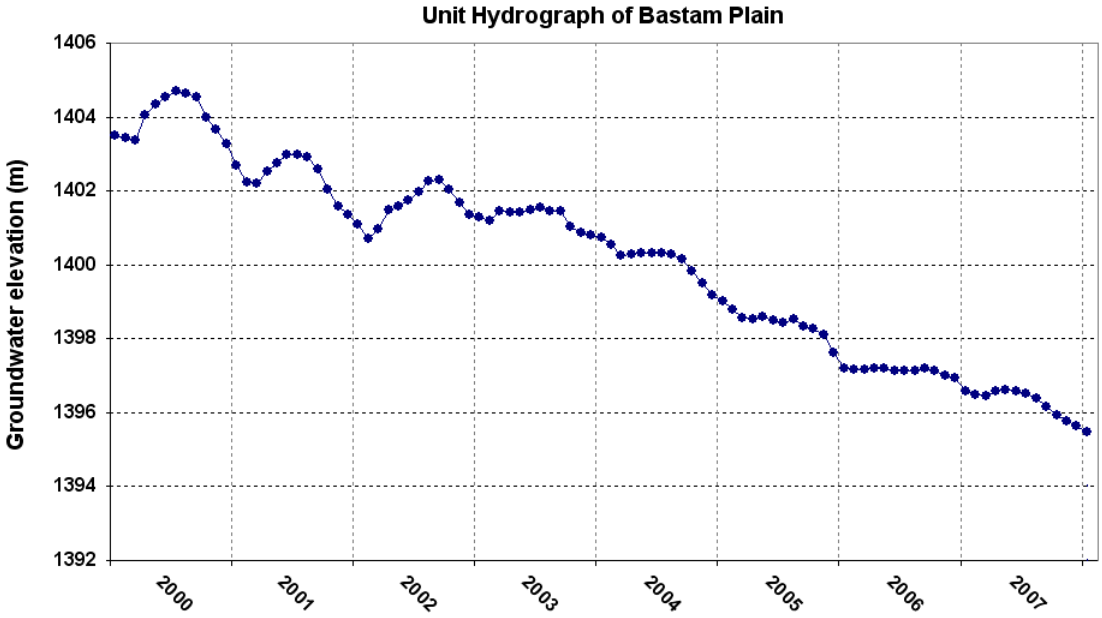

Figure 3 The unit hydrograph of eight years period in Bastam plain

plain for a 20 years period has been brought in Figure 4. As can be seen from the figure, there is a continuous decline in groundwater level in this plain which reflects a heavy pumping from this aquifer. Based on this graph, the groundwater level decline from Oct 1988 to Oct 2008 about 7.7 m. has been calculated and shown in Table 5.

3-2-5- Chah-Jam Plain

Figure 5 shows the unit hydrograph of Chah-Jam plain for a 11 years period. As can be seen from the figure, the changes in groundwater level in this plain is quite different in comparison with above-mentioned plains (e.g. Shahrood plain). It can be seen from the figure 5 that the long-period decline of groundwater level in this plain is small which equals – 0.58 m for 11 years period. This is because in

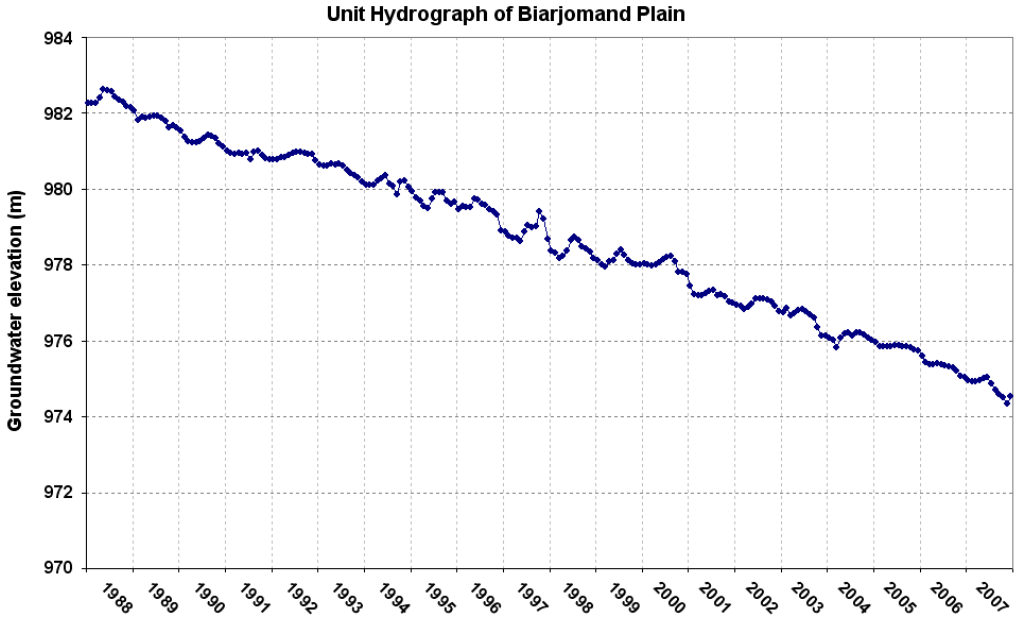

Figure 4 The unit hydrograph of 20 years period in Biarjomand plain

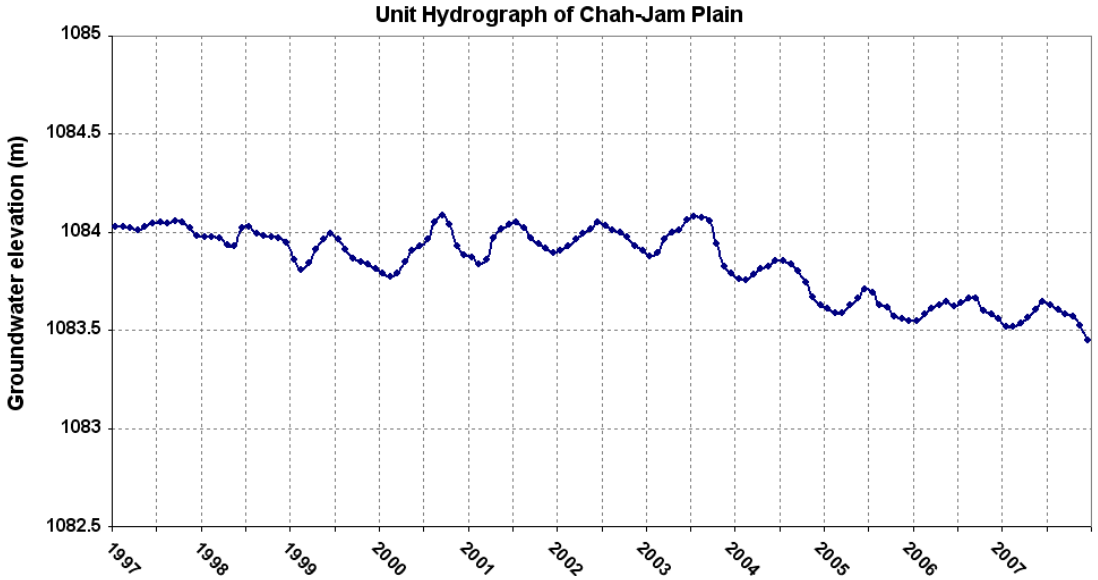

Figure 5 The unit hydrograph of 11 years period in Chah-Jam plain

this plain the quality of water and particularly soil is not appropriate for agricultural activities. Such that the values of annual groundwater discharge in this plain is about 22 Mm^3, which may be ignored in comparison with other major plains. According to this graph, the value of groundwater draft in Chah-Jam plain has been calculated and shown in Table 5.

3-2-6- Mazj and Jailan Plain

The unit hydrograph of Mazj and Jailan plain for a 14 years period has been shown in Figure 6. As can be seen from the figure, there is a steep and continuous decline in groundwater level in this plain which reflects a heavy pumping from this aquifer. Moreover, it can be seen from the Figure 6 that the groundwater decline during 14 years period equals to – 12.0 m. According to this graph, the value

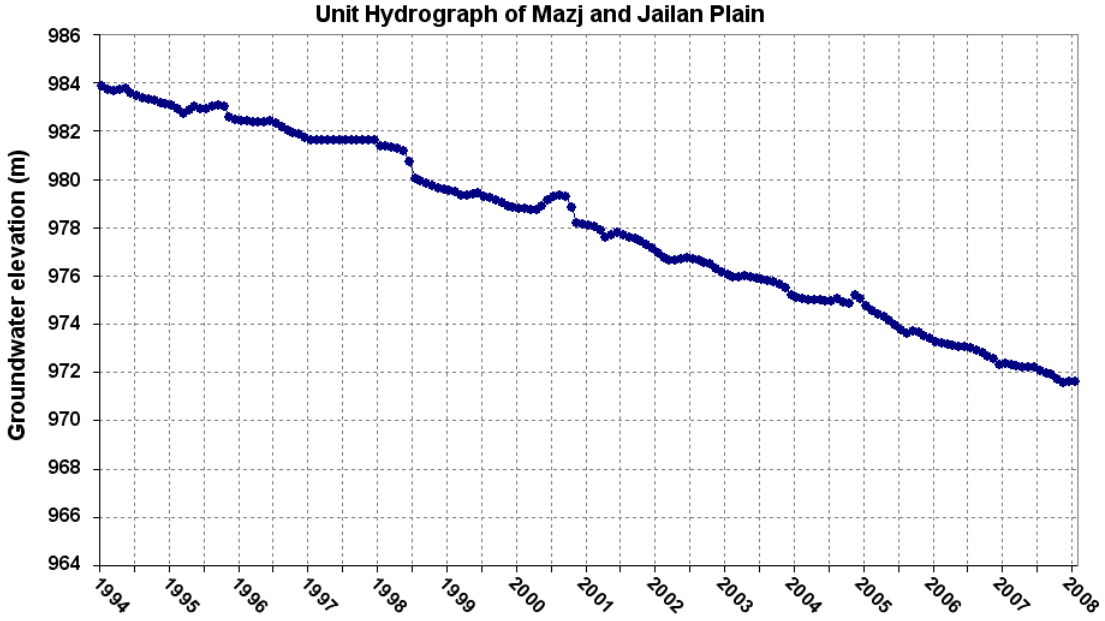

Figure 6 The unit hydrograph of 14 years period in Mazj and Jailan plain

Table 5 Aquifer characteristics and groundwater draft

Plain	Area (km^2)	Δh (m)	Period (year)	Average S	Groundwater draft (Mm^3)
Shahrood	472.3	- 9.56	14	0.04	- 180.5
Mayamey	544.0	-12.21	14	0.05	- 544.0
Bastam	201.9	- 8.00	8	0.04	- 64.6
Biarjomand	274.8	- 7.70	20	0.04	- 84.6
Chah-Jam	348.6	- 0.58	11	0.046	- 9.3
Mazj and Jailan	385.0	- 12.00	14	0.03	- 138.6

of groundwater draft in Mazj and Jailan plain has been calculated and shown in Table 5.

3-3- Evaluating the quality of water in large plains

It is obvious that the groundwater quality varies from one place to another. In most plains in Shahrood County the quality of groundwater depends mainly upon lithology of the materials in the aquifer or surrounding the aquifer. However, the quality of groundwater decreases in direction of groundwater flow, due to increase in contact time of water with aquifer materials, and also local heavy pumping. The most important parameters for presenting the general quality of groundwater and its salinity are electrical conductivity which can be measured in the field using precise portable instrument.

In Shahrood plain the electrical conductivity of groundwater ranges between 600 michromhos/cm in the north and north west of the plain and 11000 michromhos/cm in the south of plain in the outlet of the plain. The average electrical conductivity of groundwater in Shahrood plain is about 1900 michromhos/cm.

In Mayamey plain the electrical conductivity of groundwater ranges from 700 michromhos/cm in the east and south of the plain to11000 michromhos/cm in the north east and in the center of plain. The average electrical conductivity of groundwater in Mayamey plain is about 2000 michromhos/cm.

In Bastam plain the electrical conductivity of groundwater varies from 500 michromhos/cm in the north and north east of the plain to 13000 michromhos/cm in the south east of the region. The average electrical conductivity of groundwater in Bastam plain is about 720 michromhos/cm.

In Biarjomand plain the electrical conductivity of groundwater falls between 700 michromhos/cm in the south of the plain and 7000 michromhos/cm in the north east of plain. The average electrical conductivity of groundwater in Mayamey plain is about 1350 michromhos/cm.

4- Conclusion

In order to evaluate the groundwater resources in the Sharood region, the available long-period groundwater levels for six large plain were taken and the unit hydrographs prepared for these plains. Using prepared unit hydrographs, the magnitude of groundwater draft were calculated for these 6 large plains. According to the obtained data, exception for one plain (i.e Chah-Jam plain) the values of groundwater draft for all plains is too much. In Chah-Jam, the quality of water and particularly soil is not suitable for agricultural activities and also a considerable part of groundwater is discharged for animal husbandries. Therefore, the values of annual

groundwater discharge in this plain are so small and results in insignificant groundwater draft. Since the magnitude of groundwater drafts in some plains (e,g. plains of Mayamey, Shahrood, and Bastam), it may be argued that decreasing the flow rate of pumping well in some cases (such as Bastam and Shahrood) which provide water for domestic consumptions is not a effective device. It is suggested that for such places which include extreme groundwater draft, it is necessary that the government buy a large number of pumping well and stop their pumping.

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