An Evaluation Of Water Resources Management In Ramallah District

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Abstract

This study highlights the groundwater resources available in Ramallah district as well as the flow pattern and water quality. There are 16 wells in the study area, five are located in Ein Samia and are owned by Jerusalem Water Undertaking, while 11 wells are owned by Mekorot (Two of these, namely Shebtin wells No.4 and No.5, are used to provide Palestinians with drinking water through West Bank Water Department). The total number of springs whose average discharge exceeding 0.01 liters/sec is 122. These springs are used by local Palestinian communities in Ramallah district for domestic and low scale irrigation purposes. The total long term average annual flow discharge (1970-1994) of the seven major springs is estimated to be approximately 3.83 MCM which constitutes 90% of the discharge of all springs there. The study

shows that the total water quantity received from Mekorot either purchased and distributed by JWU or distributed through WBWD is 6.5 MCM in 1994. The Palestinian consumption of water in 1994 for domestic and industrial purposes was about 9.8 MCM, only 2.55 MCM was produced locally from Ein Samia well field while the rest was purchased from Mekorot and the Municipality of Jerusalem. In comparison, Israelis are pumping 9.84 MCM/Yr from their wells in Ramallah area. This quantity equals the total water quantities consumed by Palestinians in Ramallah district in 1994.

Groundwater flow has two main directions, east and west with Upper and Lower Cenomanian exposed aquifers underlying Ramallah district. There are three zones of extensive pumpage (areas where the contours representing equipotential lines become closer as pumpage occurred) in the study area. These are:

1. Ein Samia well field whose groundwater flow direction is to the east and southeast
2. Shebtin well field located in the northwestern part of study area.
3. Israeli wells at Latroun in the southwestern part of Ramallah district near the no-man area where very extensive pumpage have resulted in reversing the groundwater flow direction to be towards the southeast.

Presentation of the available hydrochemical data on Wilcox diagram reveals that water of Ein Samia wells have medium salinity hazard and low sodium hazard which is suitable for irrigation. External water sources received at Ramallah and Shu'fat connection sites have a higher values of conductivity and are located in the region of high salinity and low sodium hazard. Piper diagram analysis shows that water of Ein Samia wells are earth alkaline with prevailing bicarbonate, while water purchased from Mekorot is earth alkaline with prevailing bicarbonate and increased portion of alkalis.

Introduction

Ramallah has occupied the central location in the West Bank which is the closest city to Jerusalem, the future capital of Palestine state. Because of that reasons, the city is subjected to high influx from other Palestinian locations and from outside to live, work, and invest money there. So, water status is and will be very critical in Ramallah district as new water sources will be required to meet the domestic purposes of its population. Future demand will be also increased to meet water supplies for Industry and tourist sectors.

Hydrogeological Status

Groundwater Aquifer Systems

The Ramallah District overlies two main exposed aquifer systems:

- Lower Cenomanian Aquifer System

The geologic formations representing this aquifer system are the Lower and Upper Beit Kahil formations. Lower Beit Kahil constitutes the lower part of the Lower Cenomanian which is composed of gray marly and dolomitic limestone with some joints forming an aquitard (Rofe & Raffety, 1963). Upper Beit Kahil constitutes the upper part of the Lower Cenomanian and consists of dolomitic, chalky, and marly limestone with karstification and well-jointed features forming a good aquifer confined by the overlying Yatta aquitard (Rofe & Raffety, 1965). The Ein-Samia wells No.3 and No.4 are tapping this aquifer system.

- Upper Cenomanian Aquifer System

  The geologic formation comprising this aquifer system is the Hebron formation which is composed of limestone and dolomitic limestone with chalky bands and chert nodules. Karsts and joints give this formation an excellent aquiferous characteristics (Rofe & Raffety, 1963). Figure 1 shows the groundwater basins and the exposed aquifers in the Ramallah District.

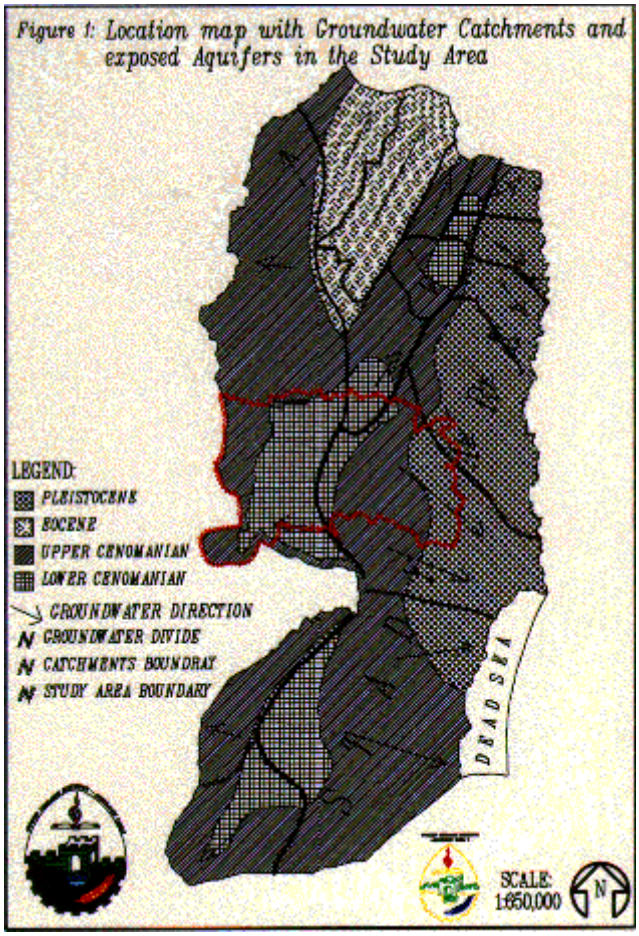


Figure 1: Groundwater basins and the exposed aquifers in the Ramallah District.

Groundwater Basins

Groundwater basins in the Ramallah District are divided as follows:

1. The western groundwater basin (Auja Tamaseeh sub-basin): This basin underlies approximately 65% of the Ramallah District and its groundwater flows towards the west. Shebtin wells are tapping this basin.
2. The eastern groundwater basin: This basin underlies the eastern part of the Ramallah District (35%). The groundwater flow direction is towards the east and southeast. A large part of the eastern area of the Ramallah District is underlain by the Jerusalem-Ramallah sub-basin.

Sources of Water

Table 1 lists the Palestinian and Israeli sources of water in the Ramallah District and their basic details. Figure 2 shows the location map of these sources in the Ramallah District. Figure 2 shows the Location map of water resources while Figure 3 shows the depths of wells and depth to water table of different groundwater wells in Ramallah district. These water sources could be divided as follows:

Table 1: Basic details on different water sources in the Ramallah District

Well Ident	**Source Name**	**SWL (m)**	**SWD (m)**	**WD (m)**	**PR/Hr (m^3)**	**PR/M (m^3)**
W6001	Ein Samia No.1	403	37	60	100	72000
W6002	Ein Samia No.2	260	154	235	35	25200
W6002a	Ein Samia No.2a	260	154	250	225	162000
W6003	Ein Samia No.3	234	198	529	175	126000
W6004	Ein Samia No 4	88	344	616	60	43200
W6006	Ein Samia No.6	-	150	250	125	90000
W6007	Shebtin Well No.4	-	-	-	90	64800
W6008	Shebtin Well No.5	-	-	-	85	61200
IW6001	Eshtaol No.6	13.64	279	605	10	6900
IW6002	Eshtaol No.3	15.08	274.7	462.5	300	216100
IW6003	Havi Yahuda	21.05	309.77	537.8	N/A	N/A
IW6004	Modiin No.3	21.13	279	1151	328	235900
IW6005	Modiin No.4	-36.77	288	1118	295	212300
IW6006	Modiin No.2	20.85	227.85	1029	106	76300
IW6007	Modiin No.1	16.63	203.91	533	21	15400
IW6008	Shebtin Levona	31.87	148.13	492.5	38	27500
IW6009	Shebtin No.15	-27.37	207.37	510	41	29300
S6001	Ajjul Spring	-	0	-	0.417	300
S6002	Delbeh+Legtan	-	0	-	4.92	3540
S6003	Zarqa Spring	-	0	-	9.38	6750

S6004	Harrasheh Spring	-	0	-	2.63	1890
S6005	Dilba Spring	-	0	-	8.3	5970
S6006	Areek Fouqa Spring	-	0	-	7.79	5610
S6007	Areek Tahta Spring	-	0	-	5.75	4140

Table Notes:
Well Ident: Identification Number
SWL: Static Water Level
SWD : Static Water Depth
WD: Well Depth
PR/hr: Pumping Rate per Hour
PR/M : Pumping Rate per Month

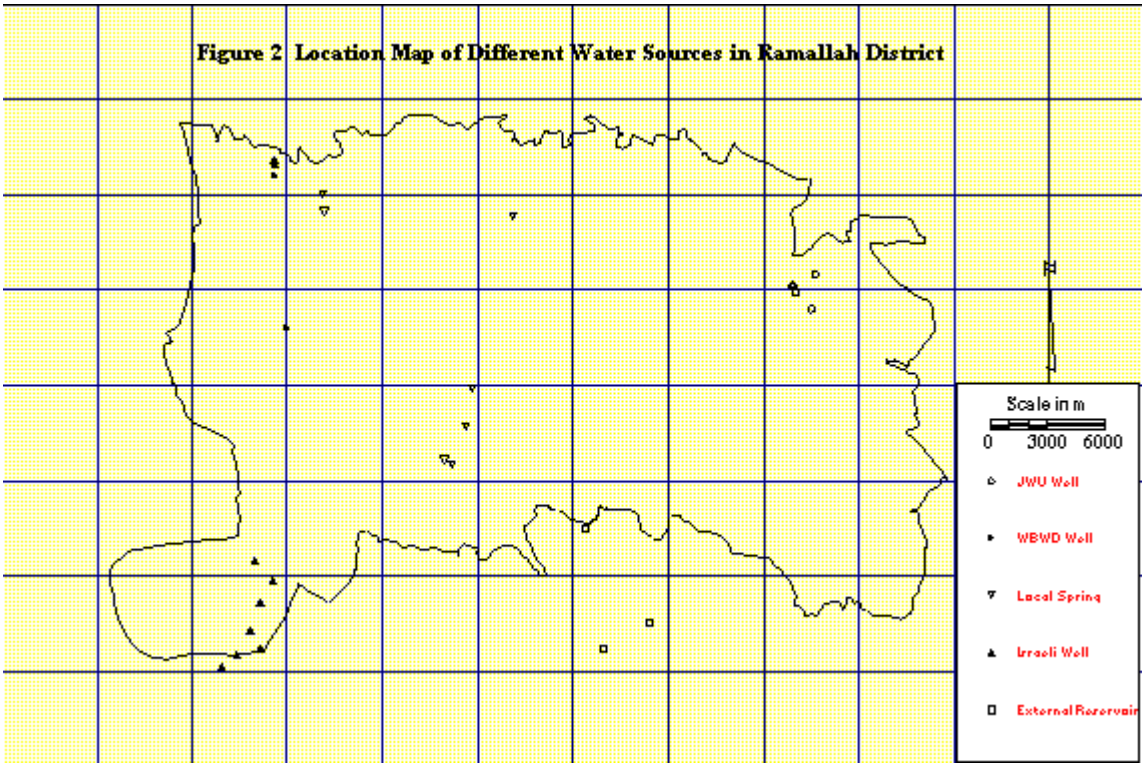


Figure 2: Location map of water resources of Different Palestinian and Israeli Groundwater Wells in Ramallah District

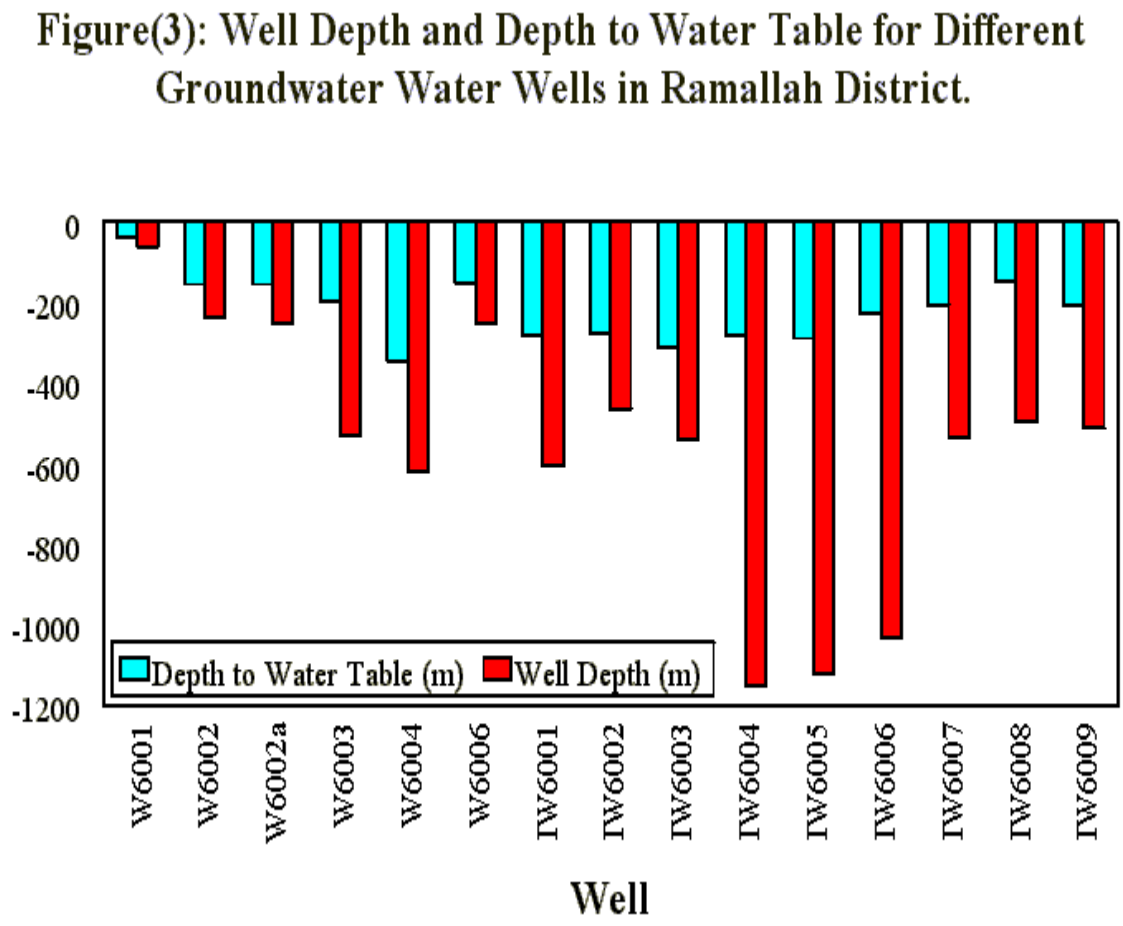


Figure 3: Well Depths and Depth to Water Table of Different Palestinian and Israeli Groundwater Wells in Ramallah District

Groundwater Wells

The groundwater wells, supplying domestic water to the people in the Ramallah District, are controlled by the Jerusalem Water undertaking (JWU), Mekorot through West Bank Water Department and Jerusalem Municipality. Mekorot Israeli Water company are also controlling another groundwater wells in the Ramallah District directed to provide the Israelis with domestic water.

Wells owned by the Jerusalem Water Undertaking(JWU)

The Jerusalem Water Undertaking (JWU) has five wells at Ein-Samia area to the east of Ramallah city. These wells are located to the east of the regional groundwater shed. tapping the eastern basin aquifer. They produce only one third of the current water supply for all purposes in the district. Basic information about Ein-Samia wells are shown in Table 1. Well No.1 is a seasonable well depending on the annual rainfall, while well No.2 is used mainly for irrigation purposes. Well No.2a is a new well, constructed as an alternative for well No.2 at the same location and expected to operate soon at a pumping rate of 300 m^3/hr. These wells (Ein-Samia wells No.1, No.2, and No.2a) tap the Upper Cenomanian aquifer system. Recently, the Ein Samia well No.3 was equipped with a higher yield pump to increase its capacity. The well

has pumped at its new capacity since December, 1995. Wells No.3 and No.4 tap the Lower Cenomanian aquifer system. The JWU is planning to construct a new well at Ein Samia (No.6) that will be funded by the German Government through GTZ.

Mekorot and West Bank Water Department Wells

A large quantity of water is purchased from Israeli sources and from Jerusalem Municipality to supplement the low water production of the Ein-Samia wells. The Israeli water company, Mekorot, controls over Shebtin wells No.4 and No.5 in the Ramallah District (Table 1). These wells located to the west of the groundwater shed and tap the Upper Cenomanian aquifer system.

Mekorot is also responsible for supplying domestic water to 22 villages and 6 Israeli Settlements within Ramallah District through the West Bank Water Department (WBWD). The total water supply from Mekorot sources is about 6.5 MCM/yr (Mekorot, 1995).

Israeli Wells

There are another nine Israeli wells in the Ramallah District. These tap the western groundwater basin and connected with the Israeli national carrier to serve the Israelis only. Their names and basic details are shown in Table 1. Figure 3 gives a comparison between Israeli wells and Palestinian wells in Ramallah district where depths of some Israeli wells are greater than 1000 meters while the greatest depth of the Palestinian

The above fact must be taken into consideration in the future Palestinian Israeli negotiations

to achieve the desired peace and our exact allocation of water especially in the western joint groundwater basin where extensive pumpage by Israelis occurs. The Israeli wells are not only illegal but also are used to exploit our Palestinian water resources that may lead to water quality problems and environmental damages of the joint aquifer.

Springs and local Cisterns

Springs constitute a major source of domestic water for many villages in the West Bank. Villages not connected to municipal water are depending on spring water on their living. Most of these springs are ignored and water flows in open channels. Water losses by evaporation and percolation through the ground are very high. In the Ramallah District, there are 122 springs with an average discharge exceeding 0.01 liters/sec. These springs are used for domestic and low scale irrigation purposes. The total average annual discharge (1970-1994) of the seven major springs is estimated to be 3.83 MCM, about 90% of the total discharge of all springs in the Ramallah District (Nuseibeh & Nasser Eddin, 1995). The basic details of these seven major springs are shown in Table 1 and Table 2 shows the annual flow discharge of the main springs in Ramallah district and Figure 4 shows the diagram of that variation during the period (82/83-93/94).

Table 2: Variation of annual discharge of main springs in the Ramallah district in thousand cubic meters during the period (82/83 to 93/94) (Nuseibeh & Nasser Eddin, 1995).

Spring Year	Ajjul	Dilba+ Legtan	Zerqa	Harrasheh	Dilba	Areek Fouqa	Areeq Tahta
82/83	76	218	386	200	289	397	226
83/84	32	113	142	37	163	145	100
84/85	34	79	76	37	113	97	87
85/86	32	63	26	26	92	89	106
86/87	29	114	160	74	276	239	202
87/88	54	142	321	186	189	399	205
88/89	32	112	244	77	210	210	145
89/90	34	129	336	52	392	183	218
90/91	32	124	263	53	287	213	200
91/92	158	399	929	214	645	591	390
92/93	60	263	759	81	491	297	302
93/94	34	131	418	39	310	158	210

Figure (4): Variation of the total discharge of main springs in Nablus district.

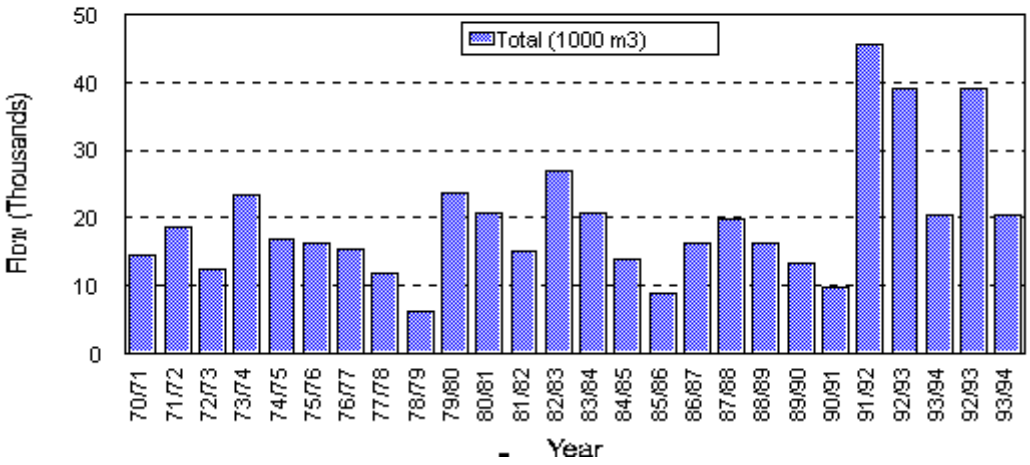


Figure 4

Rainwater harvesting

Cisterns are widely used as supplementary source of water supply in the Ramallah District. Most of the Palestinians use the rooftops of their houses as a catchment area to collect rainwater during winter time. This water is stored in cisterns of different volumes constructed underneath or next to the houses. The average capacity of the existing cisterns is 70 m^3. This source of water is very important to Palestinians all over the West Bank but more important to people not connected to a water distribution system and where there is a shortage of water during the summer.

Water Quality

Water quality is tested periodically by the JWU and the WBWD to ensure the quality of the water supply. The laboratory analysis is conducted by the Center of Environmental and Occupational Health Science at Birzeit University. Results of chemical and physical analysis indicate that the water fits within the quality parameters for drinking.

Physical Water Quality Tests

These tests include measurements of the electrical conductivity (EC), hydrogen activity product (pH), total dissolved solids (TDS), and turbidity. Results are available for Ein Samia wells No.1, No.2, and No.3, Shu'fat connection and Ramallah station from five samples taken between 1991-1995. Table 3 shows the variation with time of different physical (electrical conductivity (EC), total dissolved solids (TDS), and turbidity) and chemical water quality parameters for the Ein Samia wells as well as the purchased water at Su'fat connection and Ramallah station.

Chemical Water Quality Tests

These tests include routine chemical analysis of major cations and anions for water of Ein Samia wells and the purchased water at Shu'fat and Ramallah station connection sites as

shown in Table 3. Table 4 shows a partial chemical analysis for chloride and nitrates in the Israeli wells and the major springs in the Ramallah District..

Table 3: Physical and chemical water quality parameters of water sources in the Ramallah District

Water Source	Date	pH	EC (S/cm)	Turbidity (NTU)	TDS (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	F (ppm)	Cl (ppm)	NO3 (ppm)	SO4 (ppm)	Hardness Mg Ca CO3
Ein Samia No.1	April 91	7.79	526.00	1.80	263.00	54.57	26.7	-	-	0.22	30.08	21.3	12.57	245.87
	April 93	7.20	521.00	1.60	261.00	-	-	24.7	0.8	0.19	12	9.7	20	-
	October 93	7.57	527.00	1.50	264.00	44.8	30.8	-	-	0.1	21.5	-	-	238.7

	October 94	7.16	516.00	12.75	261.00	68.9	27.9	19.7	2.27	0.36	26.3	21.2	15.9	231.2
	April 95	7.50	524.00	0.45	265.00	63.8	21.5	15.46	3.9	-	23.5	18.62	13.74	275
Ein Samia No.2	April 91	7.74	508.00	0.30	254.00	54.57	22.7	-	-	0.2	35.3	15.99	8.9	239.78
	April 93	7.30	532.00	0.40	265.00	-	-	28.7	1.9	0.17	18	9.8	30	-
	October 93	7.48	508.00	0.45	254.00	41.9	42.1	-	-	0.1	26.4	-	-	277.7
	October 94	6.75	493.00	0.11	249.00	63.11	22.5	16.9	4.56	0.35	27.7	16.72	13.2	212.8
	April 95	7.48	509.00	0.08	254.00	58	21.2	16.48	2.62	-	35.1	14.72	11.97	265
Ein Samia No.3	April 91	7.45	585.00	0.30	291.00	60.27	22	-	-	0.26	30.08	13.37	12.77	280.42
	April 93	7.22	600.00	0.80	299.00	-	-	27.3	3.1	0.2	16	5.9	75	-
	October 93	7.34	589.00	0.65	292.00	45.8	38.7	-	-	0.1	20.5	-	-	273.7
	October 94	6.90	564.00	0.17	286.00	59.14	21.6	17.7	2.75	0.48	25.2	12.1	12.6	261.7
	April 95	7.65	571.00	0.09	289.00	63.1	30.9	15.98	1.54	-	21.6	10.46	10.04	338
Ein Samia No.4	October 94	7.15	602.00	0.24	304.00	65.3	32.6	18.5	1.73	0.48	25.2	8.6	14.6	275.9
Shu'fat Connection	April 91	7.50	873.00	0.50	445.00	63.52	30.5	-	-	1.11	165.54	10.89	11.16	302.09
	October 93	7.47	807.00	0.60	411.00	49.8	46.5	-	-	1.2	66.4	-	-	315.6
	October 94	7.14	561.00	-	280.00	69.6	28.4	-	-	0.35	32.8	15.3	14.8	249.5
	April 95	7.48	762.00	0.10	409.00	72.5	31	55.88	2.96	-	75.18	11.88	15.69	329
Ramallah Station	April 91	7.48	613.00	0.20	308.00	65.15	26.3	-	-	0.22	51.26	19.1	20.99	282.45
	April 93	7.28	586.00	0.80	293.00	-	-	29	2.7	0.18	14	8.9	25	-
	October 93	7.40	796.00	0.75	394.00	47.7	34.9	-	-	0.6	73.6	-	-	262.7
	October 94	6.89	560.00	0.96	281.00	72.1	36.7	20	1.78	0.38	29.8	16.4	14.4	246.5

	April 95	7.47	823.00	0.13	414.00	72.7	31	35.68	2.82	-	79.17	11.73	15.57	331

Table 4: Chloride and nitrates concentrations in the Israeli wells and major Springs in the Ramallah District

Well Ident	**Water Source**	**Cl (ppm)**	**NO_3 (ppm)**
IW6001	Eshtaol No.6	137	9
IW6002	Eshtaol No.3	117	13
IW6003	Havi Yahuda	_	_
IW6004	Modiin No.3	40	9
IW6005	Modiin No.4	37	12
IW6006	Modiin No.2	40	14
IW6007	Modiin No.1	65	3
IW6008	Shebtin Levona	30	6
IW6009	Shebtin No.15	30	8
S6001	Ajjul Spring	41	39
S6002	Delbeh+Legtan Spring	28.2	_
S6003	Zerqa Spring	28	3
S6004	Harrasheh Spring	22	1
S6005	Dilba Spring	25	4
S6006	Areek Fouga Spring	24	1
S6007	Areek Tahta Spring	37	21

Diagrams and contour maps are used to model the hydrochemical data to identify the quality of the groundwater. The Wilcox diagram (1955) is used to classify water for irrigation purposes depending on the conductivity (EC) and the sodium adsorption ratio (SAR) values. Figure 5 shows Wilcox diagram for water sources in the Ramallah District, Ein Samia wells No.1, No.2, No.3, and No.4 as well as the water purchased from Mekorot at the connection sites. The diagram indicates that water of the Ein Samia wells has medium salinity hazard and low sodium hazard and is therefore suitable for irrigation. The external water sources received at Ramallah and Shu'fat connection sites have greater values of EC as they are located in the region of high salinity and low sodium hazard.

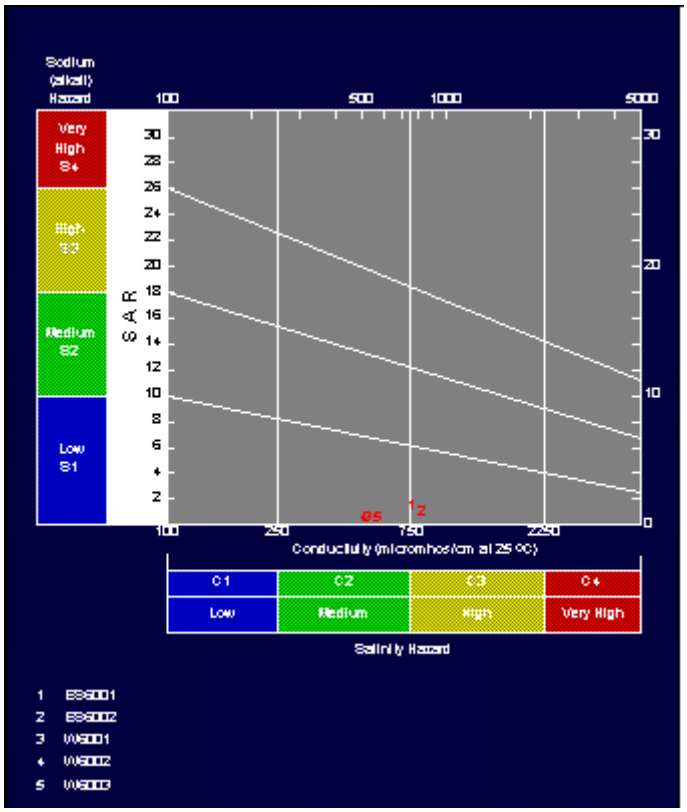


Figure 5: Wilcox diagram for water sources in the Ramallah District.

Figure 6 shows Piper Diagram which identifies water types of the water sources in the Ramallah District. The figure shows that all water sources are earth alkaline with prevailing bicarbonate except that of Ein Samia well No.2 and the water purchased from Mekorot. These two sources have earth alkaline water with prevailing bicarbonate and increased portion of alkalis.

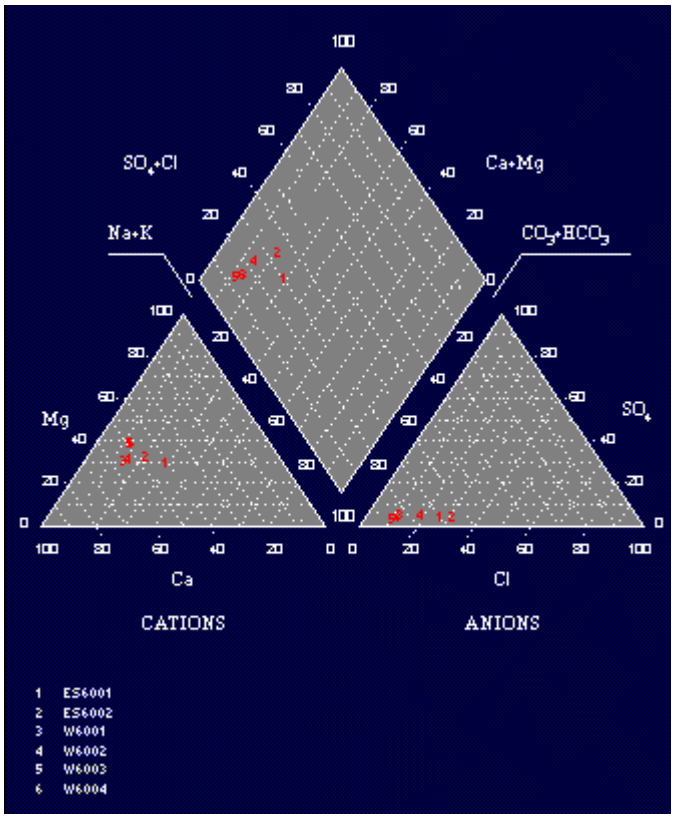
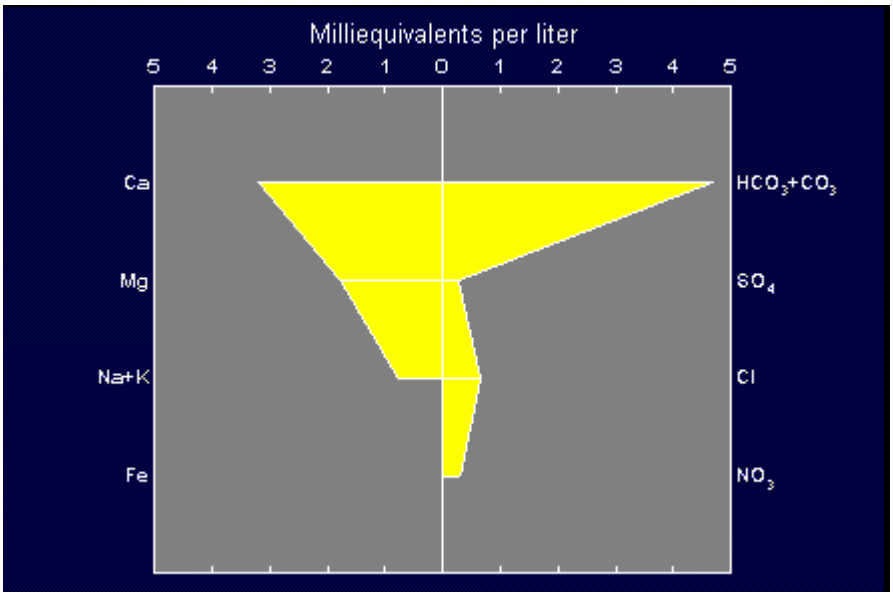
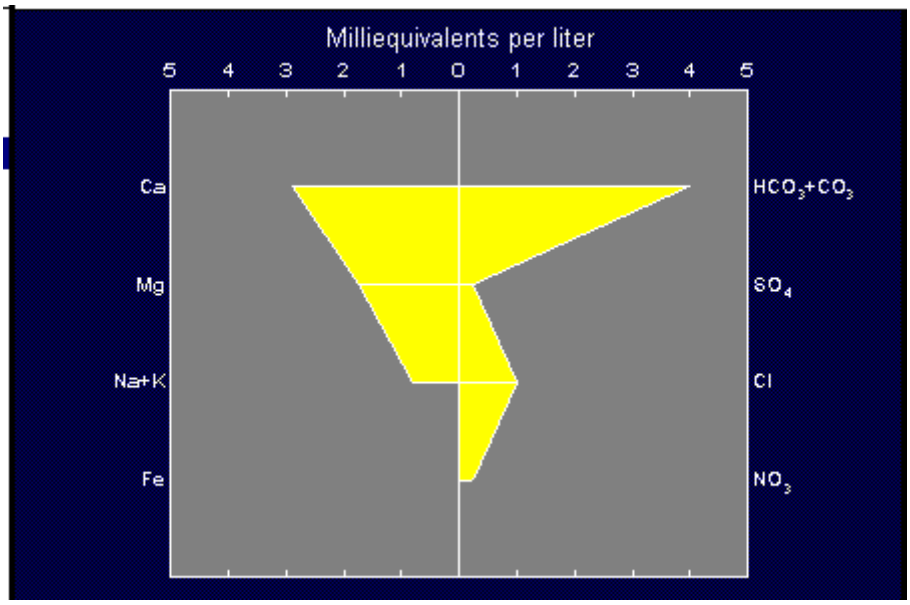


Figure 6: Piper Diagram which identifies water types of the water sources in the Ramallah District.

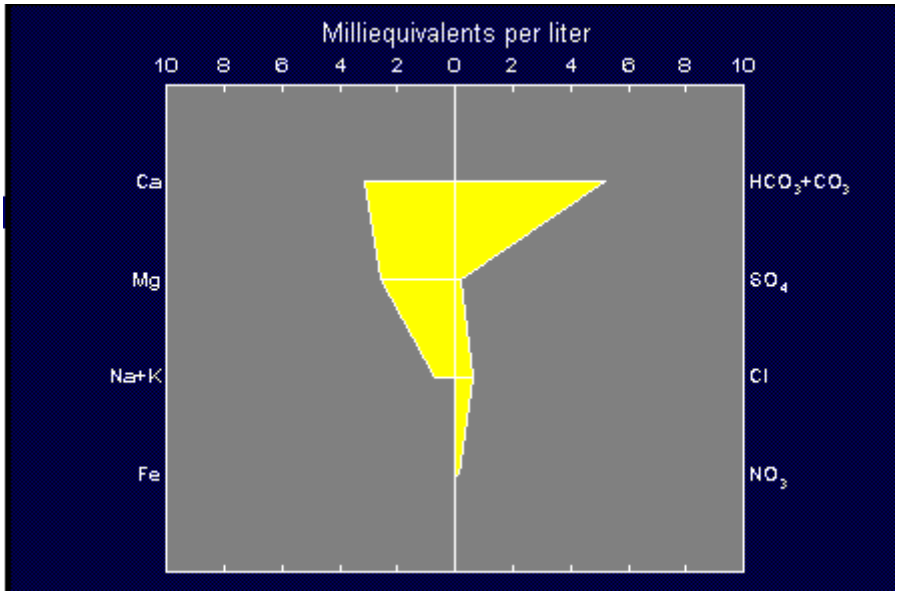
Figure 7 shows Stiff Diagram which classifies the water of Ein Samia wells No.1, No.3, and No.4 as calcium-bicarbonate, while that of Ein Samia well No.2 as sodium-bicarbonate.



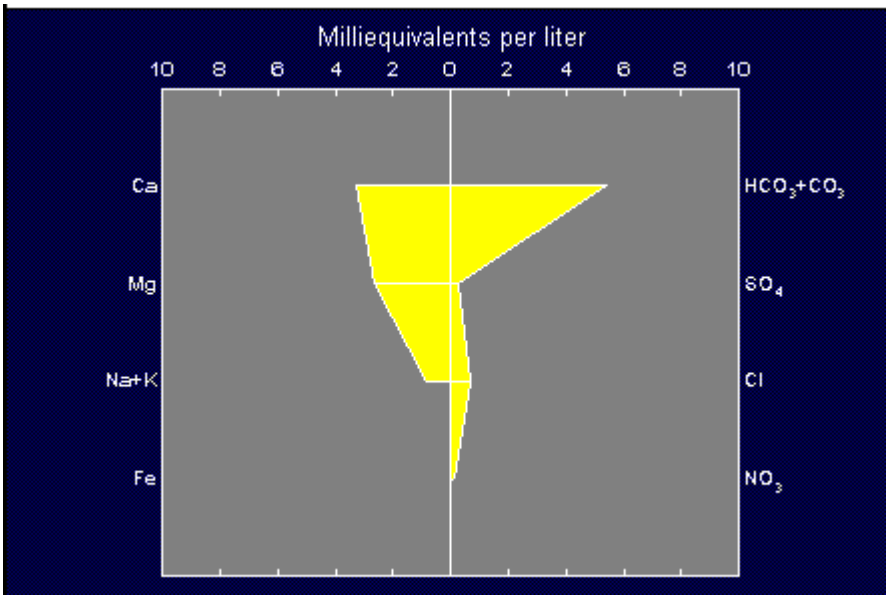
Stiff Diagram for Ein Samia well No.1



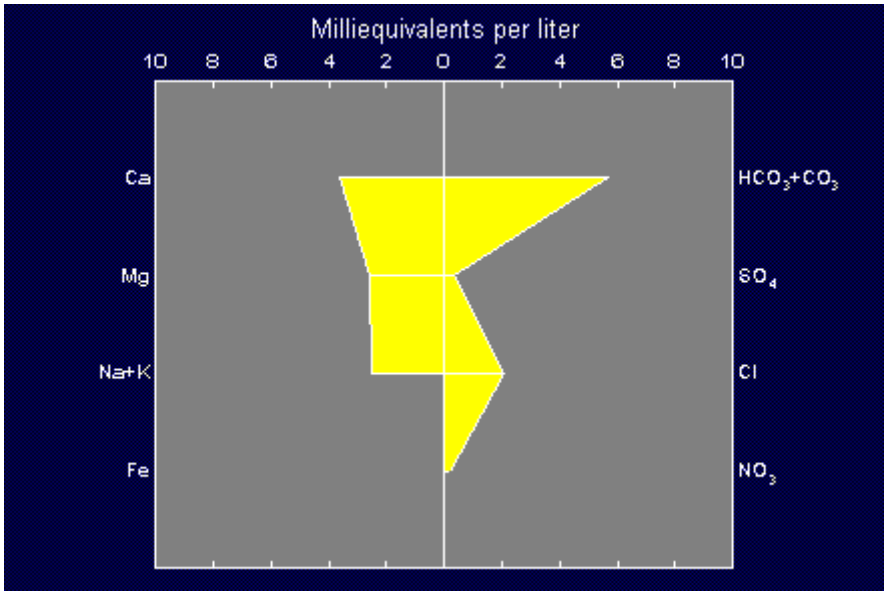
Stiff Diagram for Ein Samia well No.2



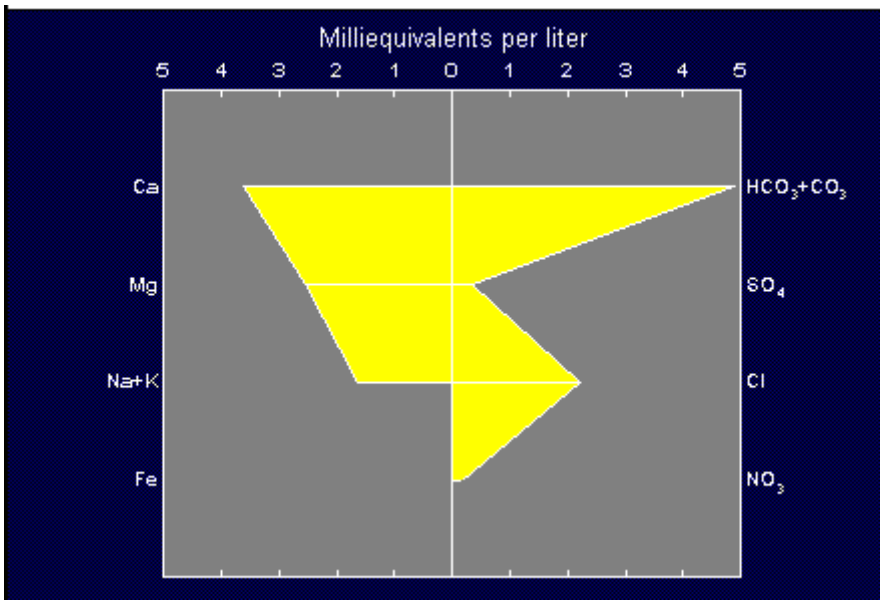
Stiff Diagram for Ein Samia well No.3



Stiff Diagram for Ein Samia well No.4



Stiff Diagram for Ein Samia well No.5



Stiff Diagram for Ein Samia well No.6

Figure 7: Stiff Diagrams for different Palestinian Water Sources in Ramallah District.

Figures 8 and 9 show contour maps for chloride and nitrate levels in the Ramallah District. Although the groundwater quality of Ein Samia Wells is better than the quality of the water purchased from external sources (Mekorot & Jerusalem Municipality), the groundwater from all sources (Ein Samia domestic wells, that purchased from Mekorot, and the water from the major springs) in the Ramallah District meets general standards for drinking water. This water does not need treatment before being used.

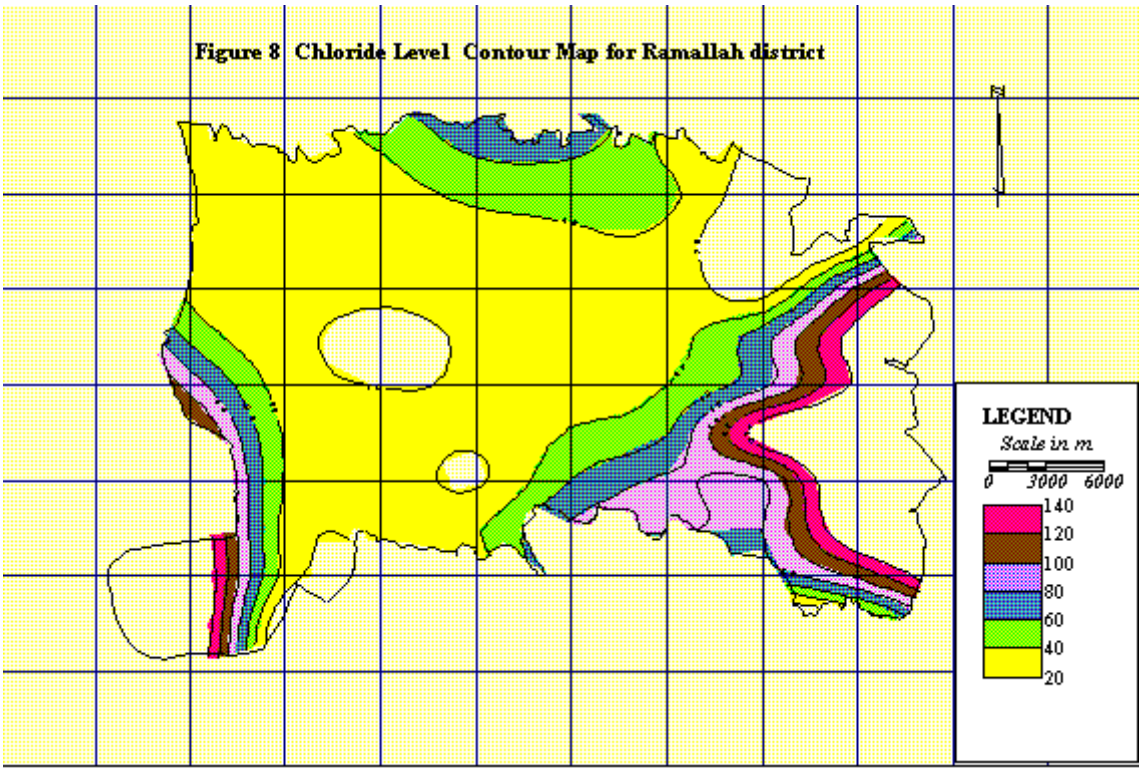


Figure 8:Chloride Level Contour Map for Groundwater in Ramallah District.

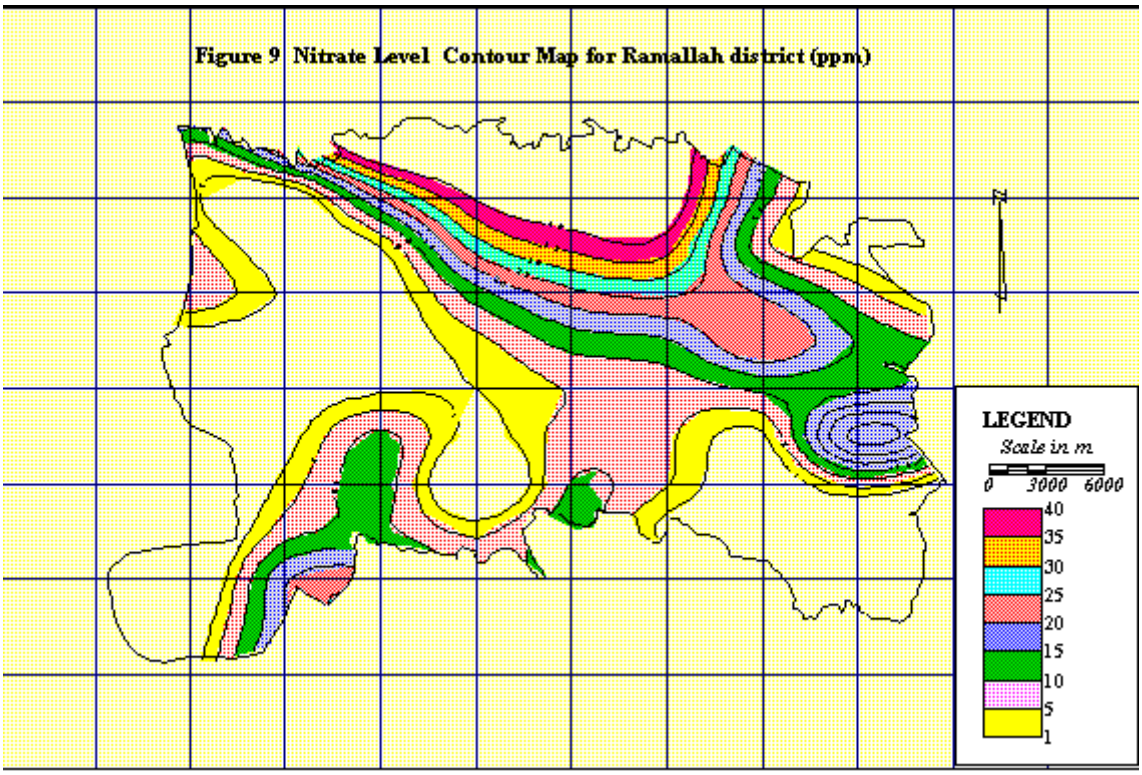


Figure 9: Nitrate Level Contour Map for Groundwater in Ramallah District.

Groundwater Flow Pattern

Groundwater flows mainly in two directions in the Ramallah District, to the east in the areas underlain by the eastern groundwater basin such as Ein Samia wells field, and to the west in the areas underlain by the western groundwater basin (Mekorot wells). Figure 10 shows a groundwater level contour map which indicates that the groundwater flow is characterized by three zones of extensive pumping, These are;

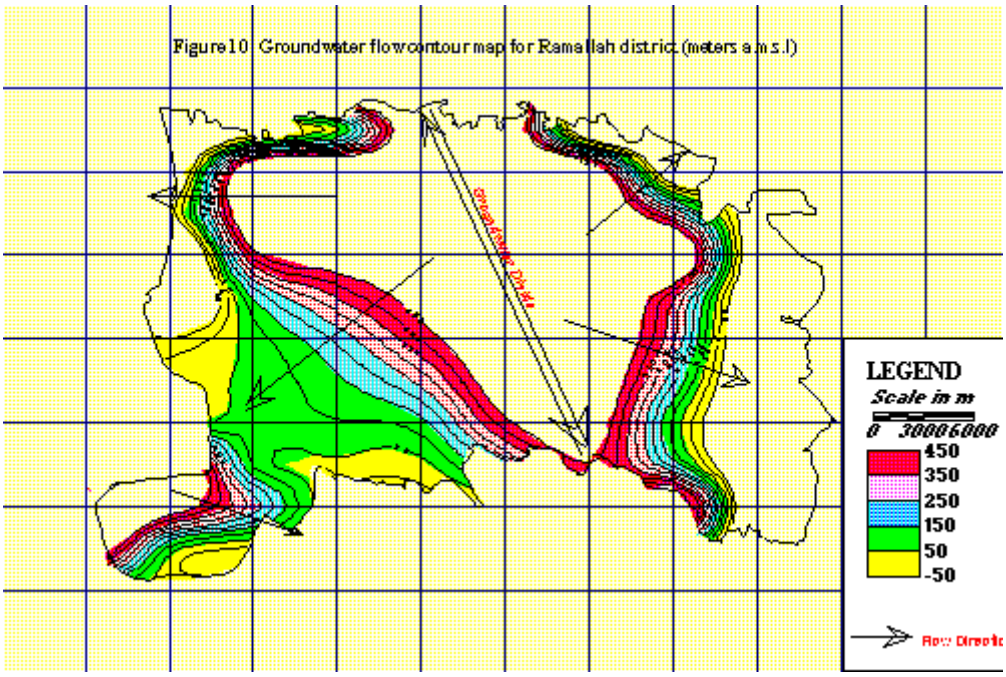


Figure 10: groundwater level contour map.

1. The Ein Samia wells field with groundwater flow direction to the east and the contours representing equipotential lines become closer as pumping occurred.
2. Shebtin wells and the two other Israeli wells located in the northwestern part of Ramallah District.
3. The Israeli wells located at the Latroun in the southwestern part of Ramallah District near the no-man land area. These wells tap the western aquifer system and there natural flow is to the west. The extensive pumping of these wells has caused the water to reverse its direction towards the southeast. Pumping in these wells should be reduced to avoid further damage of the groundwater system.

Water Supply

Water distribution in the Ramallah District is the responsibility of the Jerusalem Water Undertaking and the West Bank Water Department.

Jerusalem Water Undertaking (JWU)

The JWU distributes water to approximately 200,000 people including Ramallah and Al-Bireh cities, 44 villages in the Ramallah and Jerusalem Districts and 10,000 people from the Israeli military forces. In 1994, approximately 66.3% (5.0 MCM) of the total water distributed (7.5 MCM) was purchased from Mekorot and the Jerusalem Municipality. The rest (2.5 MCM) of the distributed water was pumped from the Ein Samia wells.

West Bank Water Department (WBWD)

Shebtin Wells No. 4 and No.5, controlled by Mekorot, are used to provide water for domestic purposes through the West Bank Water Department. These wells also serve 6 Israeli settlements and 22 Palestinian villages in the Ramallah District that are not connected to the water distribution network of the JWU.

These small villages served by the WBWD constitutes 18% of the Ramallah District's population. Approximately 2.2 MCM of water are distributed by Mekorot through the WBWD. The total water quantity received from Mekorot either purchased and distributed by the JWU or directly distributed through the WBWD is 6.5 MCM (Mekorot, 1995). Table 5 shows the external water sources and the amounts of water purchased in the 1994.

Table 5: External water sources and the purchased water in 1994

Source	Annual quantity**(m3)**	**Connection Diameter**	**Connection Site**
Mekorot *	2,217,434	_	_
Mekorot Company **	4,282,566	16"	Ramallah
Jerusalem Municipality **	636,281	6"	Shu'fat
Jerusalem Municipality **	88,397	3"	Hizma
Total	7,224,678		

* Water distributed by WBWD
** Water distributed by JWU
Source: Jerusalem Water Undertaking and Mekorot

The water quantity consumed by Palestinians in 1994 was bout 9,773,245 according to the following breakdown:

- 7,224,678 m^3 were purchased from Israeli sources and distributed by both JWU and WBWD.
- 2,548,567 m^3 were produced from Ein Samia wells.
- Additional unaccounted water quantities were consumed by some local communities of Ramallah District from cisterns and local springs .

In comparison, the Israelis pumped 9,836,400 m^3 (Israeli Hydrological Services, 1995) from eight of their nine wells in the Ramallah area. This quantity equals the

total water consumed by Palestinians in the Ramallah District in 1994, that makes the water status very critical there.

Distribution Network and Water Losses

The original network was laid by Ramallah/ Al-Bireh water company in the early fifties. Unfortunately, the pipes used did not meet the standard specifications, generally, second hand pipes of only two inches in diameter were used. The network mostly constructed for individual consumers and not for complete streets or areas. The result of this lack of standards for network construction, is a confused network that has high water losses and is extremely difficult and costly to maintain.

The present network in the main cities and villages consists of pipes connected in rings as a circulation system. At the end of 1995, the total length of the distribution network including all the different size of pipes is 749,426 meters.

Water losses were estimated by the JWU in 1994 to be approximately 25%. The total water distributed by JWU was about 7,555,811 m^3 whereas the sold water was 5,667,466 m^3 which means a loss of approximately 1,888,345 m^3 (JWU, 1995). The losses occurred through leaks in the main pipelines, the distribution network and the meters. It is also known that some water is taken illegally. No information is available from the WBWD about water losses in the network.

Conclusions and Recommendations

1. The water status in the Ramallah District is very critical as the demand for water is high and expected to increase rapidly rate in the future. Ramallah and Al-Bireh cities are considered the commercial center for Palestinians, the demand on water will increase as investors choose to live and invest in Ramallah.
2. Water rights between Israelis and Palestinians should be reexamined as Israel pumps a great deal of water from Ramallah District which reflects not only bad effects on the allocation of water for Palestinians but also affects the groundwater levels and reverses the flow pattern there. Their discharge constitute is equal to the water consumed by the whole Palestinian population in the District. This water is needed for development of the Palestinian agriculture, industry, economy and society.
3. Rehabilitating and building water collection and storage units to collect excess water, to regulate flow, facilitate spring use, and prevent waste of water.
4. The Israeli wells located at the Latroun in the southwestern part of Ramallah District near the no-man land area. These wells tap the western aquifer system and there natural flow is to the west. The extensive pumping of these wells has caused the water to reverse its direction towards the southeast. Pumping in these wells should be reduced to avoid further damage of the groundwater system.
5. The total water supplied for Palestinian community of Ramallah district (more than 200,000 people) in 1994 was about 9.77 MCM, 1.88 MCM was lost through the distribution network, while the Israelis have pumped 9.84 MCM

from thier wells there in the same year. Efforts should be employed to prevent over exploitation of the Palestinian water resources there.

6. In spite of the great importance of Ramallah in all aspects for Palestinians, water supply produced locally is still about 2.5 MCM/Yr which constitutes about 25% of all water supply while the rest quantity is being purchased from Jerusalem Municipality and Mekorot. Efforts should be employed to increase the local sources of water through constructing new wells, dams to capture rain water, cisterns, and management of water use there.

References

1. Israeli Hydrological Services (1995). Records of the Israeli, Hydrological Services files, West Jerusalem
2. JWU(Jerusalem water under taking) (1991)..Report on performance and prospects of J W U ,Ramallah ,West Bank .
3. JWU(Jerusalem Water Under Taking) (1995): The Report on Performance and prospects of JWU, Ramallah, West Bank.
4. Mekorot (1995).Records of Budget & Economics Department files
5. Nuseibeh, M. and Nasser Eddin, T.(1995).Palestinian Fresh Water Springs, Springs Description, Flow & Water Quality Data, for the Palestine Consultancy Group (PCG),Jerusalem.
6. Rofe & Rafffety Consulting Engineers (1963), Jerusalem & District water supply, Geological and Hydrogeological Report for the Central Water Authority of Jordan, Westminister. London
7. Rofe &Raffety Consulting Engineers (1965), West Bank Hydrology (1963-1965), Report for the Central Water Authority of Jordan, West Minister, London.
8. WBWD (1995).Records of the West Bank Water Department files.
9. Wilcox L. V.(1955).Ramallah Classification and use of Irrigation Water, US Departement of Agriculture.Circ.969, Weshington, D.C.19PP.