8. Evaluation of the Potential and Quality of Brackish Groundwater

8.1 Evaluation of the Maximum Exploitable Amount

(1) Criteria for Deciding the Maximum Exploitable Amount

Two types of criteria are considered for deciding the maximum exploitable amount the brackish groundwater as follows:

i) Criteria on Environment Aspects	- Draw-down effect on the existing wells
	- Land subsidence
	- Flow rate decrease of springs and rivers
ii) Criteria on Development Aspects	- Draw-down depth
	- Water quality change

It is considered that the draw-down effect on the existing wells can be neglected because there are no production wells tapped into the Kurnub and Zerqa aquifers which would be affected by the brackish groundwater development in the Study area. The draw-down influence on the Kurnub Sandstone aquifer is assumed not to extend to the existing well fields which take groundwater from the Kurnub Sandstone aquifer in the highlands (see Fig. I-7.5.11). It is also considered that the brackish groundwater development will not cause land subsidence because the aquifers to be affected are composed of sound bedrock. As the springs are brackish, they are not utilized. Despite that flow of wadis and river may reduce in accordance with the brackish groundwater development, the water quality will be improved.

According to the examination of the brackish groundwater quality change described in Section 8.2 below, it is inferred that the quality will not change greatly during the development period.

It is consequently concluded that the draw-down depth of the production wells is the sole criteria for the evaluation of the maximum exploitable amount in the Study because the groundwater development efficiency (pumping efficiency) will depend largely on the draw-down of the production wells.

For the reasons mentioned above, the depth of the water table in the production wells will be employed as the criteria for deciding the maximum exploitable amount (brackish groundwater potential).

(2) Permissible Draw-down of the Production Wells

The Permissible draw-down of a well is decided by the lifting capacity of a submergible pump. In general, it is reported that the pumping efficiency of an ordinary submergible pump decreases if the lift height is more than 70 m ~ 80 m.

The permissible draw-down of the production wells should therefore be within 80 m of the ground surface.

(3) Evaluation of Maximum Exploitable Amount

The simulated draw-down in each case is summarized in Table I-8.1.1.

Table I-8.1.1 Simulated Draw-down in Each Case

Case	Area	A. Maximum Draw-down (m)	B[1]. Piezometric Height at Maximum Draw-down Point (from ground level, m)	A+B (m)
Case 1	A	-20	0	-20
	C	-80	+70	-10
Case 2	A	-30	0	-30
	C	-110	+70	-40
Case 3	A	-40	0	-40
	C	-120	+70	-50
Case 4	A	-50	0	-50
	C	-160	+70	-90

1) see hydrogeological profile, I-I', II-II' and E-E'.

In Table I-8.1.1, the maximum draw-down in the well (A) is calcurated from the natural water table (natural piezometric height) (B). However, it is the draw-down below ground level, given by the arithmetic sum (A+B), which must be considered.

The draw-down in the production wells based on the step draw-down test results conducted in the Study are shown in Table I-8.1.2.

Table I-8.1.2 Results of the Step Draw-down Test

Area	Well No.	Maximum Safe Yield (m^3/day)	Draw-down at Maximum Safe Yield (m)
A	No. 1	>3,500	<20
B	No. 2	3,300	50
	No. 4	2,600	9
C	No. 5	7,800	50

Note: Tested in the Zerqa Group aquifer

Based on the results shown in Table I-8.1.2, 3,000m^3/day maybe used as a conservative estimate for the maximum safe yield of the production wells. From the draw-down/discharge curves shown in the Supporting Report, the draw-down at a discharge rate of 3,000 m^3/day is assumed to be less than 20 m on average.

The assumed maximum draw-down in the production wells in each case is as follows:

Table I-8.1.3 Assumed Maximum Draw-down in the Production Wells after 25 Years Development

Case	Area	Maximum Draw-down in the Production Well[1)] (from ground level, m)
Case 1	A	-50
	C	-40
Case 2	A	-60
	C	-70
Case 3	A	-70
	C	-80
Case 4	A	-80
	C	-120

1) A+B (in Table I-8.1.1) - 20 m

As mentioned in Section (2), the permissible draw-down of a production well should be within 80 m. Therefore, it is inferred that Case 3 gives the maximum, safe yield of brackish groundwater in the Study area and an amount of 75 MCM/year is reasonable for the brackish groundwater potential of the Study area.

8.2 Quality Change of Brackish Groundwater

It is supposed that the salinity of the brackish groundwater might change during the development because the inflow of high salinity groundwater from Area B to Area A and Area C may be increased by the brackish groundwater development in Area A and Area C.

Comparing Fig. I-8.2.1 with Fig. I-8.2.2, there is no significant change in the natural condition flow vector lines from Area B to Area A and Area C after the development. The brackish groundwater flows mainly in the high permeability zone running along Wadi Kafrein and this zone is assumed to be a low salinity area as shown in Fig. I-6.2.1.

The recharge of low salinity water from the Kurnub Sandstone aquifer to the Zerqa Group aquifer in Case 3 development has been simulated and the results are shown in Fig. I-8.2.3. The natural (present) seepage amount and the simulated increased amount in Case 3 development in Area C is shown in Table I-8.2.1.

Table I-8.2.1 Assumed Increase Amount of the Seepage from the Kurnub Sandstone Aquifer in Case 3 Development (after 25 years)

Condition	Seepage Amount from the Kurnub Sandstone Aquifer (MCM/year)
i Natural Condition	6.5
ii Case 3 Development	19.0
Increase Amount (ii-i)	12.5

As shown in Table I-8.2.1, the increased amount of seepage (recharge) from the Kurnub Sandstone aquifer is assumed to be about 12 MCM/year in Case 3 (after 25 years).

From the simulation results mentioned above, it is inferred that the quality of the brackish groundwater will not deteriorate but the salinity might slightly decrease during Case 3 development. However, the change will be small.

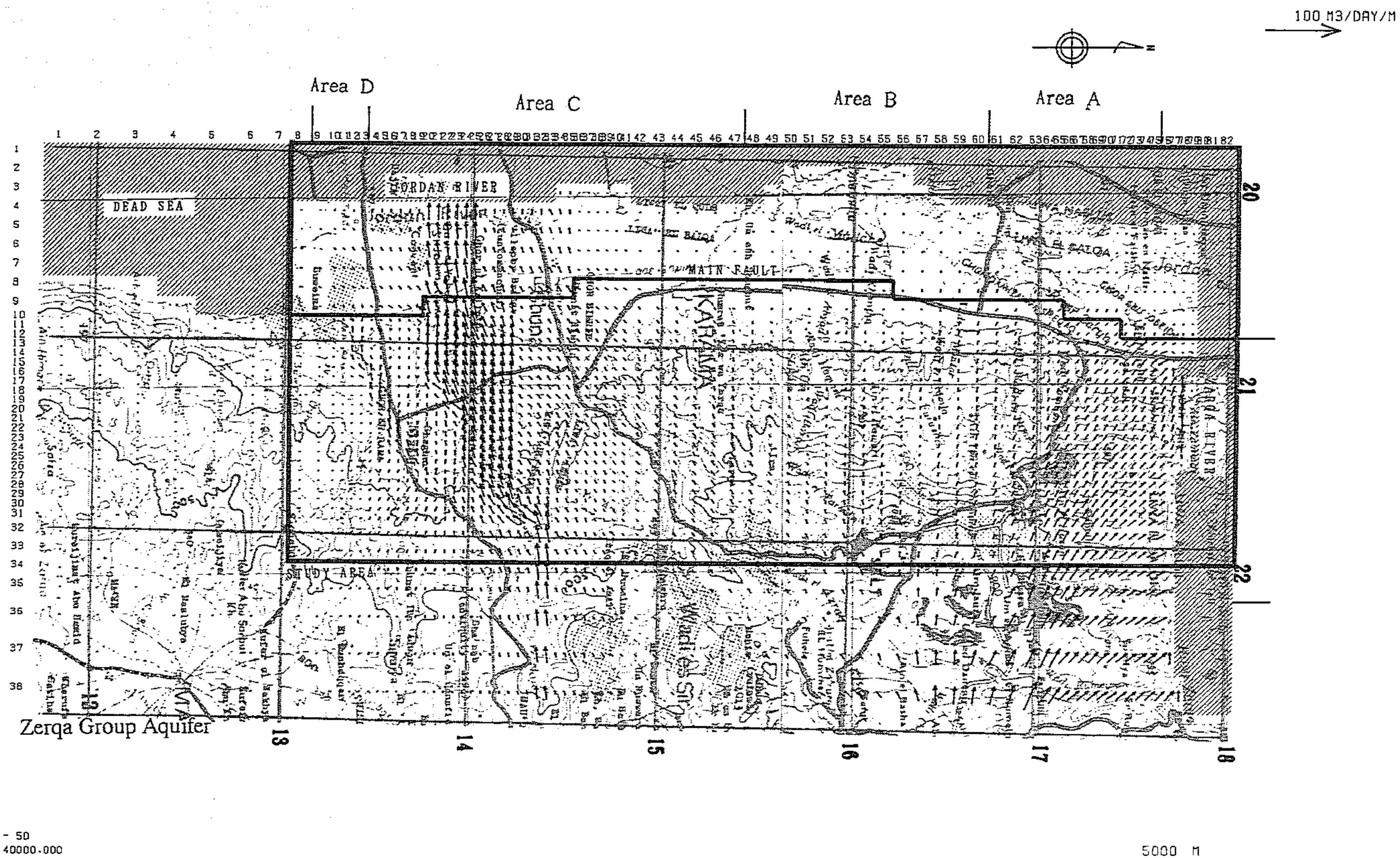


Fig. I-8.2.1 Flow Vector in the Natural Condition (before Development)

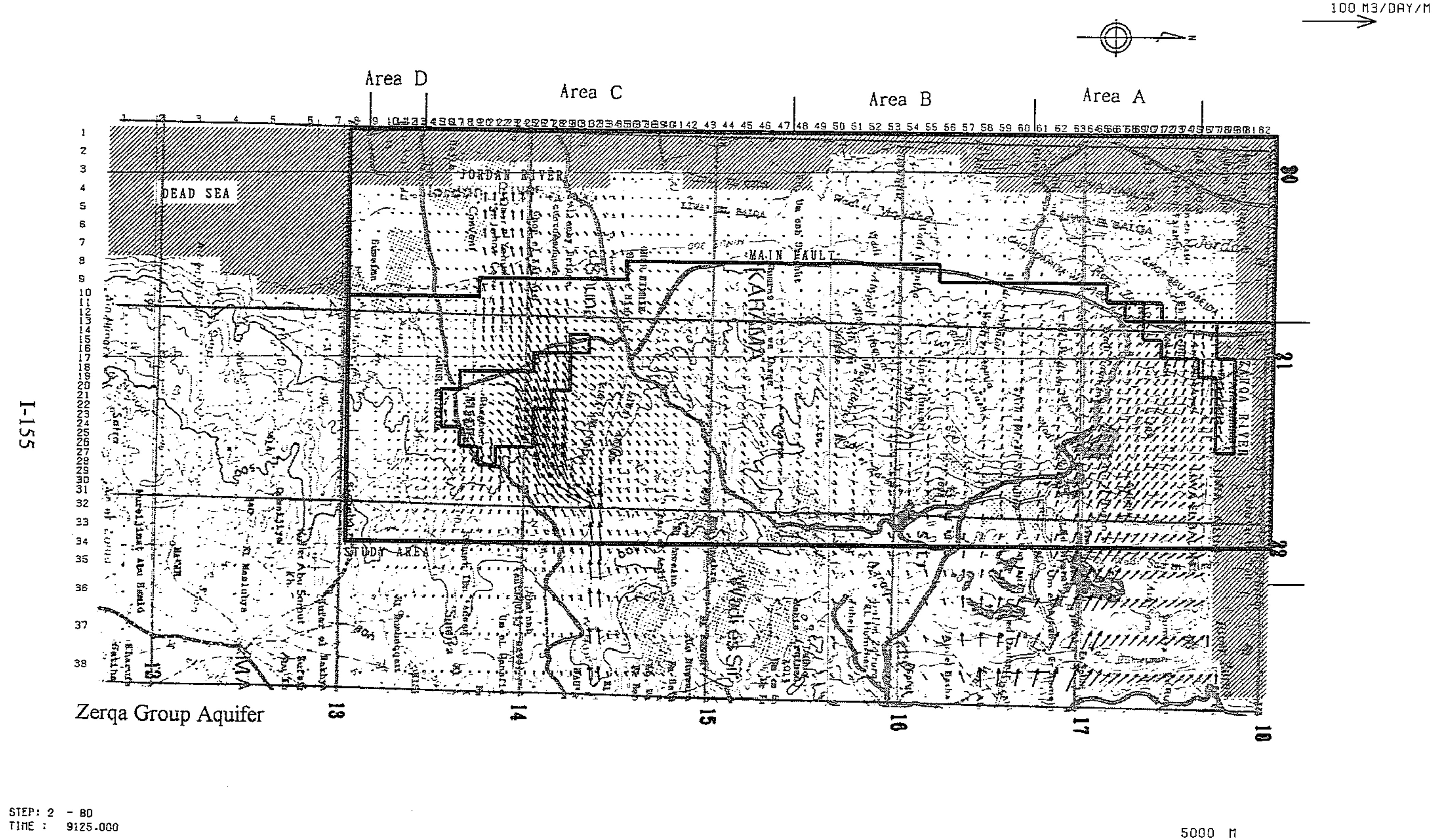
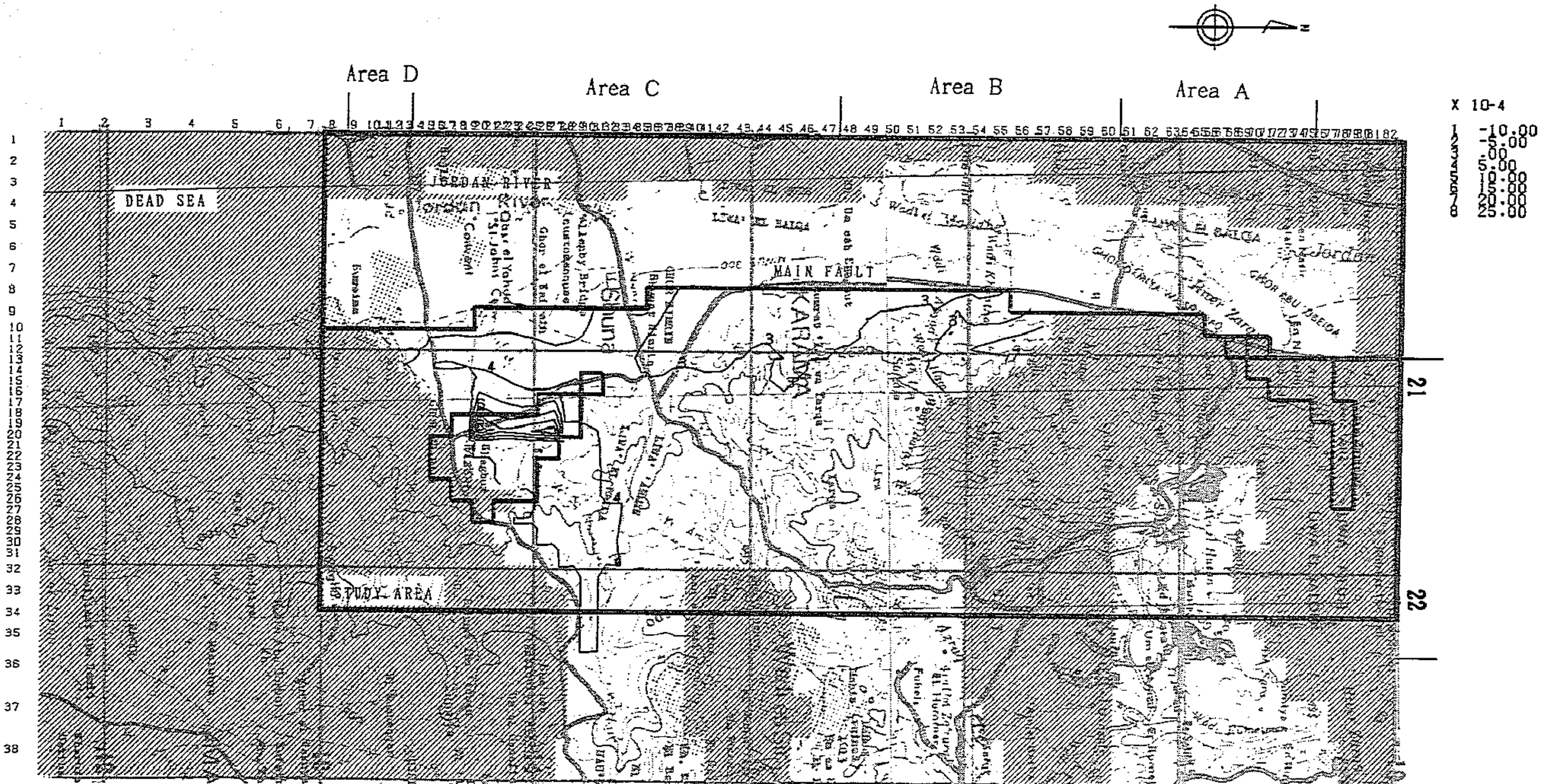


Fig. I-8.2.2 Flow Vector in Case 3 Development (after 25 years)



☐ Well Field, Development Amount .... Area A: 30MCM/year, Area C: 45MCM/year
Simulation period: after 25 years

Plus (+) : Kurnub → Zerqa (downward seepage)
Minus (-) : Zerqa → Kurnub (upward seepage)
Unit : $m^3/day/m^2$

STEP: 2 - 80
TIME : 9125.000

LEAKAGE PER UNIT AREA (M3/DAY)

5000 M

MODFLOW < CASE3 75MCM >

Fig. I-8.2.3 The Seepage between the Kurnub Sandstone aquifer and the Zerqa Group aquifer in Case 3 Development (after 25 years)

Connecting the Dead Sea water intrusion, it is supposed that the brackish ground water development in the Zerqa Group aquifer will not cause the severe intrusion of the Dead Sea water wedge. Because, according to "Water Resources of Jordan Present Status and Future Potential, P150", it is reported that the interface of Dead Sea water and ground water lies more than 1,500 m underneath the ground surface in the area more than 5 km apart from the Dead Sea. The distance between well field in Area C and the Dead Sea is about 8 km.

8.3 Conclusion

It was found that the most promising areas for brackish groundwater development are Deir Alla (Area A) and Kafrein (Area C) in terms of both the volume of flow and the quality of brackish groundwater in the Zerqa Group aquifer. The total flow volume in Areas A and C was estimated to be 110 MCM/year.

According to the simulation, brackish groundwater potential in the Study area is estimated at about 75 MCM/year (Deir Alla area: 30 MCM/year, Kafrein area: 45 MCM/year) is corresponding to 70% of the total volume of flow in the two areas.

Although the isotope analysis results showed that the Zerqa group groundwater was very old (BP 1,500 years to BP 22,000) and very few recharge took place into the aquifer, it is assumed that the present groundwater inflow (recharge) status caused by the inclination of the aquifer (uplifting of the highland) will not change within hundreds years considering the geological time scale.

Judging from the groundwater simulation results, it is inferred that the development will not cause a significant change in the quality of the brackish groundwater. The water quality of the promising areas are as follows:

- Deir Alla area: Temperature..... 32°C, TDS......7,500 mg/L
- Kafrein area: Temperature...... 32°C, TDS......5,000 mg/L

PART II

Strategy of the Brackish Groundwater Development

Part II: Strategy of Brackish Groundwater Development

1. Present Water Supply Situation

1.1 Water Use and Its Sources in the Study Area

Water resources and their usage in the whole country are examined in Chapter 6, Socioeconomic Analysis. Water use and its sources in the Study Area for Water Supply, defined as the Northern part of Jordan including the Jordan Valley and Amman City, are examined here in order to form a basic understanding and formulate the brackish groundwater desalination development strategy.

1.1.1 Representative water year

The volume of the surface water resource in the country fluctuates in time over a wide range. Therefore an average of the few years' record that are available has no value. In this study, the 1990/1991 water year (starting first of October 1990 until end of September 1991) has been selected for developing a basic understanding of the current situation, because, as shown in Table II-1.1.1, rainfall in the country in the 1991 water year was congruent with the average rate for the past six years.

Table II-1.1.1 Rain Water Compared with Average Rates

Unit: MCM/Water year

Water Year	1986/1987	1987/1988	1988/1989	1989/1990	1990/1991	1991/1992
Volume of Rain Water	6,700	12,252	10,205	7,612	8,379	10,429
Average Rate	7,100	8,381	8,424	8,424	8,419	8,558
Percentage %	94	146	121	121	100	122

Source: WAJ Annual Report 1992

1.1.2 Water Use and its Sources in the Study Area

Water use in the Study Area, i.e. the five governorates of Amman, Zarqa, Irbid, Mafraq, and Balqa in 1991 was 527 MCM for all irrigation, municipal and industrial uses including the private sector. The sources were surface water, 154 MCM including loss (waste/spill) of 20 MCM, reuse of municipal sewage treatment effluent, 30 MCM and groundwater, 370 MCM, as shown on Table II-1.1.2.

The sources available at present are fully utilized. The amount, which is fluctuating, depends on the available surface water each year and will limit maximum usage unless a new development can contribute.

Table II-1.1.2 Water Sources and Use in the Study Area (1990-1991 Water Year)

Unit: MCM/Year

Resource	Amount	Use		Loss
		Irrigation	M/I	
Surface	153.6	124.1	9.5	
Reuse	30.0	30.0	-	
Wells	370.4	226.9	143.5	
Total	554	381.0	153.0	20.0
		534.0		

*1: Surface = Yarmouk to KAC + Zarqa + Side Wadis
*2: Reuse = Effluent from Al Samra Sewage Treatment
*3: Wells includes private wells
*4: Prepared with WAJ/JVA data by JICA Study Team

On the other hand , water use in the Jordan Valley was 190 MCM in 1991. Most of the water, 173 MCM, is used for irrigation purposes. The main source is surface water which provides 153 MCM. M/I water supply in the Jordan Valley is limited to 7 MCM .

Table II-1.1.3 Water Source and Use in Jordan Valley (1990-1991 Water Year)

Unit: MCM/Year

Resource	Amount	Uses	Amount	Waste/Spill
Surface:		Irrigation	173.6	
Yarmouk to KAC	89.0	M/I:		
Side Wadis	34.6	to Amman	9.5	
Zarqa River	30.0	in the Valley	7.0	
Total (Surface)	153.6	Total (M/I)	16.5	
Samra Treatment (Re-use)	30.0			
Wells				
Mukheiba to KAC	20.0			
Wells to KAC	0.9			
Wells to WAJ	5.6			
Total (Wells)	26.5			
Total Resources	219.1	Total Used	190.1	20.0

*1: KAC = King Abudulla Canal
*2: M/I Water from Deir Alla to Amman was 33 MCM in 1992 and 31 MCM in 1993.
*3: prepared by JICA Team

The bases of the above tables are the following two data sheets provided by the Information Dept. of WAJ and Central Operation Office of JVA:

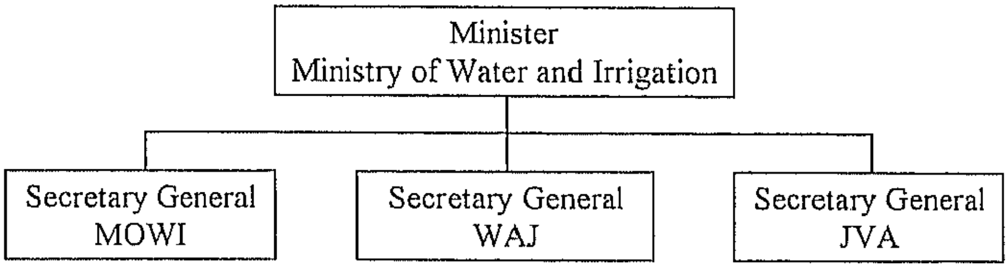
Supporting Report: Table 1.2.4 Quantities of Production from Under Ground Water Sources (including Private Sector Wells) in 1991

Supporting Report: Table 1.2.5 Water Sources in Jordan Valley (Water Year 1990-1992)

1.2 Water Supply Sector

In Jordan all the water supplied for irrigation, municipal and industrial water is managed by the Water Authority of Jordan (WAJ) of the Ministry of Water & Irrigation (MOWI), except the Jordan Valley and areas below sea level +300 m which are managed by the Jordan Valley Authority (JVA) of MOWI. JVA manages the water supply for the irrigation and the operation and maintenance of the surface and groundwater water facilities such as the offtake of the Yarmouk River, Mukheiba Wellfield, King Abdulla Canal, and the side wadis in the Valley.

Schematic relations of the three organizations are as shown below.



The Ministry of Water and Irrigation was established in 1988, combining the above two authorities and acting as the overall director. Before the establishment of the Water Authority in 1984, sectors related to water supply were managed by the following organizations:

- National Resources Authority
- Drinking Water Establishment
- Jordan Valley Authorities
- Water and Sewage Authority
- Local Municipal Council

1.2.1 Tasks and responsibilities of the Water Authority

- The Water Authority is currently responsible for the following:
- Investigation of water resources
- Developing water resources
- Management of public and private wells
- Planning water and sewage projects, construction, operation and maintenance
- Researching theoretical and applied engineering involving water and sewage
- Organizing and promoting water preservation and rational water usage

1.2.2 Organization Structure

In order to execute the above responsibilities, the organization structure of the Water Authority is made up of the following departments:

- Water resources department
- Planning and development and information
- Project department
- Operation, maintenance and workshop department
- Administration and finance department

The administrative hierarchy is shown in the detailed organization charts, Fig. II-1.2.1 and Fig. II-1.2.2.

According to the decentralization policy in management eight regional departments were established.

1.2.3 Water Tariff system

Since WAJ was established in 1984, the tariff system has been revised several times. The latest revision is as shown Table II-1.2.1. Water Tariff are distributed every three (3) months with the sewerage fee which corresponds to the consumption of domestic water.

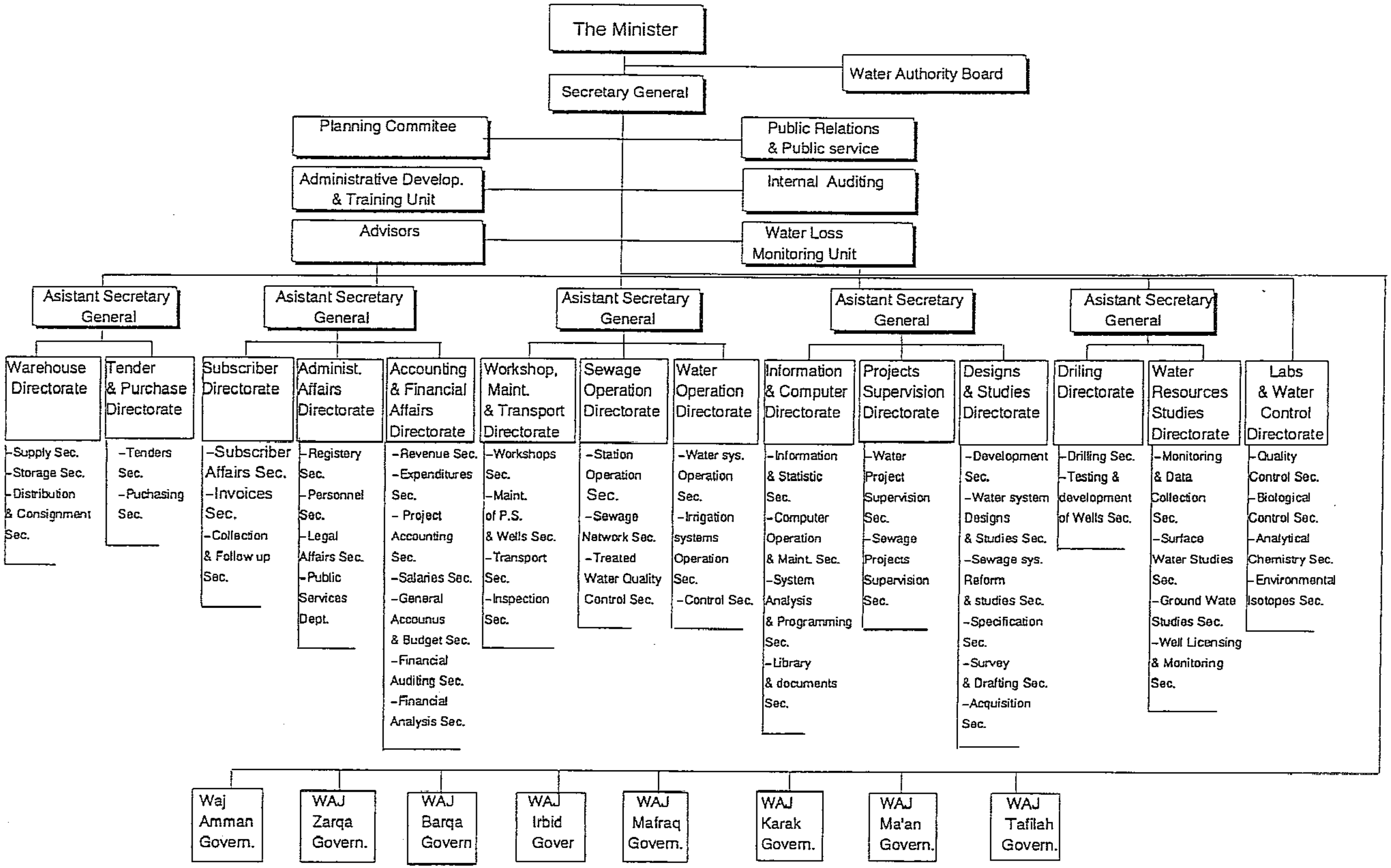


Fig. II-1.2.1 Organization of Water Authority of Jordan

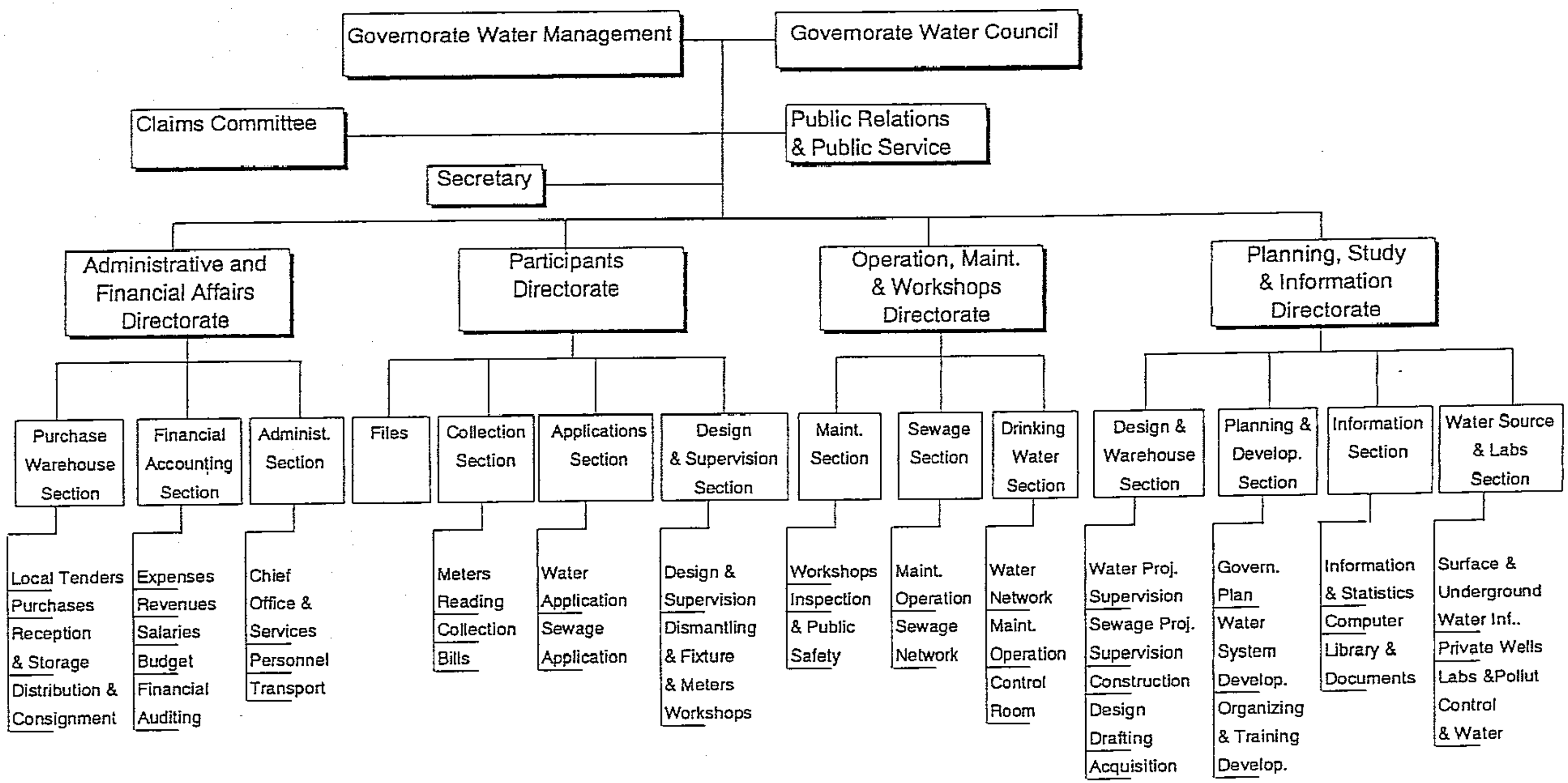


Fig. II-1.2.2 Organization of Local Governorate in WAJ

Table II-1.2.1 Water & Sewage Tariff

1. Amman Governorate Tariff

Tariff Blocks (Cubic meter for 3 months consumption)		Price (Fils/cubic meter)
from	0 - 20	100
	21 - 40	190
	41 - 70	400
	71 - 100	500
	101 +	600

2. Remaining Ghour (Jordan Valley)Areas Tariff

Tariff Blocks (Cubic meter for 3 months consumption)		Price (Fils/cubic meter)
from	0 - 20	65
	21 - 40	115
	41 - 70	250
	71 - 100	400
	101 +	600

3. Remaining Kingdom's Governorate Tariff

Tariff Blocks (Cubic meter for 3 months consumption)		Price (Fils/cubic meter)
from	0 - 20	65
	21 - 40	90
	41 - 70	300
	71 - 100	500
	101 +	600

4. Sewage Tariff

Tariff Blocks (Cubic meter for 3 months consumption)		Price (Fils/cubic meter)
from	0 - 20	30
	21 - 40	40
	41 - 70	100
	71 - 100	200
	101 +	250

Source: Information Dept., WAJ 1994

1.2.4 Unaccounted for Water

According to the result of the study, Hydraulic Analysis of the Water System in the Greater Amman Area, March 1989, unaccounted for water in 1987 is a summarized in Table II-1.2.2. Comparing the figures for 1987 and 1993, the unaccounted for water situation had not improved and efforts on improvement seem unable to catch up with the increase in supply. In order words, the ratio of sold water to production water has not become any worse but the absolute amount of unaccounted for water has increased from 35 MCM in 1987 to 57 MCM in 1993.

Table II-1.2.2 Summary of Unaccounted for Water

Component	MCM / Year	Percentage (%) of Water Produced
Billed consumption	24.88 (41.5)	41 (42)
Billing adjustment	8.29	14
Inregistration meter	11.08	18
Source meter error	1.76	0.3
Leakage	12.31	20
Transmission loss	1.87	0.4
Other loss	0.16	-
Total Production	60.28 (98.6)	100

Note: Figures in parentheses are those in 1993.

1.2.5 Current Water Supply Situation in the Five (5) Governorates of the Study Area

(1) Water Supply

In the five governorates of the study area, the population and number of households in 1993 were 3,920,000 and 475,900 respectively, corresponding to 90% of the country's population. The WAJ water supply system covers an admirable 98% of the whole population and the water supply amount to this area was 191 MCM for the year. However, out of this amount, sold water is reportedly 79 MCM, i.e. 41% of that supplied. Therefore unaccounted for water is about 59%. Details of each governorate are shown on Table II-1.2.3.

Table II-1.2.3 Water Supply and Tariff Collection in the Study Area (1993)

	Supply Total (MCM)	Population Total	Population Covered by WAJ	Number of Households	Sold Water (MCM)	Unaccounted for Water %
Countrywide	218.5	4,328,000	98.0%	531,500	92.7	58
Study Area	191.3	3,920,000		475,900	79.3	59
Amman	98.6	1,777,000	98.5%	237,500	41.5	58
Zarqa	25.6	669,000	97.5%	73,100	11.9	54
Irbid	34.5	1,041,000	97.0%	111,000	15.9	54
Mafraq	13.3	176,000	97.0%	20,100	3.7	72
Balqa	19.3	257,000	98.0%	34,200	6.3	67

Source: WAJ Information Dept., 1994

(2) Water Production and Supply in the Area

In order to fulfill the demand and utilize resources efficiently, water is transferred between governorates or imported from outside. As an example in 1993, Table II-1.2.5 shows that Amman produced 55 MCM, imported a total of 47 MCM from Zarqa, Zai, and Balqa and exported only 0.25 MCM (to Irbid). Water supply facilities in the five Governorates of the study area are linked and operated simultaneously by a trunk line network of 24 inch diameter or larger pipelines connecting the reservoirs and pumping stations.

Locations of the major water supply facilities and trunk line network are shown on Fig. II-1.2.3 "Water Supply Network for Five Governorates in the Study Area" and Fig. II-1.5.2 for Greater Amman area.

The Summary Table II-1.2.4 clearly indicates:

- In the study area, production can not fulfill the demand.
- Amman depends heavily on import for half of its supply and the ratio is increasing
- In the other four governorates, production and supply are in balance.

Table II-1.2.4 Summary of Conveyance between Governorates

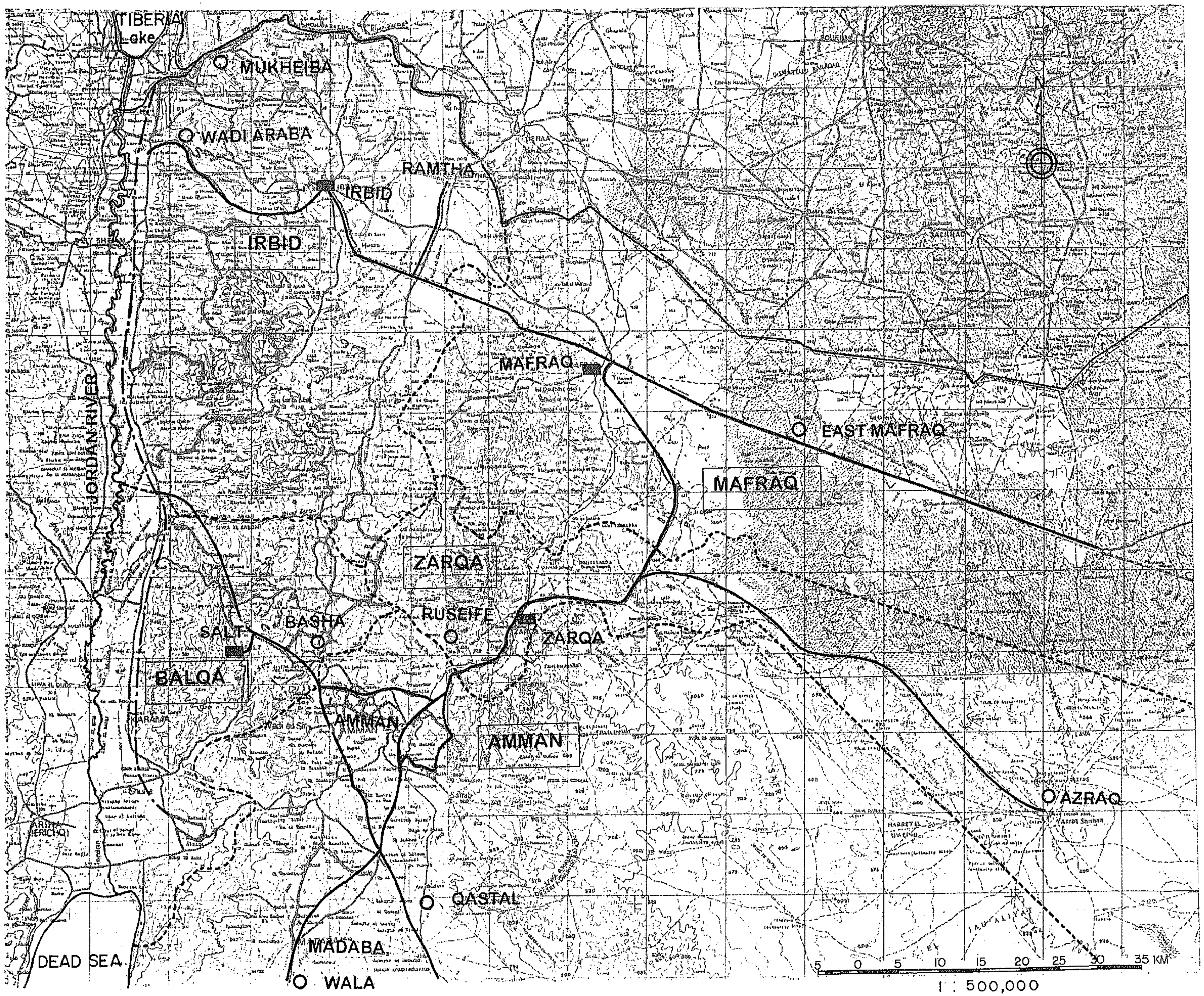
	Production	Import	Export	Supply	Net Import
Amman	54.698	46.723	0.250	101.171	46.473
Zarqa	29.489	15.230	19.439	25.280	-4.209
Irbid	30.831	3.685	0.037	34.479	3.648
Mafraq	35.566	0.000	22.266	13.300	-22.266
Balqa	17.188	1.379	0.521	18.046	0.858
Total	167.772	67.017	42.513	192.276	24.504

Source: WAJ, Information Dept., 1994

Table II-1.2.5 Conveyance between Governorates (1993)

Production MCM/ year		Import from MCM/ year		Export to MCM/ year	
Amman	54.698	Zarqa	19.439	Irbid	0.250
		Zai	26.763		
		Balqa	0.521		
Total	54.698		46.723		0.250
Zarqa	29.489	Mafraq	15.230	Amman	19.439
Total	29.489		15.230		19.439
Irbid	30.831	Mafraq	3.435	Irrigation	0.037
		Amman	0.250		
Total	30.831		3.685		0.037
Mafraq	35.566		0.000	Irrigation	3.379
				Irbid	3.435
				Jerash	0.222
				Zarqa	15.230
Total	35.566		0.000		22.266
Balqa	17.188	Zai	1.379	Amman	0.521
Total	17.188		1.379		0.521

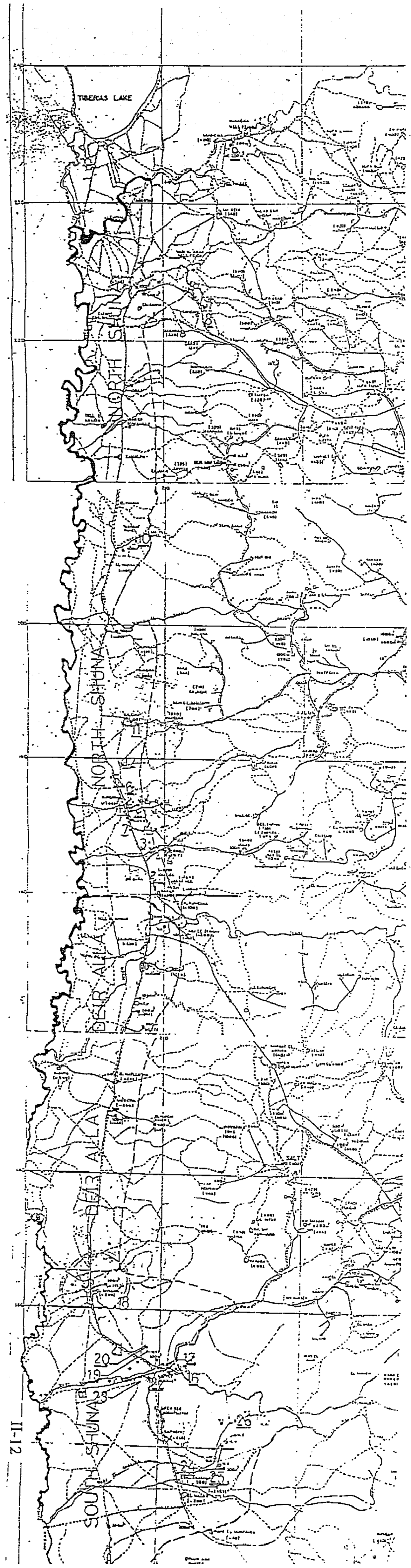
Source: WAJ, Information Dept., 1994



<u>LEGEND</u>

- ○ Well Field
- ▪ Capital of Governorate
- ▭ Governorate
- ——— Inter-Governorate Network
- —·—· King Abdullah Canal
- ----- Boundaries of Governorates

Fig. II-1.2.3 Water Supply Network for Five Governorates in the Study Area



No.	Govemorate	District	Town/ Village*	Population ('000) 1,979	1,991
1	Irbid	North Shuna	Adashya	1,016	2,050
2			Baqwra	428	700
3			North Shuna	7,838	12,400
4			Sakhna	143	155
5			Suhana	3	0
6			Shikhasin	2,535	6,500
7			Manshiya	3,065	5,200
8			El Azziya	48	0
9			Waqqas	3,791	4,200
10			Masharga	7,865	12,700
11			Ziglab	24	0
12			Zamaliya	666	850
13			Serkhan	353	230
14			Hajija	0	45
15			Tabaqat Fahel	321	500
16			Marraza	413	830
17			Arba'ein	64	0
18			Wadi Yabis	3,047	5,800
19			Karkuma	2	10
20			Subeirra	85	20
21			Abu Fara	173	10
22			Morsit	129	260
23			Sulaikhat	456	600
24			Abu Sido	1,777	2,100
25			Al Fadan	408	450
26			Kureiyma	5,026	13,000
27			Abu Ubeidea	2,899	3,450
28			Al Haquel	644	0
29			Abu Habil	593	800
30			Al Qarun	120	500
31			Salabas	0	140
32			Abu Zeiyat	6	0
33			Madraji	253	0
		North Shuna Total		44,191	73,500
34	Balqa	Dier Alla	Khazma	1,450	1,600
35			Dara	2,039	3,500
36			Er Ruweiha	954	2,200
37			Tuwale Shamali	1,529	2,350
38			Deir Alla	1,253	960
39			Et Twal	3,872	5,250
40			Abu Zaighan	399	500
41			Suwaliha	1,813	2,480
42			Muth. el Marri	742	250
43			Mu'addi	1,775	3,100
44			Ghor Kabid	1,432	1,140
45			Muth. el Arda	1,216	1,350
46			Femish	1,016	1,750
47			Damiya	421	650
48			Hudeib	1,038	1,900
49			Al Tamale	645	1,020
		Dier Alla Total		21,594	30,000
50		South Shun	Karama	3,535	5,850
51			Suknat Shunet	1,973	2,700
52			South Shuna	2,404	1,850
53			Kafrain	1,193	2,300
54			Er Rama	2,177	1,400
55			Suweima	1,089	1,100
56			Al Jofa	1,731	5,150
57			Ajaje	923	0
58			Aroda	3,068	7,650
		South Shuna Total		18,093	28,000
	Jordan Valley Total			83,878	131,500

Note*: Names of several towns and villages are not identified in topographical map.

Fig. II-1.2.4 Water Supply Network in Jordan Valley

1.2.6 Current Domestic and Industrial Water Supply Situation in Jordan Valley

Jordan Valley is divided into three municipal districts, i.e. North Shuna in Irbid Governorate, and Deir Alla and south Shuna in Balqa Governorates and consists of a total of 58 towns/villages. Topographical boundaries of these districts and the population of each town/village are shown on Fig. II-1.2.4.

Total population of the Jordan Valley is 131,500 and the number of households covered by the WAJ water supply system in 1991 was 19,740 as shown on Table II-1.2.6.

Table II-1.2.6 Population and Number of Households Covered by WAJ for Three Years (1991-1993)

District Office	Population	Number of Households		
	1991	1991	1992	1993
North Shuna District Office	73,500	8,782	9,117	9,339
Deir Alla District Office	30,000	4,395	4,491	4,563
South Shuna District Office	28,000	4,572	4,656	4,723
Total in Jordan Valley	131,500	19,740	20,256	20,618

Source: WAJ Governorate Offices and summarized by JICA Study Team

The Water supply for domestic and industrial water is managed by WAJ Governorate offices and district offices. The sources of water are all from groundwater and total production reached 10 MCM in 1993 according to a survey of three districts by JICA Study. Industrial water for factories is only supplied in Deir Alla District and the total volume supplied in 1993 was 718,000 m^3 (see Table II-1.2.7).

179 liters per capita per day were produced in 1991. However when unaccounted for water based on the records, 60%, is considered , the actual supply in 1991 is estimated at around 100 liters per capita per day which is almost same as in Amman. A summary of supplied and sold water is shown on Table II-1.2.8.

Locations of all the twenty six (26) WAJ production wells for domestic and industrial water in the Jordan Valley were surveyed by means of the Global Positioning System (GPS) and identified on the Fig. II-1.2.4.

Table II-1.2.7 Sold Water by WAJ in Deir Alla District for Industrial Purpose

Unit: m^3

Year	1991	1992	1993
Tomato Factory (F)	7,185	841,485	506,778
Polyester Factory (C)	7,645	9,455	12,006
Jordan Valley Co. (C)	16,247	290	16,730
Agr. Production Co. (C)	-	-	182,640
Total	31,077	851,230	718,154

*F: Food Industry
*C: Chemical Industry
Source: WAJ Governorate Offices and summarized by JICA Study Team

Table II-1.2.8 Water Supply (Production) and Sold by WAJ in Jordan Valley

Unit: 1,000m^3

Year	1991	1992	1993
Water Supply			
North Shuna District Office	4,182	4,067	4,442
South Shuna District Office	2,141	2,594	3,219
Deir Alla District Office	2,264	2,224	2,468
Total in Jordan Valley	8,587	8,885	10,129
Sold Water for Domestic			
North Shuna District Office	1,301	1,366	1,460
Deir Alla District Office	1,156	1,583	1,452
South Shuna District Office	966	818	970
Total in Jordan Valley	3,423	3,767	3,882
Sold Water for Industrial	31	851	718
Total Sold	3,454	4,618	4,600
Unaccounted for Water(%)	60	48	55

Source: WAJ Governorate Offices and summarized by JICA Study Team

1.2.7 Water Quality

(1) Present Condition of Water Quality Monitoring and Control

In the Study Area, as well as in the whole country of Jordan, the Water Authority is responsible for water quality monitoring and control for domestic water supply. Besides, the Ministry of Public Health (MOPH) carries out water quality monitoring independently from the point of public health.

The Department of Laboratories and Water Quality, WAJ conducts water sampling and water quality analyses daily in Amman area, and monthly in Jordan Valley area. In 1993, 25,740 samples were collected and 112,000 analyses were conducted, which included the samples from water supply stations and those from the monitoring points on the water supply networks. All the items in the Jordanian Drinking Water Quality Standards (Table II-1.2.9 with a comparison with WHO and Japanese Standards) are tested for the samples from the water supply stations, and the monitoring points and bacteria and residual chlorine were tested for the samples from pipelines for the sake of public health.

About 95% of the water supply in Amman area and Jordan Valley area depends on groundwater resources. Before distribution to consumers, the only treatment carried out is chlorination for all of the source waters except the water from Zai Water Treatment Plant where the rapid filtration process is applied to treat the surface water from King Abdullah Canal. WAJ's water quality monitoring results show that more than 95% of the supplied water is safe for drinking purposes, and MOPH's results show that more than 98% of the supplied water is safe. Seasonal fluctuation in water quality is very small.

(2) Water Quality in Greater Amman Area

The analyses results of drinking water quality in Greater Amman Area are shown in Table II-1.2.10 with the locations of the 8 water supply stations in Fig. II-1.2.5

Generally speaking, most of the water quality data meet the Jordanian Drinking Water Quality Standards. However, regarding TDS (Total Dissolved Solids) and NO_3, some of the analyzed values are higher than the recommended levels.

TDS

As is shown in Table II-1.2.9, the recommended TDS of drinking water is 500 mg/L and its allowable limit is 1500 mg/L in Jordanian Standards. WHO has set 1000 mg/L as a guideline for TDS under both the consideration of the limited water resources available for drinking purpose in the whole world and that of the health impediment of dissolved solids to human beings. Although a TDS at the allowable limit level may not cause health problems, it affects the taste of drinking water and indicates water pollution in some cases. Therefore, attention should be paid to source water with a high TDS value. In Greater Amman area, excess abstraction of groundwater has become more sever in recent years. This results in a drawdown of the groundwater table as well as a deterioration of water quality.

Nitrate (NO_3)

The concentration of nitrate in drinking water from a surface water resource, such as the water from Zai Water Treatment Plant, is usually very low, but the water from some groundwater resources contains a nitrate concentration as high as 60 mg/L. The permissible nitrate concentration is 45 mg/L as NO_3 in Jordanian Drinking Water Quality Standards and 10 mg/L as N (equivalent to 44 mg/L as NO_3) in WHO Standards. The high nitrate concentration of the groundwater is considered to result mainly from infiltration of sewage water. This has become the major water quality problem in Greater Amman area.

However, as the results of actions to protect groundwater pollution, such as the improvement of the sewage system, water quality of some groundwater resources has been improved. WAJ's historical data of the concentrations of NO_3, as well as THMs (Trihalomethanes), in drinking water show this tendency.

(3) Water Quality in Jordan Valley Area

In Jordan Valley area, water supply depends on groundwater resources. Table II-1.2.11 shows that provided by the Laboratory and Water Quality Dept., WAJ. The locations of water sampling sites are shown in Fig. II-1.2.6.

From these data, it is learnt that high salinity and high hardness are the main problems for water supply in Jordan Valley area. The water from many of the wells shows a TDS higher than 500 mg/L and that of some wells is as high as 1000 mg/L or more with a higher total hardness than 500 mg/L as $CaCO_3$. As for nitrate, its concentration is below the permissible level of Jordanian Drinking Water Quality Standards for most of the wells.

Table II-1.2.9 Jordanian Drinking Water Quality Standards with Comparison of Some Items in WHO and Japanese Standards

Items	Jordanian Permissible	Jordanian Maximum	WHO Guideline	Japanese Maximum
Turbidity*(unit)	1	5	5	2
Taste	Acceptable to most consumers		-	Not abnormal
Odor	Acceptable to most consumers		-	Not abnormal
Color** (unit)	10	15	15	5
pH	6.5 - 9.0		6.5 - 8.5	5.8 - 8.6
Temperature	8 - 25 °C		-	-
TCC (MPN/100mL)	2.2		-	Not detected
FCC (MPN/100mL)	0		0	-
Protozoa	0		0	-
Helminths	0		0	-
Free Living Organism	0		0	-
Pb		0.05	0.05	0.05
Se		0.01	0.01	0.01
As		0.05	0.05	0.01
Cr		0.05	0.05	0.05
CN		0.1	0.1	0.01
Cd		0.005	0.005	0.01
Hg		0.001	0.001	0.0005
Sb		0.01	-	-
Ag		0.01	-	-
TDS	500	1500	1000	500
Total Hardness as $CaCO_3$	100	500	500	300
ABS	0.5	1	-	-
Al	0.2	0.3	-	-
Fe	0.3	1	0.3	0.3
Mn	0.1	0.2	0.1	-
Cu	1	1.5	1	1
Zn	5	15	5	1
Na	200	400	-	-
Ni	0.05	0.1	-	-
Cl	200	500	250	200
F	1	1.5	1.5	0.8
SO_4	200	500	400	-
NO_3	45 (as NO_3)	70 (as NO_3)	10 (as N)	10 (as N)
Alpha Emitters (Bq/L)***		0.1	-	-
Beta Emitters (Bq/L)		1	-	-
Endrin		0.0002	-	-
Lindain		0.004	-	-
Methozychlor		0.1	-	-
Toxaphene		0.005	-	-
2,4 Dichloriphenoxy Acetic Acid		0.1	-	-
2,4 - 5 Trichlorophenoxy Propionic Acid		0.001	-	-

1) All the units in mg/L except where otherwise mentioned.
2) Other organic impurities which are not listed should comply with WHO guidelines
3) * by Jakson Candle Turbidimeter
** Platinum - Cobalt Standard
*** except Radon

Table II- 1.2.10 Drinking Water Quality in Greater Amman Area

Date	EC (μS/cm)	TDS (mg/L)	pH	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	K (meq/L)	Cl (meq/L)	SO_4 (meq/L)	HCO_3 (meq/L)	TH (mg/L)	NO_3 (mg/L)
Yajuz Pump Station												
1993/4/17	800	512	7.41	2.41	2.33	2.58	0.14	3.12	1.09	3.11	237	17.3
1993/8/29	844	540	7.56	4.18	2.28	1.84	0.12	2.53	0.42	4.8	323	44.9
1993/12/5	835	534	7.46	3.09	2.42	2.67	0.14	3.14	0.86	4.11	275.5	24.8
1994/1/23	767	491	7.44	3.4	2.1	2.04	0.11	2.32	0.63	4.32	275	24.5
1994/2/26	855	547	7.59	3.23	2.32	2.84	0.17	3.39	0.91	3.74	277.5	25.7
Average	820	525	7.49	3.26	2.29	2.39	0.14	2.9	0.78	4.02	277.5	27.4
Ain Ghazal Pump Station												
1993/4/11	932	596	7.87	2.02	2.48	3.92	0.2	4.7	1.32	2.26	225	18.1
1993/9/5	1010	646	7.36	3.43	2.5	3.87	0.2	4.89	1.12	3.31	296.5	33.6
1993/12/22	951	609	7.79	2.15	2.53	4.11	0.22	5	1.22	2.34	234	18.3
1994/1/16	1037	664	7.73	2.36	2.86	4.4	0.23	5.69	1.63	2	261	22.2
1994/2/5	1223	783	7.23	3.64	2.4	5.56	0.23	6.32	1.47	3.41	302	33
Average	1031	660	7.6	2.72	2.55	4.37	0.22	5.32	1.35	2.66	263.5	25
Qastal Pump Station												
1993/5/6	1134	726	7.39	4.31	3.13	3.67	0.08	4.22	1.72	5.07	372	3.2
1994/1/1	1133	725	7.45	4.26	3.3	3.68	0.08	4.38	1.88	5.15	378	3.5
1994/2/16	1145	733	7.76	4.34	3.27	3.69	0.1	4.35	2.06	5.07	380.5	5
Average	1137	728	7.53	4.3	3.23	3.68	0.09	4.32	1.89	5.1	376.5	3.9
Dabuq Reservoir												
1993/4/1	730	467	7.55	2.66	2.1	2.29	0.15	2.14	1.26	3.55	238	14.4
1993/11/24	912	584	7.6	3.32	2.58	3.03	0.17	2.94	1.7	4.42	295	13.4
1994/1/4	886	567	7.71	2.59	3.06	2.93	0.16	2.65	1.83	4.22	282.5	13.2
1994/2/5	830	531	7.56	3.1	2.3	2.87	0.18	2.52	1.63	3.97	270	12.5
Average	840	537	7.61	2.92	2.51	2.78	0.17	2.56	1.61	4.04	271.5	13.4
Shahab Reservoir												
1993/5/13	1062	680	7.76	4.06	3.12	3.34	0.08	4.04	1.75	4.99	359	5.9
1993/9/9	1090	698	7.71	4.1	3.38	3.72	0.09	4.37	1.76	5.02	374	3.6
1994/1/5	1106	708	7.82	4.18	3.23	3.55	0.08	4.17	1.59	5.07	370.5	5
Average	1086	695	7.76	4.11	3.24	3.57	0.08	4.19	1.7	5.03	367.5	4.8
Nafaq Pump Station												
1993/3/7	630	403	7.31	4.2	1.1	0.99	0.05	1.47	0.44	3.77	265	42
1993/4/11	681	436	7.44	4.3	1.2	1.11	0.05	1.63	0.3	3.83	275	46.5
1993/5/3	718	460	7.33	4.17	1.16	1.34	0.07	1.84	0.37	3.73	266.5	47.6
1993/7/5	707	452	7.38	4.13	1.28	1.33	0.06	1.95	0.39	3.83	270.5	47.1
1993/8/2	777	497	7.25	4.16	1.31	1.71	0.08	2.19	0.32	3.81	273.5	48
1994/2/5	941	602	7.35	3.46	2.04	3.36	0.19	3.93	1.15	3.2	275	39.4
Average	742	475	7.34	4.07	1.35	1.64	0.08	2.17	0.5	3.7	271	45.1
Taj Pump Station												
1993/3/7	870	557	7.5	3.26	1.96	2.96	0.17	3.36	1.12	3.33	261	39.2
1993/4/11	968	620	7.38	4	2.1	2.97	0.19	3.72	0.9	3.73	305	53
1993/5/3	1005	643	7.42	3.47	2.15	3.41	0.21	4.34	0.98	3.25	281	44
1993/7/5	1053	674	7.32	3.86	2.44	3.44	0.2	4.56	0.91	3.72	315	53.3
1993/8/15	1043	668	7.2	3.49	2.67	3.63	0.18	4.9	1.16	3.36	308	42
1994/2/5	964	617	7.39	3.67	2.1	3.28	0.2	3.95	0.98	3.49	288.5	41.1
Average	984	630	7.37	3.63	2.24	3.28	0.19	4.14	1.01	3.48	293.5	45.4
Racing Club Pump Station												
1993/5/3	957	612	7.16	4.96	1.99	2.27	0.15	3.3	0.5	4.62	347.5	62.2
1993/4/27	874	559	7.15	4.5	1.92	2.09	0.11	2.98	0.38	4.22	321	56
1993/3/14	950	608	7.16	4.95	1.94	2.18	0.12	3.14	0.34	4.78	344.5	61.5
1993/8/8	902	577	7.08	4.57	2	2.16	0.1	3.03	0.14	4.6	328.5	54
1994/2/5	960	614	7.23	4.44	2.08	2.39	0.12	3.28	0.51	4.28	326	50.9
Average	929	594	7.16	4.68	1.99	2.22	0.12	3.15	0.37	4.5	333.5	56.9

(1) Source: The Laboratories and Water Quality Control Dept., WAJ

(2) Total Hardness (TH) as $CaCO_3$

Table II-1.2.11 Drinking Water Quality in Jordan Valley Area

Date	EC (μS/cm)	TDS (mg/L)	pH	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	K (meq/L)	Cl (meq/L)	SO_4 (meq/L)	HCO_3 (meq/L)	TH (mg/L)	NO_3 (mg/L)
Al-Slikhat Well No.6												
1994/1/11	1775	1154	7.5	9.73	4.55	6.53	0.37	10.8	0.85	4.39	714	29.7
1994/4/4	1892	1130	7.38	5.37	4.88	7.33	0.42	12	1.22	4.28	512.5	30.9
1994/7/10	2120	1378	7.44	6.17	5.8	8.38	0.43	14.6	1.6	3.99	598.5	29.2
Al-Smahiyat Well No.2												
1994/1/11	788	512	7.55	5.46	2.64	2.25	0.13	2.54	0.97	3.81	405	23.3
1994/4/4	797	518	7.55	3.04	2.72	2.13	0.14	2.31	1.4	3.93	288	21.7
1994/7/24	831	540	7.35	-	-	-	-	-	-	-	-	20
Jraiah Wells (1+2+3)												
1994/1/16	980	637	7.53	3.99	3.08	2.69	0.14	3.58	1.49	4.43	353.5	34.4
1994/4/17	993	645	7.51	3.97	3.01	2.69	0.15	3.59	1.5	4.34	.349	35.3
Wadi Rajib Well No.2												
1994/1/31	1512	983	7.04	6.24	5.86	4.16	0.58	3	6.99	6.65	605	1.4
1994/4/4	1350	878	7.16	5.48	5.03	3.77	0.48	2.98	5.92	5.7	525.5	0.9
1994/7/24	1310	852	7.33	-	-	-	-	-	-	-	-	1.5
Wadi Arab Well No.5												
1994/1/27	807	525	7.27	4.72	2.99	0.96	0.06	1.14	0.66	6.75	385.5	10.3
1994/4/24	792	515	7.32	4.99	2.66	0.86	0.07	1.12	0.57	6.63	382.5	6.5
Kafrein Well												
1994/2/16	711	462	7.25	3.63	1.95	1.52	0.11	1.48	1.46	4.08	279	0.3
1994/4/17	722	469	7.14	3.91	1.98	1.48	0.11	1.54	1.56	4.37	294.5	0.1
1994/8/14	730	475	-	-	-	-	-	-	-	-	-	0.5
Mukhieba Well No.1												
1994/1/26	1686	1096	7.07	7	3.67	6.65	0.47	6.27	5.9	5.41	533.5	1.7
1994/4/28	1606	1044	7.66	6.49	3.51	6.1	0.45	6.2	5.21	4.96	500	0.5
1994/7/28	1606	1044	7.4	6.54	3.4	6.15	0.4	6.22	5.74	4.63	497	0.6
Fahel Spring												
-	970	631	7.13	5.04	2.6	1.65	0.1	2	0.53	6.46	382	16.7
-	820	533	7.06	4.87	2.48	1.39	0.08	1.69	0.52	6.32	367.5	16.7
-	869	565	7.08	4.96	2.24	1.63	0.12	1.92	0.39	6.24	360	16.7
Jam'iatt Al-Mussala Well												
1994/1/16	1507	980	7.16	5.68	5.39	4.1	0.21	6.69	1.79	6.05	553.5	58
1994/4/17	1517	986	7.28	5.84	5.08	4	0.22	6.55	1.52	5.94	546	59.1
1994/7/10	1650	1073	7.35	6	5.72	4.62	0.2	7.95	1.65	5.8	586	60.6
Al-Shuna Well												
1994/1/22	840	546	7.41	3.99	2.43	1.84	0.14	2.47	0.94	4.33	321	29.7
1994/4/17	735	478	7.5	3.87	2.11	1.48	0.11	2.04	0.95	4.28	299	25.6
Rawda Well No.1												
1994/1/23	1063	691	7.31	4.44	3.2	2.92	0.19	3.67	2.3	4.3	382	25.8
1994/4/17	1054	685	7.48	4.5	3.01	2.89	0.18	3.67	2.17	4.34	375.5	24.8
1994/7/10	1121	729	7.41	4.84	2.98	3.24	0.19	4.14	2.41	4.28	391	24.4
Sukneh Wells (1+2)												
1994/1/16	1167	759	7.48	3.91	3.61	3.91	0.19	5.42	1.68	4.45	376	16.9
1994/4/17	1136	738	7.52	3.93	3.31	3.63	0.18	5.05	1.5	4.38	362	17.3
1994/7/10	1095	712	7.4	3.91	3.19	3.36	0.14	4.69	1.44	4.38	355	16.8
Kraimeh Well No.1												
1994/1/23	1302	846	7.19	4.88	5.8	2.87	0.5	2.85	6.06	4.98	534	7.3
1994/4/24	1254	815	7.6	5.24	5.2	2.78	0.48	2.81	5.78	4.83	522	6.9
1994/7/24	1273	827	7.42	5.25	5.29	2.78	0.47	2.85	5.76	4.9	527	5.7
Al-Slikhat Well No.5												
1994/1/11	936	608	7.45	6.52	2.92	2.7	0.17	3.41	0.91	4.62	472	29.6
1994/4/4	922	599	7.35	3.49	2.9	2.27	0.18	3.29	1.11	4.51	319.5	30.1
1994/7/10	906	589	7.58	3.47	2.99	2.67	0.15	3.47	1.26	3.91	323	28.1
Al-Sikhat Well No.4												
1994/1/11	570	371	7.35	4.5	2.36	1.31	0.06	1.46	0.71	3.88	343	0.6
1994/4/4	574	373	7.75	2.23	2.23	1.35	0.07	1.46	0.61	3.74	223	0.5
1994/7/10	570	371	7.73	2.06	2.47	1.37	0.06	1.51	0.68	3.81	226.5	0.4

(1) Source: The Laboratories and Water Quality Control Dept., WAJ

(2) Total Hardness (TH) as $CaCO_3$

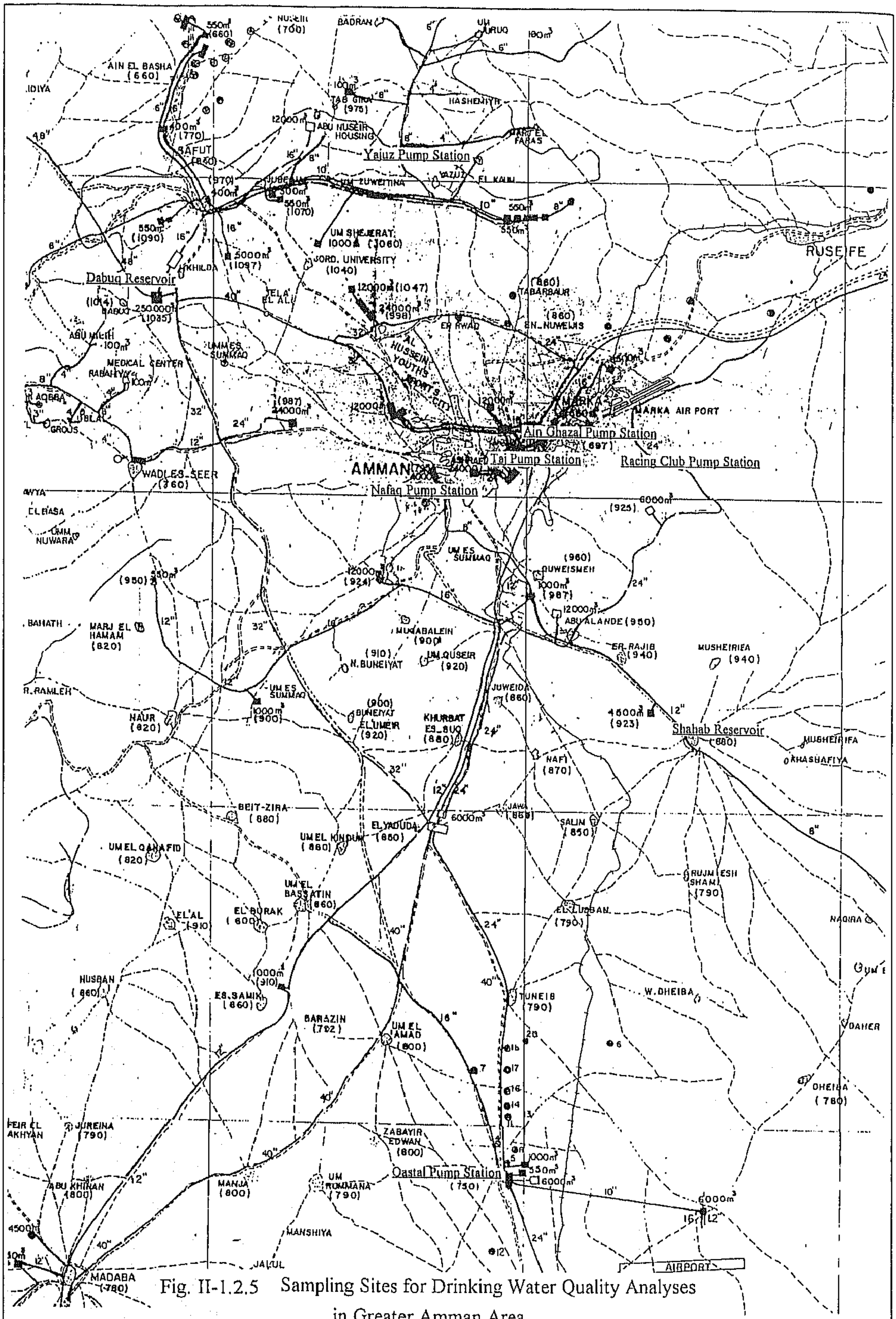


Fig. II-1.2.5 Sampling Sites for Drinking Water Quality Analyses in Greater Amman Area

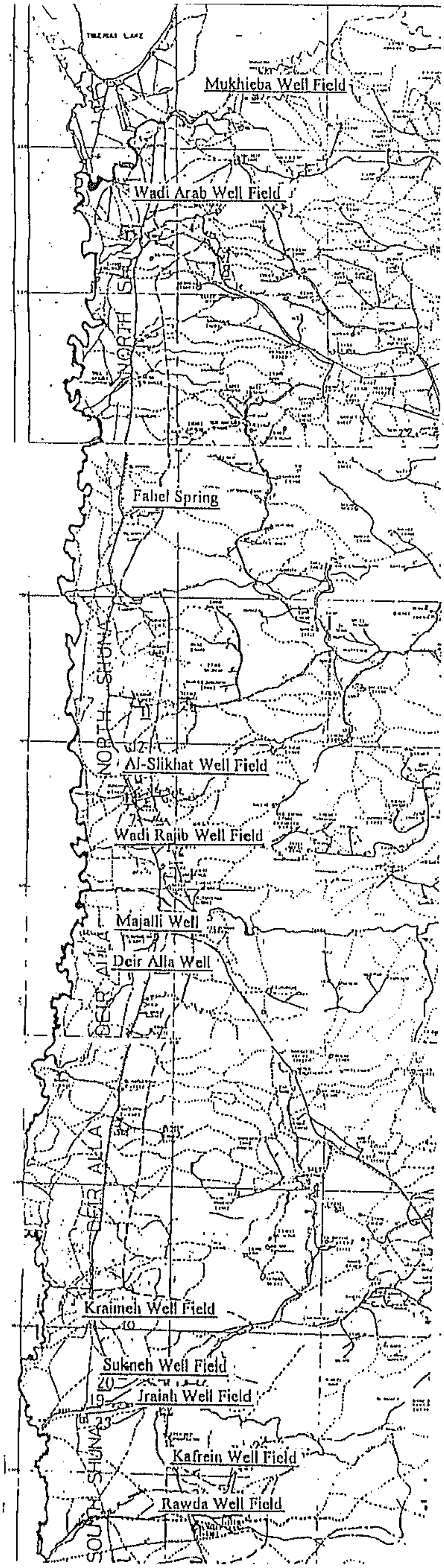


Fig. II-1.2.6 Sampling Sites for Drinking Water Quality Analyses in Jordan Valley Area

1.2.8 Operation and Maintenance

Operation and maintenance of the water supply and sewage system are managed by the three directorates of Water Operation, Sewage Operation and Maintenance under one responsible assistant secretary general in WAJ as shown on the organization chart Fig. II-1.2.1.

(1) Operation of Water Supply

WAJ deal with domestic and industrial water for the whole country and irrigation water other than the Jordan Valley area by means of a Water System Operation Section and an Irrigation Water System Operation Section respectively with the coordination of local governorate offices.

(2) Maintenance

Maintenance of the water supply system managed by WAJ is assigned to the following categories depending on the maintenance services concerned:

- General maintenance of water supply and distribution system
  by Directorate of Maintenance and Transportation
- Routine and minor maintenance of the system and house connection meters
  by each governorate office, pump station etc.
  (Note: A special department has been established recently for the maintenance and calibration of the house connection meters in Water Authority of Amman Governorate.)
- Zai Water Purification Plant and Samra Sewage Treatment Plant
  by their own maintenance teams at inside workshops
- Maintenance of drilling rigs
  by Directorate of Drilling

(3) Ras Al Ain Maintenance Workshop

The directorate of Maintenance and Transportation is located at Ras Al Ain, Amman with the following sections and staff:

- Pump and motor section for general transfer pumps
- Submergible pumps for well section
- Chlorination equipment section
- Diesel engine section

- Vehicle section

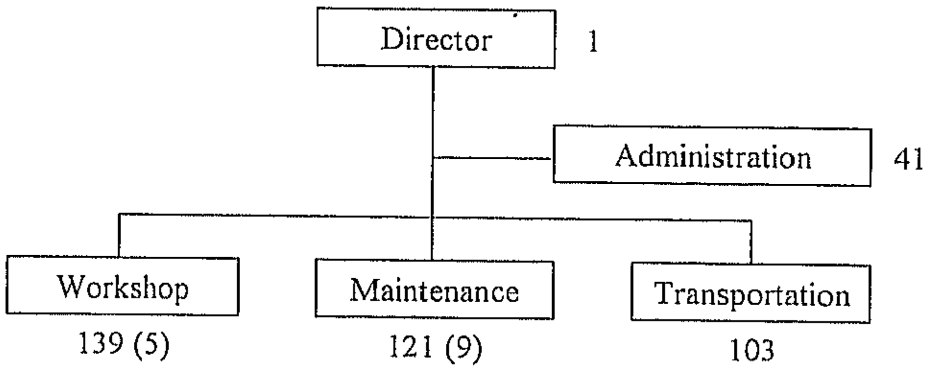
  engine, body, painting, electricity
- Machining section

  Here most of the parts are prepared for the pumps except the impeller and ball bearings using raw stainless and bronze materials.
- Electrical equipment section

  In this section a new group was formed for the maintenance services of instrumentation devices such as pneumatic control.

These activities are executed by the organization and number of staff below, where the number of engineers is shown in parentheses.

Fig. II-1.2.7 Maintenance Organization



(4) Maintenance Program

Regular and preventative maintenance are generally carried out in the winter season (from October to March) because in summer, facilities are almost in full load operation. The maintenance program in summer is prepared according to both the requests from the local operating staff regarding their facilities and also periodical overhaul interval of each piece of equipment for which maintenance records are filed in an inventory in the Directorate.

1.2.9 Electric Power Facilities

In Jordan, electricity is basically managed by Jordan Electric Authority (JEA) of the Ministry of Energy and Mineral Resources and JEPCO and IDECO are private companies buying electricity from JEA and selling it to consumers in Amman and Irbid.

Total installed capacity of electricity power facilities in Jordan was approximately 1,030 MW in 1993. 1,023 MW is generated by thermal power and 7 MW is generated by hydropower.

(1) National Power Distribution Network.

Main transmission lines connect the main cities and areas in the country with the high voltage of 132KV. There is a super high voltage trunk line of 400 KV. between Amman and Aqaba (see Fig. II-1.2.8 Electrical Power System in Jordan).

(2) Jordan Valley

33 KV lines are used for local trunk lines through 132KV/33KV step down substations. In Jordan Valley there is a 33 KV line from North to South which is linked to the three 132 KV line at Irbid, Subeihi and Bayader Wadi Esseer substations

From Abu Zeigan / Deir Alla area, new transmission line will be constructed connecting to Subeihi because the capacity of the existing transmission line is not sufficient. In the case of Wadi Hisban Kafrain area, the nearest 132 KV substation is at Byader.

If the desalination development plan considers utilizing large scale potential, requiring a large amount of electricity, additional construction of power generation plant will be needed.

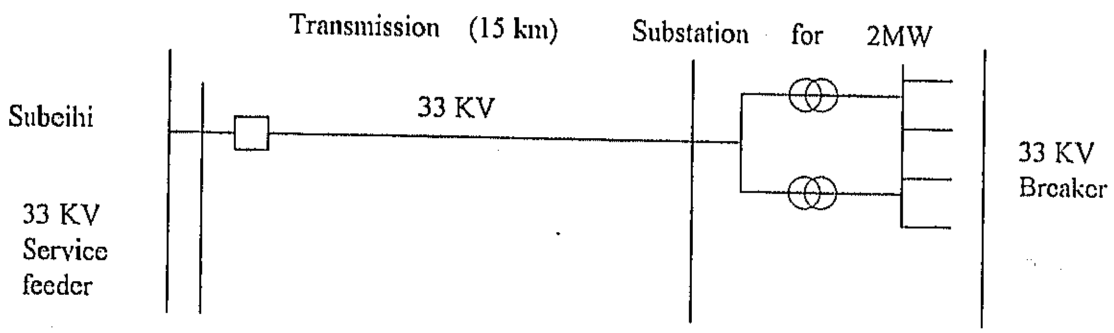


Fig. II-1.2.9 Necessary Facilities for Electricity Supply in Case of Abu Zeigan

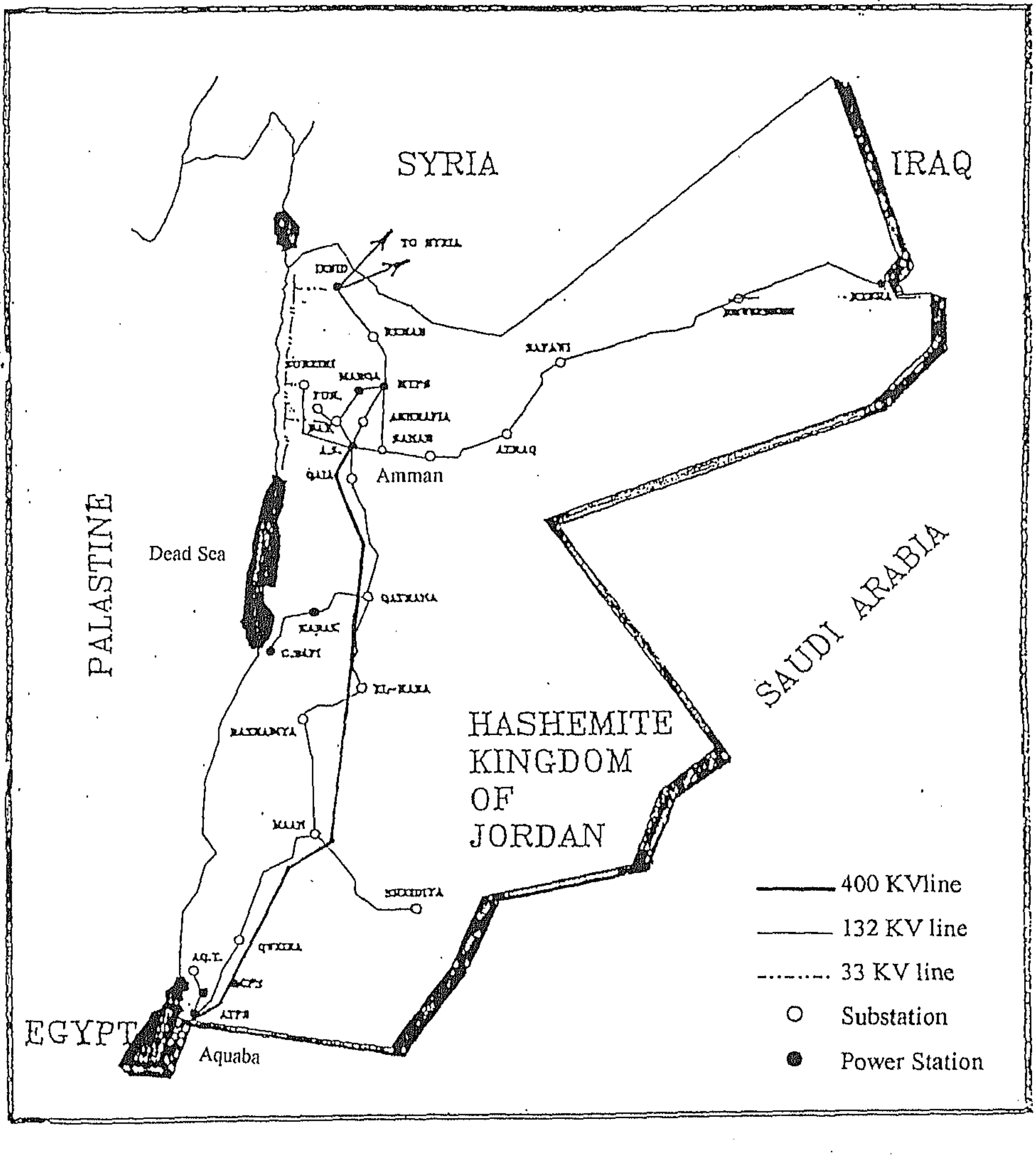


Fig. II- 1.2.8 Electrical Power System in Jordan

(3) Standard price of electricity in Jordan

Table II-1.2.12 Retail Tariff (fils/KWh)

Consumers	Day	Night	Remarks
Domestic	28-70	same	four blocks
Broadcasting	45	same	
Commercial	50	same	
Small Industry	30	same	< 200 KW
Medium Industry	25	20	+ JD 3.05/KW/month
Agriculture	21	same	
Water Pumping	30	same	
Hotel	50	same	

Source: Jordan Electricity Authority, Electricity Tariff, 15-6-1993.

1.3 Existing Water Resource Development Projects in Jordan

Needless to say, water resources in Jordan are scarce and a concentrated effort has covered the whole country with studies. As the remaining significant water resources, from the development of which a considerable amount can be expected, the following two projects can be mentioned:

Surface resource: Wehdah dam at Maqarin on the Yarmouk River
Annual yield of the dam, 100 MCM

Groundwater: Disi sandstone aquifer in south east Jordan
Annual yield, 110 MCM

While the full development of the Wehdah Dam is impeded by regional political considerations, development of the Disi aquifer was started on a substantial scale for the irrigation of private sector and M/I water for Aqaba.

1.3.1 General

In the Study of Water Treatment and Water Resources Planning, Ministry of Planning 1988, the Disi Sandstone has been reported to be capable of yielding up to 110 MCM/year but staged development is recommended exploiting up to 50 MCM/year only in the initial stages.

The development scheme the North Jordan is being updated in the Qa Disi Aquifer Study by WAJ and U.K. ODA and expected to be finalized by the end of 1994. The following are excerpts from the previous study.

1.3.2 Resource Allocation

(1) Aqaba Municipal and Industrial Supplies

The 1985 municipal and industrial water demand of Aqaba was 7.13 MCM/year. This is anticipated to rise to approximately 22 MCM/year by 2005. Of these quantities, 2 MCM/year can be supplied from wells at Wadi Yetum but it is assumed that the remainder (20 MCM/year in 2005) would come from Disi.

(2) Agricultural Demands

Agricultural abstractions from the aquifer in 1987 were estimated at around 13.5 MCM/year. The ultimate irrigation demand for the 173,000 dunums already leased to the private agricultural sector is thought to be at least 173 MCM/year, far in excess of the recommended yield of the aquifer.

(3) Future Source Allocation

Three scenarios have been considered, each involving a restriction of the irrigation abstractions from the Disi aquifer in order to release part of the available supplies for municipal and industrial use. (See Table II-1.3.1)

Table II-1.3.1 Water Source Allocation (2005)

Unit: MCM/year

	Option 1	Option 2	Option 3	1993*1
Aqaba M/I Water	20	20	20	12
Irrigation	15	40	65	65
M/I Water for North Jordan	75	50	25	-
Total Assumed Yield	110	110	110	77

*1: Present production quantity in the progress report by WAJ/UK ODA, June 1994

1.3.3 Water Quality And Treatment

Water Quality in this aquifer is generally good with Total Dissolved Solids between 220 and 500 mg/1. It is assumed that the water would not require treatment other than chlorination.

1.3.4 Transmission and Pumping

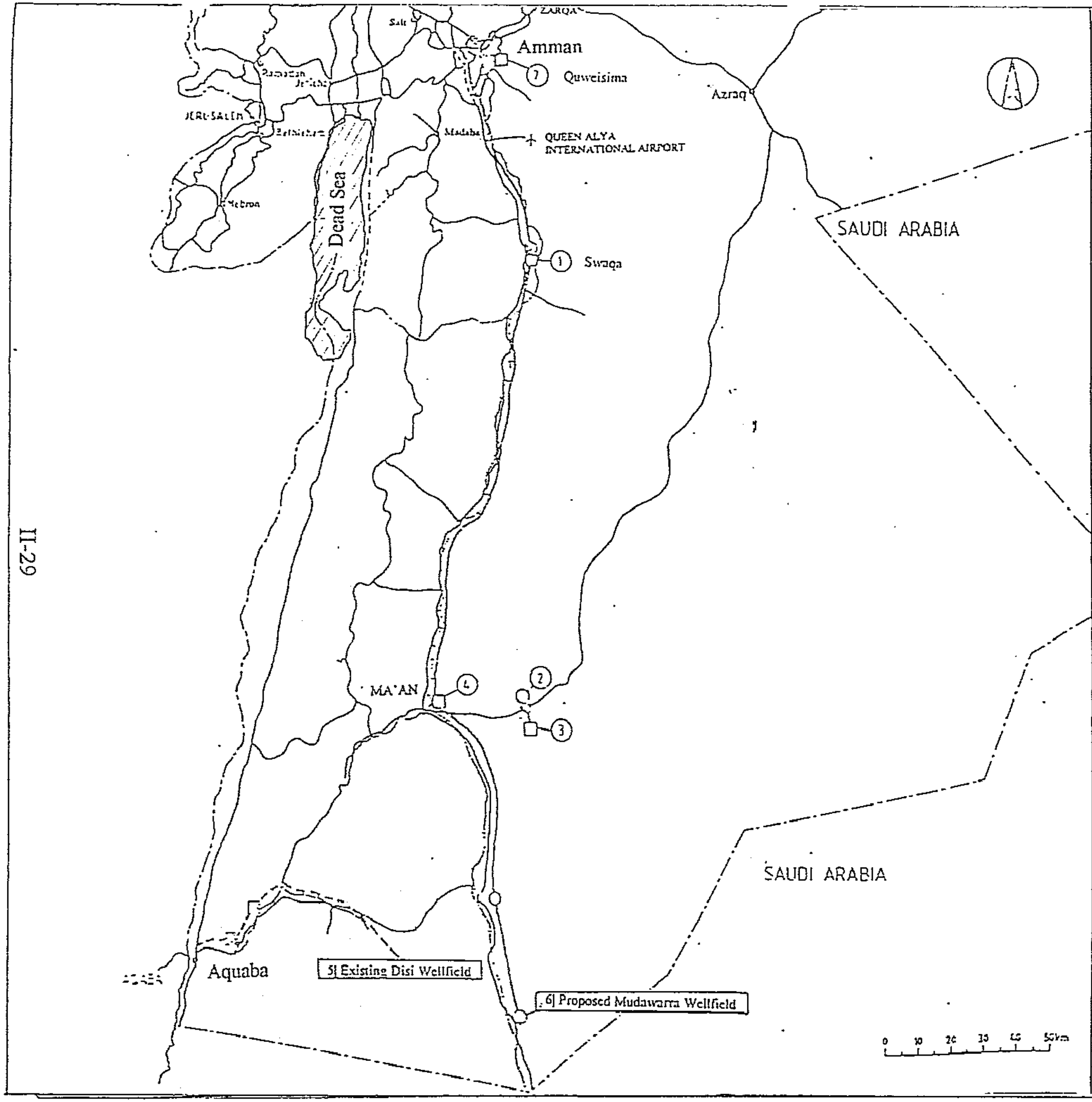
A Wellfield near to the existing Disi Wellfield can be considered but this study assumed development of a wellfield near Muddawara for North Jordan abstractions. The pipeline route and profiles are shown in Fig. II-1.3.1 and Fig. II-1.3.2 and the summary is shown in Table II-1.3.2. The total distance between the wellfield and Amman is approximately 350km. The preliminary outline design assumes that water would be pumped for the first 104km to a reservoir at Ma'an from where it would go by gravity to Swaqa for onward pumping at Quweisima in Amman. On the route from Disi wellfield, there is the highland of Ras Al Nugab, El.+1,500 m before Ma'an while in the case of Muddawara wellfield, the highest point is El.+1,100 m at Maan.

Table II-1.3.2 Disi / Muddawara Wellfield Transmission Mains to Amman

		Option 1	Option 2	Option 3
Design Capacities				
Average Source Yield allocated to N. Jordan Municipal/Industrial use	MCM/year	75	50	25
Peak Abstraction Rate	MCM/year	90	60	30
Capital Works Requirements				
Number of Wells (duty/standby)	No	53+7	35+5	18+2
Chlorination Equipment Capacity	MCM/year	90	60	30
Wellfield Collection Reservoir	m^3	30,000	20,000	10,000
2 No. Pumping Stations on Muddawara to Ma'an Pumping Main: Capacity	MCM/year eac	90	60	30
104km Pumping Main to Ma'an	dia mmh	1,400	1,200	1,000
Ma'an Reservoir	m^3	30,000	20,000	10,000
136km Gravity Main from Ma'an to Swaqa	m^3	1400/ 1500	1200/ 1300	900/ 1000
Receiving Reservoir at Swaqa	m^3	13,500	9,000	4,500
Pumping Station at Swaqa	MCM/year	90	60	30
60km Pumping Main to Amman	dia	1,400	1,200	900
Terminal Reservoir in Amman	m^3	495,000	330,000	165,000

1.3.5 Costs

Capital construction costs and annual pumping costs for the three optional schemes with capacities of 25, 50 and 75 MCM/year are tabulated in Table II-1.3.3 together with present values of capital, annual and mechanical/electrical replacement costs.



LEGEND

- Existing Supply Mains
- Proposed Primary Mains
- Existing Pumping Station
- Proposed Pumping Station
- Existing Treatment Works
- Proposed Treatment Works
- Existing Reservoir
- Proposed Reservoir
- Dam
- Road
- Road (under construction)

KEY

1. Proposed Swaqa reservoir and pumping station
   Res TWL +860
2. Proposed Shidiya wellfield
3. Shidiya phosphate mine
4. Proposed Ma'an reservoir TWL +1125
5. Existing Disi wellfield
   Wellhead level about +800 m
6. Proposed Mudawarra wellfield in Disi Sandstone
   Wellhead level about +775
7. Proposed terminal reservoir at Quweisima
   TWL +530

Fig. II-1.3.1 Route Map and Pipeline

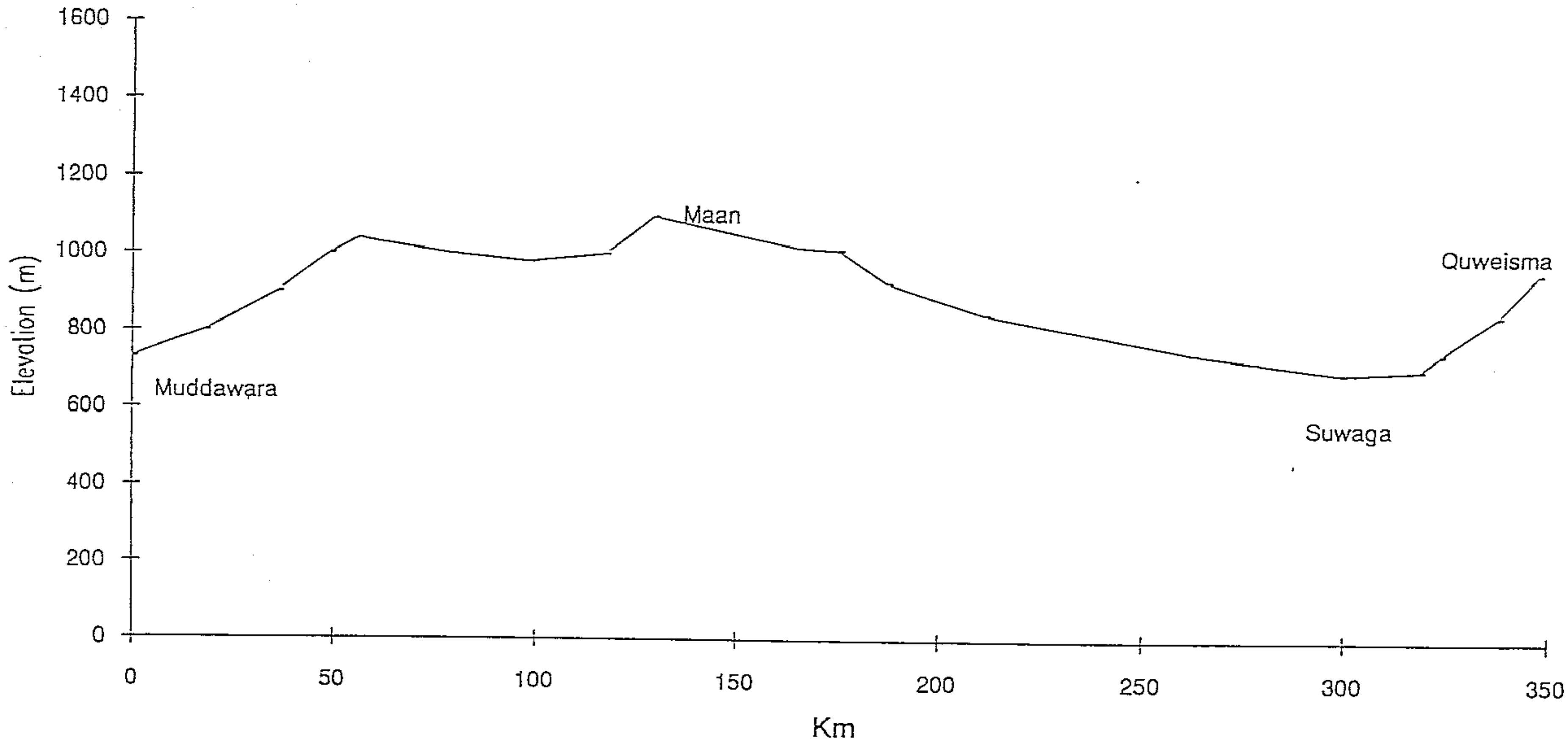


Fig. II-1.3.2 Profile of Conveyance Pipeline from Muddawwara

Table II-1.3.3 Cost Estimates for Alternative Sources

(All costs in million JDs)

	Deir Alla via Zai	Mukeiba via Deir Alla	Wells via Irbid	Wadi Wala Springs Wellfield 1.2 McM/yr	Wadi Wala Dam & Recharge 12 McM/yr	Al Wehdah Dam 25 McM/yr	Al Wehdah Dam 50 McM/yr	Al Wehdah Dam 75 McM/yr	Disi (Mudawarra) Wells 25 McM/yr	Disi (Mudawarra) Wells 50 McM/yr	Disi (Mudawarra) Wells 75 McM/yr
SOURCE DETAILS											
Yield: Annual Average McM/yr	37.5	20	20	12	12	25	50	75	25	50	75
Peak Summer McM/yr	45	25	25	12	14.4	30	60	90	30	60	90
Elevation m40D	-227	-80	-80	350	490	30	30	30	775	775	775
Distance from Amman km	31	91	96	51	51	94	94	94	300	300	300
Treatment Required Y/N	Y	Y	Y	N	Y	Y	Y	Y	N	N	N
CAPITAL COST											
Sourceworks	Existing	1.02	1.02	1.02	9.20	19.12	38.23	57.35	8.10	16.20	24.30
Treatment	-	1.25	3.75	0.19	2.58	6.00	12.00	18.00	0.25	0.50	0.70
Pumping Stations	-	-	8.24	3.35	-	6.72	10.24	19.76	5.04	7.53	8.??
Pipelines		11.38	24.92	5.81	0.37	23.97	33.02	35.47	57.28	85.83	111.??
Reservoirs		3.11	6.39	0.81	6.05	10.34	14.66	21.74	8.38	16.38	24.5?
Total Capital Cost	-	16.76	44.32	11.18	18.20	63.15	108.15	152.32	79.05	126.44	169.0?
ANNUAL COSTS											
Treatment	0.75	0.50	0.30	0.04	0.12	0.50	1.00	1.50	0.05	0.10	0.3?
Power Cost for Pumping	4.40	2.41	2.13	0.78	0.71	2.39	4.74	7.03	1.80	3.45	5.??
Total Annual Costs	5.15	2.91	2.43	0.82	0.83	2.89	5.74	8.53	1.85	3.55	5.40
REPLACEMENT COSTS											
M & E Plant Replacement (50%) after 15 years llife	5.80	6.15	3.82	1.50	0.70	3.25	5.46	7.53	2.90	5.06	6.8?
TOTAL PRESENT VALUE AT 5%	99.62	76.76	93.79	27.97	34.81	121.36	223.29	323.13	116.70	198.45	278.9?
10%	47.91	45.66	68.14	19.27	26.19	91.16	163.57	234.53	97.18	161.12	221.90
PRESENT VALUE PER McM OF (AVERAGE) YIELD 5%	2.77	3.84	4.69	2.33	2.90	4.85	4.47	4.31	4.67	3.97	3,71
10%	1.33	2.28	3.41	1.61	2.18	3.65	3.27	3.13	3.89	3.22	2.96

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2. Water Demand Analysis

2.1 Water Demand Analysis

2.1.1 Study Scope for Water Demand Projection

Since the desalinated water will be used for municipal purposes, the water demand analysis basically focuses on the domestic and industrial water demand in the Jordan Valley and the Uplands. However, the irrigation water in the Jordan Valley, i.e. King Abdullah Canal Water, is linked with the domestic water supply in the Uplands through the existing Deir Alla / Amman Pipeline. The treated waste water from the Uplands flows to the Zarqa River, and then goes back to the irrigation water supply system in the Jordan Valley (see Fig. II-2.1.1).

Therefore, the water demand analysis sets its study scope on 1) the domestic/ industrial and agricultural water demand in the Jordan Valley, 2) agricultural water demand in the Jordan Valley, and 3) the domestic/ industrial water demand in the Uplands (see Table II-2.1.1).

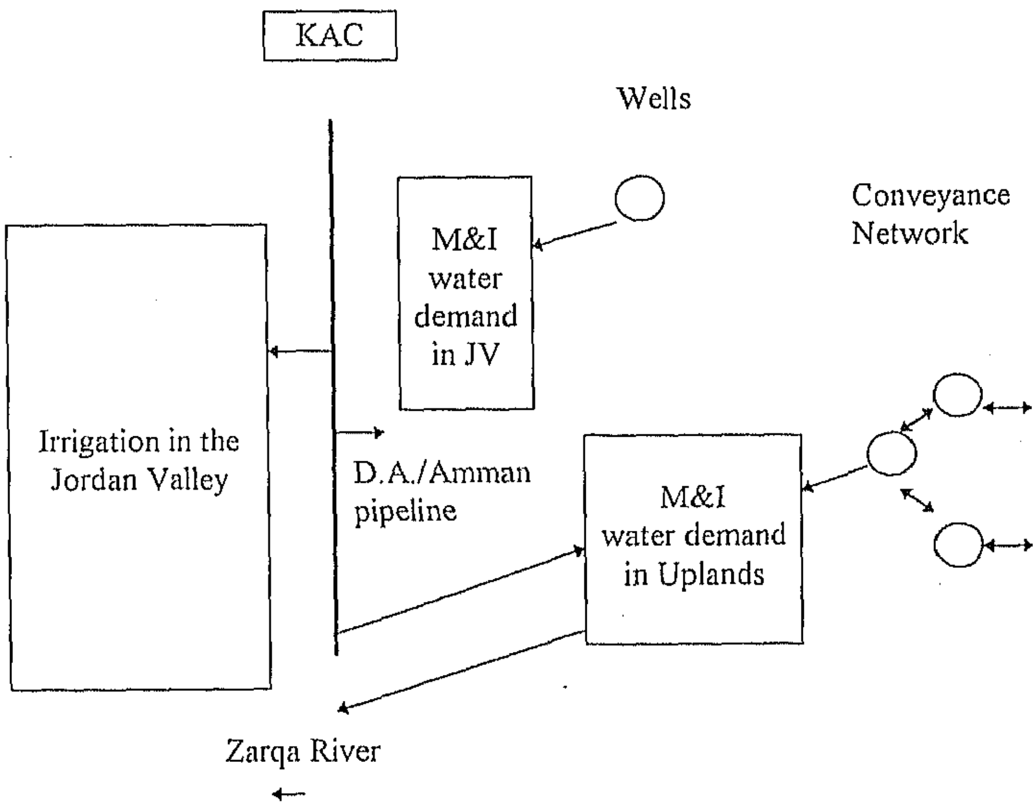

Fig. II-2.1.1 Schematic View of Water Supply System in the Study Area

Table II-2.1.1 Study Scope for Water Demand Projection

	Demand Projection		
	Domestic	Industrial	Irrigation
Jordan Valley	Yes	Yes	Yes
Uplands	Yes	Yes	none

2.1.2 Water Demand Projection in the Jordan Valley: Domestic, Industry and Tourism

(1) Current Water Production and Consumption in the Jordan Valley

Water from wells is a major source of domestic and industrial water in the Jordan Valley. The amount of pumped well-water in the Valley totaled 10.1 MCM in 1993. Although the supply of well water seems to have increased from previous years, there are indications of over-exploitation, which have resulted in a decline in the water table in the wells.

We have assumed that conveyance and distribution losses are 20 % of the total amount (10.1 MCM) (See Table II-2.1.2). Thus, water consumption in the Valley in 1993 was estimated to be 8.1 MCM. However, water sold in the same year was only 4.6 MCM (See Table II-2.1.3). This indicates that the Water Authority of Jordan (WAJ) failed to collect water bills for 3.5 MCM, or 55% of the total volume.

Table II-2.1.2 Domestic Water Production in the Jordan Valley, 1991-3

	Water Supply			(MCM)
	North Shuna	Deir Alla	South Shuna	Total
1991	4.182	2.264	2.141	8.587
1992	4.067	2.224	2.594	8.885
1993	4.442	2.468	3.219	10.129

Source: WAJ Governorate Offices and summarized by JICA Study Team

Table II-2.1.3 Domestic Water Sold in the Jordan Valley, 1991-3

	Water Sold				(MCM)
	North Shuna	Deir Alla	South Shuna	Industrial	Total
1991	1.301	1.156	0.966	0.031	3.454
1992	1.366	1.583	0.818	0.851	4.618
1993	1.460	1.452	0.970	0.718	4.600

Source: WAJ Governorate Offices and summarized by JICA Study Team

(2) Population in the Jordan Valley

Population in the Valley is said to be 200,000. The Statistical Yearbook of Jordan, however, contained only 140,000 in 1993. It is understood that this discrepancy is caused by the number of foreign laborers in the Valley who seldom register in the census office. The actual population of the Valley of 1993 was calculated by considering Jordanian locals plus foreign laborers. (See Table II-2.1.4a)

Jordanian locals in the Valley can be forecast by extrapolating the current population with the average rate of population growth in the Valley during 1986 to 1993. The growth rate was 4.4% and this figure exceeded the national average population growth (3.3% in 1993). The results show that the Jordanian population in the Valley will be 153,000 in 1995 and 298,000 in 2010. The largest population growth is expected in the Deir Alla District.

Population projection of the foreign laborers in the Valley is based on the area of farmland in which they can find jobs. In 1993, 244,000 dunums of farmland in the Valley was irrigated. The previous record of employment shows that 96 foreign laborers were employed for every 1,000 dunums of farmland in the Valley.[1] By applying the same number to the areas to be irrigated in future, an estimation can be made of 29,000 foreign laborers in 1995 and 35,000 in 2010. The largest growth is expected in the South Shuna District, because of completion of the 14 km extension project and a large area of to-be-developed lands.

Based on these calculations for the Jordanian population and the number of foreign laborers, the estimation concluded that the actual population in the Valley will be 182,000 in 1995, and 333,000 in 2010.

[1] Jordan Valley Authority, The Jordan Valley: Dynamic Transformation 1973-1986, p166.

(3) Domestic Water Demand

1) Net Water Demand for Domestic Uses (see Table II-2.1.4a)

WAJ estimates a net water requirement per person for their planning purposes. WAJ employs two figures for their national water demand projection; 150 liter per person per day and 180 liter per person per day. These are the average water consumption of one person at his/her house in a day. Since the Valley is a rural area and is supposed to consume less water than the urban areas like Greater Amman, this analysis employs the lower number for the projected water demand in the Valley.

The results of the calculation show that net water demand in 1993 for domestic uses in the Valley was 8.996 MCM. If water demand follows the same trend in future, the demand will be 10.032 MCM in 1995, and grow further to 18.317 MCM in 2010.

2) Domestic Water Balance in the Jordan Valley (See Table II-2.1.5)

If we apply the conveyance efficiency rate to the net water demand, the gross water demand will be obtained and may be compared to the water production from the wells. The conveyance efficiency rate in the Valley is assumed to be 80 %, giving a gross water demand in 1993 of 11.25 MCM, rising to 12.54 MCM in 1995 and 22.90 MCM in 2010. The largest water demand is found in the North Shuna District throughout the period of the projection.

If we compare the gross water demand with the water supply of the Valley, the water shortage in the Valley can be examined. The result shows that the Valley currently faces a water shortage for domestic use. The shortage in 1993 was about 1.8 MCM for the whole of the Valley. The largest water shortage is found in North Shuna District which has the largest population in the Valley. Deir Alla District also faces a water shortage. South Shuna is the only district which has an annual surplus. However, the projection shows that it will also face a water shortage by the year 2000.

The projection shows that the total water shortage in the Valley will be 3.1 MCM in 1995 and reach 13.5 MCM in 2010.

Table II-2.1.4a Population and Domestic Water Demand in the Jordan Valley

Year	Population ('000)				Foreign Laborer ('000)					Net Water Demand (MCM)			
	North	Central	South	Total (1)	North	Central	South	Total (2)	(1)+(2)	North	Central	South	Total
1986	57	23	23	104	10	8	4	22	126	3.709	1.706	1.490	6.904
1987	59	29	24	112	10	8	4	22	134	3.818	2.003	1.535	7.356
1988	61	30	25	116	10	8	4	22	138	3.930	2.058	1.580	7.568
1989	63	31	26	120	10	8	4	22	142	4.046	2.117	1.627	7.789
1990	68	34	28	130	10	8	4	22	152	4.329	2.279	1.763	8.371
1991	74	30	28	132	10	8	5	24	155	4.617	2.076	1.836	8.530
1992	75	31	29	135	10	8	5	24	158	4.700	2.120	1.891	8.711
1993	78	32	30	140	10	8	5	24	164	4.851	2.189	1.956	8.996
Average Growth Rate													
	4.6%	5.1%	3.8%	4.4%									
1995	85	35	33	153	10	8	11	29	182	5.250	2.373	2.409	10.032
2000	106	45	39	191	10	8	13	31	222	6.419	2.922	2.885	12.226
2005	133	58	47	238	10	8	15	33	272	7.879	3.627	3.438	14.944
2010	166	75	57	298	10	8	17	35	333	9.705	4.530	4.082	18.317
2015	207	96	69	372	10	8	17	35	407	11.986	5.688	4.729	22.403
2020	259	123	83	465	10	8	17	35	500	14.838	7.172	5.510	27.521
2025	324	157	100	582	10	8	17	35	617	18.403	9.076	6.452	33.930

Source: The Hashimite Kingdom of Jordan, Dept. of Statistics, Statistical Yearbook 1987-93.
Jordan Valley Authority, The Jordan Valley, Dynamic Transformation 1973-1986.
The Hashimite Kingdom of Jordan, Dept. of Statistics, Annual Agricultural Statistics 1986-93.

Note 1: The number of foreign laborer is estimated by multiplying average number of foreign laborers per dunum into area of farm land in the Valley.

Note 2: Population of the Jordan Valley in 1986 estimated by the Jordan Valley Authority was 124,715.

Table II-2.1.4b Irrigated and to-be-Irrigated Area in the Jordan Valley

Year	Irrigated and to-be-Irrigated Area ('000 dunums)			
	North Shuna	Deir Alla	South Shuna	Total
1986	110	79	39	228
1991	110	79	55	244
1992	110	79	55	244
1993	110	79	55	244
1995	110	79	115	304
2000	110	79	135	324
2005	110	79	155	344
2010	110	79	175	364
2015	110	79	175	364
2020	110	79	175	364
2025	110	79	175	364

Source: Jordan Valley Authority.

Table II- 2.1.5 Domestic Water Balance of the Jordan Valley, 1991-2025

(MCM)

Year	Gross Water Demand at Well				Water Balance at Well			
	N. Shuna	Deir Alla	S. Shuna	Total	N. Shuna	Deir Alla	S. Shuna	Total
1991	5.772	2.595	2.296	10.662	(1.590)	(0.362)	(0.155)	(2.106)
1992	5.875	2.650	2.364	10.889	(1.808)	(1.277)	0.230	(2.855)
1993	6.064	2.736	2.445	11.245	(1.622)	(0.986)	0.774	(1.834)
1995	6.563	2.966	3.011	12.540	(2.121)	(1.216)	0.208	(3.129)
2000	8.023	3.653	3.607	15.283	(3.581)	(1.903)	(0.388)	(5.872)
2005	9.849	4.533	4.297	18.679	(5.407)	(2.783)	(1.078)	(9.268)
2010	12.131	5.662	5.103	22.896	(7.689)	(3.912)	(1.884)	(13.485)
2015	14.983	7.110	5.912	28.004	(10.541)	(5.360)	(2.693)	(18.593)
2020	18.548	8.965	6.888	34.401	(14.106)	(7.215)	(3.669)	(24.990)
2025	23.004	11.345	8.064	42.413	(18.562)	(9.595)	(4.845)	(33.002)

Source: Estimated by JICA Study Team.

(4) Industrial Water Demand in the Jordan Valley

1) Factories in the Jordan Valley

There are four factories in the Valley which are large consumers of WAJ well water. The largest consumer is a tomato factory located in the Deir Alla District. In 1993, this factory alone consumed 507,000 cubic meters. A polyester factory consumed 12,000 cubic meters in 1993. Jordan Valley Co. and Agricultural Production Co., which process chemicals and food respectively, consume about 200,000 cubic meters. (See Table II-2.1.6)

2) Industrial Water Demand in the Jordan Valley

It is difficult to predict the expansion of these factories and further industrial agglomeration in the Valley, because the current political environment seems to prefer agricultural development in the Valley to industrial development. Thus, the water demand projection for industrial use does not need to anticipate rapid expansion. In this analysis, the same growth rate as the population growth rate of the Valley is assumed for the projection of industrial water demand in the Valley.

Table II-2.1.6 Industrial Water Supply in the Jordan Valley, 1991-3

Year	Tomato Factory	Polyester Factory	Jordan Valley Co.	Agriculture Production Co.	Total ('000CM)
1991	7	8	16	-	31
1992	841	9	-	-	850
1993	507	12	17	183	719

Source: WAJ Governorate Offices.

Table II-2.1.7 Industrial Water Demand in the Jordan Valley, 1995-2025

Year	Industrial Water Demand ('000CM)	
	Net	Gross
1995	784	980
2000	972	1,215
2005	1,205	1,506
2010	1,495	2,318

Note: Gross demand includes water leakage and is evaluated by 'Net demand/0.8'.
Source: JICA Study Team.

(5) Tourism Water Demand in the Jordan Valley

The Ministry of Water and Irrigation is currently considering a tourist development in the East coast of the Dead Sea. The first phase of the study of the plan is scheduled to start in 1995. The study divides the East coast region of the Dead Sea into three zones; Suweimeh, Zara and El Mazra'a. It has been proposed that Suweimeh, located in the North zone, will receive its water supply from South Shuna District.

This study considers Suweimeh as the major tourism development area in the Valley. However, due to the water shortage in the area, a new water resource development will be probably needed in order to meet the demand for the tourism development. A report on tourism by MOWI, Tourism Development Project of East Coast of the Dead Sea, revealed that the number of beds in the planned hotels in Suweimeh will be 5,280 in 2000 and 11,780 (=5,280+6,500) in 2010. Assuming the daily water consumption per person to be 300 liters and the water conveyance efficiency to be 80%, the tourism water demand in Suweimeh will be 0.36 MCM in 2000 and 1.27 MCM (=0.36+0.91) in 2010 (see Table II-2.1.8).

Table II-2.1.8 Tourism Development Program in Suweimeh

Accommodation	Development in beds		Water Demand* in MCM/yr	
	2000	2010	2000	2010
Hotels	1,200	+ 2,000	0.16	+ 0.28
Camp Site	480	+ 600	0.06	+ 0.09
Weekend Houses	3,600	+ 3,900	0.14	+ 0.54
Total	5,280	+ 6,500	0.36	+ 0.91

Note: Daily water consumption per habitant in bed is assumed 300 liters, and the water conveyance efficiency is assumed 80 percent.

Source: MOWI, Tourism Development Project of East Coast of the Dead Sea, Interim Report, Nov. 1994.

Table II-2.1.9 Summary of the Domestic and Industrial Water Balance in the Jordan Valley

Year	Domestic	Water Demand Industry	Tourism	Total	Water Supply (MCM)	Water Balance (MCM)
1991	10.66	0.04	-	10.70	8.59	-2.22
1992	10.89	1.06	-	11.95	8.89	-3.06
1993	11.25	0.90	-	12.15	10.13	-2.02
1995	12.54	0.98	-	13.52	10.13	-3.39
2000	15.28	1.22	0.36	16.86	10.13	-6.73
2005	18.68	1.51	0.82	21.01	10.13	-10.88
2010	22.90	2.32	1.27	26.49	10.13	-16.36

Source: JICA Study Team.

2.1.3 Water Demand Projection in the Uplands: Domestic and Industry

(1) Domestic Water Supply and Consumption in the Uplands

This section describes the domestic and industrial water supply in the five Uplands governorates of the Kingdom: Amman, Zarqa, Irbit, Mafraq and Balqa. These areas of the Uplands are connected to each other by means of water conveyance network so that once water is produced in one area, it can be transported to an other area through the network. Table II-2.1.10 shows the population and volume of water supplied to the Uplands.

Table II-2.1.10 Population and Domestic Water Supply in the Study Area, 1991-93

	Governorate Amman*	Zarqa*	Irbit**	Mafraq	Balqa**	Total
Population in 1993('000)	1,680	614	937	167	193	3,591
Water supply (MCM)						
1991	75	22	26	13	9	145
1992	98	22	27	14	11	172
1993	101	25	30	13	12	181

Source: WAJ Annual Report 1992 and its internal document.
Note*: Water supply in Amman includes the volume of water pumped through Deir Alla/Amman pipeline. It was 3.7 MCM in 1991, 30.6 MCM in 1992 and 28.3 MCM in 1993.
Note**: Population and water supply in Irbit and Balqa do not include those of the Jordan Valley.

The Uplands consumed 181 MCM of water in 1993. Amman Governorate is the largest consumer of water in the Uplands region. In Amman, WAJ supplied 101 MCM of water to a population of 1,680,000. WAJ had to increase its water supply to Amman in 1992 because of the substantial number of returnees from abroad during the Gulf War.

Table II-2.1.11 Water Billed and Per capita Net Domestic Water Consumption in the Study Area, 1993

	Amman	Zarqa	Irbit	Mafraq	Balqa	Total
Water Billed(MCM)	41.5	11.9	15.9	3.7	34.2	79.3
Unaccounted for Water	58%	54%	54%	72%	67%	59%
Per capita Net Water Consumption*(liter/day)	124	84	66	160	128	104

Source: WAJ internal documents.
Note*: Per capita net water consumption is estimated by including not only water billed but also the unaccounted for water caused by inappropriate water meters. An adjusted unaccounted for water is assumed to be 75 percent throughout the Uplands.

Although the unaccounted water of every governorate is more than 50% of the water supplied, the volume of water actually consumed is expected to be more than the volume of water billed. A previous study reported that leakage or transmission losses are only 20.4%, and the largest part of unaccounted water was caused by inappropriate water meters. The demand projection analysis assumes that leakage and transmission losses are 25 % of water supply, and 75 % is consumed.

The per capita net domestic water consumption at houses of these governorates is 104 liters per day. Mafraq and Balqa governorates have the highest per capita net water consumption in the region although their unaccounted water is extremely high. It implies that a large volume of water is being taken free in these governorates. On the other hand, Zarqa and Irbit governorates have the lowest per capita net consumption in the region. The net per capita water consumption in governorate is close to the regional average.

(2) Population in the Uplands (see Table II-2.1.12)

The population of the Uplands in 1993 was 3,618,000. The domestic water demand projection in the Uplands has been extrapolated based on population size and population growth rate. The population growth rate is expected to be 3.6 % up to the year 2000, and then the growth rate is assumed to decline gradually to 3 %. Population of the Uplands in 2010 will be 6,289,000.

(3) Domestic Water Demand in the Uplands (See Table II-2.1.12)

1) Net Water Demand for Domestic Uses in the Uplands

WAJ estimated the domestic water demand of the Kingdom by applying two scenarios of per capita water consumption: 150 liters / day and 180 liters / day. The target set by WAJ is to increase the water supply so that these figures can be achieved. A substantial improvement in the domestic water supply will be required to achieve these scenarios. However, it is also obvious that these figures are still far below industrialized countries such as the U.S. and Japan, and even the Gulf countries, which consume more than 300 liters per day per person.

Jordan is entering a new era of peace with her neighbors, and is promoting foreign investment (FDI) as one of the fruits of peace. Once the Jordanian economy starts to expand, per capita water consumption will also grow to the level of the developed countries.

This analysis uses the same two scenarios as WAJ for the national water projection: 150 liters / day and 180 liters / day. The result shows that the current annual net water demand is estimated to be 199 MCM per year in a low consumption scenario and 239 MCM per year in a high consumption scenario. It will grow to 346 MCM per year (low consumption) and 415 MCM per year (high consumption) in the year of 2010.

2) Gross Domestic Water Demand

The gross water demand is given by adding the 25% conveyance loss to the net water demand. The current gross domestic water demand is 265 MCM per year in the low consumption scenario and 318 MCM per year in the high consumption scenario, rising to 461 MCM per year (low consumption) and 553 MCM per year (high consumption).

Table II-2.1.12 Population and Domestic Water Demand in the Upland, 1987-2010

	Population in the Upland						Growth	Net Water Demand		Gross Water Demand**	
	Amman	Zarqa	Irbit*	Mafraq	Balqa*	Total	Rate	(150 lit./day) (MCM)	(180 lit./day) (MCM)	(150 lit./day) (MCM)	(180 lit./day) (MCM)
1987	1,203	419	647	102	148	2,519		139	166	185	222
1988	1,249	434	667	105	153	2,608	3.5%	143	172	191	230
1989	1,297	450	690	109	158	2,704	3.7%	149	178	198	238
1990	1,444	531	747	127	173	3,022	11.8%	166	199	222	266
1991	1,573	601	876	156	181	3,387	12.1%	186	224	248	298
1992	1,625	622	904	160	183	3,494	3.2%	192	231	256	307
1993	1,680	641	937	167	193	3,618	3.5%	199	239	265	318
1995	1,803	688	1,006	179	207	3,883	3.6%	214	256	285	342
2000	2,152	821	1,200	214	247	4,634	3.6%	255	306	340	408
2005	2,519	961	1,405	250	289	5,425	3.2%	298	358	398	477
2010	2,920	1,114	1,629	290	335	6,289	3.0%	346	415	461	553

Source: Dept. of Statistics, Statistical Yearbook 1987-93, and the estimation by JICA study team.
Note* : Population of the Jordan Valley is excluded from those Governorates.
Note **: Gross Water Demand assumes the conveyance loss of 25 percent.

(4) Industrial Water Demand in the Uplands

1) Water Demand Projection for Industry by the Joint Technical Committee

Current water supply for industry in Jordan is 33 MCM[2] per year. The joint Technical Committee of MOWI, WAJ and JVA has estimated the future water demand for industry in the Kingdom. It has projected that 50 MCM of water will be needed in 1995 and 119 MCM will be needed in 2010. It has assumed a 6 % growth rate in industrial water consumption throughout the period. This growth rate is considered to be relatively high.

The contribution of manufacturing and mining sectors to the GDP of Jordan in 1992 was only 16.4 %. It has grown slowly, and a major sectoral shift has not occurred in Jordan. Although the peace era in Jordan will create a better environment for investment in Jordan, a schedule of a large number of industrial establishments has not been promised yet. Besides, large factories in Jordan usually have their own water sources, and do not depend upon the WAJ water supply. However, once a higher level industrial development does begin in the region, a large volume of water will be required. Therefore, it is expected that WAJ will take the responsibility for the future water demand.

2) Industrial Water Demand in the Uplands

A previous study[3] showed that the industrial water demand of the five Governorates was only 35 % of total industrial water demand of the Kingdom in 1985. It also expected that this share would decline because of the establishment of a large number of factories in the South. The analysis assumed that the Uplands would continue to consume 35 % of the total industrial water used in the Kingdom.

The results show that industrial net water demand in the Uplands is expected to be 17.5 MCM in 1995, and will grow to 41.7 MCM in 2010. In order to obtain the gross water demand, the conveyance loss of 25 % has been applied (see Table II-2.1.13).

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[2] The Star, " Regional Seminar Examines Water Uses Under Peace." November 25,1994; pp 1-2,5.

[3] The World Bank, Jordan Water Resources Sector Study, June 27, 1988

Table II-2.1.13 Industrial Water Demand in the Uplands (MCM)

Year	Jordan (Net)	Uplands (Net)	Uplands (Gross)
1991	33	11.6	15.4
1995	50	17.5	23.3
2000	78	27.3	36.4
2005	93	32.6	43.4
2010	119	41.7	55.5

Sources: The World Bank, Jordan Water Resources Sector Study, June 27, 1988, and JICA Study Team.

Table II-2.1.14 Summary of Domestic and Industrial Water Demand in the Uplands

Year	Domestic Water Demand		Industrial Water Demand	Water Supply	Balance	
	(low)	(high)			(low)	(high)
1993	265	318	15.4	181	-99	-153
1995	285	342	23.3	181	-127	-184
2000	340	408	36.4	181	-195	-263
2005	398	477	43.4	181	-260	-339
2010	461	553	55.5	181	-336	-428

Source: JICA Study Team.
Note*: Water supply of 181 MCM includes 28.3 MCM of treated water through the Deir Alla/Amman pipeline.

2.1.4 Water Demand Projection for the Jordan Valley: Irrigation

(1) Farm Land and Water Supply in the Jordan Valley

244 thousand dunums of land in the Jordan Valley are currently irrigated (see Table II-2.1.15). North Shuna District irrigates 110 thousand dunums that includes the North Ghor Conversion (73 thousand dunums), Wadi Arab (12 thousand dunums) and North East Ghor (25 thousand dunums)[4] irrigation projects. Deir Alla District irrigates 79 thousand dunums that include the Zarqa Triangle (14 thousand dunums) and the Middle Ghor (65 thousand dunums). South Shuna District irrigates 55 thousand dunums that include the 18 km Extension (37 thousand

[4] The coverage area of JVA's regional office in the Valley goes beyond the district boundary. This is because their projects are sometimes located between two districts.

dunums), the Wadi Shueib (2.5 thousand dunums)[5] and the Hisban-Kafrein (16 thousand dunums). The 14 km extension project that will allow development of 60 thousand dunums of irrigable lands in South Shuna is nearly completed, and irrigation is expected to start in 1995. There are 60,000 dunums of undeveloped land, mostly located in South Shuna.

Farming intensity in the Valley is calculated by dividing the total area of farmland by the area of arable land in the Valley. Farming intensity of the Valley is 1.06 on average. The highest intensity is found in North Shuna. The intensity declines towards the South of the Valley. Since South Shuna faces a water shortage, some parts of the available arable land remains unirrigated.

The annual water supply for irrigation in the Jordan Valley was 227.9 MCM per year during the water years from 1989/90 to 1991/92 (see Table II-2.1.16) This volume of water did not include winter flood water that was wasted to rivers and side wadis. For example, the discharge of the Yarmouk River in 1991/92 was 739 MCM but the volume wasted in winter floods was 580 MCM. As a result, the useable water from the Yarmouk River was only 159 MCM.[6]

The volume of water available for irrigation in the Valley varies from year to year. The year of 1989/1990 and 1990/1991 were said to be water scarce years. The volume of water for irrigation in those years was around 200 MCM. On the other hand, there was heavy rain in the winter of 1991/92, and the year was said to be a water abundant year. Total water supply for irrigation reached nearly 300 MCM and a large quantity of surplus water was pumped from the King Abdullah Canal to Amman via the Deir Alla/Amman pipeline.

[5] Wadi Shueib project irrigated by ground water but not by surface water. This project has wells for its own irrigation.

[6] Wasted discharge from rivers and wadis are as follows:

Water Year	Yarmouk	Zarqa River	Side Wadis	Total
1989/90	58.0	12.0	5.9	75.9
1990/91	58.0	13.1	6.9	78.0
1991/92	580.0	115.3	61.7	757.0

Source: Jordan Valley Authority, and WAJ Annual Report.

Table II-2.1.15 Farm Land and Farming Intensity of the Jordan Valley

	North Shuna	Deir Alla	South Shuna	Total ('000 dunums)
Area of Irrigated (A)	110	79	55	244
Irrigable	-	-	60	60
Undeveloped	-	-	60	60
Farming (B)				
1988-92 average	125	82	51	258
Farming intensity				
(B)/(A)	1.13	1.04	0.93	1.06

Source: JVA interview, and Dept. of Statistics, Annual Agricultural Statistics 1988-92.

Table II-2.1.16 Water Supply Sources for Irrigation in the Jordan Valley (MCM)

Water Year	Yarmouk	Zarqa River	Side Wadis	Wells and Springs	Deir Alla/ Amman Pipeline*	Total
1989/90	105.0	61.0	29.0	22.2	-8.8	208.4
1990/91	89.0	46.9	27.9	20.9	-3.7	181.0
1991/92	159.0	59.6	99.2	9.6	-33.2	294.2
Average	117.7	55.8	52.0	17.6	-15.2	227.9

Source: Jordan Valley Authority, and WAJ Annual Report.
Note *: Water volume transported to Amman through Deir Alla/ Amman Pipeline refers to the calendar years from 1990 to 1992 but not to the water years. Those data are obtained from WAJ Annual Report cited as the quantities of treated water in Zai Treatment Plant.

(2) Method of Water Demand Projection

Water demand for irrigation in the Jordan Valley is theoretically calculated from the net water requirement of maximum crop production and the farming areas of those crops in the Valley. The Harza Report (1989) introduced the net water requirement of the crops in the Valley. The numbers in the tables take into account both the optimum water volume for irrigation and the local climate of the Valley (see Table II-2.1.17). This net water requirement is multiplied by the farming areas of the corresponding plant species. Aggregation of net water requirements of all the plant species in the Valley results in the net water demand for irrigation in the Valley. The (gross) water demand for irrigation in the Valley is calculated by considering the efficiencies of water conveyance and on - farm irrigation.

The projection of gross water demand considers the farming intensity desired by JVA, the improvement of irrigation efficiency, and the land development scenario of the Jordan Valley. It extrapolates the water demand to 2010.

(3) Assumptions for Water Demand Projection

1) Net Water Requirement for Plant Species

The net water requirements for the plant species in the Valley are given in Table II-2.1.17. The theoretical net water requirement and Harza's adjusted net water requirement to the local climate of the Jordan Valley are shown in the table. The Harza report classified crop plant species into fruits and field crops, winter vegetables and summer vegetables. At the same time, the report took into account the climatic differences of the north region and the south region of the Valley. For example, fruit trees require the largest quantity of water, but their requirements are different between the North and the South. Bananas consume 1,717 cubic meters per dunum a year in the north region, and 1,853 in the south region.

The net water requirement is applied to the farming areas of the Valley, and the aggregation of the water requirements of all the farming areas results in the net water demand for agriculture in the Valley.

Table II-2.1.17 Net Water Requirement for Crop Plant Species in the Jordan Valley

(m3/dunum)

	Theoretical Net Water Requirement *	HARZA Report 1989**	
		North	South
(Fruits and Field Crops)			
Orange	1,700	888	1,244
Banana	2,769	1,717	1,853
Grapes	1,324	888	888
Cereals	742	460	437
Corn	900	547	980
(Winter Vegetables)			
Tomato	1,052	408	417
Eggplant	1,340	709	578
Cucumber	518	497	450
Potato	327	327	462
Squash	800	272	343
Cauliflower/Cabbage	1,050	300	342
Onion/Garlic	634	168	580
Broadbeans	342	212	278
Peppers	1,127	333	600
Melon	800	n.a.	n.a.
Leaf Vegetable	1,000	154	407
(Summer Vegetables)			
Tomato	1,052	652	417
Eggplant	1,340	832	593
Cucumber	518	321	450
Potato	327	327	380
Squash	800	293	343
Cauliflower/Cabbage	1,050	484	484
Onion/Garlic	634	393	580
Broadbeans	342	181	191
Peppers	1,127	699	616
Melon	800	519	765
Leaf Vegetable	1,000	154	407

Precipitation in the Valley

Source: JVA, The Jordan Valley, Dynamic Transformation: 1973-1986, USAID 1987.
The Hashemite Kingdom of Jordan, Meteorological Department, Jordan Climatological Data Handbook, 1988. JVA, Storage Facilities in Jordan Valley, Final Report on Technical, Economic and Financial Feasibility and Preliminary Design, HARZA Engineering Co., April 1989.

Note *: Theoretical net water requirement is obtained from USAID report (1987).

Note **:Harza Report considers local climate of the Jordan Valley.

2) Water Conveyance Efficiency

According to a report by JVA[7], " Water is delivered to the farms in several ways. It can be diverted into KAC and then into pressure pipe or open ditch systems, or it can be diverted directly into a pressure pipe system as in the case of Carrier Pipe No. 1 on the Zarqa River. The delivery system has some influences on whether the on-farm system will be a surface or drip. With the main canal included as a part of the delivery system, the efficiency for a pressure pipe system is estimated to be 85 %. Data on actual distribution losses with the KAC recorded by the JVA ranges from 76 % in the summer and fall to about 84 % in the winter and spring. The efficiency was measured as water sold plus water distributed free plus water spilled divided by total canal inflow."

The efficiency of the water delivery system in different areas of the Jordan Valley is calculated by assuming the percentage converted to pressure pipe irrigation in the area (see Table II-2.4.4). In North Shuna, conversion is 60 % complete. In Deir Alla and South Shuna, conversion is 100 % complete. Before this conversion, the efficiency of the water delivery system (surface irrigation) is assumed to remain at 0.5. Conversion to pressure pipe improves the efficiency to 0.85. Multiplying the efficiency by the percentage of conversion completion of the district gives the water delivery efficiency of the district. The efficiency in North Shuna is 0.71, and that in Deir Alla and South Shuna is 0.85. However, North Shuna will improve soon by completing its conversion program.

The type of on-farm application of irrigation also affects the efficiency of water delivery. Drip irrigation is generally accepted as the most efficient irrigation system.[8] The efficiency of drip irrigation is assumed to be 0.84, and to maintain this level throughout any climate in the Valley. The efficiency of sprinkler irrigation is assumed to be 0.75, and declines along the

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[7] Jordan Valley Authority, Storage Facilities in the Jordan Valley, Final Report on Technical, Economic and Financial Feasibility and Preliminary Design, Vol. III, Part II-Appendices to Main Report, Harza Engineering Co., April 1989, pp. C-22.

[8] Recent study on the farm irrigation of the Valley showed that modern irrigation technology encouraged the farmers to overuse water. It also showed that the efficiency of irrigation by using modern technology was lower than conventional surface irrigation in the Valley. (R. Hagan, " Constraints to High Efficiency in Irrigation water Management in the Jordan Valley," Regional Seminar on the Optimization of Irrigation in Horticulture, November 21, 1994.)

climatic changes towards the South of the Valley. The efficiency of surface irrigation is assumed to be lowest, 0.65, and also declines toward the South.

By considering both delivery system efficiency and on-farm application, the water conveyance efficiency of each district is estimated to be 0.53 in North Shuna, 0.67 in Deir Alla and South Shuna. North Shuna is expected to improve its efficiency to the same level as the other districts by completing the pressure pipe conversion program in 1995.

3) Farming Intensity

The current farming intensity of the Jordan Valley is 1.06 (see Table II-2.1.15). Jordan Valley Authority plans to increase it to 1.3, once the Valley receives sufficient water resources. The analysis uses this number for the water demand projection of the irrigation in the Valley.

(4) Land Development Scenario

Current irrigation in the Jordan Valley covers 244 thousand dunums. Another 60 thousand dunums will be added by completion of the 14 km extension project in 1995. The Valley still has 60,000 dunums of undeveloped land. In this analysis, this land is assumed to be developed progressively till 2010. The farming area assumes a farming intensity of 1.3 in the Valley (see Table II-2.1.21).

(5) Cropping Pattern

Agricultural production and farming areas in the Jordan Valley from 1989 to 1992 are summarized in Table II-2.1.22. The current cropping pattern is assumed to continue during the projection period. It is also applied to irrigable and undeveloped land in the Valley once they are developed.

Table II-2.1.18 Water Delivery System Efficiency

	North Shuna	Deir Alla	South Shuna
Delivery System Conversion			
Surface	40%	0%	0%
Pressure pipe	60%	100%	100%
Delivery System Efficiency			
Surface	0.5	0.5	0.5
Pressure pipe	0.85	0.85	0.85
Weighted Average	0.71	0.85	0.85

Source: Jordan Valley Authority, Storage Facilities in the Jordan Valley, Final Report on Technical, Economic and Financial Feasibility and Preliminary Design, Vol. III, Part II-Appendices to Main Report, Harza Engineering Co. , April 1989.

Table II-2.1.19 On-farm Water Application Efficiency

	North Shuna	Deir Alla	South Shuna
On-farm Application			
Drip	49%	77%	77%
Surface	50%	22%	22%
Sprinkler	1%	1%	1%
Application Efficiency			
Drip	0.84	0.84	0.84
Surface	0.65	0.62	0.60
Sprinkler	0.75	0.72	0.70
Weighted Average	0.74	0.79	0.79

Source: See Table II-2.1.18.

Table II-2.1.20 Water Conveyance Efficiency

	North Shuna	Deir Alla	South Shuna
Overall Efficiency	0.53	0.67	0.67

Source: JICA study team calculated from Table II-2.1.5 and 2.1.19.

Table II-2.1.21 Land Development Scenario of the Jordan Valley

Year	Irrigated Area ('000 dunums)	Farmed Area ('000 dunums)
1993	244	317.2
1995	304	395.2
2000	324	412.2
2005	344	447.2
2010	364	473.2

Source: JICA study team.

Table II-2.1.22 Cropping Pattern in the Jordan Valley: Production and Farm Land

	North Shuna					Dair Alla					South Shuna				
	Fruit	Field crop	Winter vegetables	Summer vegetables	Total	Fruit	Field crop	Winter vegetables	Summer vegetables	Total	Fruit	Field crop	Winter vegetables	Summer vegetables	Total
Production: '000 MT															
(1988-92)	141	6	58	118	322	16	6	71	87	181	17	2	63	23	104
1988	103	8	49	85	245	14	4	59	112	189	21	1	72	54	148
1989	157	3	38	139	337	13	3	62	64	142	12	1	37	10	60
1990	152	8	68	90	318	16	7	105	93	221	16	1	96	13	126
1991	144	6	65	97	312	18	5	70	41	134	23	1	87	11	122
1992	149	4	70	177	400	21	10	61	126	218	11	4	23	25	63
Area: '000 dunums															
(1988-92)	51	22	26	26	125	11	15	31	25	82	12	3	26	10	51
1988	50	30	25	26	131	10	16	28	28	82	11	4	27	18	60
1989	51	18	22	25	116	11	9	27	23	70	12	1	22	9	44
1990	51	26	28	23	128	11	17	39	28	95	12	2	31	9	54
1991	51	23	28	25	127	11	21	36	23	91	13	2	29	7	51
1992	51	12	29	30	122	12	10	27	23	72	13	5	20	6	44

Source: Dept. of Statistics, Annual Agricultural Statistics 1988-92.

(4) Water Demand Projection for Irrigation

1) Current Water Demand

The net water requirement of the farm land in the Jordan Valley was calculated. The calculation was undertaken for each year from 1988 to 1992, and the yearly average was calculated. The net water demand was converted to gross water demand by considering the desirable farming intensity and water conveyance efficiency.

Current net water demand in the Valley is estimated to be 224 MCM. This volume could have been consumed in the Valley if the water supply had been sufficient. The gross water demand, taking takes into account the conveyance efficiency and farming intensity, is estimated to be 370 MCM. (see Table II-2.1.23).

Table II-2.1.23 Current Water Demand (1988-92 Average)

	North Shuna	Deir Alla	South Shuna	Total (MCM/yr.)
Net Water Demand				
Current farming intensity	81	48	50	180
Planned farming intensity (1.3)	93	61	70	224
Gross Water Demand	175	90	105	370

2) Water Demand Projection

By assuming the land development scenario of the Jordan Valley and the improvement of water conveyance efficiency in North Shuna (see Table II-2.1.20), future water demand for irrigation in the Valley can be estimated. It will increase from 370 MCM at present to 600 MCM by the year of 2010 (see Table II-2.1.24). If we assume the current level of water supply, the water deficit in irrigation will grow from -143 MCM to -373 MCM during the same period (see Table II-2.1.25).

Table II-2.1.24 Water Demand and Water Balance for Irrigation in the Jordan Valley

Year	North Shuna	Deir Alla	South Shuna	Total* (MCM/yr.)	Water Balance
Average 1988-92	175	90	105	370	-143
1995	175	90	220	485	-258
2000	175	90	258	524	-297
2005	175	90	296	562	-335
2010	175	90	334	600	-373

Source: Estimated by JICA Study Team.

Note*: JVA estimated the agriculture water demand in the Jordan Valley; 370 MCM with 228 thousand dunums and 425 MCM with 360 thousand dunums.

Table II-2.1.25 Summary of Water Demand Projection for Irrigation of the Jordan Valley

Year	Land Development ('000 dunums)	Water Demand for Irrigation (MCM) (A)	Water Supply for Irrigation (MCM) (B)	Water Balance (MCM) (B)-(A)
Average 1988-92	244	370	228	-142
1995	304	485	228	-257
2000	324	524	228	-296
2005	344	562	228	-334
2010	364	600	228	-372

2.2 Water Balance in the Study Area

2.2.1 Peace Treaty Water

The Peace Treaty between Jordan and Israel was ratified and concluded in November 1994. The treaty is expected to have an effect on solving the water issues between two countries. The treaty is understood to bring a total of 215 MCM of new water resources to Jordan. Table II-2.2.1 examines the water annex of the treaty in terms of volume of water, its sources, time to be realized, means of delivery and water quality.

The table shows that Jordan will receive 55 MCM of drinkable quality water soon: 8 MCM by reducing Israel's summer pumping from the Yarmouk, 17 MCM by reducing Israel's winter pumping, 20 MCM by storing winter flood flow in the Yarmouk in Tiberias and releasing the same amount from Tiberias during summer, and 10 MCM from the desalination plant in Israel or from Tiberias before the plant is built.

In the mid-term period, probably after five years or so, an additional 70 MCM will be brought to Jordan by constructing a diversion dam in Adassiya and several storage dams in the Yarmouk River and the Jordan River. In the long term period, probably after 10 years or even longer, the remaining 90 MCM of water will be brought to Jordan by rehabilitation of the Jordan River water, and finding and developing a new water resource somewhere.

2.2.2 Water Resource Development in the Study Area

Water resource developments that might ease the water shortage in the study area are summarized in Table II-2.2.2. The table includes water from the Peace Treaty as well as dams in construction or rehabilitation, and fossil or brackish ground water developments. It also lists the projects for which the year of supply is uncertain, such as Amman recycled water, saline spring development probably by desalination, and the Unity Dam. The table estimated the probable volume of water allocation drinking and irrigation.

A total of 840.3 MCM of water resource developments are envisaged in Jordan, and will be fed to the study area; 345 MCM will be used for domestic, industrial and tourism uses, and 495.3 MCM will be used for irrigation.

Table II- 2.2.1 Water Resources expected from Peace Treaty between Jordan and Israel

Item in Treaty	Water to Jordan (MCM)	Season of supply	Sources	Available year	Conveyance*	Water Quality
I.1.a	8	summer	by reducing Israel`s summer pumping from the Yarmouk	soon	KAC	drinkable
I.1.b	17	winter	by reducing Israel`s winter pumping from the Yarmouk	soon	KAC	drinkable
	20	summer	by storing in Tiberias the winter flood of the Yarumouk	soon	KAC	drinkable
II.1	30	winter	by construction of diversion dam in Adassiya	mid-term	KAC	drinkable
	20	winter	by construction of dam(s) in the Jordan River	mid-term	KAC	drinkable
I.2.b	20	winter	by construction of dam(s) in the Yarumouk	mid-term	KAC	drinkable
I.2.c	40	all year	by rehabilitation of the Jordan River water	long term	unknown	irrigation
1.2.d	10	off summer	from Tiberias and later from desalination plant	soon	KAC	drinkable
1.3	50	not specified	by finding within a year and developing new water resources	long term	unknown	drinkable

Source: Treaty of Peace between the Hashemite Kingdom of Jordan and the State of Israel.

Note *: Means of conveyance is not specified in the Treaty. However, King Abdulla Canal (KAC) is a most probable mean of conveyance.

Table II- 2.2.2 Water Resource Development in the Study Area, Jordan

No.	Project	Year of Supply	Yield (MCM/yr.)	Uses D/I/T*	Uses Agriculture
1	Peace Treaty Water (short term)	1995-	55	30**	25**
2	Peace Treaty Water (mid-term)	2000-	70	15**	55**
3	Peace Treaty Water (long term)	2005-	90	0**	90**
4	Dams in Highland and Desert	1995-	16.7	0	16.7
5	Karameh Dam	1997-	55	0	55
6	Elevation of Kafrain Dam	1997-	4.6	0	4.6
7	Rehabilitation of King Abdulla Canal	1998-	24	0	24
8	Disi/Mudawwara	2000-	75-100	75-100	0
9	Brackish Groundwater Desalination	1998-	5-60	5-60	0
10	Amman Recycled Water	?	100	0	100
11	Saline Spring Desalination	?	40	40	0
12	Unity Dam	?	225	100**	125**
	Total		840.3	345	495.3

Sources: JVA, Dam and Irrigation Projects of Jordan Valley Authority, Amman, 1994.
Ministry of Planning, Integrated Development of the Jordan Rift Valley, October 1994.
WAJ, Report of Current and Future Plans, 25 Jan. 1993.

Note *: Domestic, Industrial and Tourism.

Note **: Probable water allocation.

2.2.3 Water Balance in the Study Area

(1) Study Area: municipal and industrial (See Fig. II-2.2.1.)

The water balance in the study area during the period between 1993 and 2010 can be demonstrated by plotting the water demand estimated in the previous sections and the water resource development scheme together in the same diagram. Fig. II-2.2.1 shows the municipal and industrial water shortage in the Jordan Valley and Uplands and their water resource development plans from 1993 to 2010.

The diagram shows that the Peace Treaty water in both the short term and mid-term does not satisfy the municipal and industrial water shortage in the Jordan Valley and Uplands. Complete development of Disi/Muddawara groundwater (100 MCM) and brackish groundwater desalination (60 MCM) will probably be required to solve the water shortage in the area. In addition, earlier implementation than the development schedule in the diagram is desirable for solving the problem. Unity dam will be needed for meeting the demand from 2004 to 2010.

(2) Jordan Valley: municipal and industrial (See Fig. II-2.2.2.)

The municipal and industrial water balance in the Jordan Valley can be analyzed by applying the same method as for the study area. The municipal and industrial water shortage in the Jordan Valley is 3.39 MCM in 1995. However, it will grow as the population in the Jordan Valley increases, and will exceed 5 MCM by 1998. If the pilot desalination plant is built before 1998, the water produced by the plant will ease the water shortage in the region.

It needs to be noted that if no other water development than the 5 MCM desalination plant is undertaken, the current level of water shortage will be realized again by 2001.

(3) In the Jordan Valley: Irrigation (See Fig. II-2.2.3.)

Dams in the Highlands and desert were completed in 1994. Karameh Dam and Kafrain Dam are under construction, and the rehabilitation of KAC will start soon. These projects will bring 100.3 MCM of water for irrigation into the Jordan Valley. Peace Treaty water in the short and mid term will bring an additional 80 MCM to the Jordan Valley. Altogether an additional 180.3 MCM will be available by the year 2000. However, this volume is far below the water demand of irrigation in the Jordan Valley.

Long term Peace Treaty water(90 MCM), rehabilitation of the Jordan River water (100 MCM) and Unity Dam (125 MCM) are supposed to bring a large volume of irrigation water in to the region. Implementation of two of these schemes will be required before 2005 in order to meet the irrigation water demand of the Jordan Valley.

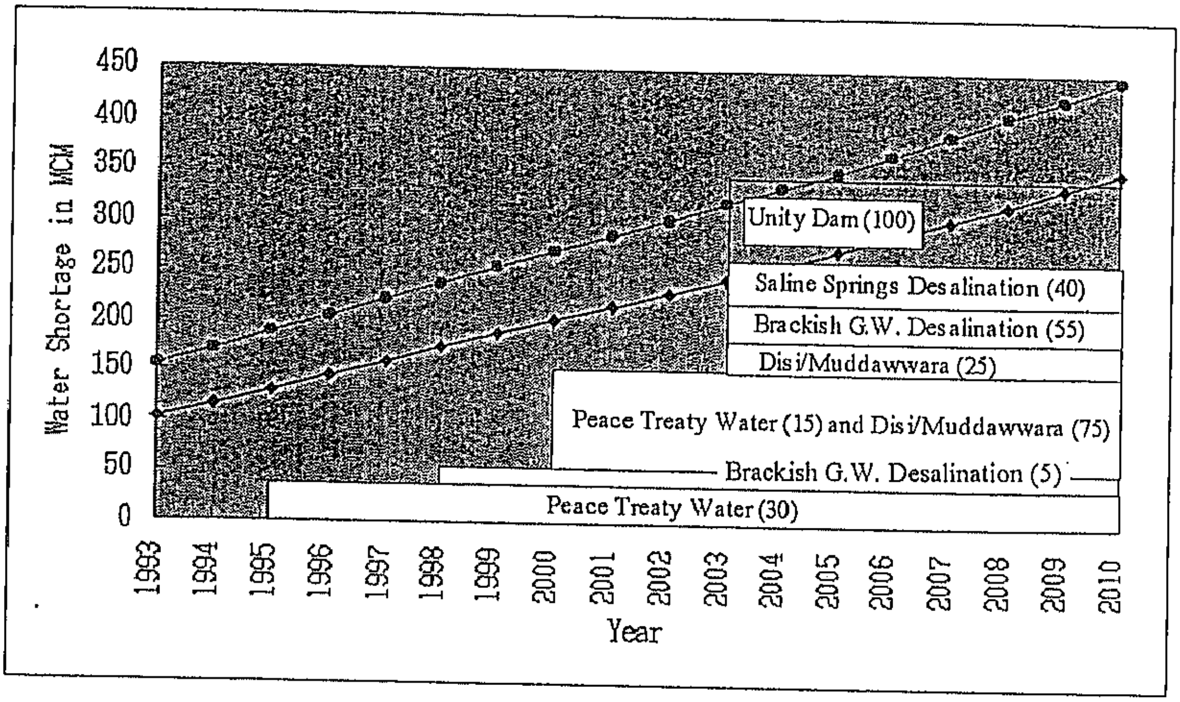

Fig. II-2.2.1 Municipal and Industrial Water Shortage in the JV and Ulands

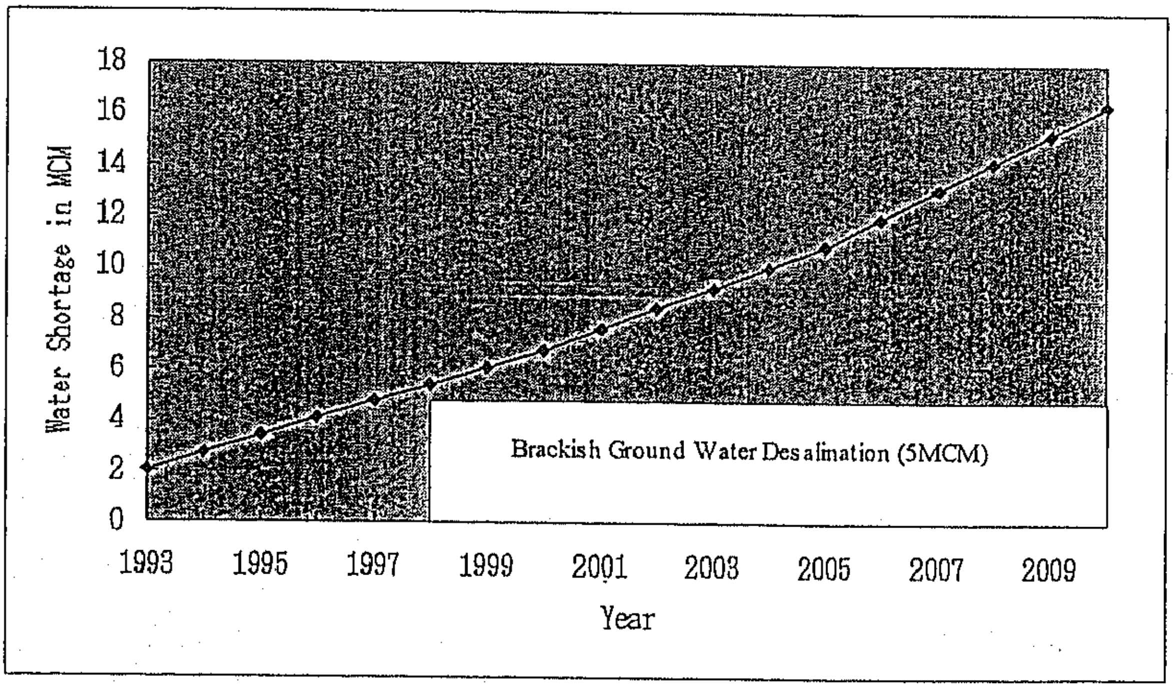

Fig. II-2.2.2 Municipal and Industrial Water Shortage in the Jordan Valley

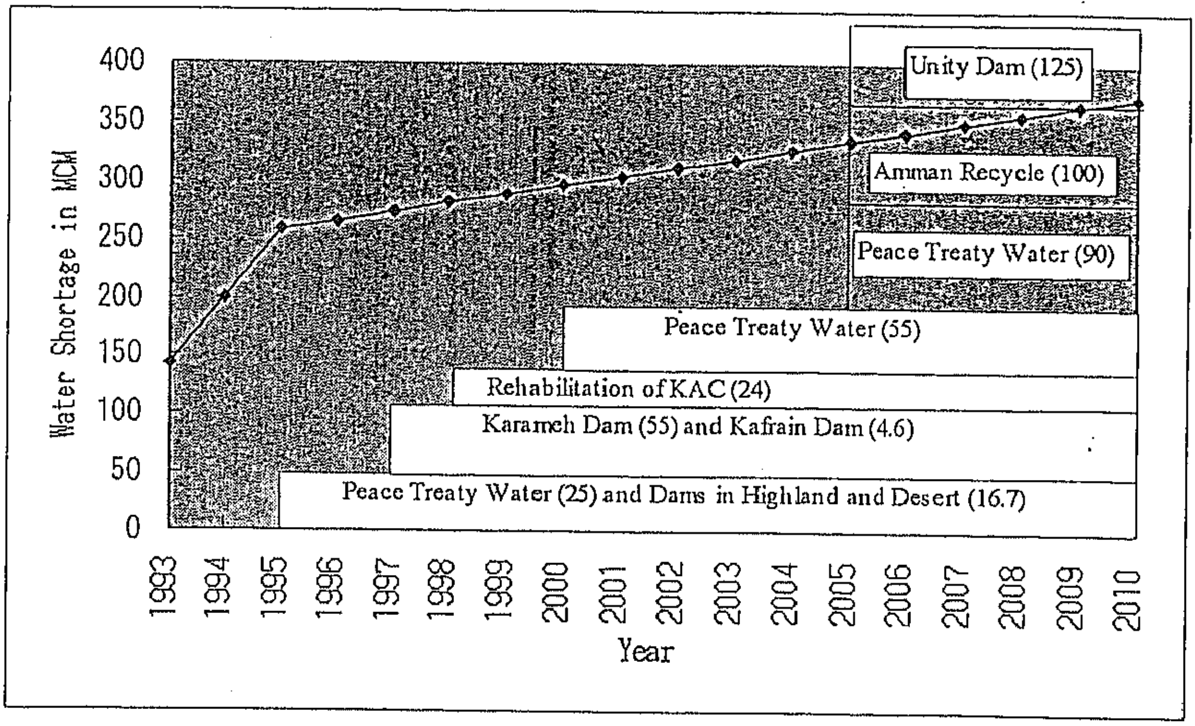

Fig. II-2.2.3 Water Shortage for Irrigation in the Jordan Valley

2.3 Socio-economic Implication of Water Resource Development in Jordan

Brackish groundwater desalination is a new water resource in the region. It has become available due to the advancement of desalination technology and the discovery of a virgin brackish water aquifer in the Jordan Valley. This new resource is promising and is expected to ease the municipal and industrial water balance in Jordan.

However, water development becomes costly as marginal water resources are developed. The Jordanian lifestyle is expected to become more westernized, and a large volume of water for uses other than agriculture will be required in the future. The question is whether the current water consumption pattern is sustainable or not.

In 1993, total water consumption in Jordan was 983 MCM. Irrigation use was 75 percent or 736 MCM, domestic use was 22 percent or 214 MCM and industrial use was only 3 percent or 33 MCM. This share of water uses could be seen as an unfair allocation of water from the economic production point of view. The economic contribution of agriculture in the same year was only 8 percent in terms of gross domestic production (GDP) in Jordan. Manufacturing, transport and communication, and other services contributed more than 50 percent of GDP. The current water consumption pattern in Jordan is obviously distorted in favor of the agriculture sector. If the industrial sectors grow in the future, a large volume of water that is currently used for irrigation will be demanded more strongly by these industrial sectors.

However, the economic productivity of agriculture leads to a different conclusion regarding the water allocation. The economic productivity of agriculture in Jordan is 3,221 JD per person per year with 44,400 employed. The productivity of the mining and manufacturing sectors is 4,908 JD per peson per year and their total employment is 61,800. The construction sector's productivity is lower than agriculture with the same level of employment. Wholesale, retail trade, restaurant and hotel services also show lower productivity than agriculture. The Government sector, a giant employment sector serving 292,200 jobs in Jordan, has the lowest productivity. Thus, Jordan does not have many choices in the creation of employment: Jordan needs the industrial sector which has both good productivity and high employment. The Agriculture sector is certainly the main industrial sector by representing fairly good productivity and a large number in employment. Unless Jordan finds a sector of that can replace agriculture in productivity and employment, it should retain agriculture as an important sector of the economy. In this regard, agriculture is justified in demanding water for irrigation.

The Socio-economic implications are inconclusive regarding the water allocation among industries. However, this section illustrates the complicated issues of water allocation in Jordan.

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