the worst with many cracks in the concrete wall and exposed reinforcement. It would appear to be inoperable.

Storage capacity, year of construction, configuration and structure of the tanks are summarized in Table - 4.9. Total storage capacity of these functioning tanks is 51,100 m3, equivalent to 20 hours of water consumption in Zarqa District. As far as this number is concerned, storage capacity is seemingly sufficient to supply water on a continuous basis.

In addition, there are 9 abandoned reservoirs in the service area; three in Rusaifa, one in Zarqa, three in Hashemeyeh and two in Sukhna, of which total storage capacity exceeds 2,000 m3.

4.6 HOUSE CONNECTIONS

The standard drawing for the installation of house connections prepared by WAJ does not specify details of the installation method but rather simply lists the materials required. WAJ makes branch connections by to cutting the service mains and installing a tee (T) with threaded ends. This method is slightly obsolete and can lead to leakage at the joints. To minimize the risk of leakage, the standard method in Japan and most developed countries is to use saddles, clamps and stop cocks to branch from service mains.

Meters are installed on all subscriber connections. Most of the meters are located in the customers' yards but sometimes they can be found inside their homes which makes it difficult for WAJ staff to monitor and maintain. The UFW survey suggests that meter tampering may be one of leading causes for the high percentage of unaccounted-for water.

It was also observed that some large consumers have plural meters on their premises to avoid paying the higher tariffs set by the progressive block structure. This situation, whether legal or not, does not comply with the original intent of the water tariff structure.

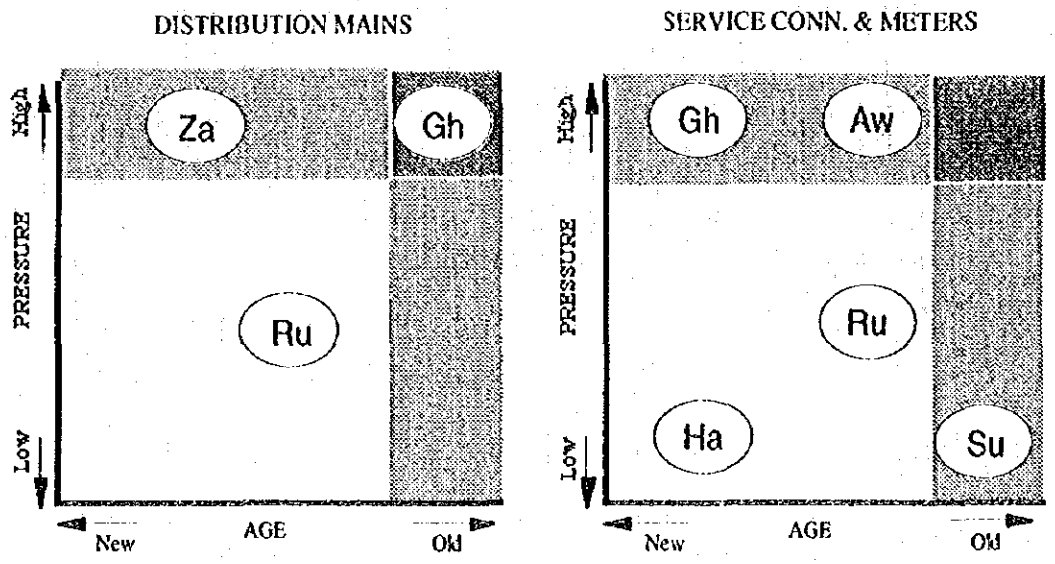
As described in the preceding section, most households have roof tanks to store water. Tank storage capacity is 1m3 or 2m3 for 2-3 days of storage. According to the survey conducted under the present study, residual chlorine levels decrease by half after 36 hours storage. Lower chlorine residuals may no longer be sufficient to provide effective disinfection. Contact with foreign matter or wastes which is highly probable would contaminate the water immediately.

4.7 UNACCOUNTED-FOR WATER

To identify major components of UFW and leak patterns of the pipe network, UFW survey was carried out under the current study. Under this heading, the results of UFW survey and its findings and recommendation are outlined.

Survey areas are selected in consideration of hydraulic profile, water pressure distribution, pipe network characteristics, and socioeconomic conditions: three pilot areas for Combined and District Metering Method, including (1) Rusaifa, (2) Al Ghoarieyeh, (3) Janaa and Zarqa Refugee Camp and five areas for Meter Replacement Method, including (1) Rusaifa, (2) Hashemeyeh, (3) Sukhna, (4) Al Ghoarieyeh, and (5) Awajan. They are all shown in Fig.-4.4.

Distribution mains and service connections laid in each area have general characteristics which are portrayed on the following two coordinates in terms of pipe age and water pressure, and briefed hereunder.



Note: (Za), (Gh), (Ru), (Aw), (Ha) and (Su) denotes pilot and/or subzone areas, Zarqa Camp and Janaa, Al Ghoarieyeh, Rusaifa, Awajan, Hashemeyeh, and Sukhna respectively.

4.7.1 Method Applied

CDWM method is generally effective for leakage control and pipeline maintenance. To this end, service area blocks are usually separated into several subzones by boundary valves. Inflow to the block drops simultaneously by closure of the boundary valves at each subzone. Draw down of the inflow rate suggests which subzones leakage or water losses dominate.

Meter Replacement method aims to identify major reasons of water losses from relatively small pipelines including service mains and house connections. This method may be applicable for smaller service blocks than those of the CDWM method. Before and after customer meter replacement, all meter are read twice. Difference in these meter reading provides information on magnitude of meter inaccuracy and any other water losses related to the customer meters, while difference between total amount of customer meter readings and inflow rate to the zone gives

UFW ratio. Further, measured minimum night flow can be assumed as amount of leakage from the pipe works.

Followings were major procedures undertaken for CDWM.

1) prepare maps with a scale of 1:500 or 1:1,000 which show distribution pipelines including smaller pipe network, based on information from WAJ staff and the pipe detection by using pipe and valve locators.
2) set up subzones from the pipe and valve alignment.
3) confirm that all inlet and outlet valves are completely closed by sounding water flow and that all water are supplied to the area completely through the boundary valves.
4) confirm the area completely isolated.
5) measure average midnight flow at subzone.
6) close valves by area to confirm zero flow,
7) conduct step tests by closing valves and measuring draw down of flow rate.
8) compute leakage ratio by area.

Following procedures were undertaken for meter replacement method.

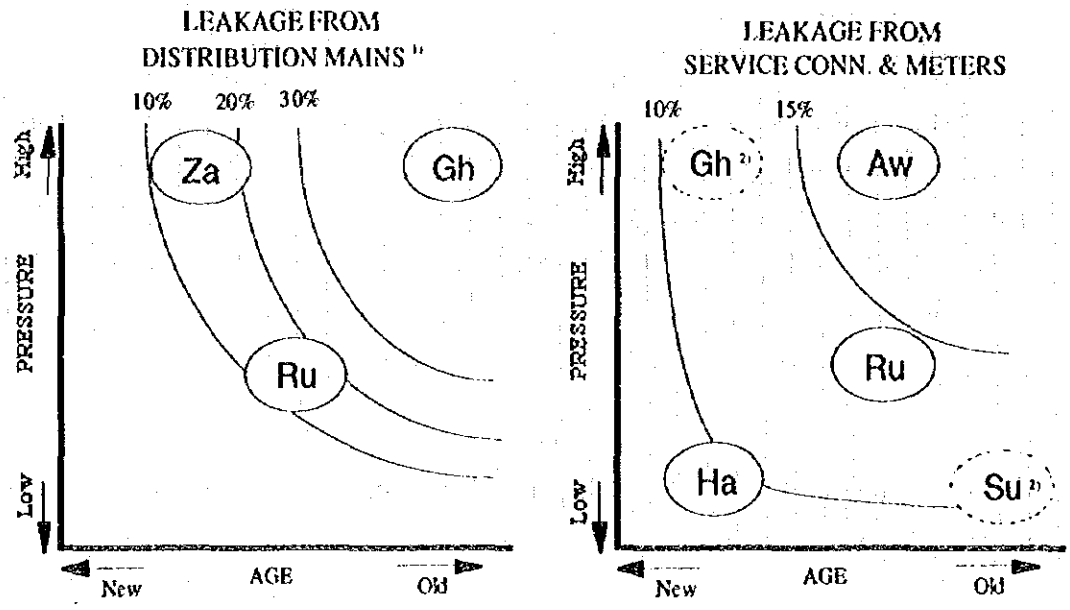
1) conduct topographical survey and prepare maps of subscribers and service mains contained in the subzone by means of pipe locators and information by WAJ staff.
2) conduct pipe detection survey to locate illegal connections.
3) confirm the area completely isolated by closing all inlet and outlet valves.
4) confirm all roof tank saturated.
5) measure inflow by reading all customer meters and outflow by ultrasonic flow meters for continuous 24 hours.
6) measure minimum night flow by ultrasonic flow meter.
7) compare inflow and outflow rates to obtain UFW ratio and compute leakage ratio from the minimum night flow.
8) replace all house meters.
9) reiterate procedures above from 3) to 7).

4.7.2 Results of Survey

Results of UFW survey at each area are portrayed in the figure below.

The leakage from distribution mains is detected siginificant particularly in old distribution mains under high water pressure like in Ghoarieyeh. But the pipe works in Zarqa Camp and Janaa and Rusaifa installed in 1980s and 1990s has relatively small percentage of leakage.

Leakage from house connections and service mains is generally in a range between 10% and 15% in every area. But Awajan area where high water pressure dominates recorded extraordinary high leakage ratio of 25%.



Note:
1) Leakage from distribution mains excludes that from service mains and house connections.
2) Flow meter measurement made at Ghoarieyeh subzone area was not successful because of much air contained in the piped water. At Sukhna area, customers roof tanks could not be saturated before initiating survey due to extremely low water pressure.
3) (Za), (Gh), (Ru), (Aw), (Ha) and (Su) denotes pilot and/or subzone areas, Zarqa Camp and Janna, Al Ghourieyeh, Rusaifa, Awajan, Hashemeyeh, and Sukhna respectively.

Results of survey are also described hereunder referring to CDWM Method and Meter Replacement method.

(1) CDWM Method

The survey in Rusaifa pilot area suggests around 27.8% of leakage are responsible from its old pipe works and house connections. It is assumed leakage from major pipe works rehabilitated in 1986 and 1987 is relatively small.

The step test at Ghoarieyeh pilot area shows particularly high percentage, 70%, of leakage from distribution mains of 150 mm - 100 mm, which were laid in 1960s and have been left without proper maintenance. It also suggests minor amount of leakage from the service pipelines and house connections, all rehabilitated in 1980s.

The survey at Janaa and Zarqa Refugee Camp found about 30% of leakage in average although most of the old deteriorated pipe works have been replaced in 1980s and 1990s. More than half of the leakage are probably taking place at the old house connections and service pipelines installed in 1960s.

(2) Meter Replacement Method

The survey at Rusaifa area found 14.3% of leakage, which dropped significantly to 3.3% after meter replacement. This may imply most of water losses at service pipelines are resulting from meter inaccuracy and/or illegal water use by meters tampering, etc.

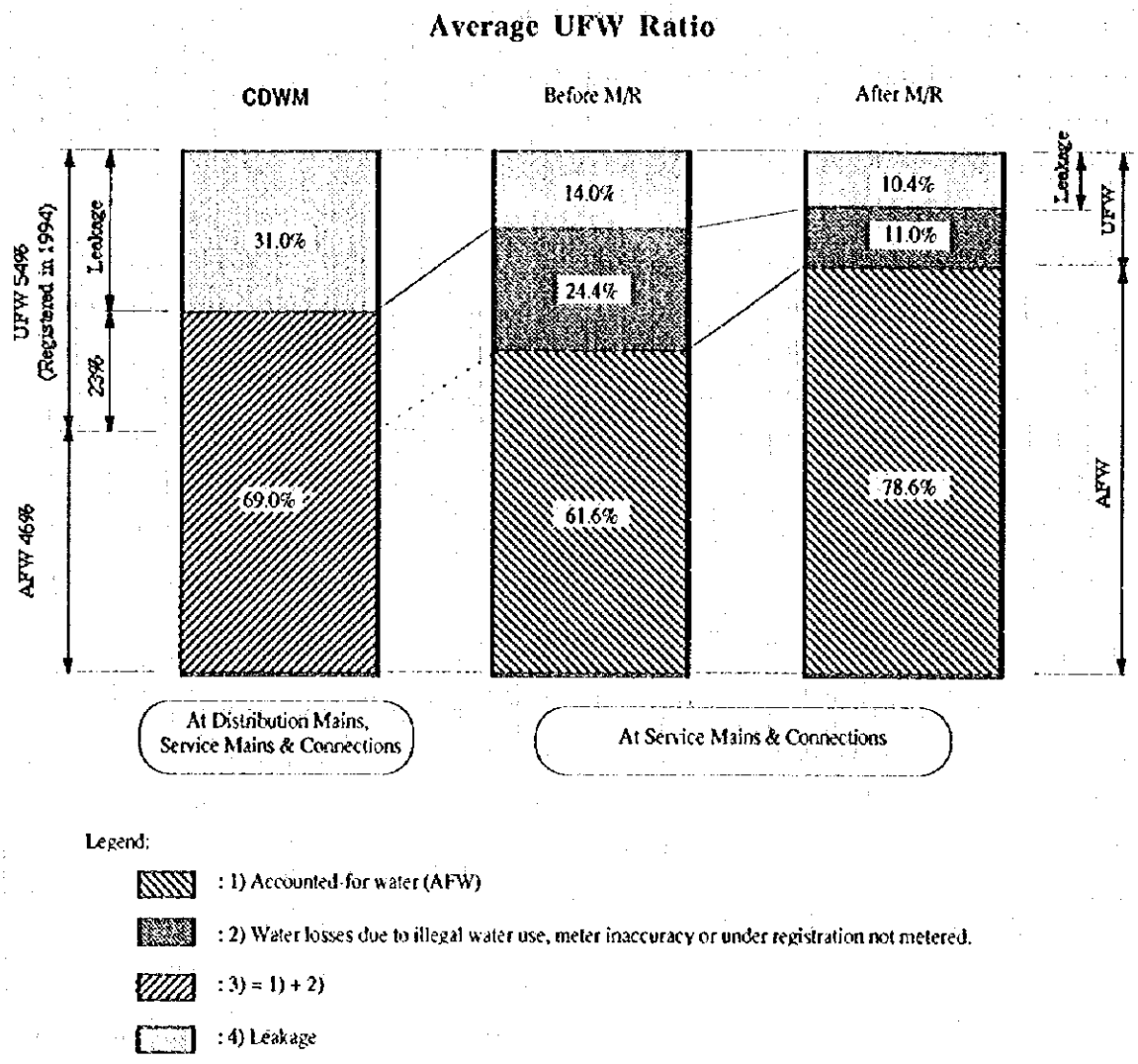
Hashemeyeh area showed a low level of leakage, 10%. The value was stable before and after meter replacement. This can be explained from the fact that the low water pressure dominates the area and relatively new house connections. Furthermore, nearly a quarter of the meters and pipes laid in the area had been rehabilitated by WAJ, just before initiation of the field survey.

As for Ghoarieyeh area, UFW survey was not successful due to air bubble in the water. One out of three ultrasonic flow meters installed recorded extremely large flow rate. Measurement was made several times but all were in vain.

Residents in Sukhna area, due to insufficient diameter of 100mm main, cannot receive water on continuous basis. Efforts made by WAJ Zarqa to supply water incessantly before initiation of the UFW survey could not overcome this situation. Most storage roof tanks in the survey area could not be saturated. This may be understood from the survey results that the flow rate in the night time exceeded that of the daytime flow and any minimum night flow was not observed. The UFW ratio obtained, however, suggests a large percentage of leakage and water losses are occurring from its old deteriorated pipe works.

Unaccounted-for water ratio in Awajan area decreased from 27% to 20% by meter replacement. On the other hand, leakage ratio stands almost constant rate of 20%. This implies major component (20%) of UFW is leakage and the remaining 7% is water losses due to meter inaccuracy and tampering by customers.

In addition to the above, UFW and leakage ratios in all areas are averaged to overlook major component of water losses at distribution mains, service mains and house connections. Figure below illustrates the averaged UFW and leakage ratios obtained. In computing these averaged figures, pressure difference between the areas is not taken into consideration.



The above figure demonstrates that around 30% of supplied water is a leakage from pipe works including distribution, service mains and house connections. Form the leakage ratio (14.0%) obtained through meter replacement method, a half of them may be taking place at large diameter distribution mains and the remaining half at small service mains and house connections. Physical leakage from the house meters stands merely 5% from the figures obtained after meter replacement. Water losses due to illegal water use, meter inaccuracy, etc., however, are significantly large, around 25%.

4.7.3 Recommendation

The UFW survey suggests that the characteristics of each pipes and hydraulic conditions may be decisive factors of the leakage amount. It also suggests that water losses related to customer meters are not negligible. Major causes of these water losses and leakage are attributable to 1) the old deteriorated pipe lines in service under high water pressure, 2) illegal water use, 3) under-registration or meter inaccuracy. From these results, it is recommended to take immediate actions for pipe rehabilitation or leakage control as follows:

1) to replace the pipe network laid in 1960s

As seen in Ghoarieyeh pilot area, a large amount of water is wasted as leakage from the distribution mains. They are all installed in 1960s and still in service under high water pressure. The old deteriorated pipe network established in 1960s particularly at Zarqa municipal center and Rusaifa old township will require a full scale rehabilitation, preferably by replacement.

2) to repair/replace service mains and service pipelines

Although leak from smaller diameter pipelines is not major, some of them which have not been maintained in an appropriate condition since its installation in 1960s showed relatively large amount of the leakage. Such old and small diameter pipes as in Awajan and Sukhna are recommended to be replaced.

3) to install and replace customer meters

It is observed during the survey that many customer meters are installed on inner floors /walls of their houses. To avoid customers' access to the meters, it is recommended to remove and install them on their premises/yards with meter boxes. Old house connections installed in 1960s which are left unrepaired will also require immediate replacement.

4) to conduct positive leak detection on routine basis

Since the leakage from the relatively new pipelines is not major component, it is considered more effective to maintain such pipe works in appropriate conditions than to replace/install new pipelines. To attain this purpose, positive leak control at all pipe works shall be exercised on an routine basis.

5) to improve meter reading practice of WAJ Zarqa and strengthen staffing and organization for meter reading, accounting and billing procedures.

WAJ engineers believe an absence of meter reading under some special circumstances. It is urgent to reorganize meter reading procedures into normal ones applied worldwide. Staffing for metering and billing, as described in Supporting Report - L Organization and Operation & Maintenance Plan, will require a drastic change in number and organization. Further, the current slightly obscure billing zones shall be readjusted in accordance with the distribution zones and/or district metering zones to be established in an early stage of the project development.

Table - 4.1 TECHNICAL DIMENSION OF WELLS

WELL	No.	YEAR Construction	WELL Depth(m)	DIA.(inch) Casing	LEVEL(m) Ground	LEVEL(m) Groundwater (in 1993)	LEVEL(m) Groundwater (in 1994)	YIELDS (m3/h) Present	YIELDS (m3/h) Recommended
AZRAQ	1	1981	203	13'3/8"	537	34.8	35.5	170	171
	2	1981	212	13'3/8"	527	25.7	26.4	270	313
	3	1981	210	13'3/8"	521	19.6	19.7	180	240
	4	1981	206	13'3/8"	536	39	41.4	170	230
	5	1981	204	13'3/8"	541	47.4	48.5	60	122
	6	1981	206	13'3/8"	548	38	38.6	150	170
	7	1981	204	13'3/8"	516	13.5	14.3	170	225
	8	1981	202	13'3/8"	553	55.4	-	180	141
	9	1981	204	13'3/8"	525	30.6	33.5	170	161
	10	1981	203	13'3/8"	521	17.7	18.6	180	257
	11	1981	61	13'3/8"	517	13.5	14.4	220	200
	12	1981	209	13'3/8"	532	48.7	49.2	170	300
	13	1981	205	13'3/8"	532	40	41.5	170	304
	14	1981	205	13'3/8"	533	-	31.6	0	270
	15	1981	210	13'3/8"	524	20.2	28.5	170	203
	18	1983	171	13'3/8"		46.3	47.4	170	150
Sub-total								2,600	3,457
HALLABAT	3			12'				0	60
	3A	1993	132	17.5'			95.5	62	62
	3B	1993	136				82.8	150	
	5	1989	160	12'3/4"		80.4		25	100
	6	1991	156	8'5/8"		88.2	118.7	90	150
	7	1991				77.2	75.5	90	
	8	1991	136.5	13'3/8"		77.4	79.1	120	150
	10	1993					99.1	50	65
Sub-total								587	587
AWAJAN	21	1987	148	13'3/8"				150	190
	22	1988	184	12'3/4"				100	110
	23	1987	151	13'3/8"		16.4	20.3	300	185
Sub-total								550	485
HASHMYEH	1					41.2		15	
	2		128	12'		52.6	52.3	70	79
	3		103			46.2	47	180	200
	5	1986	106	12'3/8"		50.4	52	100	200
Sub-total								365	479
MURHIB	1		255		625	68.2	89.2	10	30
	2		217	8'5/8"	651	43.4	33.5	40	95.7
	3		140		671	86.7	88	20	60
	4		217		706	73.4	21	15	35
Sub-total								85	220.7
OTHERS (IF ANY)									
HBTTEIN CMP	1		320		775	-		25	50
	2		226	10'3/4"	730	77.6		37	40
BASSATEIN	1		85		705	21	22.4	80	
	1A		216	13'3/8"	705	21.3	23.3	65	59
PHOSPHAT	-		452		705			90	
WELL NO.18	18		300		710		172.4	50	
ZARQA	14		246.85	12'				100	300
	14A		170	16'					300
ELTAFEH			260	10' 314"		NOT USED			
UM ROMANA						NOT USED			
TOTAL								447	749

Source: WAJ Zarqa

Note: A newly constructed well with a capacity of 200 m3/hour in Murhib will start its operation in 1995.

Table - 4.2 WELLFIELDS INSTRUMENT (PUMPS)

WELL	No.	INTAKE PUMPS					FLOW METER			PRESSURE GAUGE	
		Depth (m)	Type	Capacity(m3/h)	Head(m)	Conditions	Type	Dia. (mm)	Conditions	Type	Conditions
AZRAQ	1	48	SUMBERS	180	130	Good	SPARLING	150	Bad	-	-
	2	40	SUMBERS	280	126	Good	SPARLING	200	Bad	-	-
	3	40	SUMBERS	200	138	Good	SPARLING	200	Bad	-	-
	4	63	SUMBERS	160	172	Good	MCCROMETER	200	Bad	-	-
	5	40	SUMBERS	50	200	Good	KATHING	150	Bad	-	-
	6	54	SUMBERS	150	180	Good	KATHING	200	Bad	-	-
	7	31	SUMBERS	200	102	Good	SPARLING	200	Bad	-	-
	8		SUMBERS				MCCROMETER	150	Bad	-	-
	9	54	SUMBERS	150	150	Good	MADLING	150	Bad	-	-
	10	30	SUMBERS	150	150	Good	SPARLING	200	Bad	-	-
	11	27	SUMBERS	180	130	Good	SPARLING	200	Bad	-	-
	12	49	SUMBERS	200	145	Good	SPARLING	200	Bad	-	-
	13	59	SUMBERS	200	150	Good	SPARLING	200	Bad	-	-
	14		SUMBERS							-	-
	15	43	SUMBERS	200	102	Good		150	Bad	-	-
	18	132	SUMBERS	145	125	Good	HANNOVER	200	Good	-	-
Sub-total				2,445			ULTRASONIC	600			
HALLABAT	3										
	3A	120	SUMBERS	50	150	Good	MCCROMETER	100	Good	-	-
	3B	120	SUMBERS	150	100	Good	HANNOVER	150	Bad	-	-
	5	138	SUMBERS	20	135	Bad	MCCROMETER	200	Bad	-	-
	6	120	SUMBERS	90	132	Good	HANNOVER	150	Good	-	-
	7	95	SUMBERS	72-103	97-110	Good	HANNOVER	150	Good	-	-
	8	102	SUMBERS	200	100	Good	HANNOVER	150	Good	-	-
	10	130	SUMBERS	100	100	Good	SPANNER	150	Good	-	-
Sub-total							-				
AWAJAN	21	60	SUMBERS	150	150	Good	SPARLING	150	FAIR	-	-
	22	86	SUMBERS	80	200	Good	SPANNER	150	Good	VDO	BAD
	23	64	SUMBERS	230	210	Good	WLTEX	200	Good	VDO	GOOD
Sub-total											
HASHMYEH	1	15	EIMO	19	157	Good					
	2	112	SUMBERS	90	150	Good	MCCROMETER	100	Good	NOTHING	
	3	84	SUMBERS	150	147	Good	SPANNER-POLUX	150	Good	NOTHING	
	5	91.4	SUMBERS	196	110	Good	SPANNER-POLUX	150	Good	NOTHING	
Sub-total											
MURHIB	1	90	SUMBERS	27	160	Good	VLTRA-SONIC	100	Good	KOBOLD	Good
	2	40	SUMBERS	95	60	Good	VLTRA-SONIC	150	Good	KOBOLD	Good
	3	90	SUMBERS	60	120	Good	VLTRA-SONIC	100	Good	KOBOLD	Good
	4	110	SUMBERS	33	135	Good	VLTRA-SONIC	100	Good	KOBOLD	Good
Sub-total											
OTHERS (IF ANY)											
HETTEIN CMP	1	135	SUMBERS	-	-	Good	WOLTEX	150	Good	DIN.WIKA	Good
	2	156	SUMBERS	42	156	Good	WOLTEX	150	Good	DIN.WIKA	Good
BASSATEIN	1	100	SUMBERS	63	100	Good	MOCROMETER	150	Good	DIN.WIKA	Good
	1A	160	SUMBERS	50	125	Good	MOCROMETER	150	Good	DIN.WIKA	Good
PHOSPHAT	-	244	SUMBERS	100	200	Good	MOCROMETER	150	Good	DIN.WIKA	Good
WELL NO.18	18	150	SUMBERS	50	138	Good	SPX	150	Good	CONCEPT	Good
ZARQA	14	99	SUMBERS	180	130	Good	ULTRA-SONIC	DN-	Good	NOTHING	-
	14A	93	SUMBERS	180		Good	ULTRA-SONIC	400	Good	NOTHING	-
Sub-total											
Total											
GRAND TOTAL											

Source: WAJ Zarqa

Table - 4.3 WATER PRODUCTION AT WELLFIELDS (1994)

Unit: m3

WATER RESOURCE	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
AZRAQ WELLS	1,586,280	1,403,950	1,543,276	1,603,670	1,613,520	1,656,010	1,644,010	1,562,112	1,643,768	1,729,230	1,687,310	1,642,760	19,315,896
HASHMEIA WELL (1)	0	0	0	8,250	0	0	0	2,250	0	510	0	0	11,010
HASHMEIA WELL (2)	9,111	14,654	16,940	17,558	20,383	10,727	50,295	52,080	49,220	48,172	40,591	35,093	364,824
HASHMEIA WELL (3)	4,119	23,837	18,068	43,163	44,284	19,000	126,480	126,480	123,100	86,400	93,470	70,842	779,243
HASHMEIA WELL (5)	0	2,820	0	1,715	49,760	0	89,280	89,280	76,730	71,020	49,997	25,343	455,945
AWAJAN WELL (21)	79,200	77,760	86,400	83,610	86,397	83,610	89,280	89,280	104,490	103,640	98,070	101,530	1,083,267
AWAJAN WELL (22)	68,538	58,050	48,935	48,935	50,566	70,510	74,520	74,900	73,125	72,340	69,550	71,070	781,039
AWAJAN WELL (23)	37,954	153,985	189,336	186,917	217,359	197,110	218,071	213,829	212,635	219,722	212,635	196,098	2,255,651
HALLABAT WELL (3A)	44,640	40,320	44,640	43,200	44,640	43,200	44,640	40,540	35,643	39,075	37,572	32,677	490,787
HALLABAT WELL (3B)	111,600	100,800	111,600	108,000	111,600	108,000	111,600	101,350	89,108	97,685	93,930	81,693	1,226,966
HALLABAT WELL (5)	18,600	16,800	18,600	18,000	18,600	18,000	18,600	16,890	14,851	16,280	0	13,616	188,837
HALLABAT WELL (6)	66,960	60,480	66,960	64,800	66,960	64,800	66,960	60,805	53,465	58,610	56,358	49,016	736,174
HALLABAT WELL (7)	52,080	47,040	52,080	50,400	52,080	50,400	52,080	47,295	41,584	45,585	43,835	38,123	572,582
HALLABAT WELL (8)	89,280	80,640	89,280	86,400	89,280	86,400	89,280	81,080	71,286	78,145	75,145	65,354	981,570
HALLABAT WELL (10)	0	0	0	0	0	0	0	0	29,703	32,560	31,310	27,231	120,804
ZARQA WELL	0	0	0	0	0	0	0	0	98,700	44,300	20,320	0	163,320
MARHAB WELLS	32,243	30,865	32,870	39,505	33,988	45,516	68,643	65,321	60,070	61,200	61,200	61,592	593,013
OM RUMANEH WELL	0	5,800	12,900	12,900	13,330	0	25,296	0	0	0	0	0	70,226
RUSAIFA WELL (18)	1,960	90	10,012	15,674	39,093	38,901	36,884	31,576	15,570	2,931	1,899	0	194,590
BASATIN WELL (1)	0	0	9,403	51,719	51,822	50,959	53,693	55,285	50,365	43,059	15,916	2,623	384,844
BASATIN WELL (1A)	0	0	7,824	42,790	42,382	41,623	44,990	48,970	45,891	33,001	7,317	1,768	316,556
HITTEEN CAMP WELL (1)	0	0	0	9,200	10,804	9,962	8,765	22,586	18,758	0	0	0	80,075
HITTEEN CAMP WELL (2)	0	0	0	11,383	8,649	9,413	2,255	0	0	0	0	0	31,700
POTASH WELL	0	0	0	0	0	0	0	16,150	48,760	38,649	5,944	21,002	130,505
SROUT WELL	4,080	4,862	5,838	5,838	6,032	3,600	6,746	6,517	6,295	6,275	5,972	4,513	66,568
ALOUK WELL	7,000	7,000	7,000	7,000	7,233	6,590	7,742	7,120	6,081	5,191	0	0	67,957
KENIA WELL	0	0	12,440	23,920	26,230	29,270	28,290	30,940	25,550	24,400	11,910	7,670	220,620
TOTAL	2,213,645	2,129,753	2,384,402	2,584,547	2,704,992	2,643,601	2,958,400	2,842,636	2,994,748	2,957,980	2,720,251	2,549,614	31,684,569

Source: WAJ Zarqa, 1994

Table - 4.3 WATER PRODUCTION AT WELLFIELDS (1994)

Unit: m3

WATER RESOURCE	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
AZRAQ WELLS	1,586,280	1,403,950	1,543,276	1,603,670	1,613,520	1,656,010	1,644,010	1,562,112	1,643,768	1,729,230	1,687,310	1,642,760	19,315,896
HASHMEIA WELL (1)	0	0	0	8,250	0	0	0	2,250	0	510	0	0	11,010
HASHMEIA WELL (2)	9,111	14,654	16,940	17,558	20,383	10,727	50,295	52,080	49,220	48,172	40,591	35,093	364,824
HASHMEIA WELL (3)	4,119	23,837	18,068	43,163	44,284	19,000	126,480	126,480	123,100	86,400	93,470	70,842	779,243
HASHMEIA WELL (5)	0	2,820	0	1,715	49,760	0	89,280	89,280	76,730	71,020	49,997	25,343	455,945
AWAJAN WELL (21)	79,200	77,760	86,400	83,610	86,397	83,610	89,280	89,280	104,490	103,640	98,070	101,530	1,083,267
AWAJAN WELL (22)	68,538	58,050	48,935	48,935	50,566	70,510	74,520	74,900	73,125	72,340	69,550	71,070	781,039
AWAJAN WELL (23)	37,954	153,985	189,336	186,917	217,359	197,110	218,071	213,829	212,635	219,722	212,635	196,098	2,255,651
HALLABAT WELL (3A)	44,640	40,320	44,640	43,200	44,640	43,200	44,640	40,540	35,643	39,075	37,572	32,677	490,787
HALLABAT WELL (3B)	111,600	100,800	111,600	108,000	111,600	108,000	111,600	101,350	89,108	97,685	93,930	81,693	1,226,966
HALLABAT WELL (5)	18,600	16,800	18,600	18,000	18,600	18,000	18,600	16,890	14,851	16,280	0	13,616	188,837
HALLABAT WELL (6)	66,960	60,480	66,960	64,800	66,960	64,800	66,960	60,805	53,465	58,610	56,358	49,016	736,174
HALLABAT WELL (7)	52,080	47,040	52,080	50,400	52,080	50,400	52,080	47,295	41,584	45,585	43,835	38,123	572,582
HALLABAT WELL (8)	89,280	80,640	89,280	86,400	89,280	86,400	89,280	81,080	71,286	78,145	75,145	65,354	981,570
HALLABAT WELL (10)	0	0	0	0	0	0	0	0	29,703	32,560	31,310	27,231	120,804
ZARQA WELL	0	0	0	0	0	0	0	0	98,700	44,300	20,320	0	163,320
MARHAB WELLS	32,243	30,865	32,870	39,505	33,988	45,516	68,643	65,321	60,070	61,200	61,200	61,592	593,013
OM RUMANEH WELL	0	5,800	12,900	12,900	13,330	0	25,296	0	0	0	0	0	70,226
RUSAIFA WELL (18)	1,960	90	10,012	15,674	39,093	38,901	36,884	31,576	15,570	2,931	1,899	0	194,590
BASATIN WELL (1)	0	0	9,403	51,719	51,822	50,959	53,693	55,285	50,365	43,059	15,916	2,623	384,844
BASATIN WELL (1A)	0	0	7,824	42,790	42,382	41,623	44,990	48,970	45,891	33,001	7,317	1,768	316,556
HITTEEN CAMP WELL (1)	0	0	0	9,200	10,804	9,962	8,765	22,586	18,758	0	0	0	80,075
HITTEEN CAMP WELL (2)	0	0	0	11,383	8,649	9,413	2,255	0	0	0	0	0	31,700
POTASH WELL	0	0	0	0	0	0	0	16,150	48,760	38,649	5,944	21,002	130,505
SROUT WELL	4,080	4,862	5,838	5,838	6,032	3,600	6,746	6,517	6,295	6,275	5,972	4,513	66,568
ALOUK WELL	7,000	7,000	7,000	7,000	7,233	6,590	7,742	7,120	6,081	5,191	0	0	67,957
KENIA WELL	0	0	12,440	23,920	26,230	29,270	28,290	30,940	25,550	24,400	11,910	7,670	220,620
TOTAL	2,213,645	2,129,753	2,384,402	2,564,547	2,704,992	2,643,601	2,958,400	2,842,636	2,994,748	2,957,980	2,720,251	2,549,614	31,654,569

Source: WAJ Zarqa, 1994

Table - 4.4 WATER SUPPLIED TO ZARQA GOVERNORATE (1994)

Unit m3

DESCRIPTION	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
TOTAL PRODUCTION	2,213,645	2,129,753	2,384,402	2,584,547	2,704,992	2,643,601	2,958,400	2,842,636	2,994,748	2,957,980	2,720,251	2,549,614	31,684,569
WATER TRANSMITTED FROM (MONTHLY)													
FROM AMMAN	38,862	35,102	38,862	370,609	38,862	37,609	38,862	38,862	37,150	38,466	36,305	40,075	789,626
FROM MAFRAQ	1,263,070	1,191,450	1,150,935	1,225,980	1,218,990	1,101,830	1,179,580	1,137,990	1,143,750	1,239,540	1,290,380	1,356,880	14,500,375
TOTAL	1,301,932	1,226,552	1,189,797	1,596,589	1,257,852	1,139,439	1,218,442	1,176,852	1,180,900	1,278,006	1,326,685	1,396,955	15,290,001
WATER TRANSMITTED TO (MONTHLY)													
TO AMMAN	1,733,880	1,552,490	1,524,290	1,654,130	1,615,230	1,479,620	1,523,320	1,505,720	1,524,140	1,665,580	1,541,120	1,686,110	19,005,630
TO MAFRAQ	0	0	4,280	9,760	7,530	7,550	10,120	12,000	8,800	6,570	2,910	2,030	71,550
TO BALQA & JERASH	34,080	34,080	34,080	34,080	34,080	34,080	34,080	34,080	34,080	29,704	29,280	21,757	387,461
TOTAL	1,767,960	1,586,570	1,562,650	1,697,970	1,656,840	1,521,250	1,567,520	1,551,800	1,567,020	1,701,854	1,573,310	1,709,897	19,464,641
PURE WATER FED	1,747,617	1,769,735	2,011,549	2,483,166	2,306,004	2,261,790	2,609,322	2,467,688	2,608,628	2,534,132	2,473,626	2,236,672	27,509,929

Source: WAJ Zarqa, 1994

Table - 4.4 WATER SUPPLIED TO ZARQA GOVERNORATE (1994)

Unit: m3

DESCRIPTION	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL
TOTAL PRODUCTION	2,213,645	2,129,753	2,384,402	2,584,547	2,704,992	2,643,601	2,958,400	2,842,636	2,994,748	2,957,980	2,720,251	2,549,614	31,684,569
WATER TRANSMITTED FROM (MONTHLY)													
FROM AMMAN	38,862	35,102	38,862	370,609	38,862	37,609	38,862	38,862	37,150	38,466	36,305	40,075	789,626
FROM MAFRAQ	1,263,070	1,191,450	1,150,935	1,225,980	1,218,990	1,101,830	1,179,580	1,137,990	1,143,750	1,239,540	1,290,380	1,356,880	14,500,375
TOTAL	1,301,932	1,226,552	1,189,797	1,596,589	1,257,852	1,139,439	1,218,442	1,176,852	1,180,900	1,278,006	1,326,685	1,396,955	15,290,001
WATER TRANSMITTED TO (MONTHLY)													
TO AMMAN	1,733,880	1,552,490	1,524,290	1,654,130	1,615,230	1,479,620	1,523,320	1,505,720	1,524,140	1,665,580	1,541,120	1,686,110	19,005,630
TO MAFRAQ	0	0	4,280	9,760	7,530	7,550	10,120	12,000	8,800	6,570	2,910	2,030	71,550
TO BALQA & JERASH	34,080	34,080	34,080	34,080	34,080	34,080	34,080	34,080	34,080	29,704	29,280	21,757	387,461
TOTAL	1,767,960	1,586,570	1,562,650	1,697,970	1,656,840	1,521,250	1,567,520	1,551,800	1,567,020	1,701,854	1,573,310	1,709,897	19,464,641
PURE WATER FED	1,747,617	1,769,735	2,011,549	2,483,166	2,306,004	2,261,790	2,609,322	2,467,688	2,608,628	2,534,132	2,473,626	2,236,672	27,509,929

Source: WAJ Zarqa, 1994

Table- 4.5 WATER DISTRIBUTED FROM MAJOR PUMPING STATIONS (1994) Unit: m3

WATER RESOURCE	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
AZRAQ STATION	1,149,840	993,055	1,458,290	1,506,640	1,513,330	1,498,570	1,545,850	1,497,770	1,583,550	1,641,915	1,388,213	1,642,760	17,419,783
KHAW STATION	2,489,473	2,251,355	2,288,535	2,366,553	2,399,239	2,227,790	2,272,798	2,311,137	2,794,848	2,941,143	2,212,245	2,987,135	29,542,251
ZARQA STATION	642,660	451,740	658,337	658,430	602,659	653,762	694,560	1,433,400	1,410,847	907,709	1,333,280	1,348,290	10,795,674
HASHMEIA STATION	344,136	339,190	480,530	448,670	464,743	461,360	430,850	460,550	625,186	618,550	100,320	89,680	4,863,765
HALLABAT STATION	362,307	289,911	48,233	329,793	351,048	341,858	352,755	348,550	335,640	367,940	338,150	307,710	3,773,895
MARHAB STATION	32,243	30,865	32,780	39,505	33,988	45,516	68,643	65,321	60,070	61,200	61,200	61,592	592,923
OM RUMANEH STATION	0	5,800	12,900	12,900	13,330	0	25,296	0	14,515	0	0	0	84,741
BOSTER (4)	103,354	94,018	109,052	109,871	105,823	105,822	109,350	110,541	123,022	108,098	105,193	53,355	1,237,499
BOSTER (18)	75,036	71,965	93,829	107,335	104,655	100,386	102,883	113,397	98,560	86,717	57,958	53,560	1,066,281
BOSTER AL BASATIN	0	0	0	0	0	0	35,235	47,617	50,358	45,362	21,284	23,640	223,496
SROUT STATION	4,080	4,862	5,838	5,838	6,032	3,600	6,746	6,517	6,295	6,275	5,972	4,513	66,568
ALOUK STATION	7,000	7,000	7,000	7,000	7,233	6,590	7,742	7,120	6,081	5,191	0	0	67,957
KENIA STATION	0	0	12,440	23,920	26,230	29,270	28,290	28,250	23,790	24,400	11,910	9,700	218,200
TOTAL	5,210,129	4,539,761	5,207,764	5,616,455	5,628,310	5,474,524	5,680,998	6,430,170	7,132,762	6,814,500	5,635,725	6,581,935	69,953,033

Source: WAJ Zarqa, 1994

Table- 4.5. WATER DISTRIBUTED FROM MAJOR PUMPING STATIONS (1994) Unit: m3

WATER RESOURCE	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	TOTAL
AZRAQ STATION	1,149,840	993,055	1,458,290	1,506,640	1,513,330	1,498,570	1,545,850	1,497,770	1,583,550	1,641,915	1,388,213	1,642,760	17,419,783
KHAW STATION	2,489,473	2,251,355	2,288,535	2,366,553	2,399,239	2,227,790	2,272,798	2,311,137	2,794,848	2,941,143	2,212,245	2,987,135	29,542,251
ZARQA STATION	642,660	451,740	658,337	658,430	602,659	653,762	694,560	1,433,400	1,410,847	907,709	1,333,280	1,348,290	10,795,674
HASHMEIA STATION	344,136	339,190	480,530	448,670	464,743	461,360	430,850	460,550	625,186	618,550	100,320	89,680	4,863,765
HALLABAT STATION	362,307	289,911	48,233	329,793	351,048	341,858	352,755	348,550	335,640	367,940	338,150	307,710	3,773,895
MARHAB STATION	32,243	30,865	32,780	39,505	33,988	45,516	68,643	65,321	60,070	61,200	61,200	61,592	592,923
OM RUMANEH STATION	0	5,800	12,900	12,900	13,330	0	25,296	0	14,515	0	0	0	84,741
BOSTER (4)	103,354	94,018	109,052	109,871	105,823	105,822	109,350	110,541	123,022	108,098	105,193	53,355	1,237,499
BOSTER (18)	75,036	71,965	93,829	107,335	104,655	100,386	102,883	113,397	98,560	86,717	57,958	53,560	1,066,281
BOSTER AL BASATIN	0	0	0	0	0	0	35,235	47,617	50,358	45,362	21,284	23,640	223,496
SROUT STATION	4,080	4,862	5,838	5,838	6,032	3,600	6,746	6,517	6,295	6,275	5,972	4,513	66,568
ALOUK STATION	7,000	7,000	7,000	7,000	7,233	6,590	7,742	7,120	6,081	5,191	0	0	67,957
KENIA STATION	0	0	12,440	23,920	26,230	29,270	28,290	28,250	23,790	24,400	11,910	9,700	218,200
TOTAL	5,210,129	4,539,761	5,207,764	5,616,455	5,628,310	5,474,524	5,680,998	6,430,170	7,132,762	6,814,500	5,635,725	6,581,935	69,953,033

Source: WAJ Zarqa, 1994

Table - 4.6 Groundwater Quality

Well	Date	EC	TDS	Alkalinity	Total Hardness	Cl	SO_4	NO_3	Total Bacteria
Permissible/		-	500/	-	100/	200/	200/	45/	2.2(MPN/ 100ml)
Maximum			1,500		500	500	500	70	
Azraq Basins									
Azraq	Feb. 95	553	390	61	84	110	21	6.9	4
	Mar. 95	572	420	52	180	142	12	7.7	90
	June 95	698	410	60	110	**309**	3	6.0	0
	Aug. 95	702	435	24	172	120	14	7.7	0
Za'atari	Feb. 95	497	340	73	134	107	6	10.5	60
	Mar. 95	540	370	46	224	89	6	8.5	0
	June 95	625	425	70	133	**207**	3	7.8	0
	Aug. 95	608	400	25	240	103	4	27.6	8
Khaldia	Feb. 95	6190	**2,296**	32	**1,077**	**721**	33	53.9	5
	Mar. 95	3740	**2,413**	32	**1,243**	**739**	23	60.2	10
	June 95	4250	**2,680**	48	**1,550**	**773**	3	8.7	0
	Aug. 95	3630	**2,965**	20	**1,750**	**802**	17	39.0	0
Halabat	Feb. 95	718	406	58	176	178	28	7.1	1000
	Mar. 95	796	525	50	270	195	12	6.8	0
	June 95	850	525	65	177	172	2	5.0	0
	Aug. 95	840	540	19	280	154	6	10.3	0
Amman-Zarqa Basin (in 1994)									
Hashemeyeh	lowest	-	1,363	-	-	422	192	24.5	-
	highest	-	**1,696**	-	-	**535**	240	57.1	-
Awajan	lowest	-	768	-	-	191	10	57.3	-
	highest	-	1,125	-	-	333	62	**73.0**	-
Zarqa 14	lowest	-	1,439	-	-	415	191	45.2	-
	highest	-	**1,768**	-	-	**525**	255	60.9	-

Source: Azraq basin by JICA Study Team, Amman-Zarqa basin by WAJ
Location of sampling:
Outlet of collector pumping station for Azraq basin
Outlet of each well pump for Amman-Zarqa basin by WAJ
Numerical figures:
1,768: exceeding maximum limit
45.2: exceeding permissible limit but below maximum limit

Table - 4.6 Groundwater Quality

Well	Date	EC	TDS	Alkalinity	Total Hardness	Cl	SO4	NO3	Total Bacteria
Permissible/ Maximum		-	500/ 1,500	-	100/ 500	200/ 500	200/ 500	45/ 70	2.2(MPN/ 100ml)
Azraq Basins									
Azraq	Feb. 95	553	390	61	84	110	21	6.9	4
	Mar. 95	572	420	52	180	142	12	7.7	90
	June 95	698	410	60	110	**309**	3	6.0	0
	Aug. 95	702	435	24	172	120	14	7.7	0
Za'atari	Feb. 95	497	340	73	134	107	6	10.5	60
	Mar. 95	540	370	46	224	89	6	8.5	0
	June 95	625	425	70	133	**207**	3	7.8	0
	Aug. 95	608	400	25	240	103	4	27.6	8
Khaldia	Feb. 95	6190	**2,296**	32	**1,077**	**721**	33	53.9	5
	Mar. 95	3740	**2,413**	32	**1,243**	**739**	23	60.2	10
	June 95	4250	**2,680**	48	**1,550**	**773**	3	8.7	0
	Aug. 95	3630	**2,965**	20	**1,750**	**802**	17	39.0	0
Halabat	Feb. 95	718	406	58	176	178	28	7.1	1000
	Mar. 95	796	525	50	270	195	12	6.8	0
	June 95	850	525	65	177	172	2	5.0	0
	Aug. 95	840	540	19	280	154	6	10.3	0
Amman-Zarqa Basin (in 1994)									
Hashemeyeh	lowest	-	1,363	-	-	422	192	24.5	-
	highest	-	**1,696**	-	-	**535**	240	57.1	-
Awajan	lowest	-	768	-	-	191	10	57.3	-
	highest	-	1,125	-	-	333	62	**73.0**	-
Zarqa 14	lowest	-	1,439	-	-	415	191	45.2	-
	highest	-	**1,768**	-	-	**525**	255	60.9	-

Source: Azraq basin by JICA Study Team, Amman-Zarqa basin by WAJ
Location of sampling:
Outlet of collector pumping station for Azraq basin
Outlet of each well pump for Amman-Zarqa basin by WAJ
Numerical figures:
1,768: exceeding maximum limit
45.2: exceeding permissible limit but below maximum limit

Table - 4.7 PUMPING STATION INSTRUMENTS (PUMPS) IN ZARQA DISTRICT

PUMPING STA.	NO.	YEAR OF INSTALL.	TYPE	CAPACITY (m3/h)	HEAD (m)	CONDITIONS
AZRAQ	1		JEUMONT SCHNEIDER	500	350	Fair
	2	1994	STANDART SKM-200	500	350	Good
	3	1994	STANDART SKM-200	500	350	Good
	4	1994	STANDART SKM-200	300	350	Good
	5		JEUMONT SCHNEIDER	300	350	Fair
	6	1994	STANDART SKM-800	500	350	Good
	7	1994	STANDART SKM-800	500	350	Good
Sub-total				3,100		
HALLABAT	1	1993	KSB	500	100	Good
	2	1993	RITZ	300	120	Good
	3	1994	KSB	100-150	220-280	Good
	4	1994	STANDART TSE	100	200	Good
Sub-total				1,000-1,050		
KHAW	1	1982	JEUMONT SCHNEIDER	300	350	Fair
	2	1982	JEUMONT SCHNEIDER	300	350	Fair
	3	1982	JEUMONT SCHNEIDER	300	350	Fair
	4	1982	JEUMONT SCHNEIDER	300	350	Fair
	5	1982	JEUMONT SCHNEIDER	300	350	Fair
	6	1982	JEUMONT SCHNEIDER	300	350	Fair
	7	1986	JEUMONT SCHNEIDER	500	350	Fair
	8	1987	JEUMONT SCHNEIDER	500	350	Fair
	9	1985-1988	KSB	300	100	Fair
	10	1985-1988	SPP	400	130	Fair
	11	1985-1988	RITZ	300	120	Fair
	12	1993	KSB	500	100	Good
Sub-total				4,300		
ZARQA	1	1994	DRAKOS-POLEM	300	100	Good
	2	1992	TURBO SAN	300	100	Good
	3	1968	BRUSH	300	95	Fair
	4	1985	RITZ	300	120	Good
	5	1985	JEUMONT SCHNEIDER	500	250	Good
	6	1988	KSB	500	230	Good
	7	1990	TURBO SAN	300	250	Good
	8	1990	TURBO SAN	160	160	Good
	9	1968	BRUSH	300	95	Bad
Sub-total				2,960		
HASHMYEH	1	1982	KSB	75	132	Good
	2	-	RITZ	118	125	Good
Sub-total				193		
MURHIB	1	1993	STANDART	50	85	Good
	2	1993	STANDART	100	85	Good
	3	1993	STANDART	200	100	Good
	4	1993	STANDART	50	300	Good
	5	1993	STANDART	100	275	Good
Sub-total				500		
RUSAIFABSTR	1	1989	TURBO SAN	170	250	Good/Standby
	2	1989	RITZ	200	250	Good/Working
BSTR ALBASA	1	1994	HALBERC	100	200	Good/Working
	2	1994	PLAZZ HLYRIE 9	50	210	Good/Working
UM-ROMMAN	1	1993	KSB	50	300	Good
	2	1993	KSB	70	310	Good
EL-QUNAIEH	1	1994	GOULDS	50	150	Good
	2	1994	GOULDS	50	300	Good
BSTR NO.18		1992	TURBO SAN	150	250	Good/Working
Sub-total				890		
Total				12,943		

Source: WAJ Zarqa

Table - 4.8 PUMPING STATION INSTRUMENTS (FLOW METERS & PRESSURE GAUGE) IN ZARQA DISTRICT

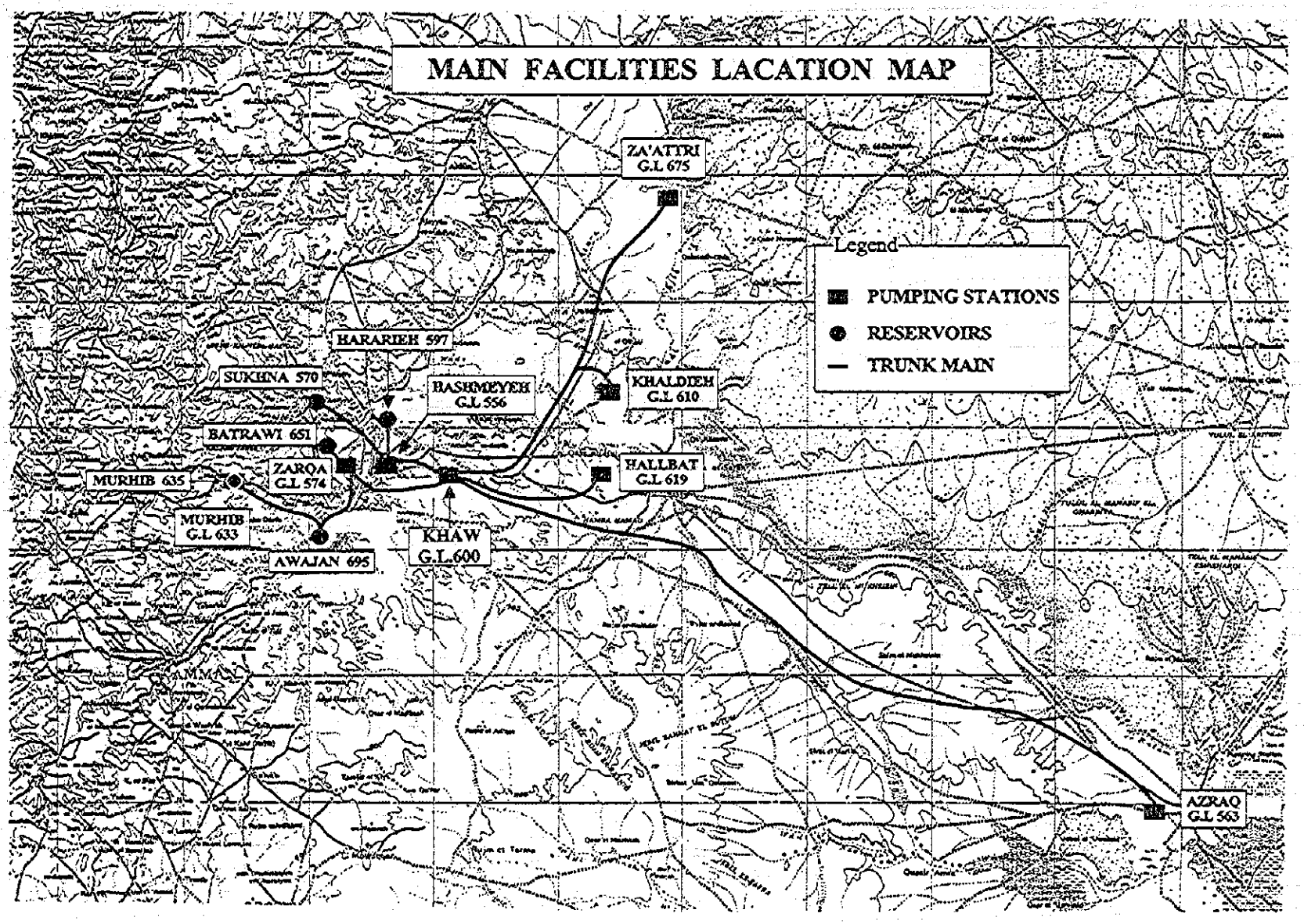
PUMPING STA.	NO.	FLOW METER			PRESS. GAUGE	
		Type	Dia. (mm)	Conditions	Type	Conditions
AZRAQ	1					
	2					
	3					
	4	Ultrasonic	600	Good	Protais	Not working
	5					
	6					
	7					
HALLABAT	1				VDO	Good
	2	Ultrasonic	600	Good	VDO	Not working
	3	Woltex	200	Good	VDO	Good
	4	Woltex	150	Good	Kalani	Not working
KHAW	1					
	2					
	3					
	4					
	5	Ultrasonic	600	Good	Protais	Not working
	6					
	7					
	8					
	9					
	10	Ultrasonic	400	Good	-	-
	11				-	-
	12	SPX	300	Good	-	-
ZARQA	1	-	-	-		
	2	-	-	-		
	3	-	-	-	WIKA	Good
	4	-	-	-		
	5					
	6	Mccrometer	400	Good	VDO	Good
	7					
	8	Mccrometer	150	Good	VDO	Good
	9					
HASHMYEH	1	Sparling	200	Good	VDO	Good
	2				MSH	Good
MURHIB	1				Kobold	Good
	2	Ultrasonic	200	Good	Kobold	Good
	3				Kobold	Good
	4	Ultrasonic	200	Good	KFM	Good
	5				KFM	Good
RUSAIFA BSTR NO.4		Mccrometer	150	Good	WIKA	Good
BSTR ALBASATEEN		SPX	150	Good	KALAN	Good
RUSAIFA NO.18		Mccrometer	150	Good	TERRA	Good
EL-QUNAIEH	1	H-Meineck-AJ	150	Good	LABOM	Good
	2	H-Meineck-AJ	150	Good	LABOM	Good

Source: WAJ Zarqa

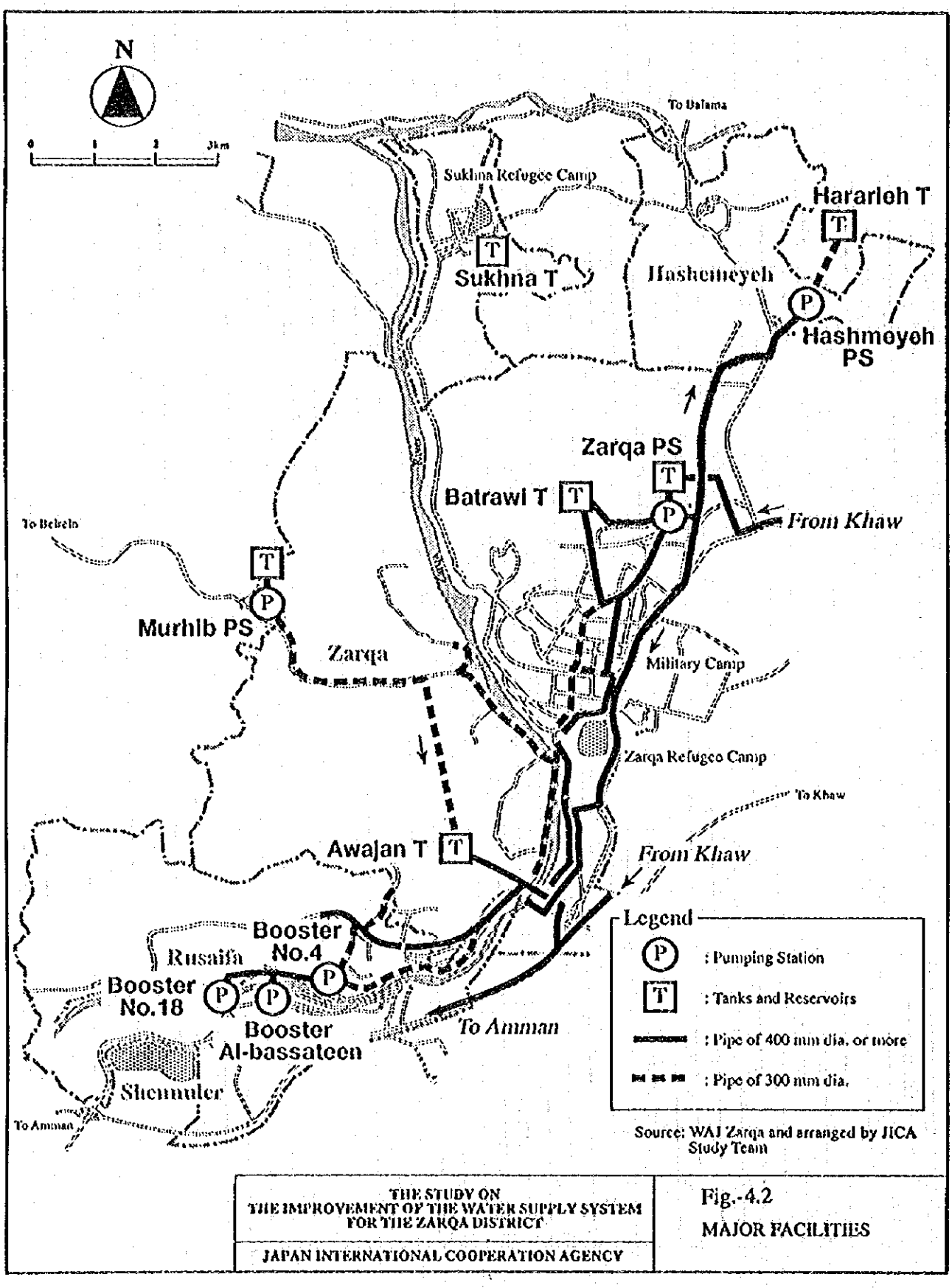
Table - 4.9 TANKS AND RESERVOIRS

NAME		CAPACITY (m3)	STRUCTURE	LEVEL (M)			LEVEL METER		CONTROL
				Ground	High Water	Low Water	Type	Condi.	Method
AZRAQ P/S	1	2,800	Steel/Circular				Silo Meter	Broken	Electrical
	2	5,000	Steel/Circular						
	3	12,000	Rein. Concrete/Rec.		571	563	Schaltanlagel	Good	Electrical
HALLABAT P/S		1,000		(619)			Float Gauge	Good	Manual
KHAW P/S	1	2,800	Steel/Circular	(616)			Silo Meter	Broken	Electrical
	2	12,000	Rein. Concrete/Rec.	(616)	606	599	Hawker	Good	Electrical
ZARQA P/S	1	500	Rein. Concrete/Circ.				-	-	
	2	4,000	Rein. Concrete/Rec.				Float Gauge	Good	Manual
BATRAWI		4,500	Rein. Conc./Circ.				-	-	
AWAJAN		4,500	Rein. Conc./Rec.				Float Gauge	Good	Manual
MURHIB		1,000	Rein. Concrete/Rec	(635)			Float Gauge	Good	Manual
HARARIEH		750	Rein. Concrete/Rec	(597)			-	-	
SUKHNA		250	Rein. Concrete/Rec	(572)			-	-	
Note: In addition, there are 8 abandoned reservoirs in the area. Three in Rusaifa, 3 in Hashemeyeh and 2 Sukhna,									
have a storage capacity, 1,610 m3 in total.									
		51,100							

Source: WAJ Zarqa

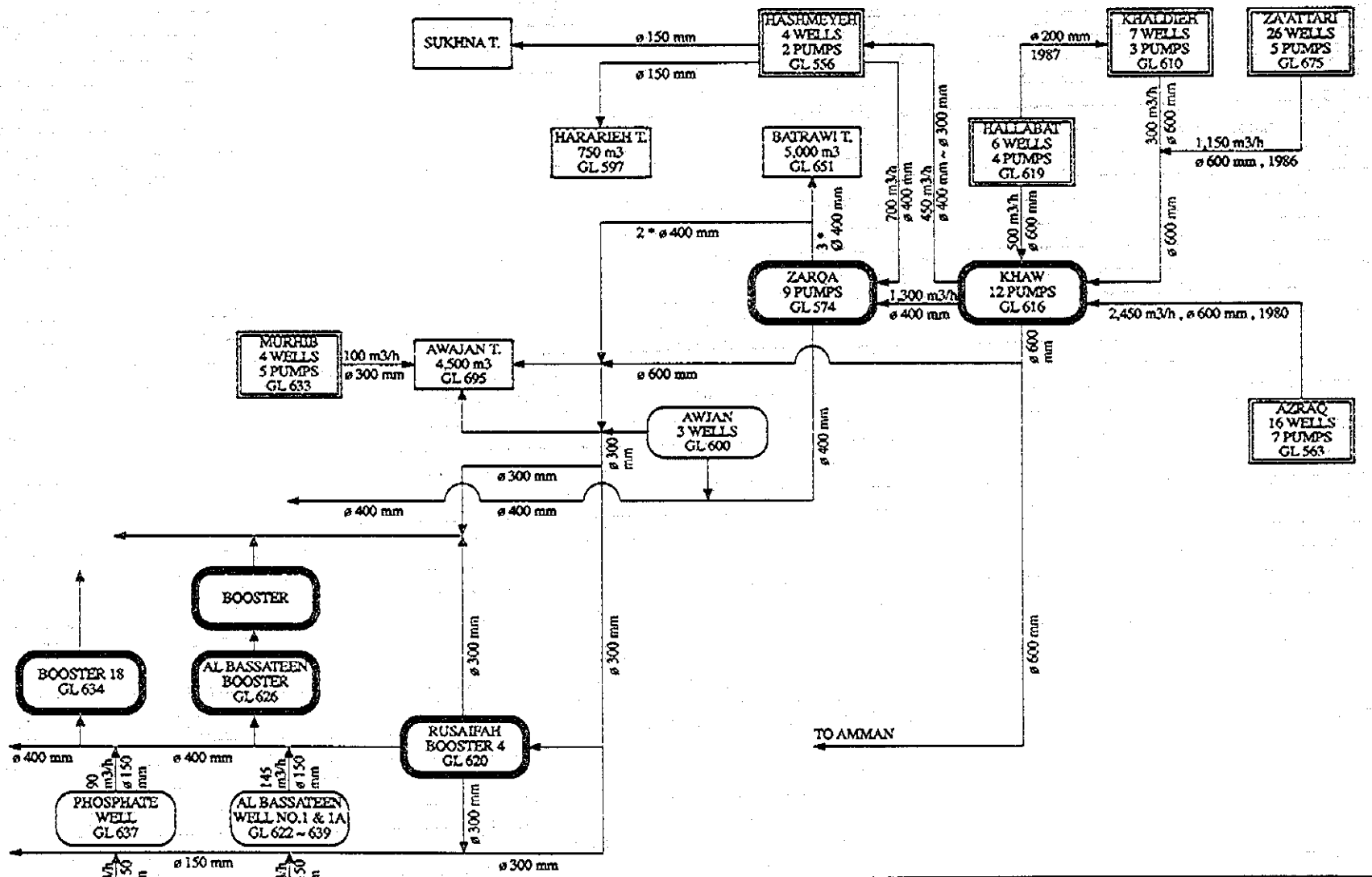


THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 4.1 MAJOR FACILITIES IN ZARQA GOVER.
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: WAJ Zarqa and arranged by JICA Study Team

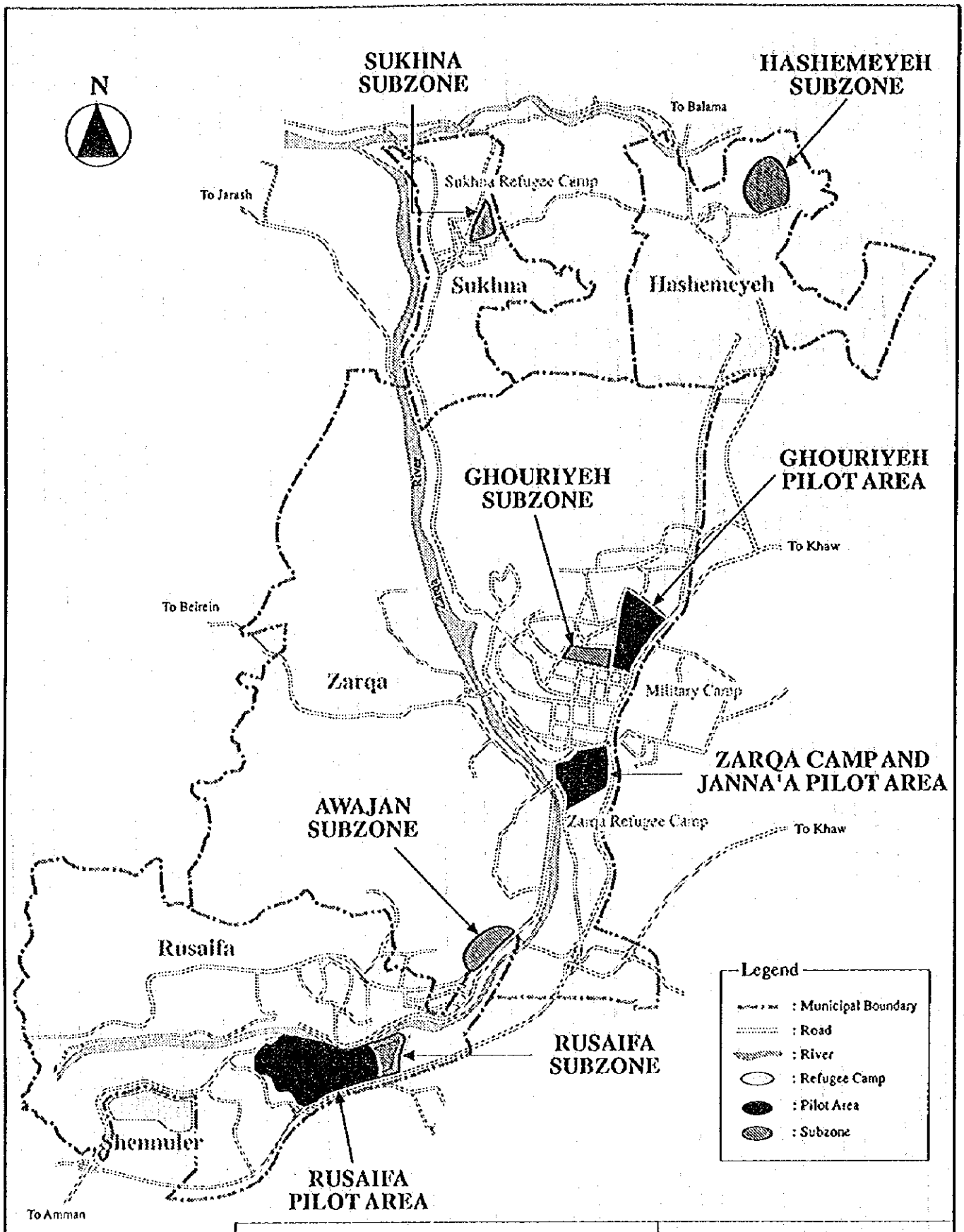
THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.-4.2 MAJOR FACILITIES



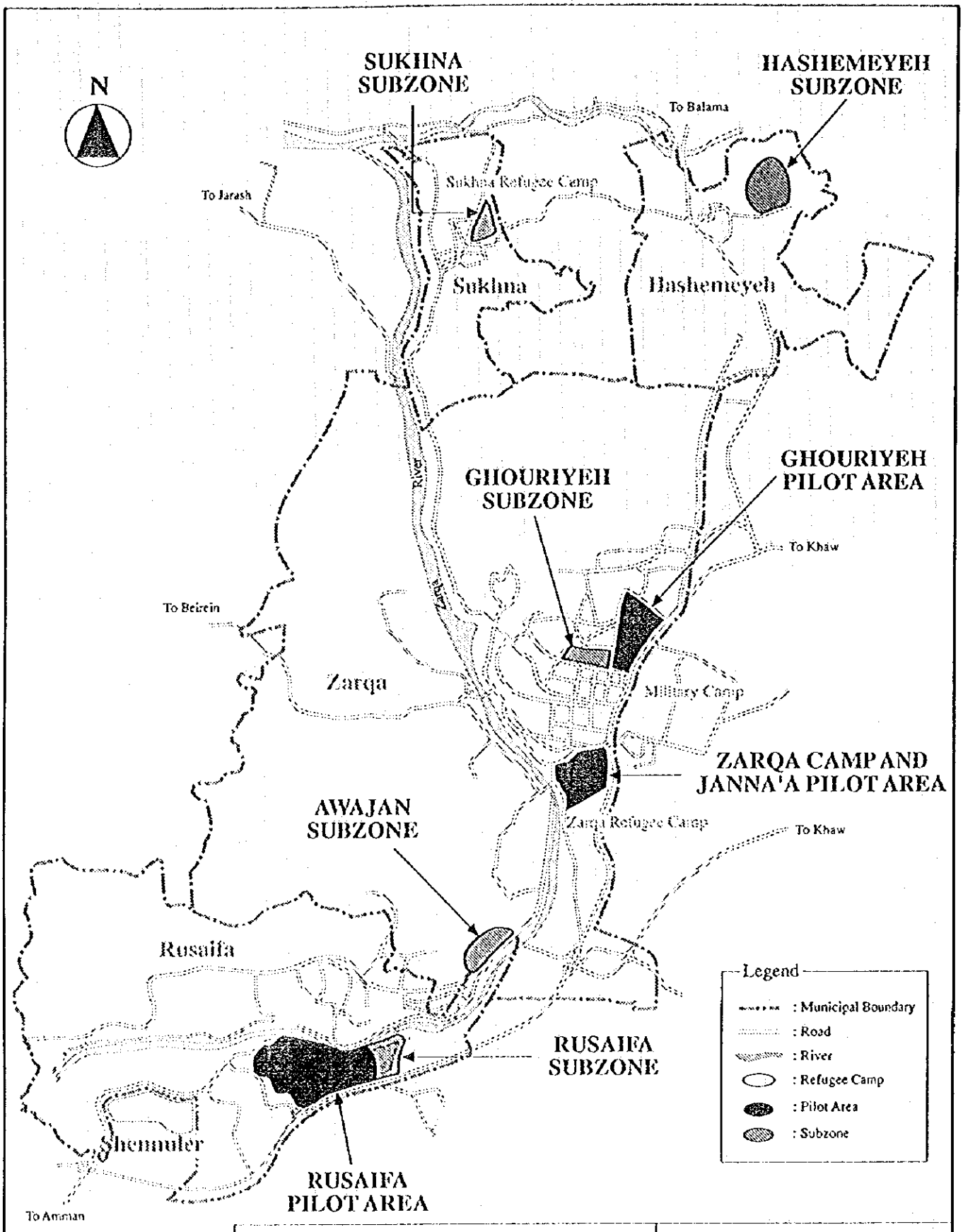
THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.- 4.3
SYSTEM FLOW CHART



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 4.4 UFW SURVEY AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 4.4 UFW SURVEY AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	

V. ORGANIZATION, OPERATION AND MAINTENANCE

V. ORGANIZATION, OPERATION AND MAINTENANCE

5.1 ORGANIZATION

Water Authority of Jordan (WAJ) was established in December 1983 and became operational in January 1984, integrating the function of the following four entities:

(1) Amman Water and Sewerage Authority
(2) Water Supply Corporation
(3) Natural Resources Authority: Water Study and Irrigation Department
(4) Jordan Valley Authority: Domestic Water Supply Section

In 1988, the ministry of Water and Irrigation (MWI) was established, and WAJ was put under the Minister of MWI.

Legally, "Water Authority Law" came into effect in March 1988, which authorized to establish the Water Authority as an autonomous corporate body with financial and administrative independence.

A Board of Directors was organized for determining the basic policy and strategy including the budget of WAJ, which consists of 12 representative of the related ministries and government organizations including the Minister of MWI, Secretary General of Jordan Valley Authority and Secretary General of WAJ. The chairman of the Board is the Minister of MWI.

5.1.1 WAJ Headquarters

WAJ Headquarters consists of five administrative departments and 12 governorate offices. Included in the administrative department are Administration and Finance, Operation and Maintenance, Projects, Water Resources, and Stores and Tender. Total number of employee of WAJ are 6,745 (in 1993) comprising of 1,701 staff at the headquarters and 5,044 staff in the governorate offices. Present organization of the WAJ headquarters including the governorate offices is presented in Fig 5.1

5.1.2 WAJ Zarqa

WAJ Zarqa governorate was established in 1985 as one of the governorate offices of WAJ and all the water administration was transferred from the Zarqa municipality. Total number of employee, WAJ Zarqa is about 607 or about 9 % of WAJ total. There are five departments under WAJ Zarqa governorate, namely, planning, studies and information department, operation and maintenance department, subscribers department, administrative and finance

department, and Ruseifa water department. Present organization of the WAJ Zarqa is presented in Fig. 5.2. Staffing levels for each department are as follows:

• Planning, studies & information department	: 10
• Operation & maintenance department	: 347
• Subscribers department	: 87
• Administrative & finance department	: 41
• Rusaifa water department	: 122
• Total	: 607

Job descriptions for the above organization is not available. Through a series of interviews with the respective departments and sections, major job functions currently undertaken are clarified and briefly described hereunder.

Under the Planning, Studies and Information Department, there are three sections; 1) Planning and Development Section. 2) Supervising & Design Section and 3) Water Resources & Labs Section. Major jobs functions include collecting and analyzing various kinds of technical data and information relevant to water sources, water supply and sewerage services, designing pipe networks, conducting laboratory testing, and keeping data and records.

The Operation & Maintenance Department has its main office at Zarqa Pumping Station. There are three sections under the department : 1) Drinking Water Section, 2) Sewage Section and 3) Maintenance Section which is responsible for the operation and maintenance of water and sewerage systems in Zarqa District except for Rusaifa and Shennuler.

The Subscribers Department has three sections; 1) Supervising Section, 2) Subscribing Requests Section and 3) Billing Section. Their jobs cover issues related to subscribers and house meters, including inspection at the site for registration of new customers, preparation of design drawing of house connections, supervisory works of their installation, customer meter calibration and maintenance, meter reading and bill collection, and receipt and response to customers' complaints.

Under the Administration & Finance Department, there are three sections; 1) Administration Section, 2) Accounting Section, and 3) Supply & Storage Section. They are responsible for general and administrative matters which extend to control of incoming and outgoing letters, employees leaves, maintaining WAJ buildings, preparing payroll for salary, determining installation fee for house connections, book keeping, supply and delivery of stored materials including chemicals, office equipment, pipes and fittings, spare parts of vehicles, etc.

Rusaifa Water Department, although organized under WAJ Zarqa, has a different structure from the above. The department carries out operation, management and administration of the entire Rusaifa water supply system. Based on the responsibility vested in it, it can be characterized as a semi-governorate water authority.

There are 73,830 households serviced by WAJ Zarqa, which is equivalent to 14% of WAJ's total customer base. The number of staff per 1,000 customers is 8.4 for WAJ Zarqa and 12.7 for WAJ. The staff to customer ratio is relatively good for WAJ Zarqa.

5.2 OPERATION AND MAINTENANCE

Operation and maintenance of the water supply system, in general, aims to maintain the facilities under normal working conditions in order to supply water to the whole service area in sufficient quantity and with adequate quality. WAJ's current practices for this are briefly explained focusing on 1) organization and staffing, 2) system operation, 3) procurement and storage and 4) workshop and laboratory.

5.2.1 Operational Organization and Staffing

In WAJ Zarqa, the "Operation and Maintenance Department, Zarqa" and "Operation and the "Maintenance Section of Rusaifa Water Department", are responsible for operation and maintenance of the water supply system including wellfields, pumping stations, transmission and distribution pipe network. To assist them in achieving optimal and effective operation, "Planning, Studies & Information Department" conducts laboratory and field testing for quality control and water resource monitoring.

(1) Operation & Maintenance Department, Zarqa

The "Operation & Maintenance Department" has its main office (Zarqa Water Office) at the Zarqa pumping station.

To manage and give direction, one management chief and 6 engineers are assigned to the department. Under them, there are 117 staff and technicians for operation and maintenance, including 44 persons at Zarqa Water Office and 73 operational staff at the pumping stations and wellfields.

The major functions of the department are:

1) to maintain and operate the pipe network including trunk, secondary and service mains, while house connections and meters are monitored and maintained under the responsibility of Customer Department;
2) to maintain and operate mechanical and electrical instruments in pumping stations;
3) to operate valves and pumps to meet the objectives of the water rationing program;
4) to maintain vehicles on a routine basis (full scale repair is carried out under the responsibility of WAJ Headquarters)
5) to convey water to the people living in high and remote area of the governorate by water tanker (2 tankers as of June 1995)
6) to supply water to the governmental institutions;
7) to record all relevant data in a standardized format including flow rate, pressure, water level, pump working hour, etc.
8) to prepare proposals for the installation of pipe networks in a newly developed areas.

(2) Rusaifa Water Department

There are 55 staff and workers assigned under "Operation and Maintenance Section". It consists of 21 workers, 14 plumbers, 12 operators, 2 engineers, 2 electric and 1 mechanical staff, 2 welders, and 1 clerk.

Duties assigned are similar to Zarqa Water Office except Rusaifa does not control and monitor large consumer meters and does not execute work item 8) above which is under responsibility of the another section.

5.2.2 System Operation and Maintenance

(1) Wellfields and Pumping Stations

As for maintenance of wellfields scattered throughout Zarqa Governorate, "Planning, Studies & Information Department" carries out the field testing for monitoring monthly fluctuations of static and dynamic water levels at each well.

The "Operation and Maintenance Department Zarqa" operates 6 pumping stations in Azraq, Hallabat, Khaw, Zarqa, Hashemeyeh and Murhib. The "Rusaifa Water Department", operates 4 pumping stations located in Rusaifa municipality.

Khaw pumping station which collects groundwater from Azraq, Hallabat, Za'atari and Khaldieh wellfields is operated in accordance with the agreement between WAJ Amman and Zarqa. This agreement which defines water allocation to each service area is usually updated yearly. According to the 1994 Agreement, a maximum of 1,700 m3/h of water can be

delivered to Zarqa District (Zarqa and Rusaifa municipalities), while Amman municipality and Army camp in Zarqa can receive a maximum of 2,200 m3/h and 100 m3/h, respectively.

There is also an allocation agreement between Zarqa and Rusaifa (as of 1994). During the summer season when water demand increases and well yields are limited, water is allocated as follows: during almost five days of the week starting from 4:00 am Wednesday up to 21:00 pm Sunday, around 400 to 500 m^3/h of water is delivered to Rusaifa. In the remaining two days of the week, 1,000 m3/h from Zarqa is boosted to supply the northern hilly areas of Rusaifa.

In compliance with the agreements stated above, pumps and valves are carefully operated by WAJ staff of Zarqa pumping station. However, residents in most Rusaifa and north-west of Zarqa areas suffer from the chronic water shortage caused from the water rationing.

(2) Water Treatment and Reservoir/Tank

WAJ does not practice periodical maintenance for cleaning, leak detection and repair. Operational staff and/or watchmen keep records on hourly fluctuation of water levels at most of the reservoirs/tanks except for the balancing tanks that float on the pipe network.

Except for chlorination water does not receive any treatment. Chlorine dosing is usually carried out at the reservoirs and tanks of major pumping stations.

Two types of chlorinators are used, a pressure dosing type and an advanced type. The dosing rate is determined to ensure safety of the water supply under direction of the qualified engineer. Chlorine containers used are of 1,000 kg and 50 kg capacity.

(3) Transmission and Distribution Mains

Maintenance crews organized under the departments carry out passive leak repair. WAJ engineers explained that broken mains and leaks are usually repaired on the same day they are located depending on site conditions and nature of the leak.

(4) Other Facilities

Customer Meters

In the WAJ Zarqa office, the Customer Department has one meter calibration set and repairs on an average, 500 house meters yearly. The Rusaifa Water Department also has one meter calibration set and in 1994 calibrated 1,000 meters.

Water Tankers

Two water tankers are operated each under Zarqa and Rusaifa offices. Since large scale repair of mechanical equipment such as pumps and vehicles is the responsibility of WAJ Headquarters. The Rusaifa and Zarqa offices retain only small tools and devices for leak repairs and pipe installation. Each office operates a sufficient number of vehicles for system operation and maintenance.

5.2.3 Procurement and Storage

Procurement is usually made by WAJ Headquarters upon request by WAJ Zarqa. WAJ Headquarters has standard specifications for all equipment and materials. Hence, their quality and quantity are kept at a certain level satisfactory to WAJ.

Small lengths of steel, ductile iron, and polyethylene pipes are stored in the yard near Zarqa Pumping Station. These materials are under the control of the Supply & Storage Section, of the Administration & Finance Department, Zarqa.

Bulk chemicals (chlorine tanks) are stored at warehouses in As-Samura and Amman. They are periodically delivered to the site when required. On average, chemicals on site last two weeks - to one month and are sufficient in quantity for normal operating conditions.

House meters are B-class, and meet ISO standards. The Subscribers Department of the WAJ Zarqa and Rusaifa Water Departments usually keep 2,000 and 500 meters respectively. The house meters are delivered from Amman Storehouse after sample calibration Meters are considered sufficient in number and performance.

5.2.4 Workshop and Laboratory

There are two minor workshops, each in Zarqa and Rusaifa. They are used for meter calibration and repair. Full scale repair of pumps, flow meters and vehicles is done at the Amman Workshop.

Laboratory testing is carried by the Water Resources & Laboratory Section, of the Planning, Studies & Information Department of WAJ Zarqa. The engineers and in-house staff take samples at major water supply facilities in Zarqa Governorate on a routine basis. The sampled water is brought into the Microbiological Laboratory in Amman. WAJ Zarqa engineers carry out all testing and analyses. These activities aim to 1) monitor trends and quality of the groundwater aquifer in the Governorate, and 2) ensure safety of the water quality based on the drinking water standard.

Biological and physical parameters such as bacteria, fecal coliform, total coliform, pH, turbidity, residual chlorine are tested on a daily basis. Due to the slightly limited capacity of the Laboratory, an average of only 20 samples in a week are brought in for testing. Chemical parameters such as fluoride, calcium, magnesium, TDS, nitrate, sodium, potassium, chloride, sulphate, carbonate, bicarbonate are examined once or twice a month according to the need. Analyses for heavy metals and trichloroethylene, are carried out once a year by WAJ. Parameters and frequency of the routine water testing are considered sound and favorable.

In addition, the Lab section carries out water sampling at all private wells for testing. Waste water from the major factories is also tested to monitor and control ground water contamination in Zarqa Governorate.

5.3 METER READING, BILLING AND BILL COLLECTION

5.3.1 Meter Reading

Meter reading is carried out by WAJ collectors (collectors conduct both meter reading and bill collection) every three months. There are 74,000 water subscribers in WAJ Zarqa Governorate, about 70% of which are in Zarqa and the remaining 30% in Rusaifa. The total number of collectors working in WAJ Governorate is 50 (35 in Zarqa and 15 in Rusaifa). The number of subscribers per collector varies from 500 to 2,000, depending on the density of the house connections.

Most of the meters installed are relatively small in diameter, 1/2" (99%) and 3/4" (1%). As WAJ frequently conducts meter calibration at their meter shop, meter malfunctions are relatively few. Meters are inadequately installed above the ground and/or in customers' homes, and some subscribers tend to tamper (remove or reversely installation) illegally.

Meter reading is usually conducted within 3 weeks (sometimes 4 weeks or more). A meter reading card is prepared at the site, based on which water consumption for each subscriber is computed and recorded in the WAJ Zarqa.

5.3.2 Billing and Bill Collection

All the data for the preparation of bills is processed by computer in WAJ Zarqa. Water bills thus prepared are distributed to subscribers every three months by collectors. In general, 2-3 weeks are required for preparation and distribution of bills. As meter readers are familiar with local

conditions, they are also engaged in bill collection. Bill collectors are not periodical shifted to other areas.

According to regulations, subscribers should pay within 7 days after receiving the bill or else WAJ has the legal authority to cut off the service. However, this regulation is not applied strictly depending on the physical situation and its practical implications. Actually it takes about two weeks to collect the bill after distributing the bill.

There are three payment methods available to subscribers: 1) pay the collector, 2)bring cash to WAJ and 3) pay at the bank. Most of the subscribers in WAJ Zarqa (60-70%) are paying the collectors. The remaining customers bring cash to WAJ Zarqa. Payment at banks is used by a limited number of customers.

The billing and collection process is summarized in Fig 5.3.

According to WAJ Zarqa statistics billing amounts and payments collected in 1994 were as follows:

Billing and Collection

QUARTER	BILLING	COLLECTED	COLLECTED/ BILLING
1st	515,156	391,878	0.76
2nd	510,281	482,540	0.94
3rd	714,159	618,185	0.86
4th	749,314	713,005	0.95
Total	2,488,912	2,205,608	0.89

Source : Subscribers Dept., WAJ Zarqa

According to statistics in WAJ Zarqa the ratio of bills collected to bills issued in 1994 was 0.89, which indicates high recovery rate compared to that of other developing countries.

According to the information collected through UFW survey and from staff at WAJ Zarqa, the following problems need to be solved or improved:

1) many subscribers tend to mistreat water meters.
2) it takes 2 months or more for collecting bills including meter reading.
3) billing is quarterly instead of monthly.
4) bill collectors work as meter readers and bill collectors, and with no periodical shifting.

5.4 FINANCIAL MANAGEMENT

5.4.1 General

As mentioned in the earlier section, management of WAJ, is still being centralized. All the budgets of the local governorates are planned and controlled by WAJ Headquarters. Water bills are collected by the local governorates and remitted to and managed by the central office. Major expenses such as payroll of the employees and electricity are paid by the central office. The budget for additional investment and repair is also being controlled by the central office.

5.4.2 Tariff Structure

Present water related charges in Jordan are presented in Table 5.1. Applied tariff rates in Zarqa District both for water and sewerage are summarized below.

Water and Sewerage Tariff

Block (3 months consumption)	Water Tariff JD/ M^3	Sewerage Tariff JD/ M^3
0 - 20 M^3	0.065	0.030
21 - 40 M^3	0.090	0.040
41 - 70 M^3	0.300	0.100
71 - 100 M^3	0.500	0.200
101 M^3 more	0.600	0.250

Source: Information Dept., WAJ

In January 1994, water tariffs for domestic consumers and bulk consumers such as commercial and industry were made the same.

Besides the above two tariffs, other fees and charges are to be imposed in the following manner :

For water supply

Meter charge : JD 0.300 per quarter

Connection fees for domestic use

a) Fees : JD 88 for 1/2 or 3/4-inch pipe
JD 103 for 1-inch pipe
JD 209 for 2-inch pipe
JD 551 for 4-inch pipe

b) Stamps : JD 5

c) Refundable deposit : JD 15, if the area is 200 m2 or less
JD 15 + JD 10/100m2, if the area is more than 200m2
JD 100 for non Jordanian

Connection fees for commercial and industrial

Fee and stamps are same as above.

c) Refundable deposit : JD 300 as the minimum , and to be decided by WAJ Director

For sewerage:

Connection fees : 25% of the rental value of property (house)

Sewerage tax : 3% of the rental value of property (house)

5.4.3 Financial Statement

(1) Financial Statements of WAJ Headquarters

Income statements of WAJ during the past 5 years are presented in Table 5.2. Figures in 1994 indicate that the total revenue almost covers salaries and wages and O&M cost. However, depreciation cost and interest on loans could not be covered by the revenue. Deficit for the year reached J.D 49.3 million in 1994, which is larger than the annual income.

Total expenses are almost twice the annual income, which results in a considerable deficit every year.

Based on the actual water consumption in 1994, the revenue and the cost are analyzed as presented below:

Revenue and Cost Analysis, WAJ in 1994 (JD)

	Revenue/cost	Revenue/cost per m^3
1. WAJ Revenue		
1) Water Revenue	24,269,095	0.25
2) Water revenue plus sewerage revenue and sewerage tax	34,195,141	0.35
2. WAJ OM Cost		
1) O&M Cost excluding depreciation	41,919,786	0.43
2) OM. Cost plus depreciation	69,505,770	0.71
3) OM. Cost plus depreciation and interest	85,288,268	0.87

Revenue/cost per m^3 are calculated on the basis of the water consumption (billing amount) of 97,888,825 m^3 in all WAJ.

As indicated above revenue from the sale of water is JD 0.25 /m3. Even if sewerage revenue and sewerage tax are added, the revenue only increases by 40% to JD 0.35/m3 which still does not cover OM cost of JD 0.43/m3. When depreciation is included, O&M accounts for 49% of total operating costs If interest is included with depreciation then OM accounts for 40% of total operating expenditures.

Operational and Maintenance costs of WAJ during the past 3 years are summarized as presented below:

	1992		1993		1994	
Salary and Wages	13,316,713	(19.9)	15,218,277	(21.4)	16,099,444	(18.9)
Electricity	8,318,353	(12.4)	14,996,061	(21.1)	16,966,535	(19.9)
Repair and Others	11,192,675	(16.7)	4,518,724	(6.3)	8,853,807	(10.4)
Depreciation	22,332,096	(33.4)	24,388,270	(34.3)	27,585,984	(32.3)
Interests	11,838,784	(17.6)	12,043,867	(16.9)	15,782,498	(18.5)
Total	66,998,621	(100%)	71,165,199	(100%)	85,288,268	(100%)

As indicated above, about one fifth of the total OM costs are for salary and wages, while about 20% for electricity. The high consumption of electricity is due to the pumping required to extract groundwater resources and transmit over long distances Jordan.

Depreciation shares about 30% showing relatively high ratio, while 17-18% of the total cost was allocated to interest.

Balance sheets for WAJ during the past 5 years are presented in Table 5.3. Source and application of funds for WAJ during the period of 1989-1993 are also presented in Table 5.4. As indicated, investment in fixed assets is being financed by government contribution and long term loan. Annual income could not cover the depreciation cost and the annual deficit was finally offset by reducing WAJ working capital. WAJ's net capital has been decreasing since 1988 and reached JD 34 million in 1994, despite of considerable contributions from the government.

(2) Financial Situation of WAJ Zarqa

Independent accounting systems have not been introduced in each WAJ governorate. Accounting remains a centralized function. Individual governorate balance sheets and income statements for WAJ Zarqa are not available. Based on information provided by WAJ Zarqa the annual budget is prepared by WAJ Headquarters, as presented in Table 5.1.

The expected total revenue of WAJ Zarqa in 1995 is about JD 4.0 million which consists of revenue from water (JD 3.1 million) and revenue from sewerage (JD 0.9 million). Total expenses are projected at JD 5.0 million excluding depreciation and interest costs. The resulting net revenue is estimated at minus JD 1.0 million (deficit).

On the basis of the assumed water consumption for 1995 (14,358,000 m^3), unit revenue and cost for WAJ Zarqa are calculated as follows:

Unit Revenue and Cost

Item	Unit Rate
1) Water Revenue	JD 0.210 / m^3
2) Sewerage Revenue	JD 0.064 / m^3
3) Total Revenue	JD 0.280 / m^3
4) Total Expenses	JD 0.352 / m^3
5) Total Expenses plus Depreciation	JD 0.621 / m^3
Total Expenses plus Depreciation and Interest	JD 0.791 / m^3

From these figures, the following conclusive remarks can be made on the financial situation of WAJ Zarqa :

1) Total revenue covers about 80% of the total expenses excluding depreciation.

2) Since the total revenue is only 45% of the total expenses plus depreciation, substantial increases in revenue or cost reductions are a pre-requisite for the cost recovery.
3) If interest is included, present total revenue covers only 35% of the cost.

Table 5.1. WATER & SEWERAGE TARIFF

1. Amman Governorate Tariff

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

2. Remaining Ghour (Jordan Valley) Area Tariff

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

3. Remaining Kingdom's Governorate Tariff

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

4. Sewage Tariff

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

Source : Information Dept., WAJ 1994

Table 5.2 WAJ Income Statements, 1990-1994

	1990	1991	1992	1993	1994
Revenue					
Water Revenue	15,419,933	16,096,536	18,464,468	21,805,262	24,269,095
Revenue of Water by Tanks	190,731	241,227	185,323	243,581	332,752
Sewerage & Drainage Revenue	982,410	1,581,221	3,380,938	4,324,811	4,516,323
Sewerage Tax	2,500,003	3,717,430	4,056,347	4,170,716	5,409,723
Subscription, Maintenance & Connec	2,245,538	1,647,984	1,607,992	3,754,851	4,239,095
Bank Interest	384,788	530,618	128,218	132,554	48,431
Other Revenue	198,694	538,671	16,299	392,533	1,274,909
Total Revenue	21,922,097	24,353,687	27,839,585	34,824,308	40,090,328
Expenses					
Salaries & Wages	11,086,670	13,509,452	13,316,713	15,218,277	16,099,444
Operation & Maintenance Expense	13,166,111	16,605,450	19,057,232	19,017,254	25,187,607
General & Administrative Expense	971,872	572,821	453,796	497,531	632,735
Depreciation	15,379,082	21,679,601	22,332,096	24,388,270	27,585,984
Interest on Loans	8,868,825	7,490,219	11,838,784	12,043,867	15,782,498
Total Expenses	49,172,560	59,857,498	66,998,621	71,165,199	85,288,268
Excess of Expenses over Revenue	27,250,463	35,503,811	39,159,036	36,340,891	45,197,940
Differences in Rate of Exchange	8,693,389	4,319,173	3,213,966	2,226,909	4,129,084
Previous Years Adjustments	0	763,432	0	0	0
Deficit for the Year	35,943,852	39,059,552	42,373,002	38,567,800	49,327,024
Prior Year Deficit	74,754,262	110,698,114	149,757,666	192,130,668	230,698,468
Accumulated Deficit	110,698,114	149,757,666	192,130,668	230,698,468	280,025,492

Source: WAJ, Finance Directorate

Table 5.3 WAJ Balance Sheet at December 31, 1990-1994

	1990	1991	1992	1993	1994
Fixed Assets					
Cost	344,803,604	449,334,987	477,354,772	526,154,425	569,291,298
Accumulated depreciation	55,371,496	84,489,149	106,821,244	131,209,514	158,020,858
Net Book Value	289,432,108	364,845,838	370,533,528	394,944,911	411,270,440
Work In Progress of Projects	21,694,439	33,045,725	42,503,756	49,737,975	54,205,459
Current Assets					
Inventories	7,583,379	9,265,893	11,658,097	11,816,219	11,459,419
Prepayment On Letter of Credit	0	0	0	0	0
Debtors Net of Provision	14,103,368	11,798,444	16,535,459	14,962,137	16,757,582
Miscellaneous Debtors	876,932	975,974	2,486,375	2,733,185	2,157,188
Cash	4,424,065	4,081,580	4,099,596	1,628,895	798,357
Total Current Assets	26,987,744	26,121,891	34,779,527	31,140,436	31,172,546
Deferred Currencies Differences					
Differences of International Loans Reevaluation	91,394,298	0	0	0	0
Minus the Amount on this Year Note-B	8,639,389	0	0	0	0
Net Differences	82,700,909	0	0	0	0
Total Assets	420,815,200	424,013,454	447,816,811	475,823,322	496,648,445
	1990	1991	1992	1993	1994
Equity					
Capital	233,541,681	249,534,385	271,022,280	296,414,377	314,444,110
Accumulated deficit	110,698,114	149,757,666	192,130,668	230,698,468	280,025,492
Net Capital	122,843,567	99,776,719	78,891,612	65,715,909	34,418,618
Provision for Contingencies	1,472,820	1,462,746	1,462,686	1,462,686	1,462,548
Long Term Loans					
International Loans	147,049,326	141,044,580	134,233,955	127,344,781	127,342,326
Local Loans	17,796,621	21,682,972	39,531,742	56,598,001	76,879,347
Bonds & Debentures	15,325,000	21,325,000	21,325,000	21,325,000	21,325,000
Total Long Term Loans	180,170,947	184,052,552	195,090,697	205,267,782	225,546,673
Current Liabilities					
Creditors	5,385,313	257,369	6,367,048	9,065,294	13,887,823
Retention of Contractors	900,444	861,380	1,612,364	2,789,951	2,488,070
Deposits	17,899,892	21,599,711	24,068,073	26,047,917	26,742,896
Overdue Installments & Accrued Interest on Loans	84,427,830	109,170,233	133,533,105	158,113,581	182,168,335
Pension Fund	89,721	89,721	89,029	89,029	88,576
Banks	7,624,666	6,743,023	6,702,197	7,271,173	9,844,906
Total Current Liabilities	116,327,866	138,721,437	172,371,816	203,376,945	235,220,606
Total Equity & Liabilities	420,815,200	424,013,454	447,816,811	475,823,322	496,648,445

Source: WAJ, Finance Directorate

Table 5.4 WAJ, Source and Application of Fund, 1989 - 1993

	1989	1990	1991	1992	1993
Source of Funds					
Net deficit for the year	(26,787,389)	(35,943,852)	(39,059,552)	(42,373,002)	(38,567,800)
Depreciation	11,153,228	15,379,082	29,117,653	22,332,095	24,388,270
Contributions	10,506,738	11,595,486	15,992,704	21,487,895	25,392,097
Long Term Loans	85,566,177	16,237,517	24,088,153	29,816,111	21,035,532
Projects In Progress	61,122,897	20,583,557	0	0	0
Differed Currency Differences		334,507	0	0	0
Total Source of Fund	141,561,651	28,186,297	30,138,958	31,263,099	32,248,099
Application of Funds					
Settlement of International Loans	6,610,000	12,680,646	14,482,890	4,407,529	6,889,174
Settlement of Local Loans	3,660,666	4,108,195	5,723,659	14,370,437	3,969,273
Settlement of Bonds & Debentures	4,000,000	2,150,000	0	0	0
Fixed Assets	75,800,684	39,732,952	21,830,473	28,019,785	48,799,653
Work in Progress	0	0	11,351,286	9,458,031	7,234,219
Provision for Contingencies	27,000	180	10,074	60	0
Reevaluation L. Differences	83,035,416	0	0		
Total Application Funds	173,133,766	58,671,973	53,398,382	56,255,842	66,892,319
Decrease in Working Capital	**31,572,115**	**30,485,676**	**23,259,424**	**24,992,743**	**34,644,220**

Source: WAJ, Finance Directorate

Table 5.5 Budget For WAJ Zarqa, 1995

Item	JD
I. Revenue	
1. Water Revenue	
Water Charge	2,702,035
Connection Fee	250,286
Meter Charge	96,139
Repairing Fee & Others	62,295
(Sub - total)	(3,110,755)
2. Sewerage Revenue *	
Sewerage Charge	435,677
Connection Fee	416,000
Others	64,260
(Sub-total)	(914,937)
Total Revenue	**4,025,692**
II. Expenses **	
1. Salary and Wage	1,422,666
2. Electricity	3,007,107
3. Repair Cost and Fuel	457,053
4. Others	162,069
Total Expenses	**5,048,895**
III. Revenue minus Expenses	**- 1,023,203**

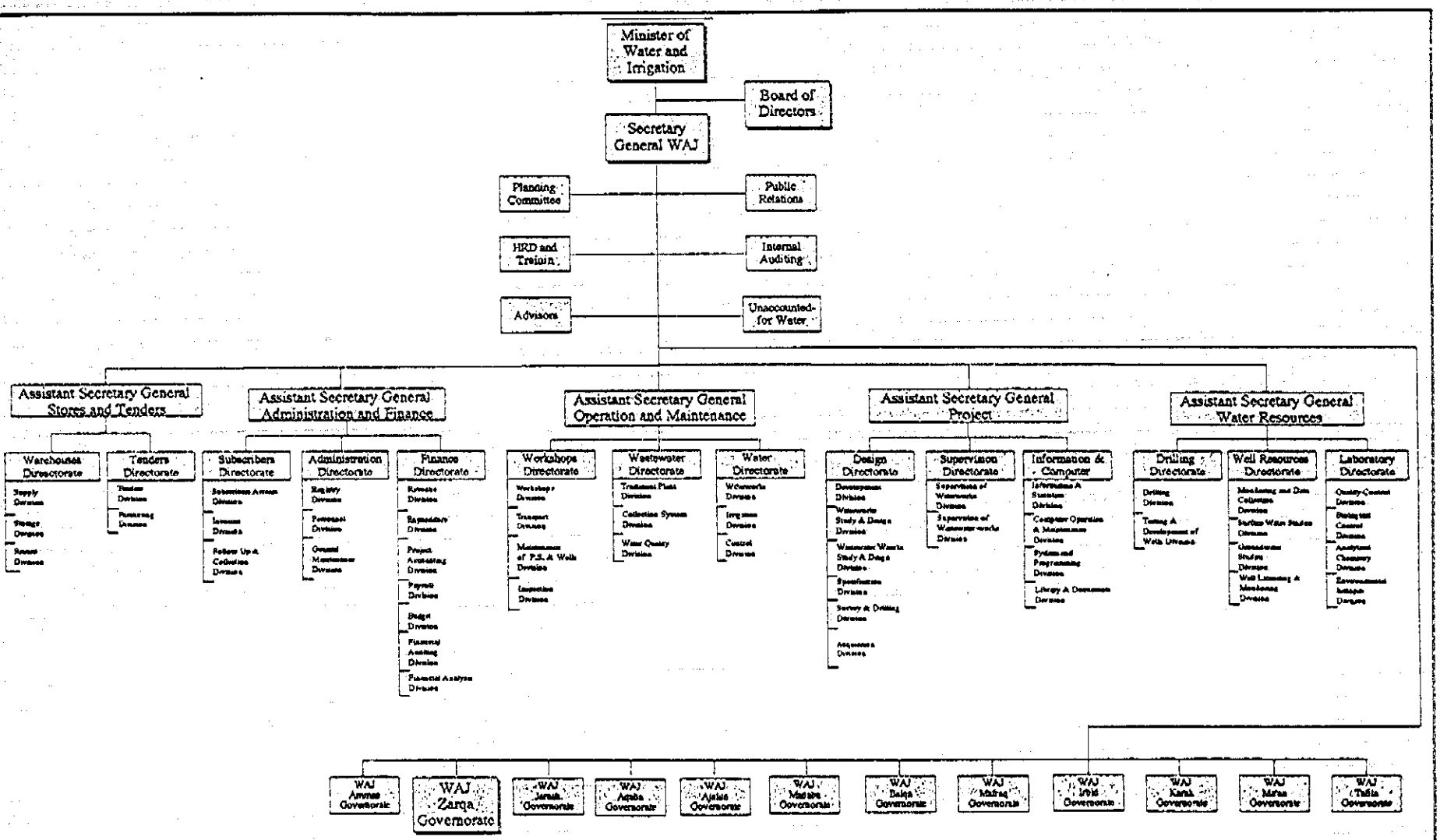
Source : WAJ Finance Directorate
* : Excludes sewerage tax to be collected by MOF
** : Excludes depreciation cost

Table 5.6 REVENUE OF WAJ ZARQA, 1990-1995

	Water Revenue	Sewerage Revenue	Metere Charge	Total Revenue	Water Consumption (m^3)	Revenue per m^3	
						Water JD	Total JD
1990	1,543,107	92,950	55,893	1,691,950	9,833,122	0,16 m^3	0,17 m^3
1991	2,009,143	149,556	82,320	2,241,019	10,630,832	0,19 m^3	0,21 m^3
1992	1,862,256	280,511	78,702	2,221,469	16,195,058	0,18 m^3	0,22 m^3
1993	2,290,052	379,294	84,825	2,754,171	11,873,092	0,19 m^3	0,23 m^3
1994	2,648,543	385,737	88,917	3,123,197	13,306,818	0,20 m^3	0,23 m^3
1995 <1	3,014,616	914,937	96,139	4,025,692	14,358,000	0,22 m^3	0,28 m^3

Source : WAJ, Finance Directorate

<1 : WAJ, Zarqa Budget



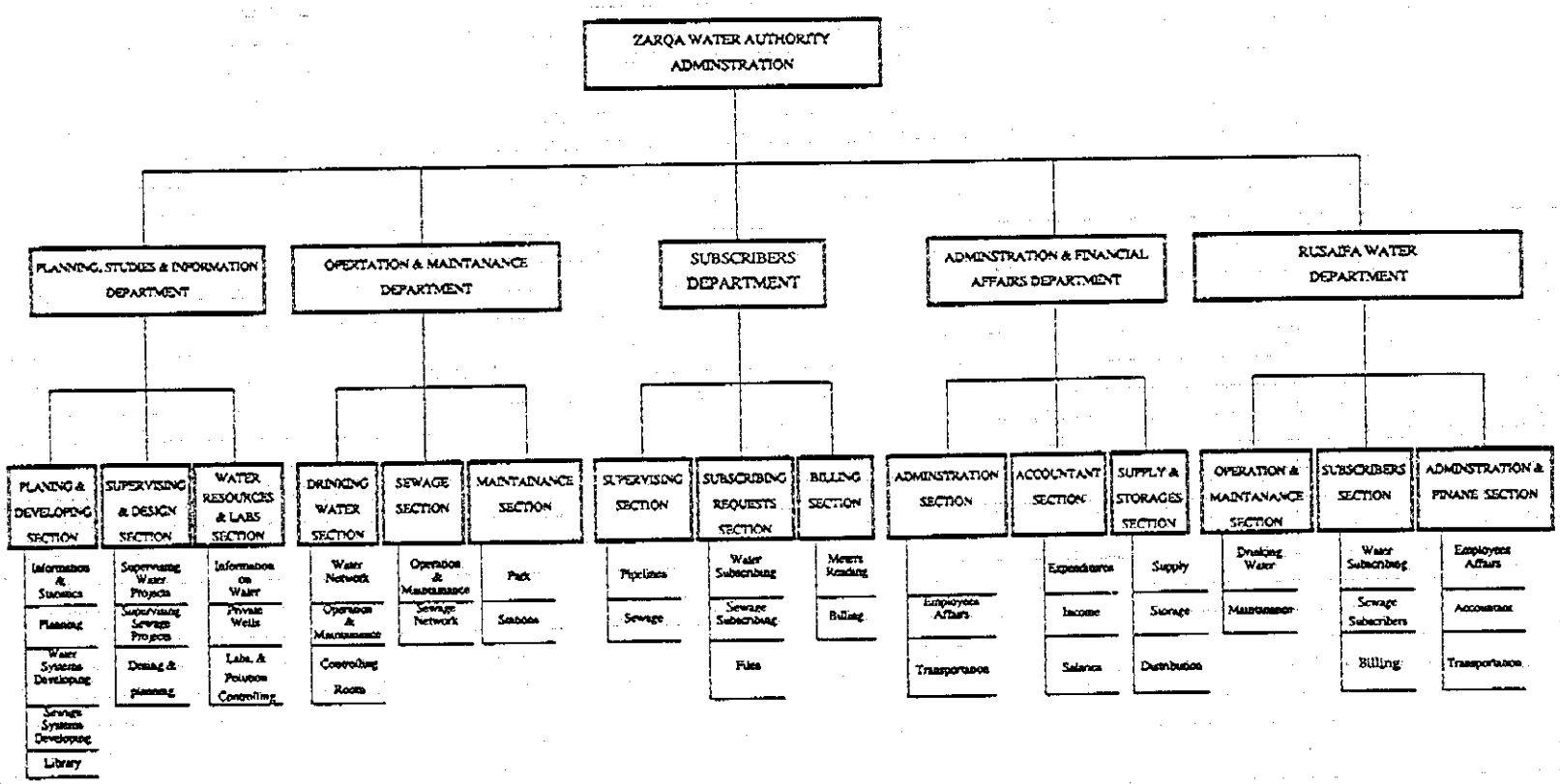
Source: WAJ

THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT

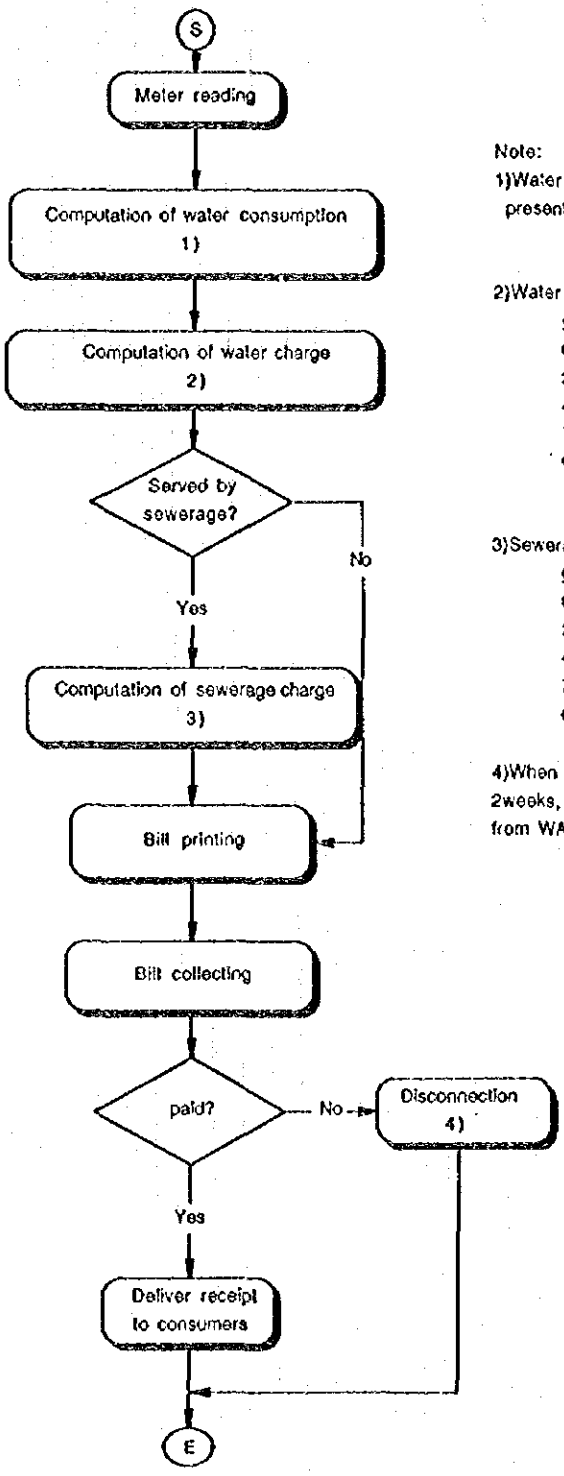
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.- 5.1
ORGANIZATION CHART OF
WAJ HEADQUATERS

Organization chart of Zarqa Water Administration



THESTUDYON THEIMPROVEMENTOFTHE WATERSUPPLY SYSTEM FOR THEZARQADISTRICT	Fig.- 5.2 ORGANIZATION CHART OF WAJ ZARQA
JAPANINTERNATIONALCOOPERATIONAGENCY	



Note:
1)Water consumption =
present reading - last reading

2)Water charge as follows:

Class m3	Tariff fils
01 - 20	65
21 - 40	90
41 - 70	600
71 - 100	600
Over 100	600

3)Sewerage charge as follwes:

Class m3	Tariff fils
01 - 20	30
21 - 40	40
41 - 70	100
71 - 100	200
Over 100	250

4)When the payment delays for more than 2weeks, customers are disconnected from WAJ pipes.

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 5.3 PROCESS OF BILL COLLECTION
JAPAN INTERNATIONAL COOPERATION AGENCY	

VI. WATER DEMAND AND WATER SOURCE

VI. WATER DEMAND AND WATER SOURCES

Future population and water demand are key factors in deciding project scale and scheme of the long-term development plan. To predict future population, a future development plan for the Study Area is drawn with consideration of the characteristics of the area and direction of development. Future land use in the Study Area is projected until the year 2015. the future population is estimated on the basis of past trends and future land use in the Study Area. As for future water demand various data and information such as domestic water consumption, number of subscribers, customers' water use pattern, water rationing programs, industrial water consumption, and customers' willingness to pay were taken into account.

Existing water resources will not be able to accommodate increases in water demand in Zarqa Therefore a water balance for the whole of Jordan, particularly in Amman is estimated to analyze additional water resources which can be made available for Zarqa.

6.1 FUTURE URBAN DEVELOPMENT PLAN FOR ZARQA

6.1.1 Development Scenario

A development scenario for the Study Area is formulated, in due consideration with the development constraints given below;

- Existence of the military camp located in Zarqa, which limits further development towards the east of Zarqa, and
- Steep land laid down around Zarqa, which limits further development towards the west and north of Zarqa.
- Existing industrial plants such as oil refinery and power plants in Hashemeych.

Given physical constraints stated above, the Study Area has a limited capacity for further development, especially housing development. Given these constraints there has been no regional development master plan for Zarqa Governorate. However, under the pressure of rapid urban and industrial development, Zarqa and Grater Amman municipality in October 1994. jointly launched the "Greater Zarqa Comprehensive Development Plan (Master Plan)"

As of September 1995 the final results of this Master Plan were not available. Preparation of the Master Plan has been delayed due to unforeseen circumstances. However, some preliminary results are used for our planning purposes. Referring to these preliminary results and based on the analysis of spatial development using topographic maps and aerial photographs (one in

1992 and the other in 1984), a development scenario for the Study Area is prepared (see Fig.6.1) as follows:

1) Due to the physical constraints, future development of the Study Area will be directed to the west and north of Zarqa city.
   The major development axis (mainly residential and partly residential/commercial mixed development) runs towards north of Zarqa, where the density of the existing housing is still low and potential lands for further development are available.
   Another major development axis runs toward the west (northwest and southwest) of Zarqa. In the northwest of Zarqa, the residential development extends along the road connecting Zarqa to Beirein. Potential land for future residential development exists in this area where the terrain is relatively flat and the population density is low. Southwest of Zarqa also has good potential for residential development and public housing projects are now underway in this area.
2) Expansion of production capacities in the existing industries will be made along the Zarqa-Amman corridor. Establishment of new factories producing mainly consumer goods is also expected in the northern part of the Study Area, though the number of new establishment will be limited.
3) The area dedicated to agriculture land will not change much in the future. In the urban area, the existing agriculture land may be transformed to residential land. Due to the limited availability of water resources, further extension of the agriculture land in the suburban area is unrealistic.
4) The area for public use will expand a little corresponding to the growth of residential development.
5) It is assumed that the area for the refugee camp will remain unchanged, though redevelopment by restoring its legal status and prevision of infrastructure will be facilitated.
6) As a whole, the residential and mixed residential area will expand to the west north-west directions and cover most of the relatively flat terrain area available in the Study Area.

6.1.2 Future Land Use

Based on the development scenario explained above, the future land use of the Study Area is projected as presented in Fig 6.2. The future land use is summarized in the following table :

Future Land Use Of the Study Area (2015) (Km^2)

Major Land Use	Area	
Existing Residential Area	29.0	(32.0 %)
Mixed Area	11.2	(12.4 %)
Future Residential Area	10.2	(11.3 %)
Industrial Area	8.0	(8.8 %)
Agricultural Area	3.4	(3.8 %)
Public Area	2.2	(2.4 %)
Open Space Area	1.6	(1.8 %)
Refugee Camp	0.8	(0.9 %)
Vacant Land	24.1	(26.6 %)
Total	90.5	(100.0 %)

The military camp area, located on the east side of Zarqa city is excluded from our Study Area and is a major constraint to the future development of the city. The area might however be incorporated in the urban area if a current proposal for Greater Zarqa development is legally accepted. This area could be used for administrative, commercial and residential land use as well as parks and social facilities. At present, thousands of military personnel and their families live in the area which will increase from 50,000 to 75,000 around 2015.

6.2 POPULATION PROJECTION

6.2.1 Framework for Population Growth Forecast

The population of the Study Area increased at 3.9% p.a., during the period of 1979-1994. Excluding a returnees from the Gulf countries, estimated at around 60,000, natural population growth is estimated at 3.1% during this period. Another indicative figure for future population projection would be the planned population growth rate set up in "Economic and Social Development Plan of Jordan, 1993 - 1997. The projected figure is 3.2% p.a. during the plan period.

Based on these figures, total population growth of the Study Area is estimated.

Period	Population Growth in the Study Area
1995 -2000	3.2% p.a.
2000 - 2005	2.8% p.a.
2005 - 2015	2.4% p.a.

During 1995 - 2000, a little bit higher rate than the past trend is applied in due consideration of the socio - economic effect of the Peace Treaty. But the higher growth rate will decrease after the year of 2000 as household incomes increase and living standards improve.

6.2.2 Population Projection by Municipality

Population projection for different municipalities is made on the basis of past trends with and growth rates estimated above. For the estimate of the future growth rate by municipality, the following assumptions are made:

(1) Past trend of high population growth observed in each municipality will slow down in the future.

(2) Higher population increase will continue in the surrounding lower density areas such as Sukhna, Hashemeyeh, and Rusaifa.

(3) Zarqa and Schenuller which have the highest population density in the Area will increase at relatively lower rate compared to other municipalities.

In order to obtain the same figures that was forecast for the total study area, the growth rate of each municipality is adjusted and finally estimated as presented below (also see Fig. 6.3).

Projected Population in the Study Area

(Person)

Municipality	1994	1994 - 2000	2000	2000 - 2005	2005	2005 - 2015	2015
Zarqa	344,524	2.8%	406,600	2.5%	460,000	2.3%	577,500
Sukhna	9,764	4.4%	12,600	3.9%	15,300	3.0%	20,600
Hashemeyeh	13,038	4.7%	17,200	4.0%	20,900	3.2%	28,600
Rusaifa	131,130	4.0%	165,900	3.3%	195,200	2.6%	252,300
Shennuller	36,218	2.7%	42,500	2.4%	47,900	2.2%	59,500
Total	534,674	3.2%	644,800	2.8%	739,300	2.4%	938,500

Source: JICA Study Team

6.3 WATER DEMAND FORECAST

Water consumption data for WAJ Zarqa does not reflect the real water demand because of water rationing. The water demand forecast is therefore based on data obtained from meter reading records of customers in Zarqa municipality who currently enjoy continuous water supply. A combination of the household survey (refer to Appendix C) and the subsequent water consumption analyses indicates the average per capita consumption of these customers varies between 75 and 80 lpcd during summer season and drops to 70 lpcd in the winter. Therefore, it is not unrealistic to assume a per capita consumption in the order of 70 lpcd.

In consideration of the future increase in per capita consumption, the results of the household survey are utilized fully. The following section explains the results.

The household survey suggests a strong correlation between the per capita consumption family size, frequency of the rationing, and water pressure. These relations are seen in Tables - 6.1 to 6.2. Per capita consumption is not related to the household income level (see Table - 6.3). This may be attributable to the suppressed water use resulting from the rationing. Furthermore there is no apparent relationship between per capita consumption and the provision of sewage collection services. This can be explained by the prominent use of the conventional pour-flush toilet with uses less water.

In addition to household survey, the Team interviewed several WAJ officials/engineers, asking about water consumption habits They explained that the majority of the households in the country depends on conventional pour-flush toilets which do not require much amount of water. They had also observed that water consumption did not increase when customers were connected to the public sewer system They noted that the average household enjoys bathing and washing, an average of three or four times a week in mid summer and two or three times in the winter.

Based on the above results, an extra 10 -15 lpcd was added to account for improvements to the living standard, and a likely decrease in household size. The resulting per capita consumption is estimated to be 90 lpcd by the year 2015 (domestic water demand on accounted-for water basis).
The following assumptions were made in estimating the 10 - 15 lpcd increments :

1) Average household size will decrease to 6 - 8 members which is equivalent to an increase of 2 - 3 lpcd,
2) Conventional pour-flush toilet use will continue even if the coverage ratio of public sewerage system increases, per capita consumption is not affected
3) The frequency of laundering, washing and bathing will not change significantly and

4) Water use appliances such as washing machines will be disseminated to some extent as the standard of living rises in future, which is equivalent to an 8 -12 lpcd increase.

To obtain future water consumption at 5 year intervals, it is assumed that the present per capita consumption of 70 lpcd will increase uniformly to the above target value, 90 lpcd by 2015. This interpolation gives design values of 75 lpcd, 80 lpcd and 85 lpcd in 2000, 2005 and 2010 respectively.

Most of the water utilized under the 'large consumers' and 'governmental institutions' categories are mainly for drinking and washing by the employees as explained in Appendix D. The consumed amount of 1.7% of the total accounted-for water in 1994, is very small and hence, for planning purposes, it is assumed included in the domestic demand.

The UFW survey suggests most of the unaccounted-for water originates from administrative aspects. Leakage losses account for 30-35% while other losses related customer connections are 20-25% of the total. As will be discussed in 7.2 Rehabilitation Plan, is assumed that the UFW ratio will be reduced from 54% in 1994 to 30% by 2015, as meter reading and billing procedures are strengthened and major deteriorated pipelines are rehabilitated in the course of the project development.

In estimating daily maximum water demand, a peaking factor (Daily maximum / Daily average) of 1.20 is used to account for the seasonal and daily fluctuation. The present 183 lpcd on a daily maximum basis will be 166 lpcd in 2005 and 154 lpcd in 2015. These estimates are considered adequate when compared to the per capita water consumption data in Amman and other similar cities. The decreasing trend is due to a corresponding decrease in UFW.

Daily Average & Maximum Per Capita Consumption (lpcd)

Year	1994	2000	2005	2010	2015
Average consumption	70	75	80	85	90
UFW ratio (%)	54	48	42	36	30
Average demand	152	144	138	133	129
Maximum demand	183	173	166	159	154

* Demand includes both consumption in subscribers and UFW in the system.

Total water demand is then computed as a product of the above per capita consumption and the predicted population served as follows:

Water Demand

Year	1994	2000	2005	2010	2015
Population Served	534,700	644,800	739,200	832,300	938,500
Avg. Demand (m^3/day)	81,000	93,000	102,000	111,000	121,000
Max. Demand (m^3/day)	97,000	112,000	122,000	133,000	145,000

The daily maximum water demand of 97,000 m^3/day in 1994, will increase to 145,000 m^3/day by 2015. The above forecast does not reflect any future regulatory changes concerning industrial water usage which could affect present water consumption patterns

6.4 WATER BALANCE

Water sources available within the Study Area are scarce. If appropriate measures for new water resource development are not advanced by the agencies concerned, the water shortage in the area will become more serious in the future.

The following table shows an estimated water balance, supposing that the present well fields continue to produce water and no additional water sources are available. (annual water demand = average daily water demand x 365 days)

Water Balance Without Additional Sources

(Daily Average Base) (MCM/year)

Year	1994	2000	2005	2010	2015
Annual Water Demand	29.6	33.9	37.2	40.5	44.2
Water Source Availability	21.9	21.9	21.9	21.9	21.9
Balance	-7.7	-12.0	-15.1	-18.6	-22.4

6.4.1 Current Water Source For Zarqa

Current water sources for the Zarqa water supply system are based on the water balance for the whole of Jordan. The population is concentrated mostly to the north of Jordan (population of which is 3.920 million while Jordan is 4,328 million in 1993). The current water balance for the northern region is as follows;

Current Water Balance in North Jordan

(MCM/year in 1993)

Governorate	Supply	Import	Export
Zarqa	25	15	19
Amman	* 101	** 46	0
Mafraq	13	0	19
Irbid	34	4	0
Balqa	19	3	0
(King Abdul Canal)	-	-	30
Total	192	68	68

* Import from South Jordan is included. ** Import from South Jordan is excluded.

Accordingly, water sources for Zarqa are classified into four groups:

1) Own resources such as Zarqa, Hashemeyeh and Awajan wells which are produced and consumed in Zarqa.
2) Imported resources such as Za'atari wells which are produced in Mafraq and used in Mafraq, Irbid, Zarqa and Amman.
3) Common resources such as Azraq, Halabat and Khaldia wells which are produced in Zarqa and consumed in Zarqa and Amman.

The location of the water sources serving Zarqa is expected to change by the development of future water resources in Jordan. Projects resulting from the Peace Treaty, the Wadi Mujib Lower basin and Disi will have a profound impact on the arrangement of the Zarqa water supply system.

6.4.2 Water Demand In Jordan

Determining the water demand is the first step to understanding the water balance in Jordan. Population in the north Jordan is projected below by using the same population growth rates applied in Zarqa.

Population Projection In North Jordan

(thousand person)

Governorate / year	Amman	Zarqa	Irbid	Mafraq	Balqa	Total	Growth rate
1995	1,803	688	1,006	179	207	3,883	3.20%
2000	2,111	805	1,178	210	242	4,545	3.20%
2005	2,424	924	1,352	241	278	5,218	2.80%
2010	2,729	1,040	1,522	271	313	5,875	2.40%
2015	3,073	1,171	1,714	305	352	6,615	2.40%

Based on the population projections, domestic water demands are projected for 2 possible scenarios: 1) a low consumption scenario where the per capita consumption will remain the

same as the current level of 150 liters per day (including 58 % of unaccounted for water) and 2) a high consumption scenario of 180 liters per day.

Water Demand In North Jordan

(MCM/year)

Governorate / year	Amman	Zarqa	Irbid	Mafraq	Balqa	Net Total	* Gross Total
Case 1	**(150 lpcd)**						
1995	99	38	55	10	11	213	234
2000	116	44	64	11	13	249	274
2005	133	51	74	13	15	286	315
2010	149	57	83	15	17	322	354
2015	168	64	94	17	19	362	398
Case 2	**(180 lpcd)**						
1995	118	45	66	12	14	255	281
2000	139	53	77	14	16	299	329
2005	159	61	89	16	18	343	377
2010	179	68	100	18	21	386	425
2015	202	77	113	20	23	435	479

* includes 10% conveyance loss and UFW ratio is 58%.

6.4.3 Water Resources Development in Jordan

If the water resources development proceed as shown below, water will be balanced between 2000 and 2010. However, after 2010, other water resources development will become necessary.

Water Balance Based On Possible Water Supply

(MCM/year)

Water Source / Year	1995	2000	2005	2010	2015
Existing Supply	192	192	192	192	192
Mukheb	-	25	25	25	25
Fahel	-	8	8	8	8
Yarmouk River	-	30	80	80	80
Degnia Gate (Lake Tiberias)	-	20	20	20	20
Desalination from Israel	-	10	10	10	10
Wadi Muj Lower Basin	-	30	30	30	30
Disi	-	-	- (90)	90 (150)	90 (150)
Total Supply	192	315	365	455	455
Demand (Low - High)	234 to 281	274 to 329	315 to 377	354 to 425	398 to 479
Water Balance (Low - High)	-42 to -89	-14 to +41	-12 to +50	+30 to +86	-24 to +42

In the above cases it is assumed that 58% of high UFW in Jordan in 1993 will not change. However, rehabilitation of the distribution systems is also planned for the rest of Jordan as it is

in this study. Although reduction of the UFW will take a long time, it is reasonable to expect that UFW will be reduced to 30% by 2010. The required demand will therefore be significantly lower at an estimated 298 MCM/year in 2010 and 335 MCM/year in 2015 for the high consumption scenario and 248MCM/year in 2010 and 279 MCM/year in 2015 for the lower consumption scenario.

Water Balance For UFW Ratio of 30 %

(MCM/year)

Year	1995	2010	2015
Total Supply	192	455	455
Demand (Low - High)	234 to 281	248 to 298	279 to 335
Water Balance (Low - High)	-42 to -89	+157 to +207	+120 to +176

It is reported that existing wells are producing at twice the safe yield limit. For both the high and low consumption case there will be a large positive water balance. Therefore it is advisable to reduce production yield of the overdrawn wells. Even when production is reduced to half, the water balance remains positive as shown below

Water Balance For UFW Ratio of 30 %

(MCM/year)

Year	1995	2000	2005	2010	2015
Existing Supply	192	192	192	* 96	* 96
Mukheb	-	25	25	25	25
Fahel	-	8	8	8	8
Yarmouk River	-	30	80	80	80
Degnia Gate (Lake Tiberias)	-	20	20	20	20
Desalination from Israel	-	10	10	10	10
Wadi Mujib Lower Basin	-	30	30	30	30
Disi	-	-	# - (90)	90 (150)	90 (150)
Total Supply	192	315	365	359	359
Demand (Low - High)	234 to 281	274 to 329	315 to 377	248 to 298	279 to 335
Water Balance (Low - High)	-42 to -89	-14 to +41	-12 to +50	+61 to +111	+24 to +80

* Reduced to half of the existing supply.

\# Disi project is planned to yield 150 MCM/year at the second stage. However, from the viewpoint of water balance, it is not necessary.

6.4.4 Future Water Source For Zarqa

From the preceding, until 2005 the quantity of water from existing sources will match the current use and the additional amount required to meet increased demands will come from the east, namely Azraq, Za'atari etc., reaching 938 l/s (30 MCM/year) in 2005. After 2006, the quantity from existing sources will be reduced by half and additional water will come from the west. The amount from the west will reach 741 l/s (24 MCM/year) in 2015. Water sources for the years 2005 and 2015 are shown in Figs. 6.5 and 6.6, respectively.

Water Source And Quantity For Zarqa

Year / Water Source	1995 (l/s)	2005 (l/s)	2015 (l/s)
Khaw (Za'atari, Khaldia, Halabat and Azraq)	* 340	# 938 (660)	555
Zarqa	140	140	70
Hashemeyeh	150	150	75
Awajan	130	130	65
Murhib	19	19	10
Wells in Rusaifa (Phosphate, Hutteen, Bassateen, Rusaifa 18)	36	36	20
Rusaifa valley wells	-	# - (278)	140
Unspecified New Source from West Side	-	-	741
Total	815	1,413	1,676

* Current yield is 1,110 l/s and the remaining is sent to Amman.

938 is required either from Khaw totally or Khaw and Rusaifa valley wells in 2005.

Table - 6.1 WATER CONSUMPTION VS. NOS. OF DAYS RECEIVED

Nos. of Days Receiv	Nos of Samples	Water Consumption (m3/quarter)	Nos. of Family Members (person)	Water Consumption percapita (lpcd)
1. One day	38	1,544	369	46
2. Two days	47	2,875	516	62
3. Three days	38	2,319	360	72
4. Four days or more	80	4,050	715	63
(Not obtained)	(52)	-	-	-
Total (or Average)	203	10,788	1,960	61

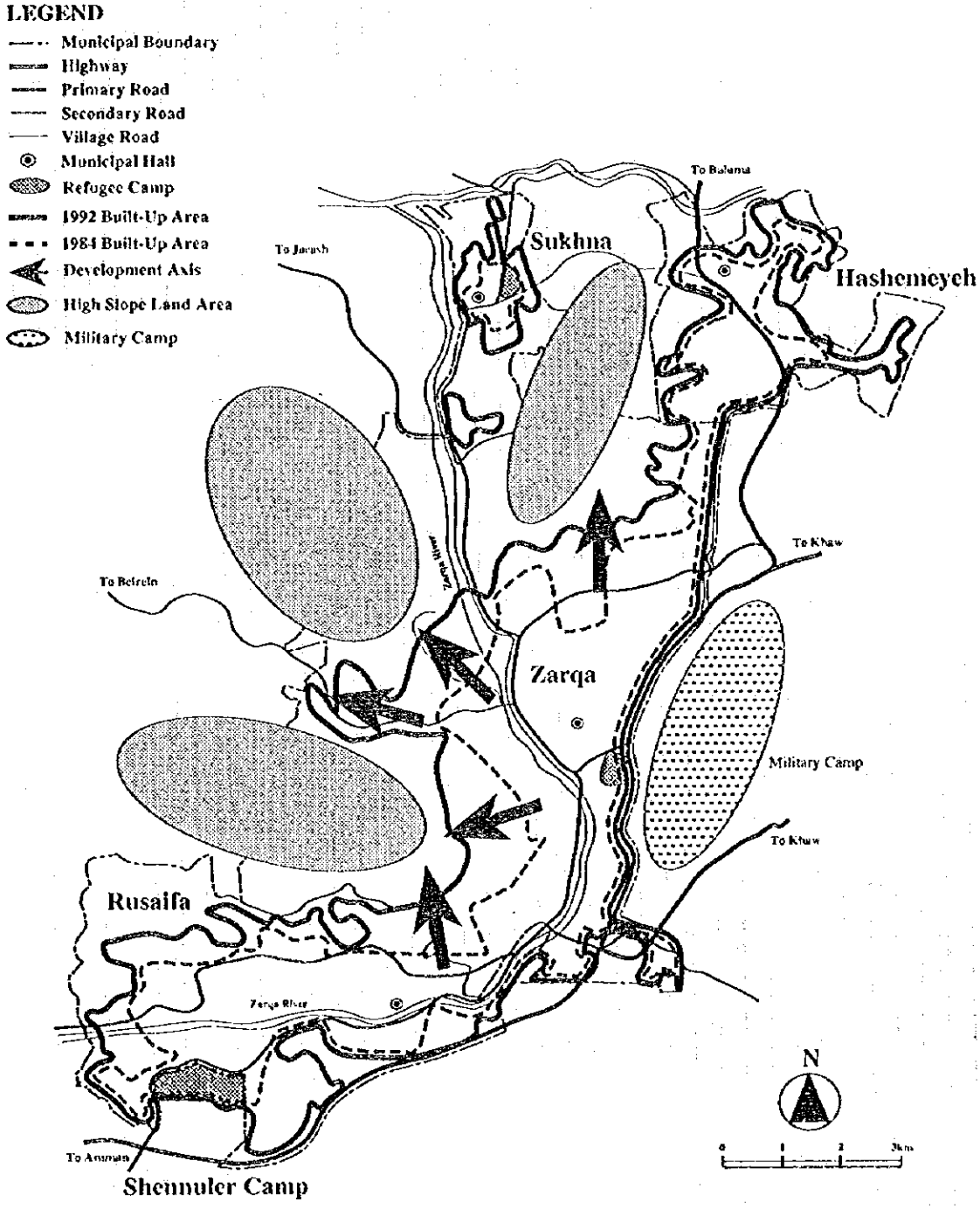
Table - 6.2 WATER CONSUMPTION VS. WATER PRESSURE

Water Pressure	Nos of Samples	Water Consumption (m3/quarter)	Nos. of Family Members (person)	Water Consumption percapita (lpcd)
1. Low	24	1,177	251	52
2. Average	156	8,413	1,525	61
3. High	20	1,058	160	73
4. Others	3	140	24	65
(Not obtained)	(52)	-	-	-
Total (or Average)	203	10,788	1,960	61

Table - 6.3 WATER CONSUMPTION VS. INCOME LEVEL

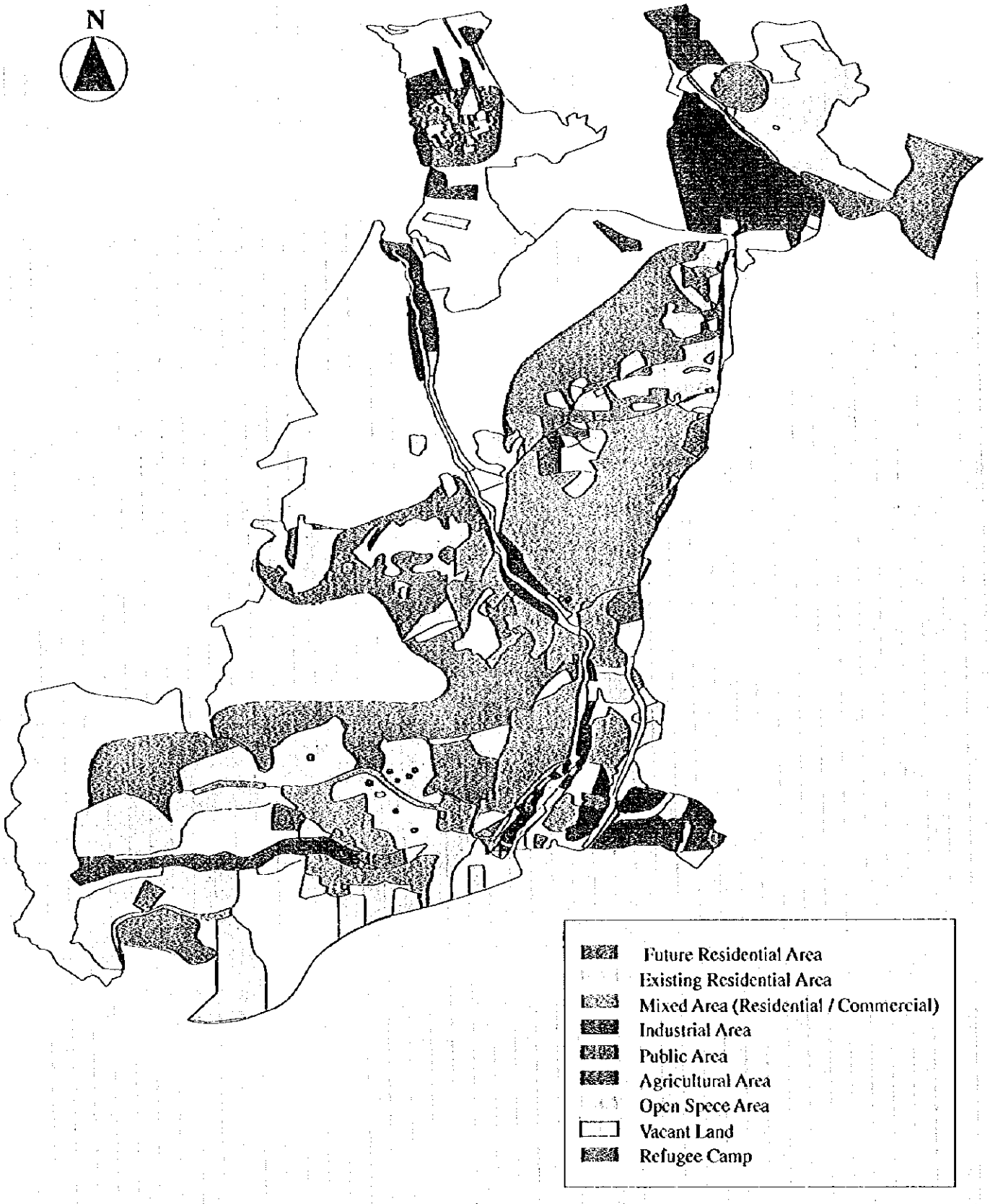
Income	Nos of Samples	Water Consumption (m3/quarter)	Nos. of Family Members (person)	Water Consumption percapita (lpcd)
Less than 100	57	2,651	538	55
100 - 200	113	6,569	1,071	68
200 - 300	23	1,145	248	51
300 - 400	6	281	71	44
400 - 500	1	20	5	44
500 - 600	2	44	13	38
More than 600	1	78	14	62
(Not obtained)	(52)	-	-	-
Total (or Average)	203	10,788	1,960	61

Source: JICA Study Team



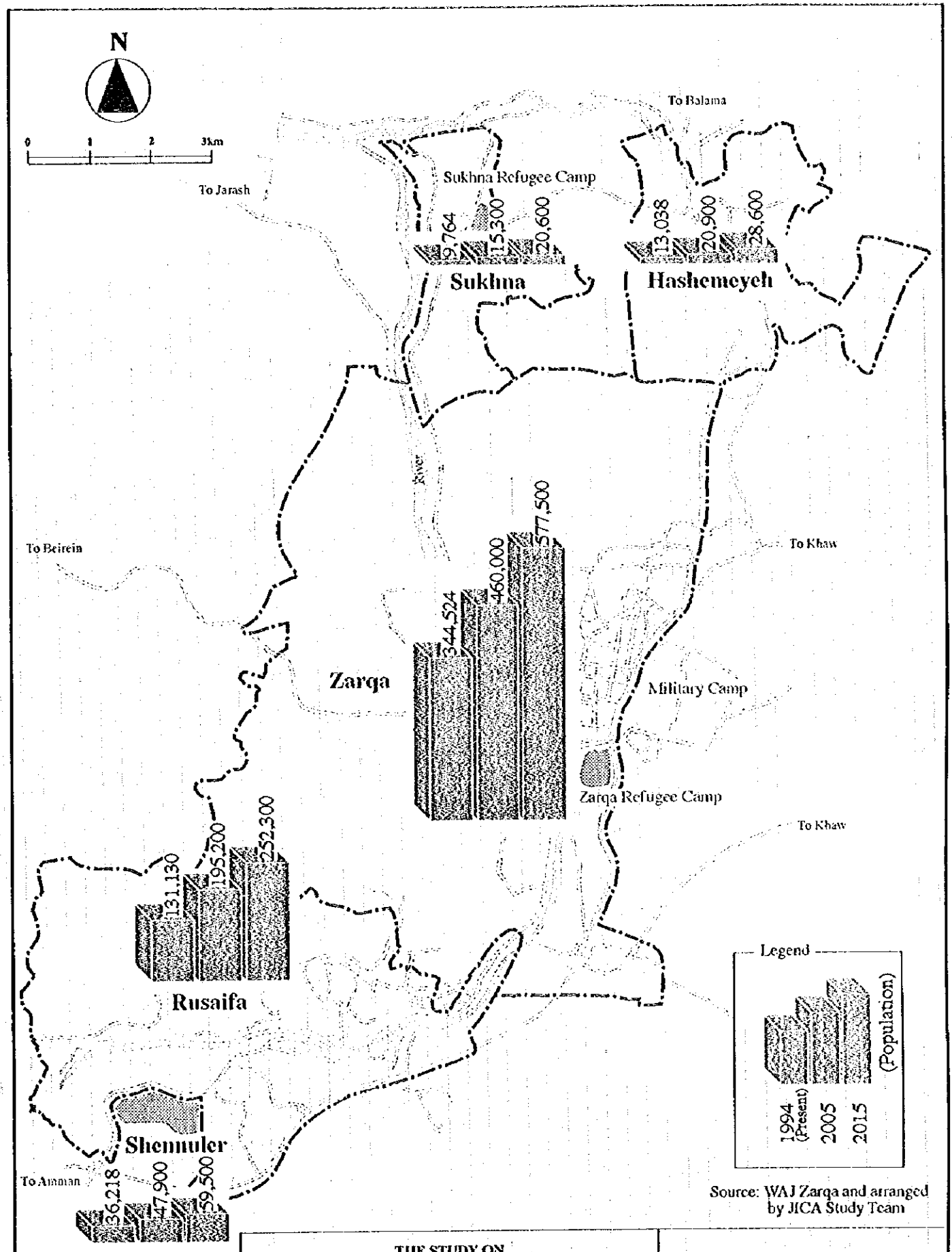
Sources: Aerial Photographs Taken in 1985 and 1992, and Topographic Maps by Royal Jordanian Geographic Center

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 6.1
JAPAN INTERNATIONAL COOPERATION AGENCY	DEVELOPMENT DIRECTION IN THE STUDY AREA



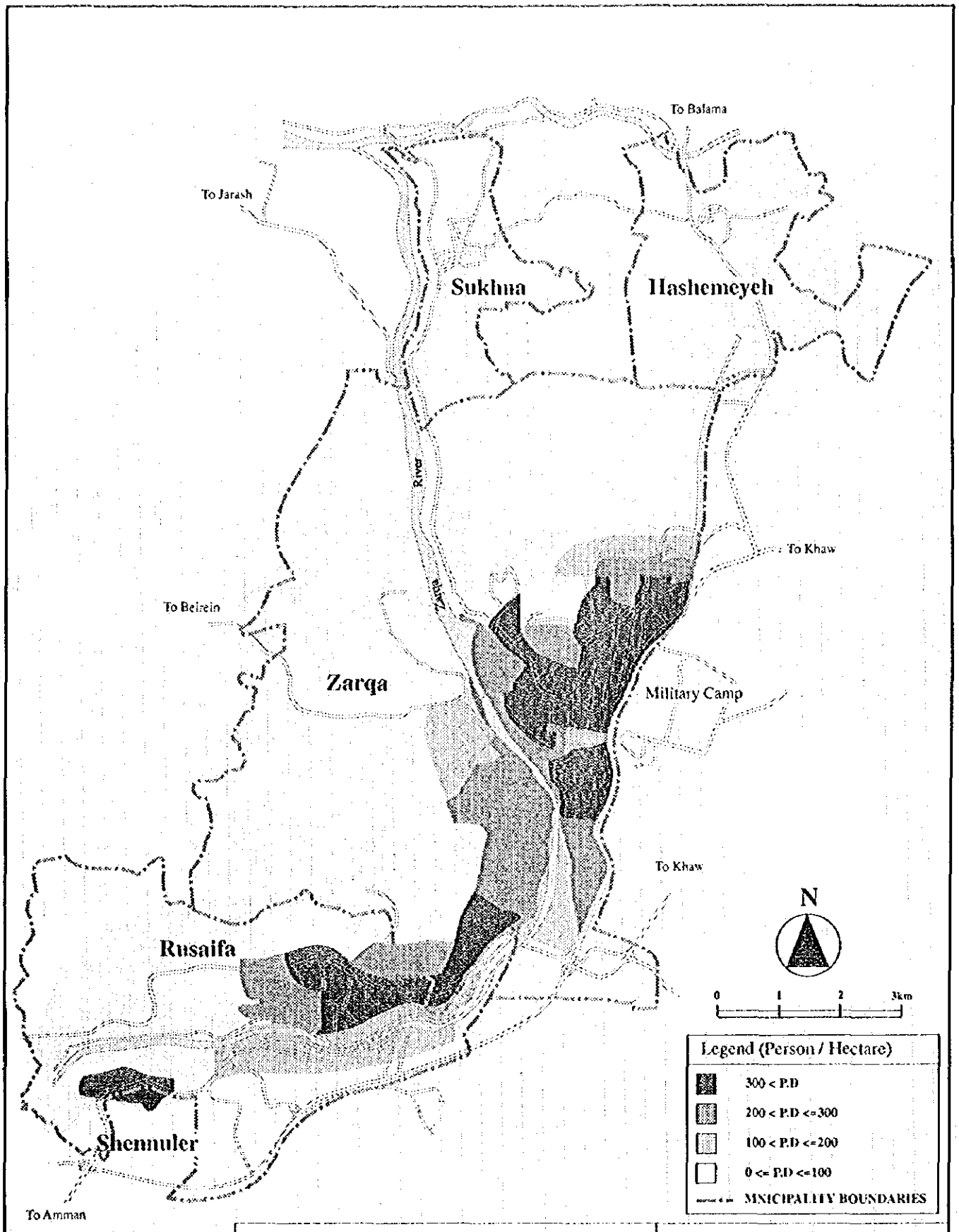
Source: Greater Zarqa Comprehensive Development Plan Study Team

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 6.2
JAPAN INTERNATIONAL COOPERATION AGENCY	Future Land Use, Study Area , 2015



Source: WAJ Zarqa and arranged by JICA Study Team

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 6.3 Present & Projected Population
JAPAN INTERNATIONAL COOPERATION AGENCY	

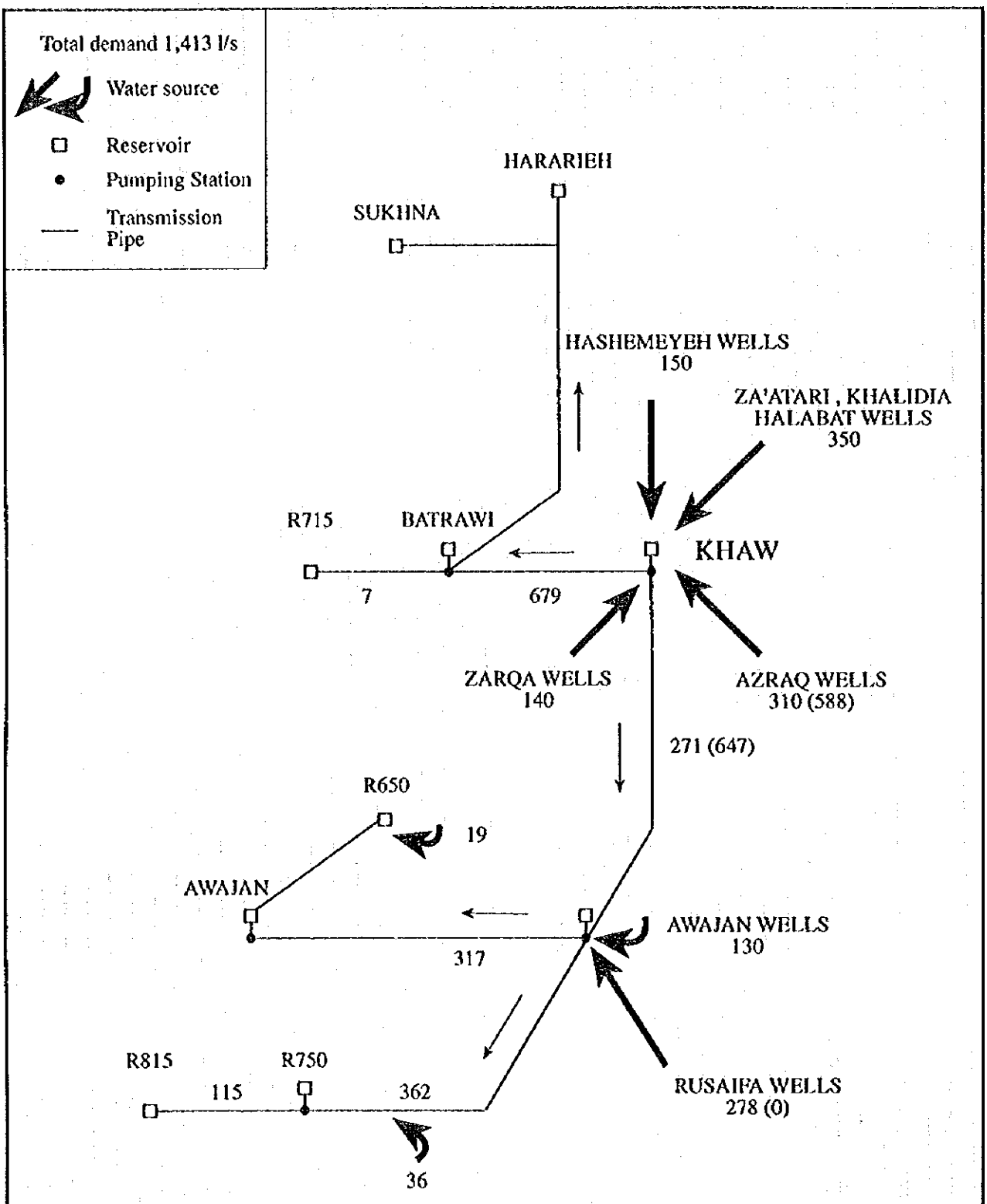


THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT

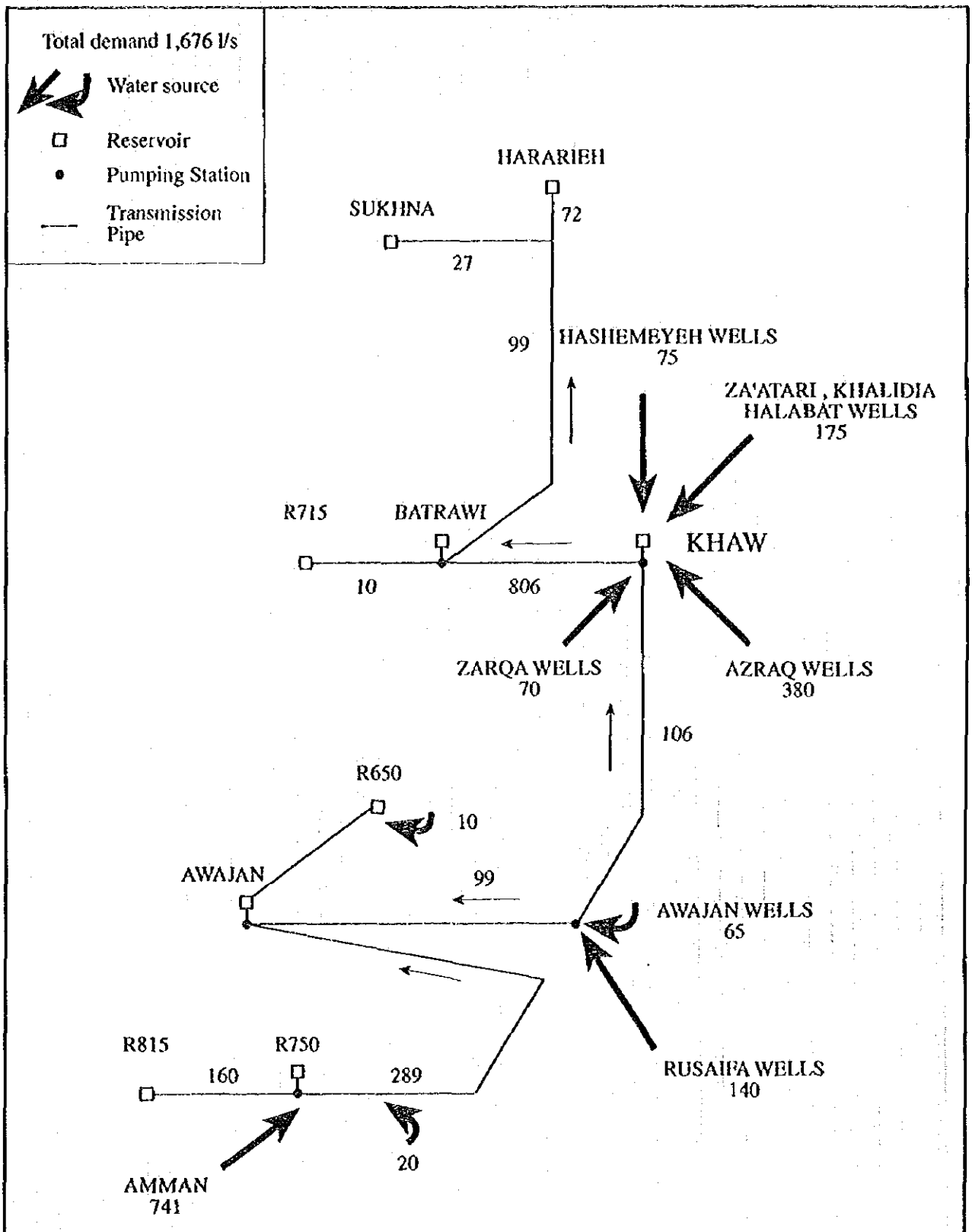
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 6.4

Population density Map 2015



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 6.5 WATER FLOW 2005
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 6.6
JAPAN INTERNATIONAL COOPERATION AGENCY	WATER FLOW 2015

VII. WATER SUPPLY IMPROVEMENT PLAN

VII. WATER SUPPLY IMPROVEMENT PLAN

7.1 DEVELOPMENT CONCEPT

Present water supply conditions in the Study Area lag far behind the need. Per capita consumption is at a low level of 52 lpcd. 30 % of the subscribers feel dissatisfied with water supply services provided by WAJ because of regular rationing in 70 % of the service area, high concentration of TDS and frequent meter reading errors.

WAJ Zarqa is facing the following problems;

1) High UFW (including leakage) ratio
2) Shortage of water resources
3) Inadequate distribution system
4) Low quality of existing water resources

For formulating the long term development plan, the following development concept is applied in due consideration of the present conditions;

1) More Efficient Use of Available Water
2) Improvement of Water Supply System
3) Re-use of Wells with low Water Quality
4) System Expansion for Future

7.1.1 More Efficient Use of Available Water

Though considerable effort has been made for expanding new water resources in the Study Area as well as in Jordan, more efficient and effective use of the available water is sought since availability of renewable water resources is quite limited in the country.

As explained in the preceding chapter, UFW in the Study Area is recorded at 54% . More than half of the water produced is simply wasted. This high UFW ratio is mainly due to illegal connection, leakage loss and meter error and some administrative loss. This high UFW ratio is planned to be reduced to the level of 30% by 2015 by implementing a rehabilitation program.

7.1.2 Improvement of Water Supply System

The existing water supply system is not well laid out because extension and expansion have were made in response to a rapidly increasing demand without overall planning and coordination during the past decades. Inefficient layout of pumping stations and distribution network is a typical.

To make the water supply system more efficient, reorganization of the distribution system is planned including;

1) introduction of a new zoning system
2) separation of distribution pipes from transmission pipe; and
3) optimization of pumping station layout including boosters, and reservoirs

A new zoning system is the most basic and important concept for the improvement plan. The Study Area is divided into 8 zones depending based on the horizontal distances and elevations. The plan is to transmit water to the reservoir in each zone, and distribute by gravity to the subscribers in the respective zone. Efficiency will increase and operating costs will decrease.

7.1.3 Re-use of Wells

Resuming operations at wells which are out of operation due to the deteriorated water quality, will help ease the severe water shortage in Zarqa district. The critical quality parameters are TDS and NO_3. Water quality can be improved with appropriate treatment, however, removal of TDS requires the costly RO method. Blending with better quality water is proposed to minimize costs since these wells will again stop production when new resources are provided to Zarqa..

Re-use of the Zarqa wells will alleviate water the deficit situation considerably. Their production capacity is almost equal to the Hasheneyeh and Awajan wells. However, this measure has a short 10-year life cycle and will no longer be required when new water resources are supplied.

7.1.4 System Expansion for Future

The improvement plan will see to the expansion of the system to prepare for future demand increases. Preparation of the expansion plan will require consideration of the location of the water sources which will be changing during the planning period

Additional water resources are being explored. These include the development of Yarmouk river (related to the Peace Treaty), and the development of Disi aquifer. The projects are aimed at increasing water supply for the whole of Jordan but a major portion will be definitely allocated to Amman's demand. When the allocation is made, the water currently exported from Zarqa can be reallocated to Zarqa exclusive use. Even the quantity imported from Mafraq can be increased for Zarqa use in the future with the exchange of water from the Yarmouk river. Therefore, it is assumed for the long-term development plan that Khaw pumping station together with the 600 mm Khaw - Amman pipeline are for the exclusive use of Zarqa.

7.2 REHABILITATION PLAN

This subsection deals with pipeline rehabilitation including replacement of house connections. The operation and maintenance plan for these pipelines is discussed in Section 7.4. UFW survey results are shown in Appendix H.

7.2.1 Transmission and Distribution Pipe Network

As discussed in Chapter IV, leaks are occurring mostly from the old distribution and service mains which were laid in 1960's and 1970's and have been left without proper maintenance. Leakage from new large diameter transmission and distribution mains installed in 1980's and 1990's are relatively small.

In case the leakage ratio is high, replacement is more economical than repair. To establish the cost benefits, the cost of rehabilitation is compared to the cost of producing water.

1) Rehabilitation Area

Results of UFW survey and the data available on the pipeline rehabilitation carried out so far by WAJ Zarqa are useful information for identifying priority areas for the pipe rehabilitation plan.

WAJ Zarqa has been exerting efforts for replacing the old distribution pipe network since 1990. Because of the limited resources from the Central Government the progress of pipeline rehabilitation has not met the expectations of WAJ Zarqa.

Deteriorated pipelines which have not already been rehabilitated by WAJ are proposed for rehabilitation as presented in Fig.- 7.1. Pipes in the following proposed rehabilitation areas were all installed in 1960s.

Al-Ghourieyeh and Hai Hussein (Zarqa): Both areas are the most populated areas of Zarqa Municipality. Water pressure in these areas averages 6.5kg/cm2. This high pressure is explained by its location adjacent to the Zarqa Pumping Station. Most of the deteriorated lines are ductile iron pipe, 100 - 150 mm in diameter which are installed in 1966. Pipelines of 75 mm or less including house connections, which have been replaced recently by WAJ, are in good condition.

Zarqa Camp and Janna: black steel pipes and galvanized steel pipes of 50 - 200 mm in diameter were installed in 1960s, some of which are partly rehabilitated in 1980s and 1990s.

Sukhna: Most of the piping installed in refugee camp are deteriorated. Materials used are black steel and galvanized steel pipes of 50 - 100 mm in diameter, installed in 1960s.

Hashemeyeh: The area receives water from Khaw pumping station. Most pipelines were laid in the 1960s except some service mains and connections which were installed in 1980's. Pipe materials are black steel and galvanized steel, 50 - 200 mm in diameter, which are all deteriorated. Although some heavily deteriorated pipes have been replaced by WAJ, most pipelines have never been repaired.

West Awajan, Jabal Al Shamali, Hai Al Hussain and Hai Al Aratfah (old Rusaifa): These densely populated areas are within the municipal boundary of old Rusaifa. Pipelines were installed in the 1960s - 1970s. Service and distribution mains of black steel and galvanized steel, 75 - 100 mm in diameter, have been left unrepaired. Pipes larger than 100 mm in diameter were rehabilitated from 1985 to 1987.

Schennuler Camp: Schennuler camp has a high population density. WAJ Zarqa engineers report that distribution mains are black steel, 150 mm and 100 mm in diameter, installed in 1960s, all of which are deteriorated.

Priority for rehabilitation shall be given those lines that are in service in high water pressure zones and were installed in 1960's. They are pipelines in Al Ghourieyeh & Hai Hussein in Zarqa, West Awajan, Jabal Al Shamali in Rusaifa.

2) Pipe Materials Recommended

There are several materials that have been used for the pipe network. Most typically used are pipes made of black steel, ductile case iron, polyethylene and galvanized steel. Each pipe material has its own characteristics. Ductile cast iron and polyethylene pipes are the most corrosion resistant materials. Polyethylene pipes is not recommended for large diameter distribution and service mains because it is too flexible. In view of the cost, installation method and maintenance aspect, ductile cast iron pipe is the most appropriate and economical material for larger mains. Polyethylene is best for small diameter pipelines.

3) Pipe Length

WAJ has very limited information available regarding the old distribution pipe network which was built in the 1960s. In the case where pipe length is not known, it is assumed from the system layout and the UFW survey maps prepared under the current study. Pipe length of the existing distribution and service mains laid in alleys and roads is measured on the survey map and summed up for each diameter pipe. The length thus obtained is proportionally allocated to the whole rehabilitation area. The following are the resulting estimates :

Scope of Pipe Rehabilitation

Name of Area	Area (km^2) or Nos. of Subscribers	150 mm DIP Pipe Length (m)	100 mm DIP Pipe Length (m)	63 mm polyethylene Pipe Length (m)
Al Goarieyeh[1)]	0.6 km^2	2,800 m	1,100 m	-
Hai Hussein	0.5 km^2	3,000 m	900 m	-
Zarqa Camp & Janaa	2,300 subscribers	1,100 m	7,800 m	-
Sukhna	800 subscribers[2)]	-	2,800 m	4,700 m [3)]
Hashemeyeh	1,700 subscribers[2)]	3,900 m	9,100 m	8,400 m [3)]
West Awajan	2,000 subscribers	-	12,550 m	-
Al Jabal Al Shamali	3,000 subscribers	-	18,250 m	-
Hai Al Aratfah & Hai Al Hussein[3)]	2,900 subscribers	-	18,100 m	-
Shennuler	0.9 km^2	6,600 m	4,400 m	-
Total		17,400 m	75,000 m	13,100 m

1) It contains ø150mm in Abu Abdeh Street and Al Jazair Street and ø100mm in Al Ordon Street.
2) It was assumed that around 70% of the total subscribers are residing in old municipal center in Sukhna and Hashemeyeh.
3) It contains ø100mm black steel mains in Prince Hasan Street and Al Bokhari Street.
4) In smaller municipalities of Sukhna and Hashemeyeh, diameter of the existing distribution mains is 100mm. Therefore, 50mm service mains are considered appropriate.

7.2.2 House Connections

House connections have been replaced intensively by WAJ since 1990. But there are still a large number of the old service pipelines left without repair. The service pipelines are mainly galvanized steel 3/4" in diameter. They are also one the major sources of leakage according to UFW survey. Therefore, replacement of connections which were made in the 1960's is considered urgent.

As is currently practiced by WAJ polyethylene is the recommended material for service pipelines. Special attention is required for meter installation. All meters should be enclosed inside a steel boxes and installed on the customers yard, and not in the home.

Based on the WAJ rehabilitation program executed so far, the number and length of house connections to be urgently replaced is determined and the results are given in a table below:

Nos. and Length of House Connections for Replacement

Area	Number of Customer Meters	Length of Service Pipelines**
Sukhna	800	32mm x 12km*
Hashemeyeh	1,700	32mm x 26km*
West Awajan	2,000	32mm x 20km
Zarqa Camp & Janaa	2,300	32mm x 23km
Al Jabal Al Shamali	3,000	32mm x 30km
Hai Al Aratfah & Hai Al Hussein	2,900	32mm x 29km
Total	12,700	32mm x 140km

* Average service pipeline length per connection, 10m, was used for the estimates except for Sukhna and Hashemeyeh where 15 m was applied.