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CHAPTER 6
WATER TRANSFER/SUPPLY SYSTEM

CHAPTER 6 WATER TRANSFER/SUPPLY SYSTEM

6.1 Current Water Transfer/Supply System in 12 Governorates

6.1.1 Current Water Transferred and Supplied Volume

The water sources for each Governorate are categorized as follows.

- Surface water through King Abdullah Canal (KAC)
- Groundwater and/or spring water supplied in the Governorate [Internal Source]
- Groundwater and/or springs imported from other Governorate(s) [External Source]

Some Governorates are currently supplying some amount of water to other Governorates. The latest record of fresh water volume supplied to each Governorate is shown in Table 6.1.1 -1.

Table 6.1.1-1 Fresh Water Supply in Each Governorate in 1998

(Unit : MCM/year)

No.	ID	Governorate	Internal Source ①	Amount Supplied by other Governorate(s) ② from KAC	③	Amount Supplying to other Governorate(s) ④	Amount Supplied in the Governorate ①+②+③−④
1	AM	Amman	31.5	32.4	24.0	4.6	83.3
2	ZA	Zarqa	36.6		15.9	19.5	33.0
3	MF	Mafraq	37.9		0.2	19.1	19.0
4	IR	Irbid	29.9		2.9	1.5	31.3
5	AJ	Ajloun	3.2		0.6	0	3.8
6	JA	Jerash	1.8		1.6	0.1	3.3
7	BA	Balqa	10.8	4.9	0.6	0.7	15.6
8	MA	Madaba	10.0		3.8	5.1	8.7
9	KA	Karak	12.7		0.2	0	12.9
10	MN	Ma'an	8.4		0	0.6	7.8
11	TA	Tafilah	1.7		0.6	0	2.3
12	AQ	Aqaba	14.0		0	0	14.0
Total			198.5 (Wells+Springs)	37.3	50.4	51.2	235.0

Data source : WIS Data of WAJ (1998)

As shown in Fig. 6.1.2.1-1, there are transfer lines that carry municipal water from one Governorate to another (hereinafter referred to as "Inter-Governorate Transfer Lines").

The transferred volumes through Inter-Governorate transfer lines are shown in Table 6.1.1-2 and Fig 6.1.1-1.

Table 6.1.1-2 Inter-Governorate Fresh Water Transfer

(#1)

													Upper / Lower	MCM/year m3/hr
CODE	to AM	to ZA	to MF	to IR	to AJ	to JA	to BA	to MA	to KA	to MN	to TA	to AQ	Total In	Total Out
AM	0	0	0	0	0	0	0.6	3.8	0.2	0	0	0	56.4	4.6
							63	436	26					
ZA	18.9	0	0.3	0	0	0.4	0	0	0	0	0	0	15.9	19.5
	2,159		29			43								
MF	0	15.9	0	2.9	0	0.3	0	0	0	0	0	0	0.3	19.1
		1,818		330		37								
IR	0	0	0	0	0.6	0.9	0	0	0	0	0	0	2.9	1.5
					66	99								
AJ	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0
JA	0	0	0	0	0	0	0.1	0	0	0	0	0	1.6	0.1
							13							
BA	32.4	0	0	0	0	0	#2 4.9	0	0	0	0	0	0.7	32.4
	3,697						556							
MA	5.1	0	0	0	0	0	0	0	0	0	0	0	3.8	5.1
	582													
KA	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
MN	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0.6
											64			
TA	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0
AQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	56.4	15.9	0.3	2.9	0.6	1.6	#2 0.7	3.8	0.2	0	0.6	0	82.9	82.9
							5.5							

Notes:
1. Fresh water includes (municipal + industrial + touristic) water.
2. Surface water from KAC to Balqa does not include in Total In and Total Out.

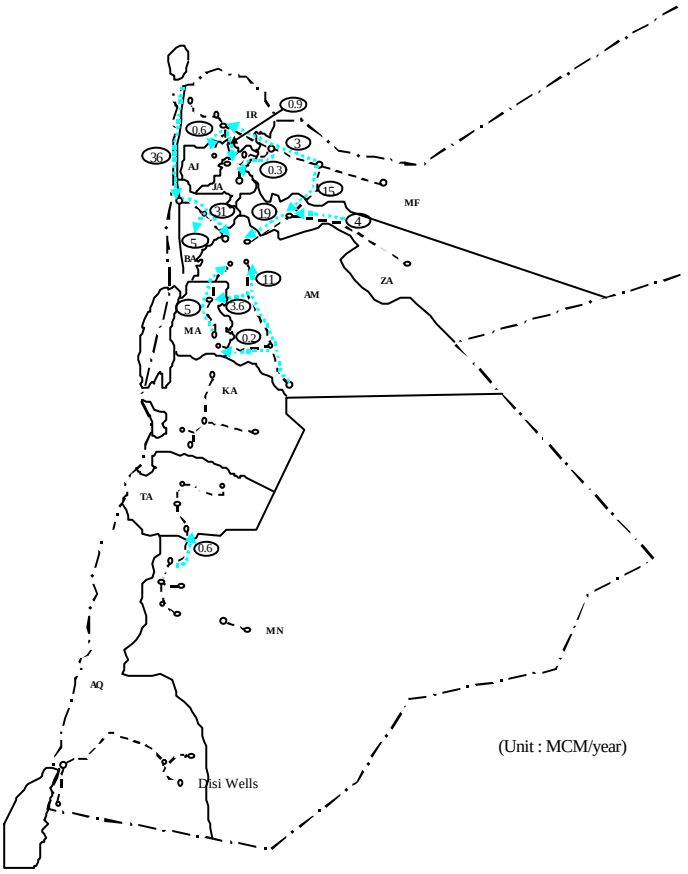

Fig. 6.1.1-1 Fresh Water Flow through Inter-Governorate Transfer Lines

6.1.2 Current Water Transfer/Supply System

6.1.2.1 Surface Water Transfer System (Deir Alla-Zai-Dabouq Transfer Line)

The Deir Alla-Zai-Dabouq transfer line is the only main surface water transfer pipeline from King Abdulla Canal to the Greater Amman area. The surface water from the Deir Alla intake pump station is transferred to the Zai Water Treatment Plant through lifting pump stations. The treated water is transmitted to the Dabouq Reservoir and distributed to the Greater Amman area. The transfer system of Deir Alla-Zai-Dabouq is shown in Fig. 6.1.2.1-1.

The Deir Alla-Zai-Dabouq transfer system consists of an intake pump station, 4 lifting pump stations, a water treatment plant, a transmission pump station and a water reservoir. At present, the system has a capacity of 125,000m^3/day (45 MCM/year) and is being expanded to 250,000m^3/day (90 MCM/year) by the Japanese and German assistance program. The expansion facilities will be ready for operation in 2002.

The current and future facilities of the surface water transfer system are shown in Table 6.1.2.1-1.

Table 6.1.2.1-1 Current and Future Facilities of Deir Alla-Zai-Dabouq Tansfer System

Facility	Current System	Future System (operation will start in 2002)
Transfer Line	[From Deir Alla to Zai WTP] - φ1200mm x 1 pipeline	[From Deir Alla to Zai WTP] - φ1200mm x 1 pipeline
	[From Zai WTP to Dabouq] - φ1200 x 1 pipeline	[From Zai WTP to Dabouq] - φ1200 x 2 pipelines
Pump Station	Intake pump station - 2,600 m^3/h x 3 units	Intake pump station 2,600m^3/h x 6 units
	Booster pump station (No.1 to 4 Pump Station) - 2,600 m^3/h x 3 units	Booster pump station (No.1 to 4 Pump Station) - 2,600 m^3/h x 6 units
	Transmission pump station (No.5 Pump Station) - 2,600 m^3/h x 3 units	Transmission pump station (No.5 Pump Station) - 2,600 m^3/h x 6 units
Water Treatment Plant	Production capacity - 125,000m^3/day (45 MCM/year)	Production capacity - 250, 000m^3/day (90 MCM/year)

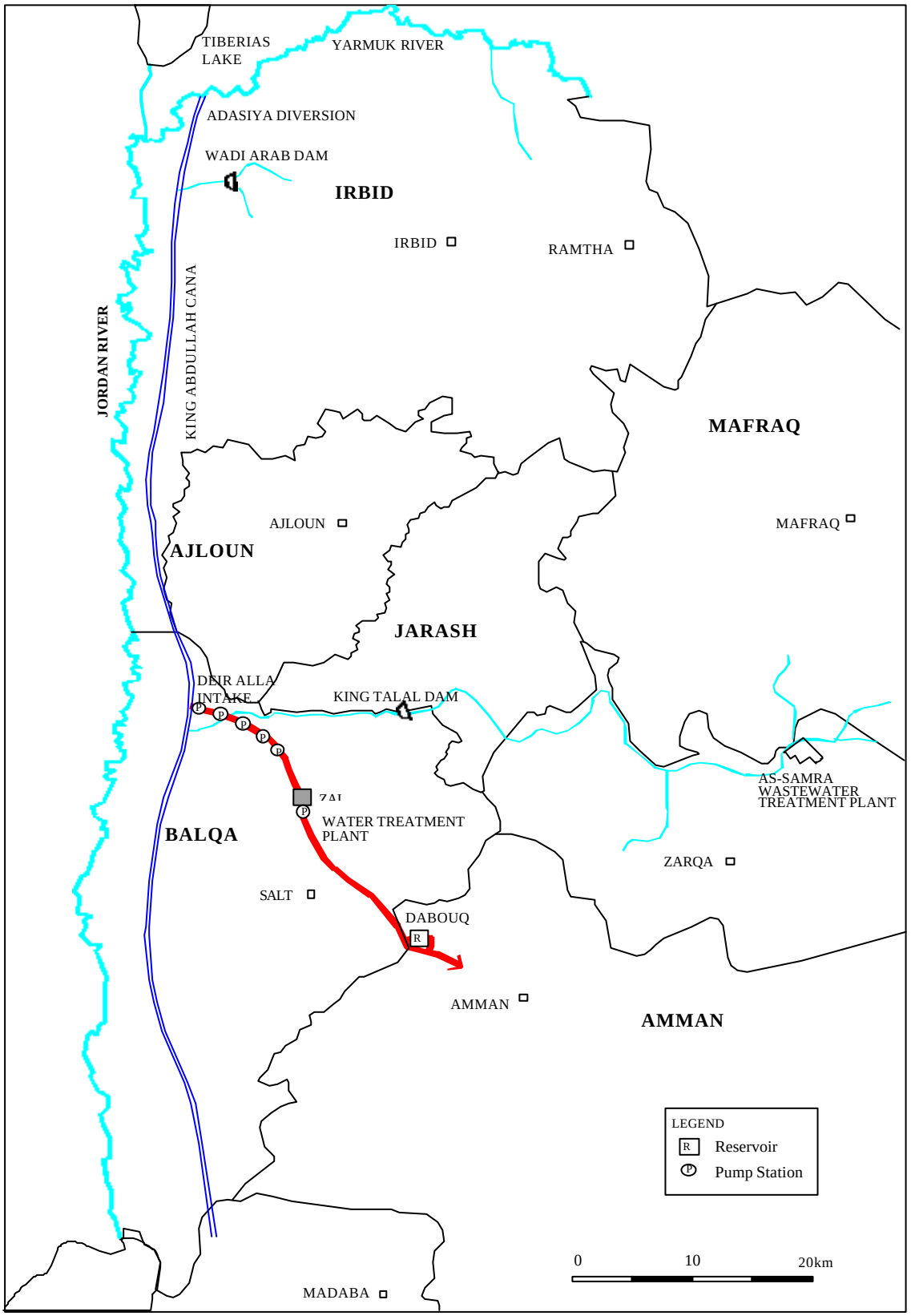

Fig. 6.1.2.1-1 Surface Water Transfer System (Deir Alla-Zai-Dabouq Transfer Line)

6.1.2.2 Groundwater Transfer System

The current groundwater transfer system in each Governorate is shown in Fig. 6.1.2.2-1 to 6.1.2.2-8 below.

(1) Amman Governorate

As shown in Table 6.1.1-2, the Amman Governorate depends substantially on the surface water from KAC and the groundwater from other Governorates. The current groundwater transfer system in the Governorate is shown in Fig. 6.1.2.2-1.

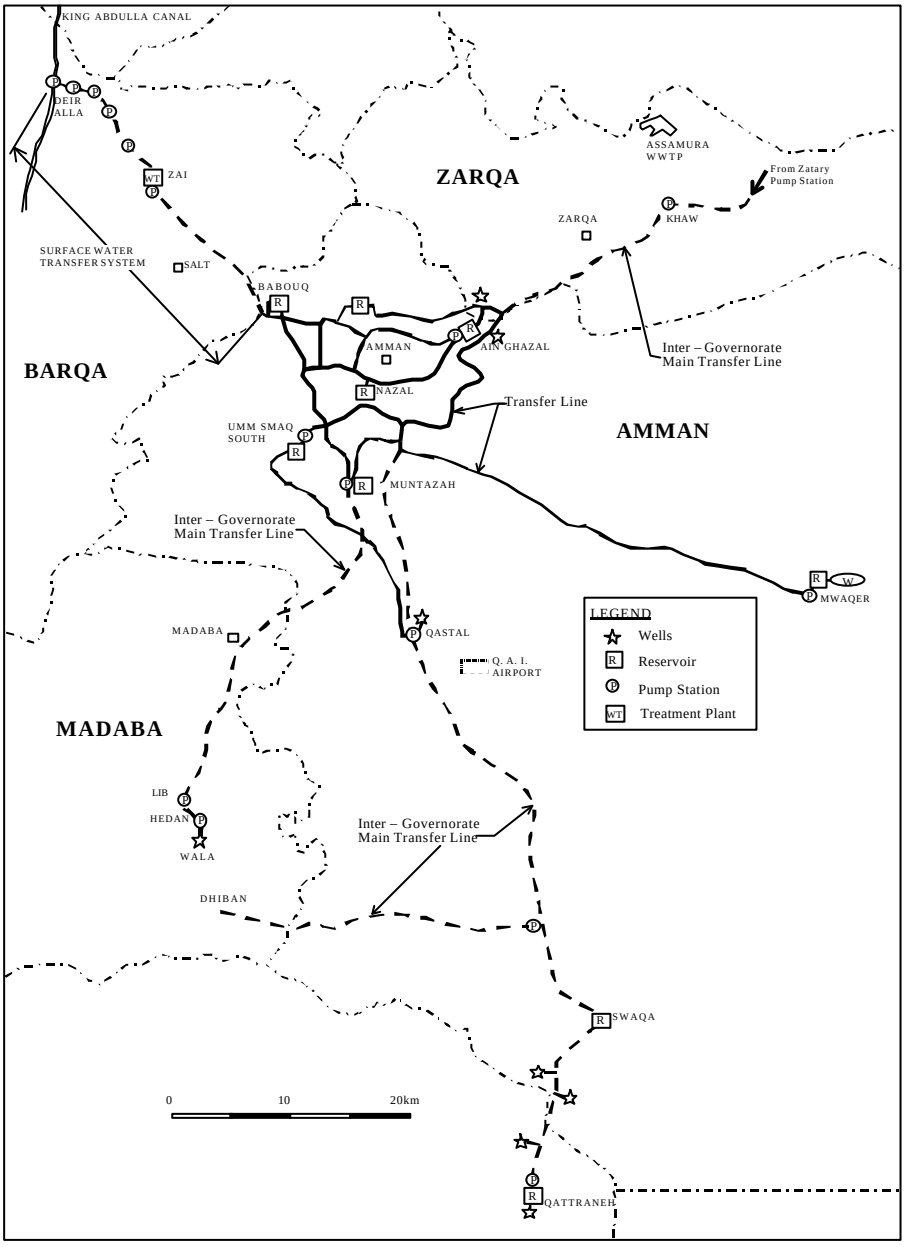

Fig. 6.1.2.2-1 Groundwater Transfer System in the Amman Governorate

(2) Zarqa Governorate

The main water source of the Zarqa Governorate is from groundwater wells in Azraq. This Governorate is now receiving water from the Mafraq Governorate and supplying to Amman. The groundwater transfer system of the Governorate is shown in Fig. 6.1.2.2-2.

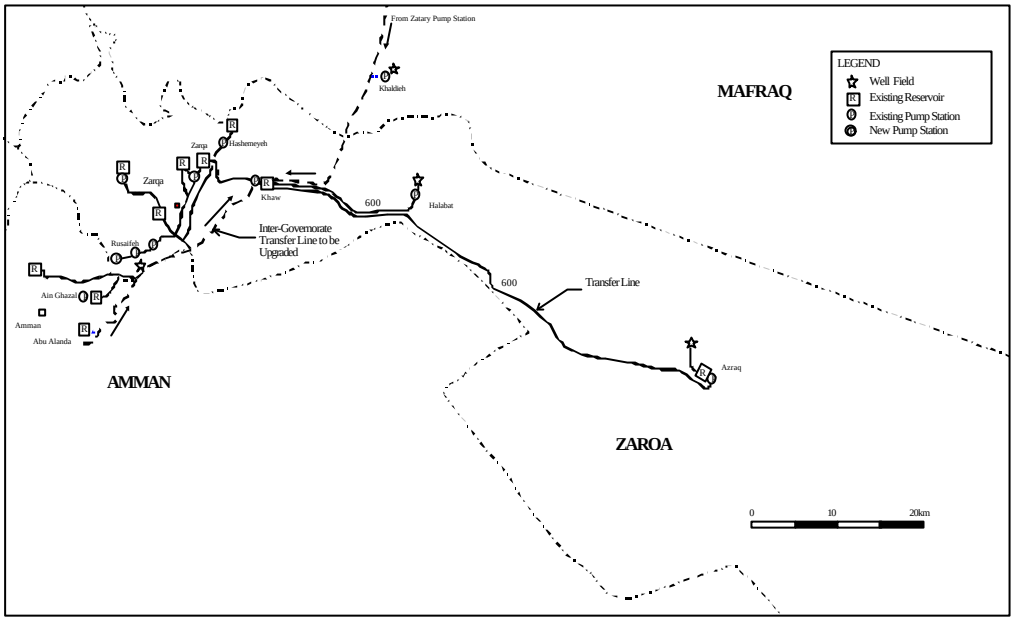

Fig. 6.1.2.2-2 Groundwater Transfer System in Zarqa Governorate

(3) Mafraq Governorate

The Mafraq Governorate is now exporting about half of the produced water in the Governorate to Amman, Irbid and Jerash. The main water source is groundwater wells along the Iraqi Road. The groundwater transfer system in the Governorate is shown in Fig. 6.1.2.2-3

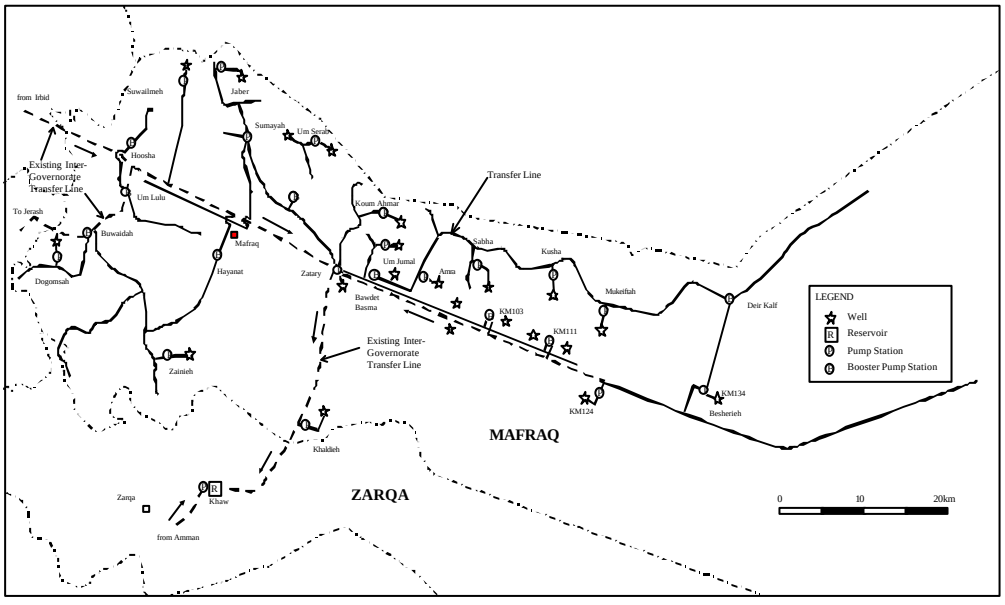

Fig. 6.1.2.2-3 Groundwater Transfer System in the Mafraq Governorate

(4) Irbid, Ajloun and Jerash Governorates

The water transfer system in the Irbid, Ajloun and Jerash Governorates is interconnected, as shown in Fig. 6.1.2.2-4.

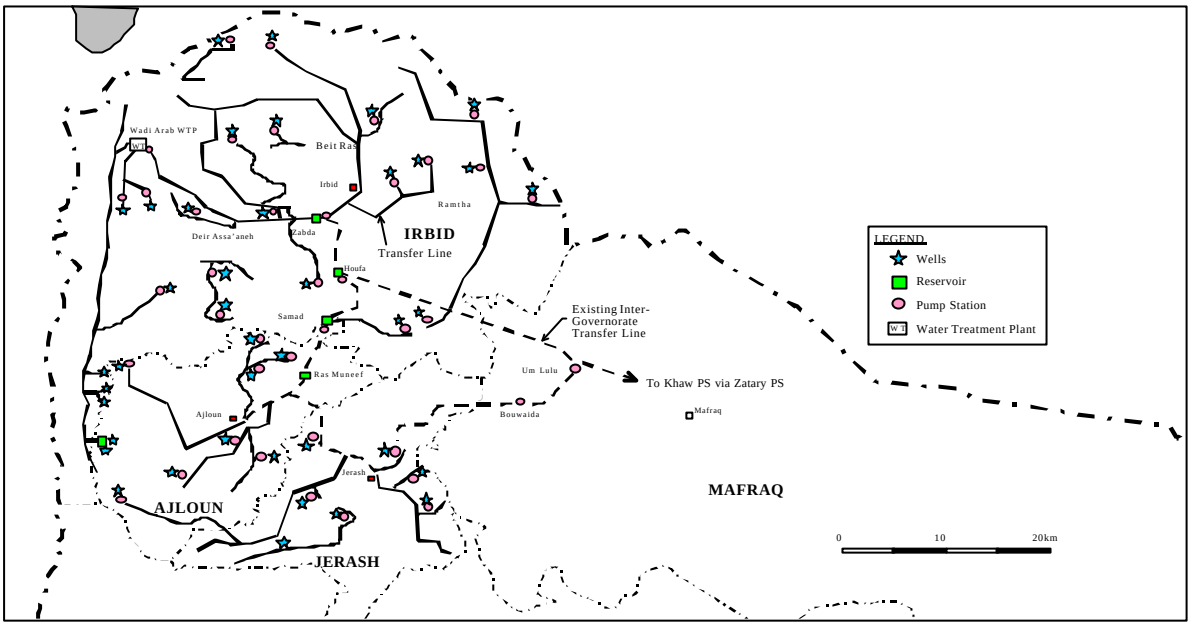

Fig. 6.1.2.2-4 Current Water Transfer System in Irbid, Ajloun and Jerash

The main water sources in Irbid are groundwater wells. There is one water treatment plant (WTP) at the Wadi Arab Dam. Most of the water from the Wadi Arab WTP is transferred to Irbid city and some to the Ajloun and Jerash Governorates.

The water sources of Ajloun and Jerash are groundwater wells and springs. As shown in Table 6.1.1-2, Ajloun and Jerash are now importing some water from the Irbid and Mafraq Governorates.

(5) Balqa and Madaba Governorates

The main water source is surface water from KAC for Balqa and groundwater for Madaba. The Madaba Governorate is now exporting water to Amman. The groundwater transfer system in these Governorate is shown in Fig. 6.1.2.2-5.

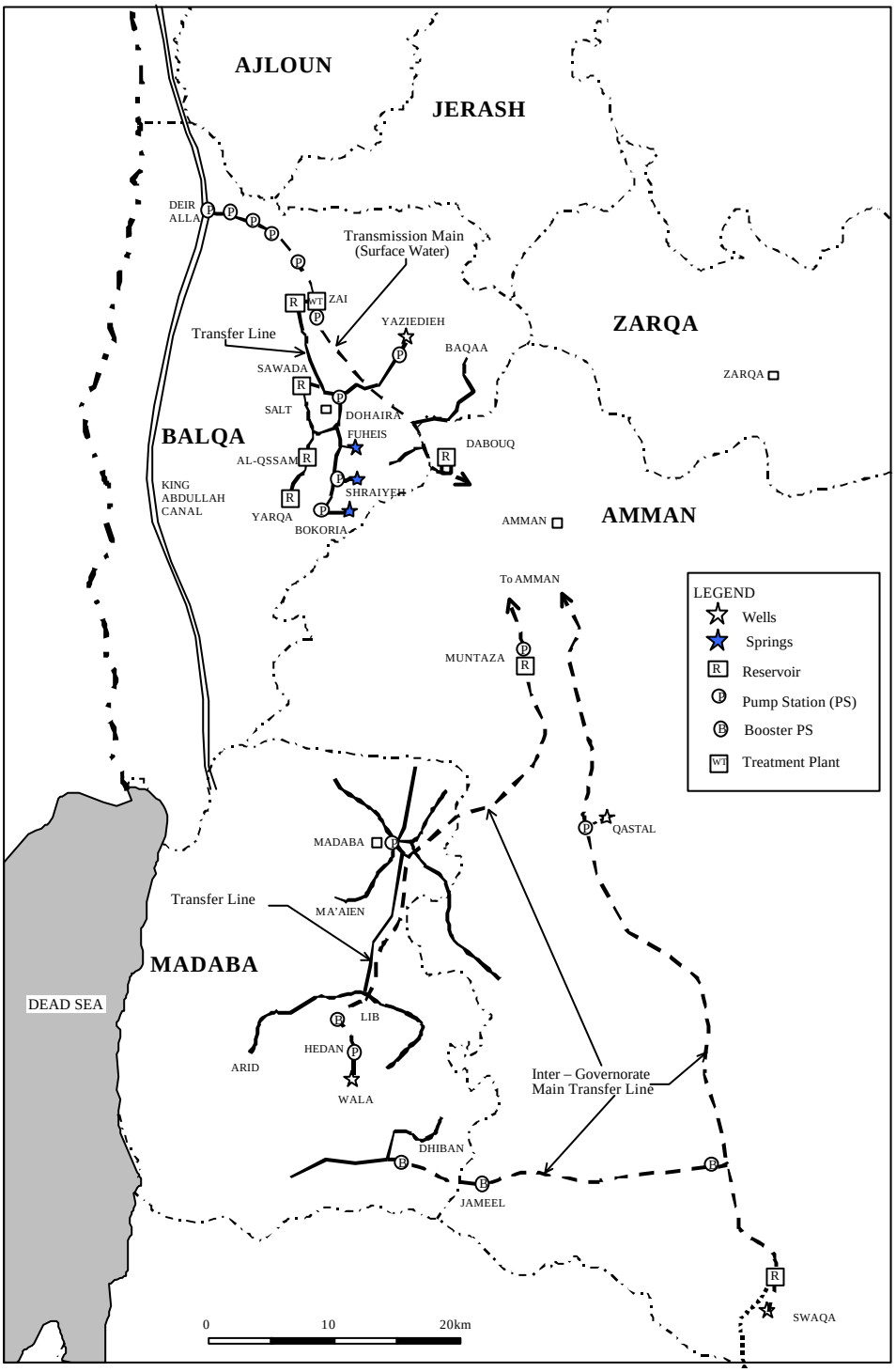

Fig. 6.1.2.2-5 Groundwater Transfer System in the Balqa and Madaba Governorates

(6) Karak Governorate

The main water source of the Karak Governorate is groundwater. The groundwater transfer system in the Governorate is shown in Fig. 6.1.2.2-6.

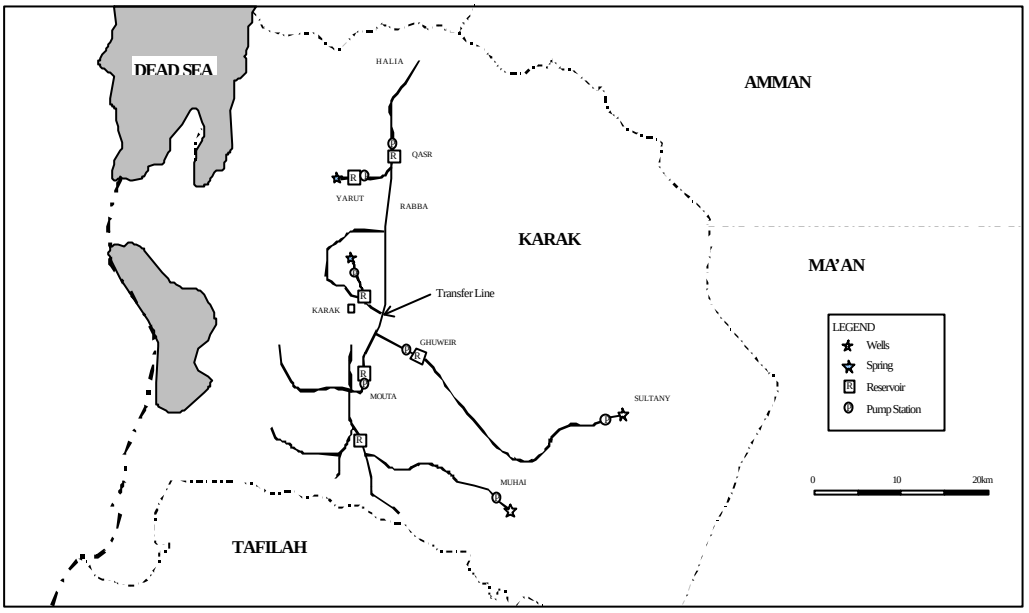

Fig. 6.1.2.2-6 Groundwater Transfer System in the Karak Governorate

(7) Tafilah Governorate

The main water source of the Tafilah Governorate is groundwater. The groundwater transfer system in the Governorate is show in Fig. 6.1.2.2-7.

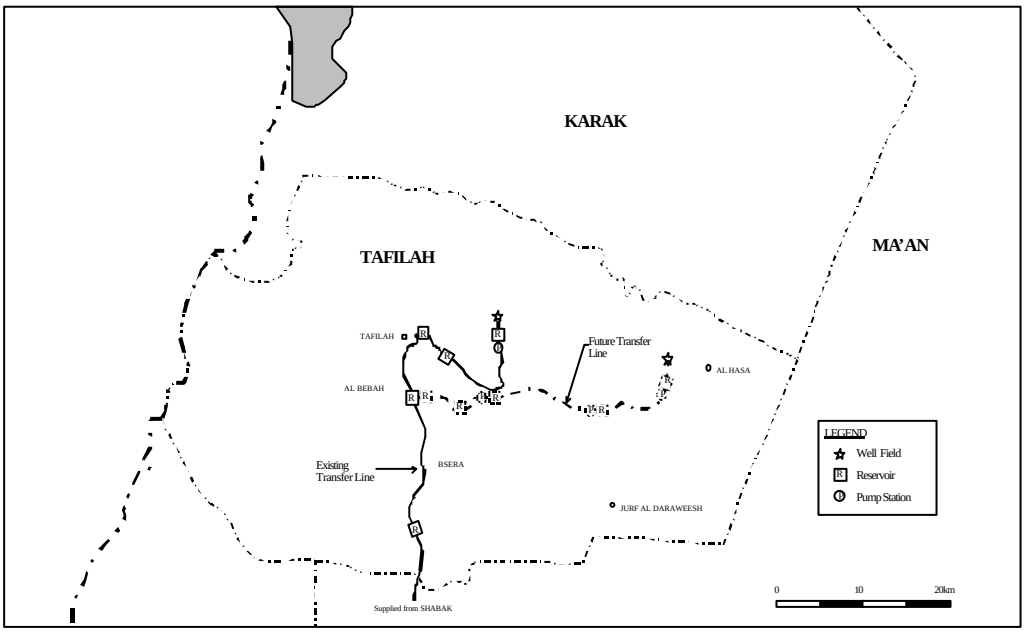

Fig. 6.1.2.2-7 Ground Water System in the Tafilah Governorate

(8) Ma'an Governorate

The main water source of the Ma'an Governorate is groundwater from the western area. At present, the Governorate is not exporting any water to other Governorates. However, it will export fossil groundwater from the Disi well field to Amman, Madaba and Zarqa in the future.

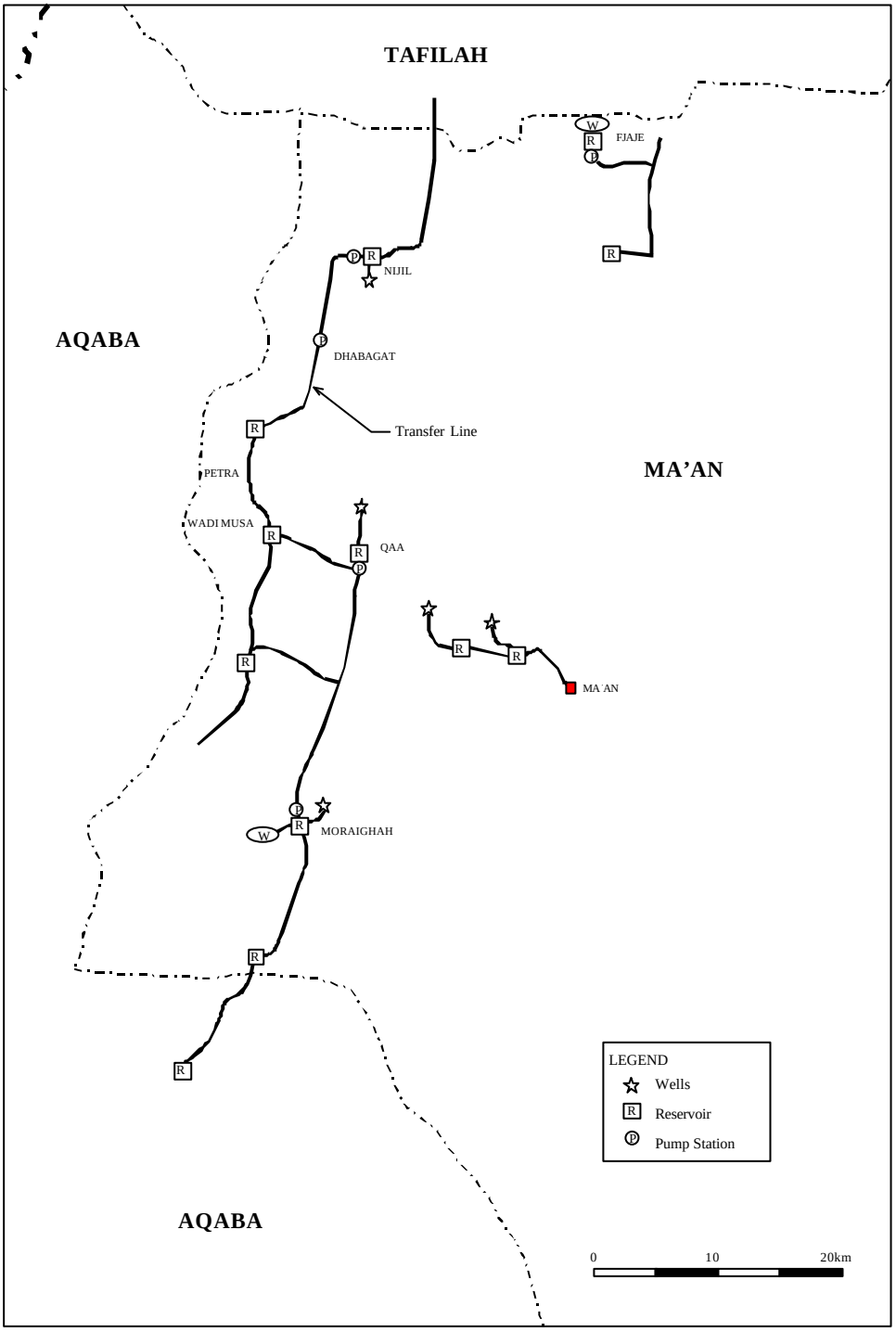

Fig. 6.1.2.2-8 Groundwater Transfer System in the Ma'an Governorate

(9) Aqaba Governorate

The main water source of the Aqaba Governorate is now fossil groundwater from the Disi well field. However, in future, the Governorate will be supplied with water from the seawater desalination plant . The fossil groundwater will be exported mainly to the Greater Amman area.

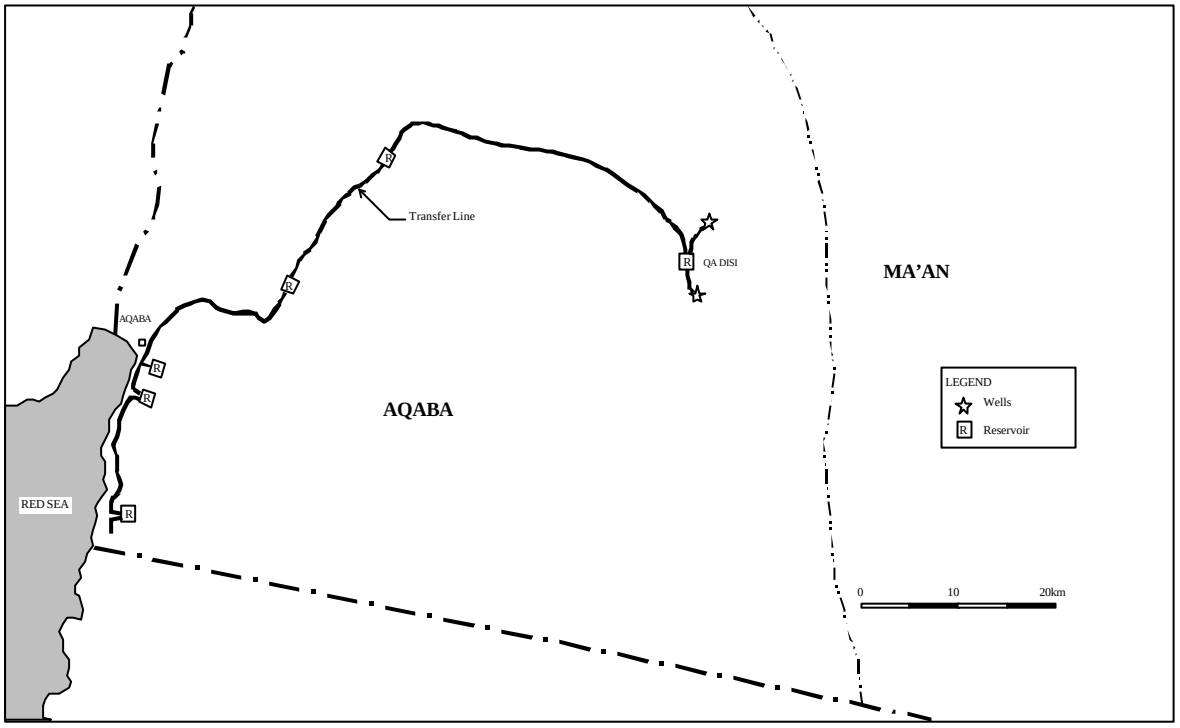

Fig. 6.1.2.2-9 Groundwater Transfer System in the Aqaba Governorate

6.1.3 Hydraulic Analysis on Current Inter-Governorate Transfer Lines

The current main Inter-Governorate water transfer systems are shown on Fig. 6.1.3-1 below.

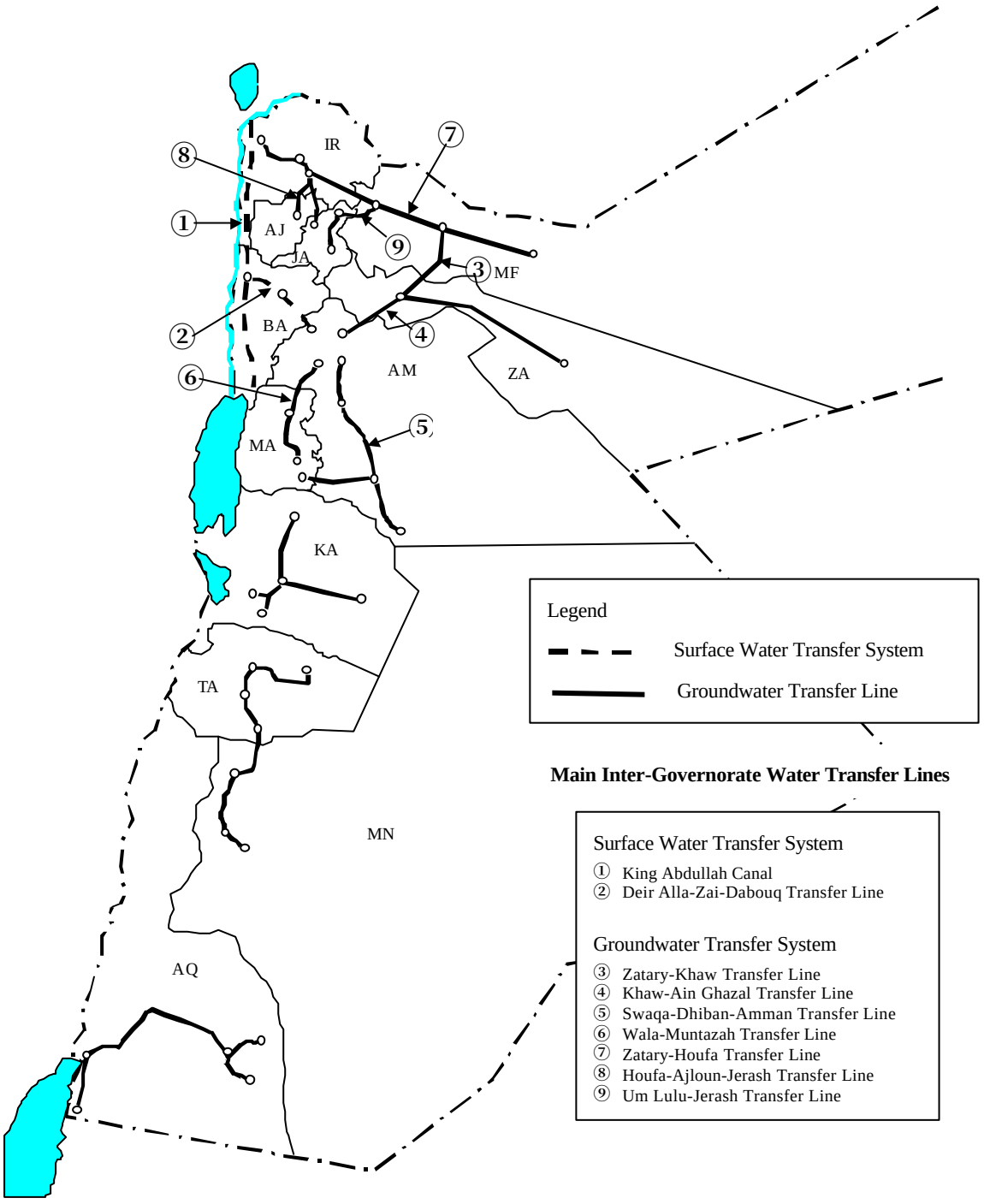

Fig. 6.1.3-1 Current Main Inter-Governorate Water Transfer Systems

6.1.3.1 Calculation Models

As mentioned in 6.1, the water transfer lines that supply water from one Governorate to another are called "Inter-Governorate Transfer Lines" in the Study. The following are the current main Inter-Governorate transfer lines.

Table 6.2.1-1 Current Main Inter-Governorate Transfer Lines

	Transfer Line Name	Reference Figure No. for Calculation Model
To Amman	Deir Alla-Zai-Dabouq transfer line	Fig. 6.1.3.1-1
	Khaw-Ain Ghazar transfer line	Fig. 6.1.3.1-2
	Swaqa-South Amman transfer line	Fig. 6.1.3.1-3
	Wala-Muntazah transfer line	Fig. 6.1.3.1-3
To Zarqa	Zatary-Khaw transfer line	Fig. 6.1.3.1-4
To Irbid	Zatary-Houfa transfer line	Fig. 6.1.3.1-5
To Ajoun and Jerash	Um Lulu-East Jerash transfer line	Fig. 6.1.3.1-6
	Houfa-Ajloun-Jerash transfer line	Fig. 6.1.3.1-6

The existing situation has been examined using hydraulic analysis. The models for the hydraulic analysis are shown on Fig. 6.1.3.1-1 to 6.1.3.1-6.

(1) Transfer Lines to Greater Amman

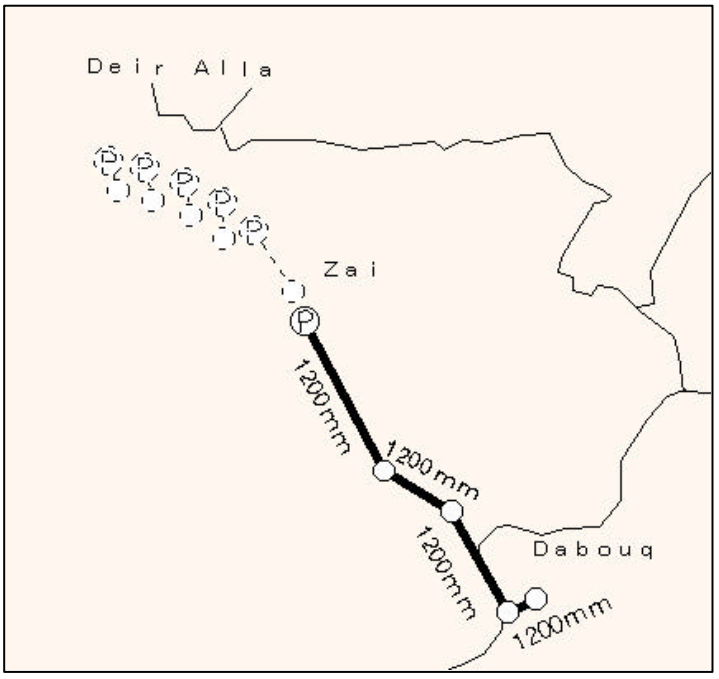

Fig. 6.1.3.1-1 Deir Alla-Zai-Dabouq Transfer Line

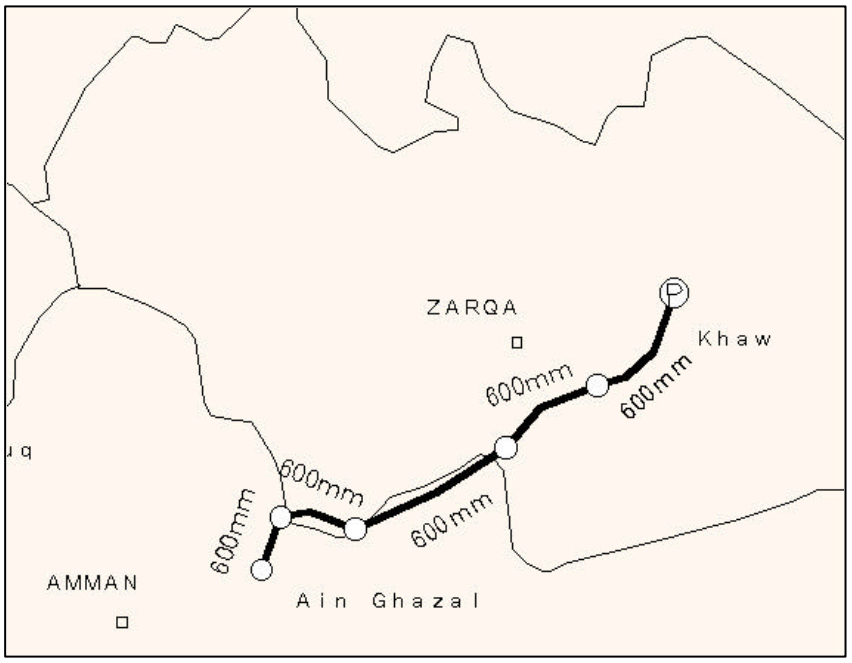

Fig. 6.1.3.1-2 Khaw – Ain Ghazal Transfer Line

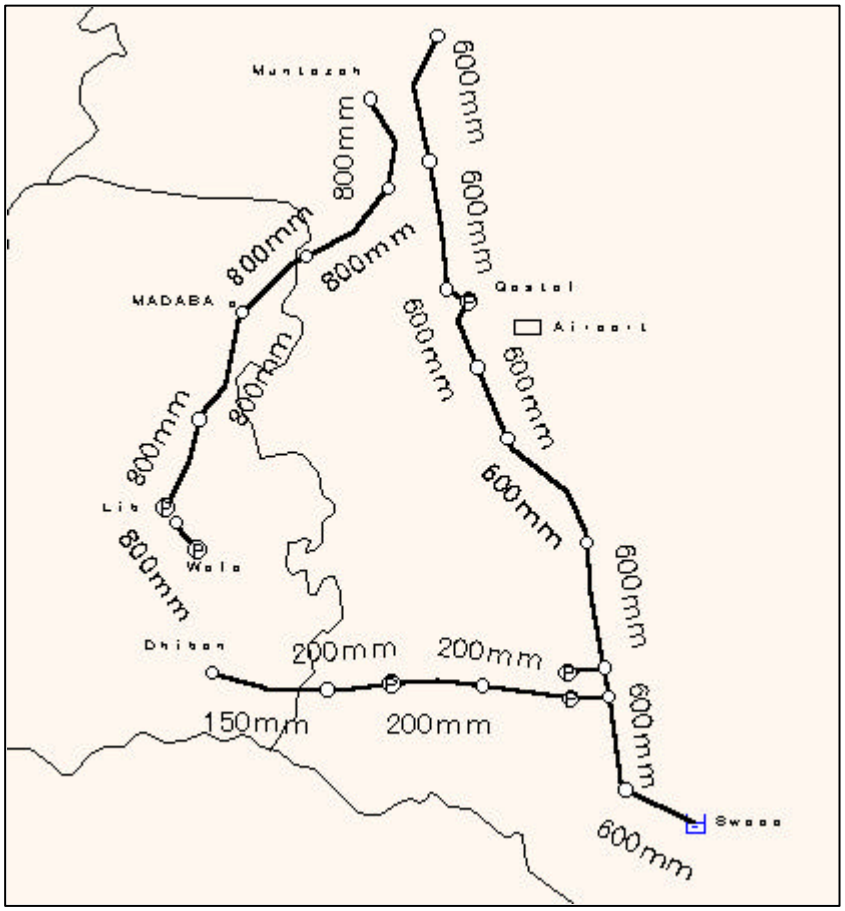

Fig. 6.1.3.1-3 Swaqa-South Amman and Wala-Muntazah Tranfer Lines

(2) Transfer Line to Zarqa

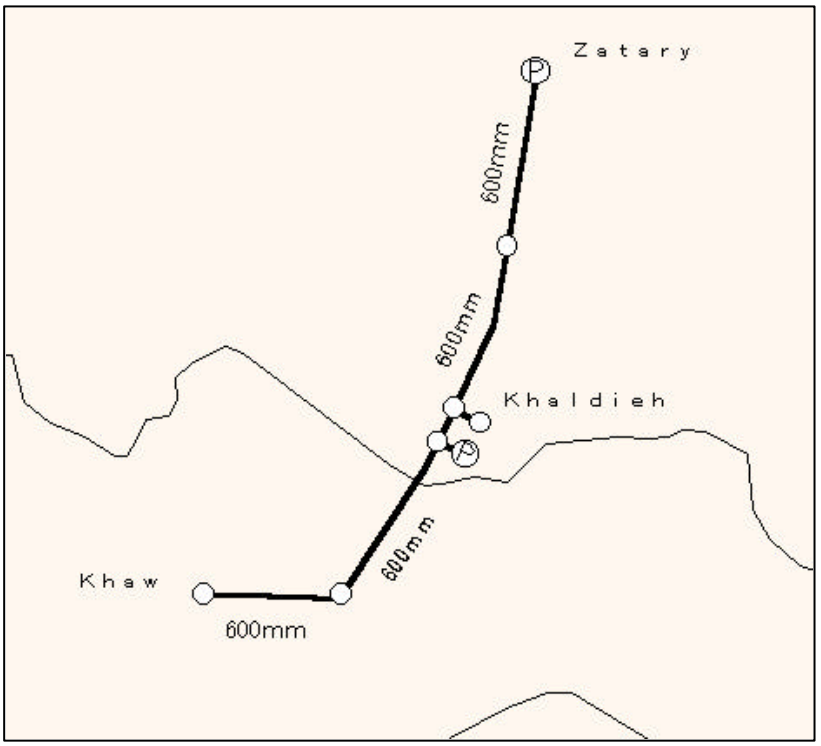

Fig. 6.1.3.1-4 Zatary-Khaw Transfer Line

(3) Transfer Line to Irbid

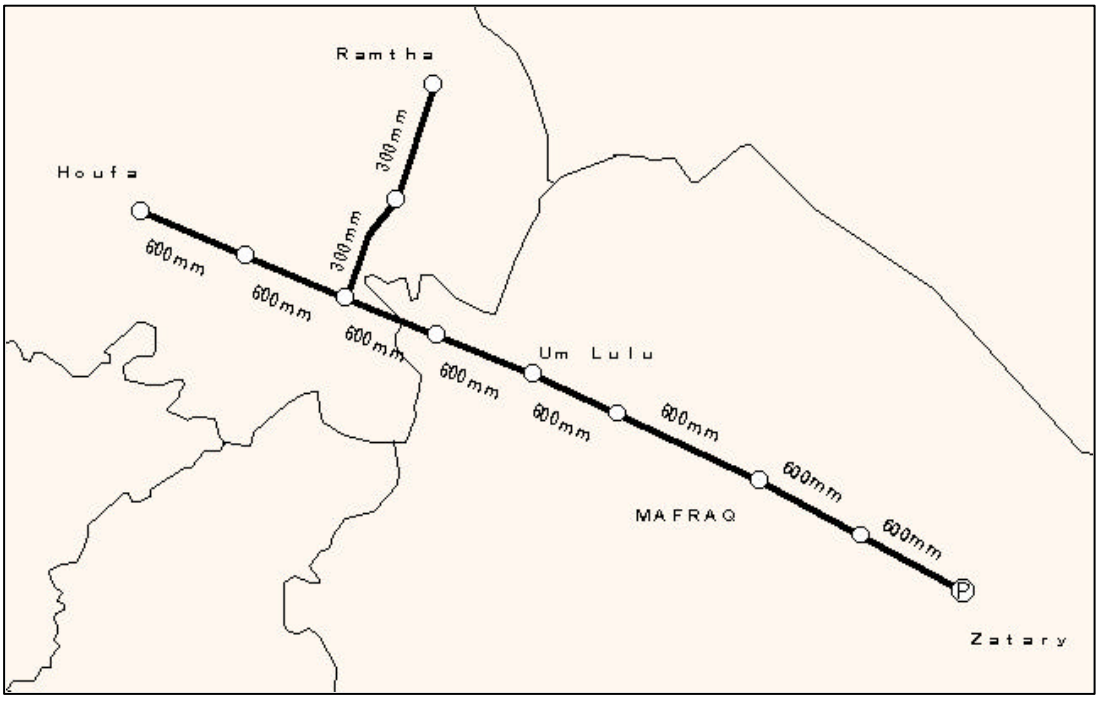

Fig. 6.1.3.1-5 Zatary-Houfa Tranfer Line

(4) Transfer Line to Ajloun and Jerash

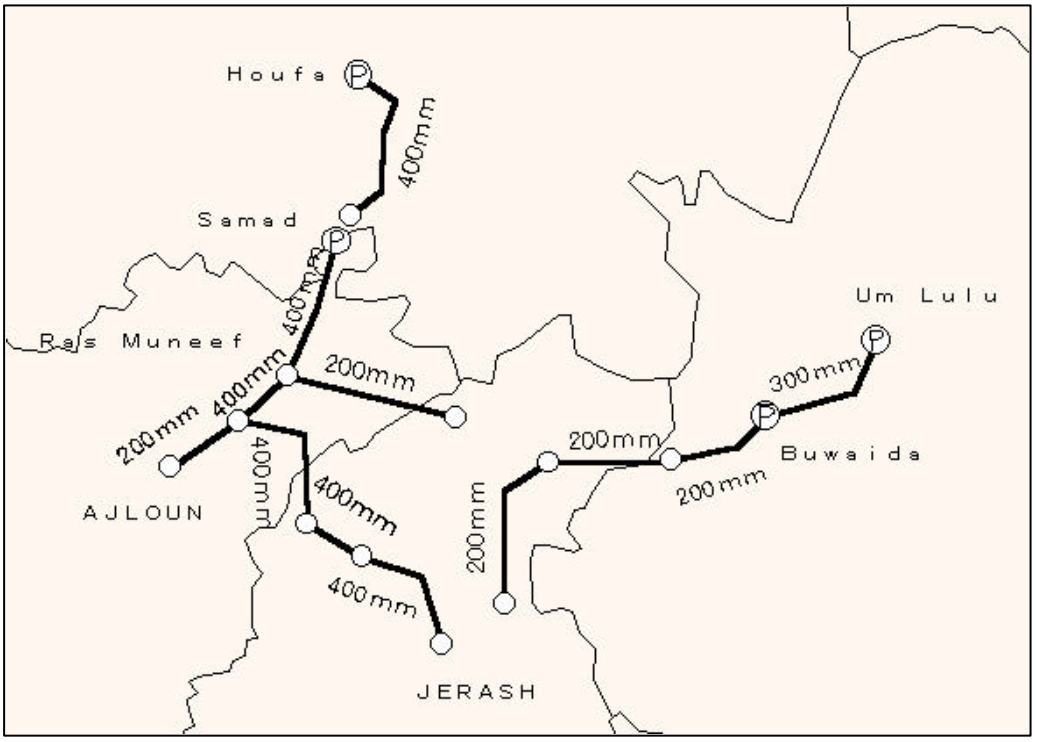

Fig. 6.1.3.1-6 Um Lulu-East Jerash and Houfa-Ajloun-Jerash Transfer Line

6.1.3.2 Result of Hydraulic Analysis

The results of the hydraulic analysis are summarized below and each result is shown on Fig. 6.1-A1 to 6.1-A6 in Annex-Section 6.1.

(1) Deir Alla-Zai-Dabouq Transfer Line
Water is currently transferred through this pipeline to the northern and central part of the Balqa Governorate and to the Greater Amman area from the Zai WTP. The transferred amount is now about 39 MCM/year (4,500 m^3/hr). This pipeline, with a diameter of 1200 mm, has a capacity of about 55 MCM/year (6,000 m^3/hr) at a velocity of 1.5 m/s.

However, since the altitude of water transmission pump station at the Zai WTP is about 180 m lower than the Dabouq reservoir and the pump head of the station is 200 m, there is almost no room to transfer additional water.

(2) Khaw-Ain Ghazal Transfer Line
Water is currently transferred through this pipeline to the Greater Amman from the Khaw pump station. The transferred amount is now about 19 MCM/year (2,200 m^3/hr). This pipeline, with a diameter of 600 mm, has a capacity of about 14 MCM/year (1,600 m^3/hr). Therefore, there is no room to transfer additional water in the future.

(3) Swaqa-South Amman Transfer Line
Water is currently transferred through this pipeline to Dhiban of the Madaba Governorate and to southern Amman from the Siwaqa and Qatrana well fields. The transferred amount is now about 11 MCM/year (1,200 m^3/hr). This pipeline consists of the line from Siwaqa to southern Amman, with a diameter of 600 mm, and a branch line to Dhiban, with diameters of 150 mm to 200 mm.

The main pipeline to Amman has a capacity of 14 MCM/year (1,600 m^3/hr). However, since water is transferred to the Qastal booster pump station by gravity directly from the Siwaqa reservoir, the effective water pressure at the station is now about 20 m. Therefore, it will be possible to transfer another 1 MCM/year (100 m^3/hr) of water in the future.

(4) Wala-Muntazah Transfer Line
Water is currently transferred through this pipeline to Madaba City and the south of Amman from the Wala well field. The transferred amount is now about 11 MCM/year (1,200 m^3/hr). This pipeline, with a diameter of 800 mm, has a capacity of 24 MCM/year (2,700 m^3/hr). Therefore, it will be possible to transfer another 13 MCM/year (1,500 m^3/hr) of water in the future.

(5) Zatary-Khaw Transfer Line
Water is currently transferred through this pipeline to the Khaw pump station from the Zatary pump station. The transferred amount is now about 15 MCM/year (1,760 m^3/hr). This pipeline, with a diameter of 600 mm, has a capacity of 14 MCM/year (1,600 m^3/year). Therefore, there is little room to transfer additional water in the future.

(6) Zatary-Houfa Tranfer Line
Water is currently transferred through this pipeline to northwest of Mafraq, Irbid for 3 days a week, and southwest of Mafraq and east of Jerash for 4 days a week. The

transferred amount is about 5 MCM/year (570 m^3/hr). This pipeline, with a diameter of 600 mm, has a capacity of transferring 14 MCM/year.

However, since the altitude of Zatary PS is about 200 m lower than the Houfa reservoir and there is no booster pump station in the pipeline, the water pressure at the Houfa reservoir is not enough at the moment.

Actually, we were informed by the WAJ staffs of Irbid that water is not supplied all the time into the reservoir, especially in summer.

(7) Um Lulu-East Jerash Transfer Line

Water is currently transferred through this pipeline to east of Jerash for 4 days a week from the Um Lulu pump station by way of the Buwaida booster pump station. The transferred amount is 0.5 MCM/year (50 m^3/hr in average and 85 m^3/hr during the supplied period). The pipeline, with a diameter of 200 to 300 mm, has a capacity of 1.5 MCM/year (170 m^3/hr). Therefore, it will be possible to transfer another 0.75 MCM/year (85 m^3/hr) in the future.

(8) Houfa-Ajloun-Jerash Transfer Line

Water is currently transferred through this pipeline to Ajloun for 3 days and Jerash for 4 days a week from the Samad pump station. The transferred amount is 0.6 MCM/year (70 m^3/hr) for Ajloun and 0.8 MCM/year (90 m^3/hr) for Jerash.

The pipeline to Ajloun, with a diameter of 200 mm, has a capacity of 1.5 MCM/year (170 m^3/hr). However, water is supplied to Ajloun for only 3 days, so that the actual amount supplied becomes 160 m^3/hr. Therefore, there is little room to transfer additional volume in this pipeline.

The pipeline to Jerash, with a diameter of 400 mm, has a capacity of 6 MCM (680 m^3/day). However, water is supplied to Jerash for only 4 days, so that the actual amount supplied becomes 160 m^3/hr. Therefore, there is some room to transfer additional volume in this pipeline.

6.2 Alternative Development/Improvement Plans for the National Water Carrier

6.2.1 Inter-Governorate Fresh Water Transfer in Target Years

6.2.1.1 Fresh Water Flow in Target Years

The fresh water flow in the target years of 2005, 2010, 2015 and 2020 are shown in Fig. 6.2.1.1-1 to 6.2.1.1-4 below.

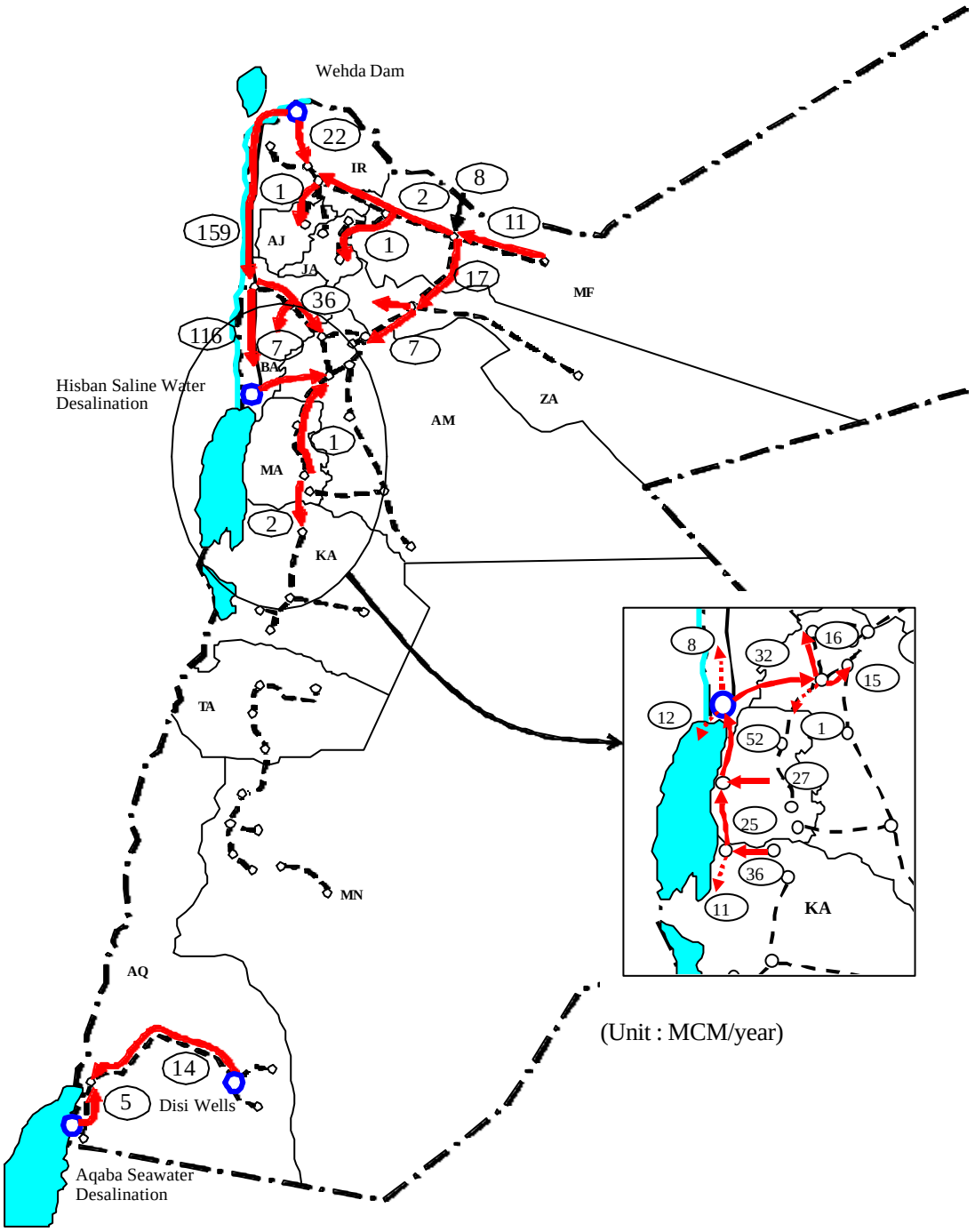

Fig. 6.2.1.1-1 Fresh Water Flow for the Transfer System in 2005

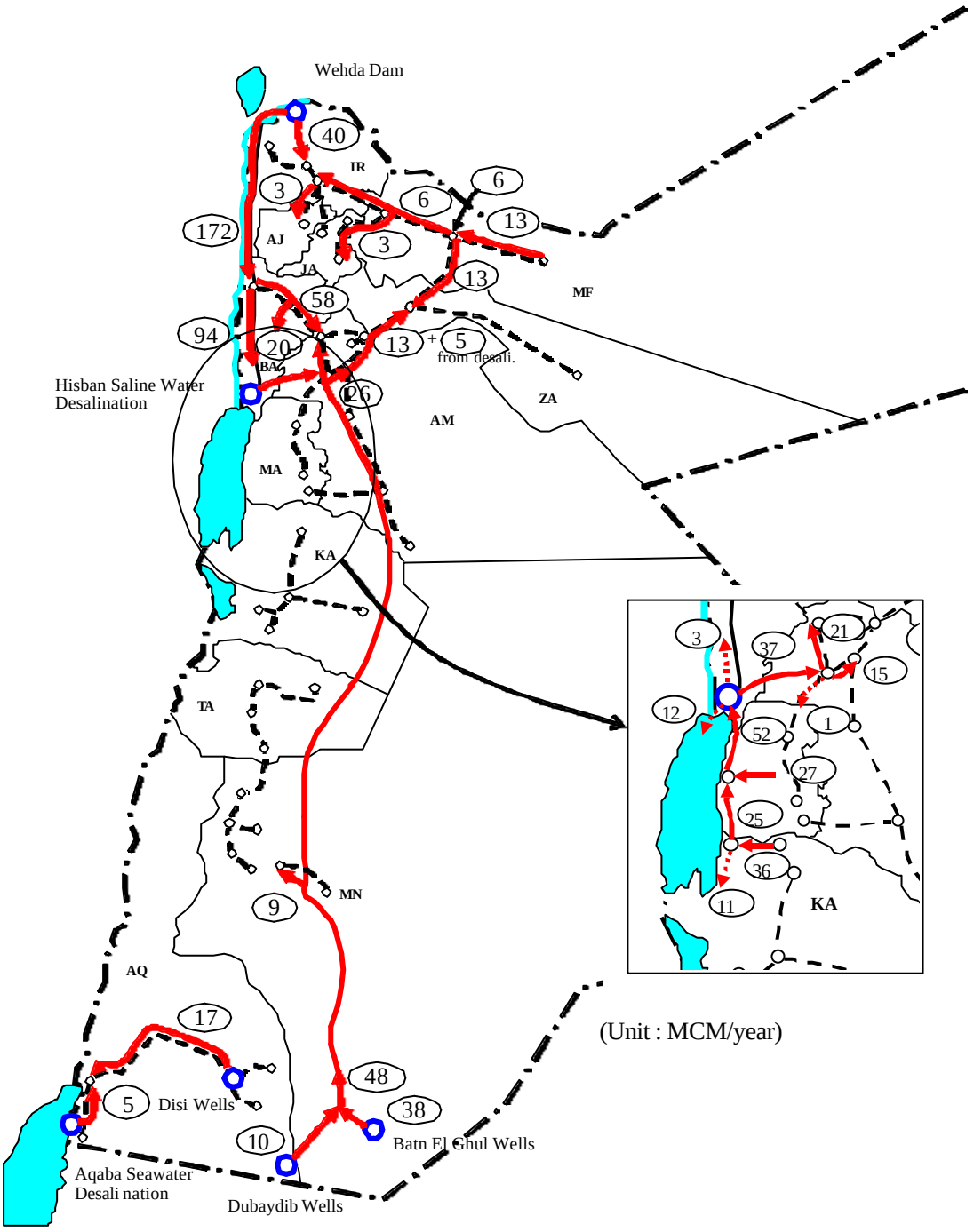

Fig. 6.2.1.1-2 Inter-Governorate Water Flow for the Transfer System in 2010

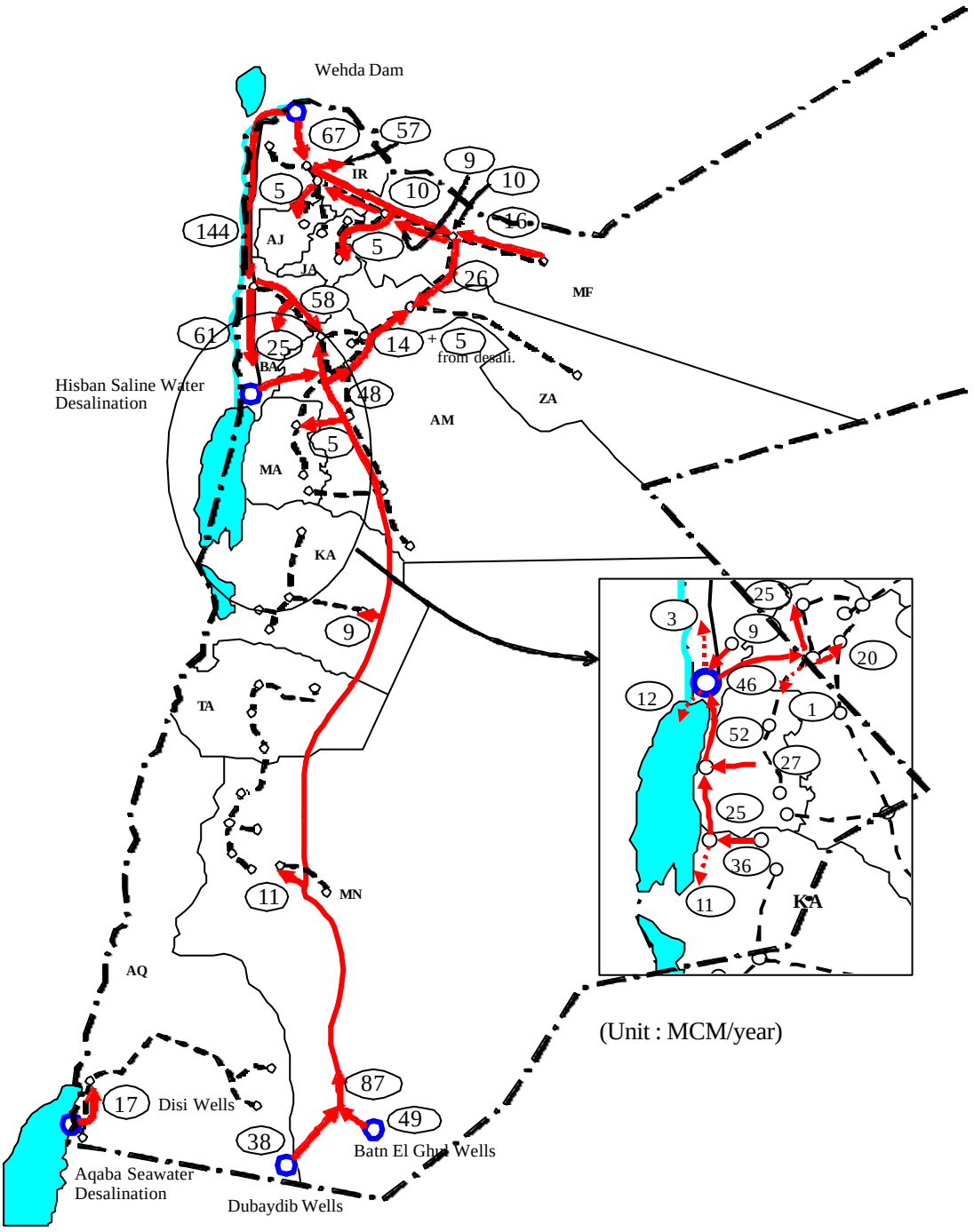

Fig. 6.2.1.1-3 Inter-Governorate Water Flow for the Transfer System in 2015

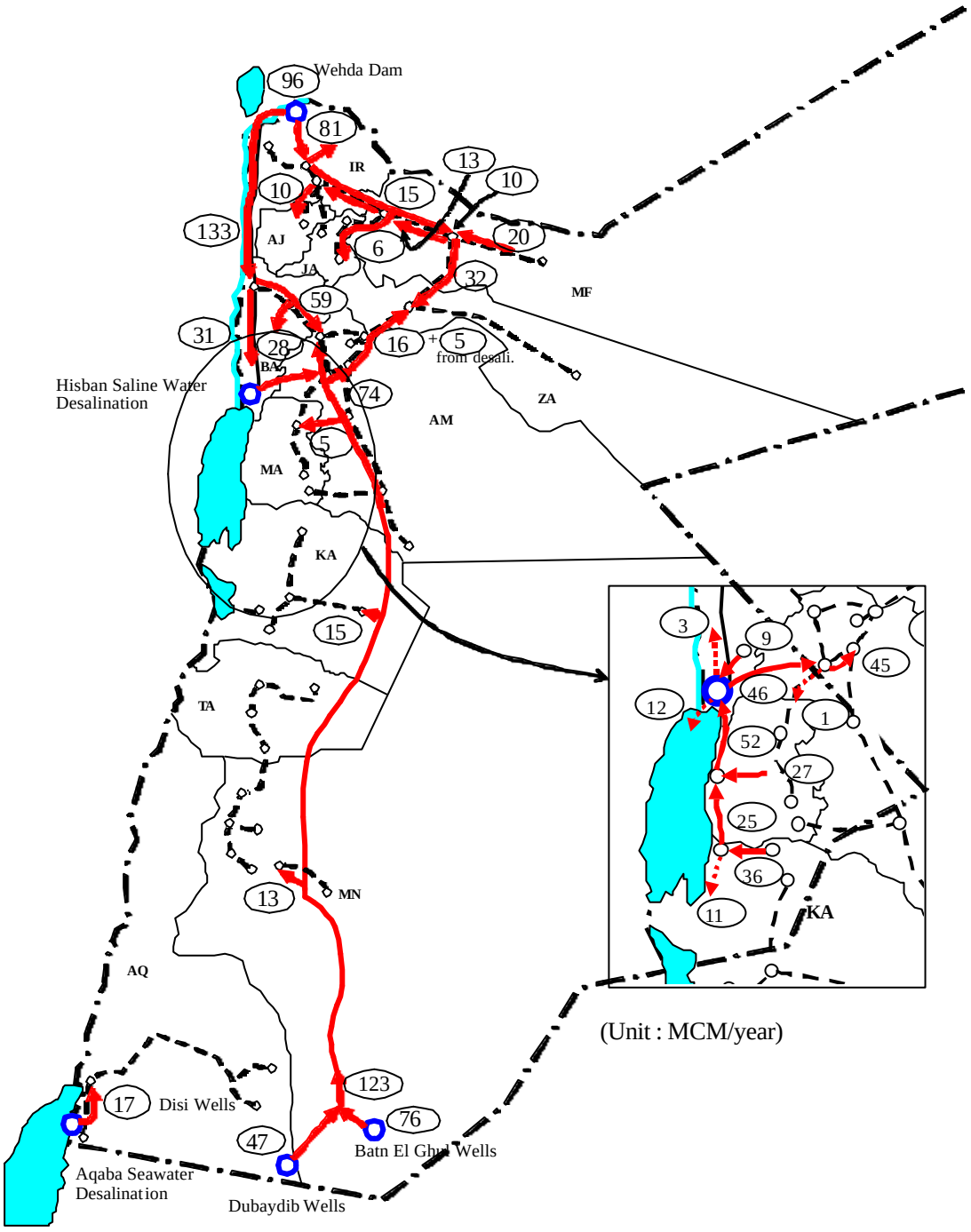

Fig. 6.2.1.1-4 Inter-Governorate Water Flow for the Transfer System in 2020

6.2.1.2 Inter-Governorate Fresh Water Transfer Volume in Target Years

The fresh water volumes to be transferred through Inter-Governorate transfer systems in the target years of 2005, 2010, 2015 and 2020 are shown in Table 6.2.1.2-1 to 6.2.1.2-4.

Table 6.2.1.2-1 Inter-Governorate Fresh Water Transfer in 2005

Upper / Lower — MCM/year / m3/hr

CODE	to AM	to ZA	to MF	to IR	to AJ	to JA	to BA	to MA	to KA	to MN	to TA	to AQ	Total In	Total Out
AM	0	0	0	0	0	0	0	0	0	0	0	0	75	0
ZA	0	0	0	0	0	0	0	0	0	0	0	0	10	0
MF	7	10	0	0	1	1	0	0	0	0	0	0	0	19
	799	1,142			114	114								
IR	36	0	0	0	0	0	7	0	0	0	0	0	0	43
	4,110				0		799							
AJ	0	0	0	0	0	0	0	0	0	0	0	0	1	0
JA	0	0	0	0	0	0	0	0	0	0	0	0	1	0
BA	31	0	0	0	0	0	0	1	0	0	0	0	32	32
	3,539							114						
MA	1	0	0	0	0	0	0	0	2	0	0	0	1	3
	114								228					
KA	0	0	0	0	0	0	25	0	0	0	0	0	2	25
							2,854							
MN	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	75	10	0	0	1	1	32	1	2	0	0	0	122	122

Table 6.2.1.2-2 Inter-Governorate Fresh Water Transfer in 2010

Upper / Lower — MCM/year / m3/hr

CODE	to AM	to ZA	to MF	to IR	to AJ	to JA	to BA	to MA	to KA	to MN	to TA	to AQ	Total In	Total Out
AM	0	0	0	0	0	0	0	0	0	0	0	0	115	0
ZA	0	0	0	0	0	0	0	0	0	0	0	0	28	0
MF	0	13	0	0	3	3	0	0	0	0	0	0	0	19
		1,484			342	342								
IR	58	0	0	0	0	0	20	0	0	0	0	0	0	78
	6,621						2,283							
AJ	0	0	0	0	0	0	0	0	0	0	0	0	3	0
JA	0	0	0	0	0	0	0	0	0	0	0	0	3	0
BA	31	5	0	0	0	0	0	1	0	0	0	0	20	37
	3,539	571						114						
MA	0	0	0	0	0	0	0	0	0	0	0	0	1	0
KA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MN	26	0	0	0	0	0	0	0	0	9	0	0	9	35
	2,968									1,027				
TA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AQ	0	10	0	0	0	0	0		0	0	0		0	10
		1,142												
Total	115	28	0	0	3	3	20	1	0	9	0	0	179	179

Table 6.2.1.2-3 Inter-Governorate Fresh Water Transfer in 2015

Upper / Lower — MCM/year / m3/hr

CODE	to AM	to ZA	to MF	to IR	to AJ	to JA	to BA	to MA	to KA	to MN	to TA	to AQ	Total In	Total Out
AM	0	0	0	0	0	0	0	0	0	0	0	0	146	0
ZA	0	0	0	0	0	0	0	0	0	0	0	0	45	0
MF	0	16	0	0	5	5	0	0	0	0	0	0	0	26
		1,826			571	571								
IR	58	10	0	0	0	0	25	0	0	0	0	0	0	93
	6,621	1,142					2,854							
AJ	0	0	0	0	0	0	0	0	0	0	0	0	5	0
JA	0	0	0	0	0	0	0	0	0	0	0	0	5	0
BA	40	5	0	0	0	0	0	1	0	0	0	0	25	46
	4,566	571						114						
MA	0	0	0	0	0	0	0	0	0	0	0	0	6	0
KA	0	0	0	0	0	0	0	0	0	0	0	0	9	0
MN	36	14	0	0	0	0	0	0	0	11	0	0	11	61
	4,110	1,598								1,256				
TA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AQ	12	0	0	0	0	0	0	5	9	0	0	0	0	26
	1,370							571	1,027					
Total	146	45	0	0	5	5	25	6	9	11	0	0	252	252

Table 6.2.1.2-4 Inter-Governorate Fresh Water Transfer in 2020

Upper / Lower — MCM/year / m3/hr

CODE	to AM	to ZA	to MF	to IR	to AJ	to JA	to BA	to MA	to KA	to MN	to TA	to AQ	Total In	Total Out
AM	0	0	0	0	0	0	0	0	0	0	0	0	173	0
ZA	0	0	0	0	0	0	0	0	0	0	0	0	53	0
MF	0	17	0	0	7	6	0	0	0	0	0	0	0	30
		1,941			799	685								
IR	59	15	0	0	3	0	28	0	0	0	0	0	0	105
	6,735	1,712			342		3,196							
AJ	0	0	0	0	0	0	0	0	0	0	0	0	10	0
JA	0	0	0	0	0	0	0	0	0	0	0	0	6	0
BA	40	5	0	0	0	0	0	1	0	0	0	0	28	46
	4,566	571						114						
MA	0	0	0	0	0	0	0	0	0	0	0	0	6	0
KA	0	0	0	0	0	0	0	0	0	0	0	0	15	0
MN	63	0	0	0	0	0	0	0	0	13	0	0	13	76
	7,192									1,484				
TA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AQ	11	16	0	0	0	0	0	5	15	0	0	0	0	47
	1,256	1,826						571	1,712					
Total	173	53	0	0	10	6	28	6	15	13	0	0	304	304

6.2.2 Alternative Development/Improvement Plans for the National Water Carrier

6.2.2.1 Design Criteria

The design criteria to formulate the development and/or improvement plans are as described below.

(1) Water Conveying and Transmission Pipe

1) Peak Factor : 1.0

2) Design Velocity

Diameter（mm）	Velocity（m/s）	Friction Loss（m/km）
50～200	less than 1.00	less than10
200～500	1.00～1.25	10～5
500 or over	1.25～1.50	5～2

3) Pipe Material

Material	Working Pressure (bar)
Steel	40～70
Ductile Iron	16～40

As a result of hydraulic analysis, it has been found that the working pressure of all of the transfer lines is less than 30 bar. Therefore, a ductile iron pipe shall be adopted, taking into account the design life and the material cost.

4) Design Life
- Steel pipe : 30 years
- Ductile iron pipe : 50 years
- Pump station equipment : 15 years (for mechanical, electrical and instrumentation)
- Foundation & building : 50 years

(2) Reservoir Capacity

1) Balancing (or Collecting) Tank
Working capacity : 30 minutes at design flow

2) Pressure Breaking Tank
Working capacity : 100m^3

6.2.2.2 Proposed Plans

(1) Description of the Proposed Plans

After examination of the future fresh water transfer and current capacity of the water transfer system, the development and/or improvement plans for Inter-Governorate water transfer systems have been formulated. The proposed plans to be implemented from 2000 to 2020 are shown in Fig. 6.2.2.2-1. This figure also includes the plans, together with their study or implementation of which has already been started.

The proposed water transfer systems in this study (hereinafter referred to as "JICA Study 2001") and those under study or implementation by others are listed in Table 6.2.2.2-1.

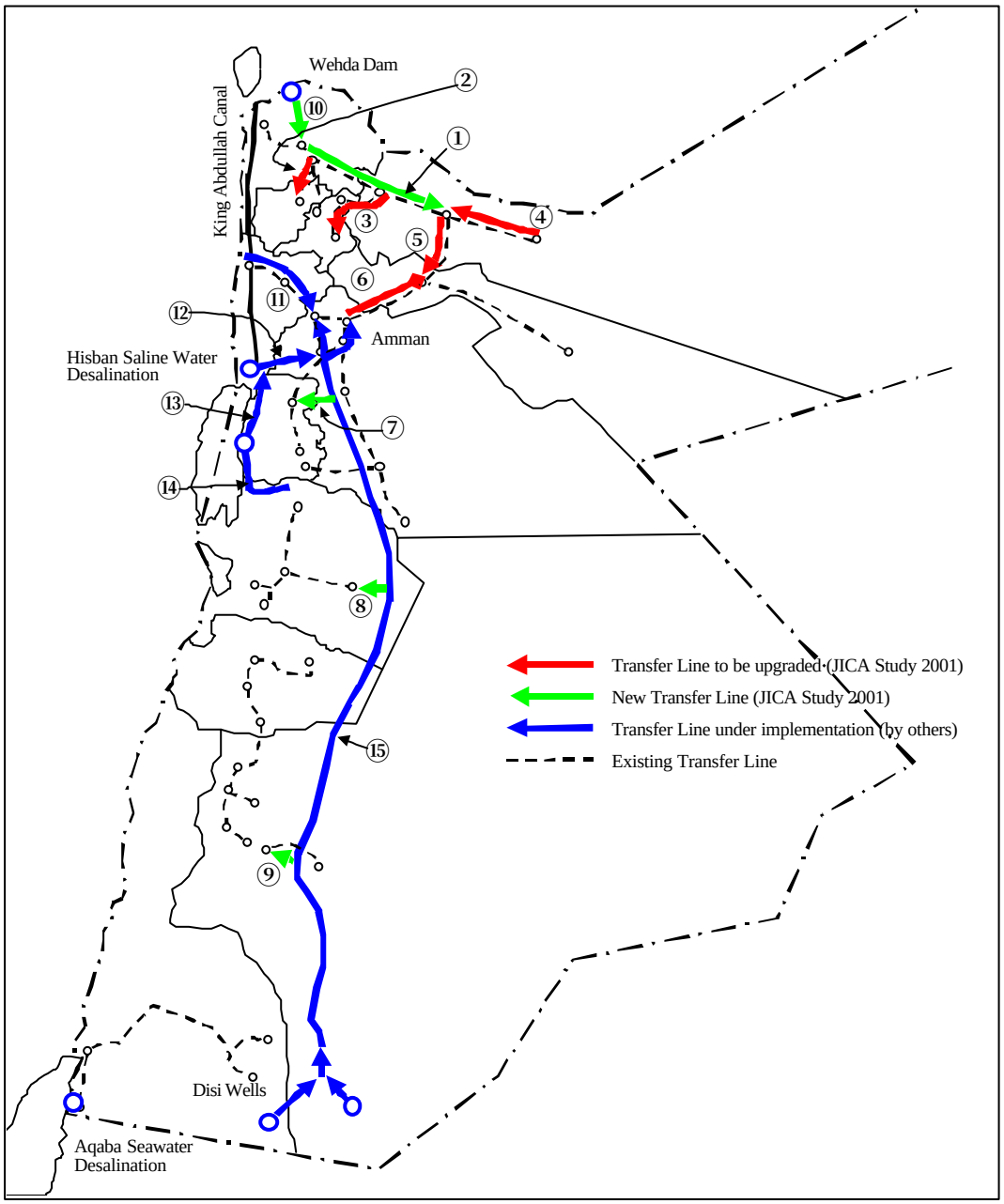

Fig. 6.2.2.2-1 Proposed Plans for Fresh Water Transfer System

Table 6.2.2.2-1 List of Water Transfer System Plans

No.	Name of Plan	Expected Completion Year
[JICA Study 2001]		
①	Zabda-Houfa-Zatary Transfer Line	2015
②	Houfa-Ajloun Transfer Line	2020
③	Um Lulu-Jerash Transfer Line	2020
④	KM124-Zatary Transfer Line	2020
⑤	Zatary-Khaw Transfer Line	2020
⑥	Abu Alanda-Khaw Transfer Line	2015
⑦	Disi-Madaba Branch	2010
⑧	Disi-Karak Branch	2010
⑨	Disi-Ma'an Branch	2010
[Pre-Feasibility Study by JICA 2001]		
⑩	Wehda Dam-Irbid Transfer Line	2006
[Under Study or Implementation by Others]		
⑪	Deir Alla-Zai-Dabouq Transfer Line	2002
⑫	Sweima-Muntaza Transfer Line	2005
⑬	Zara/Main-Sweima Transfer Line	2005
⑭	Mujib-Zara/Ma'in Transfer Line	2005
⑮	Disi-Amman Water Conveyor	2006

(2) Components of Proposed Transfer Lines

The components of the transfer lines proposed in this study are shown in Table 6.2.2.2-2.

Table 6.2.2.2-2 Components of Transfer Lines (JICA Study 2001)

No.	Transfer Line	Transmission Main			Reservoir	Pump Station
		Diameter (mm)	Length (m)	Pipe Material		
①	Zabda - Houfa - Zatary	800	57,000	DIP	(Not required : Existing reservoirs will be utilized)	(Not required : by gravity flow)
②	Houfa - Ajloun	500	15,000	DIP	(Not required : Existing reservoirs will be utilized)	1 PS : Q = 1,120 m^3/hr, H = 200 m 1 PS : Q = 1,120 m^3/hr, H = 220 m
③	Um Lulu - Jerash	500	27,000	DIP	(Not required : Existing system will be utilized)	(Not required : Existing system will be utilized)
④	KM124 - Zatary	300 600 700	8,500 17,000 8,500	DIP DIP DIP	Balancing res. x 4 units Q = 50 m^3 (1 units) Q = 400 m^3 (1 unit) Q = 700 m^3 (1 unit) Q = 1,000 m^3 (1 unit) (at each pump station)	1 PS : Q = 100 m^3/hr, H = 30 m 1 PS : Q = 780 m^3/hr, H = 50 m 1 PS : Q = 1,450 m^3/hr, H = 50 m 1 PS : Q = 2,120 m^3/hr, H = 100 m
⑤	Zatary - Khaw	1,000	33,600	DIP	Balancing res. x 1 unit Q = 1,000 m^3 (at Khaldieh PS)	1 PS : Q = 3,425 m^3/hr, H = 70 m
⑥	Abu Alanda - Khaw	800	23,000	DIP	Break pressure tank x 1 unit Q = 100 m^3 (at the elevation of about 750 m)	(Not required : by gravity flow)
⑦	Disi - Madaba branch	600	17,400	DIP	Balancing res. x 1 unit Q = 900 m^3 (at Qastal PS)	1 PS : Q = 1,710 m^3/hr, H = 100 m
⑧	Disi - Karak branch	800	5,000	DIP	Balancing res. x 1 unit Q = 900 m^3 (at Sultany PS)	1 PS : Q = 1,800 m^3/hr, H = 100 m
⑨	Disi - Ma'an branch	600	5,500	DIP	Balancing res. x 1 unit Q = 800 m^3 (in Ma'an City)	1 PS : Q = 1,600 m^3/hr, H = 100 m

Note : DIP means Ductile Iron Pipe.

(3) Location of Each Transfer Line

The detailed location of the proposed transfer line by JICA Study 2001 is shown in Fig. 6.2.2.2-2 to Fig.6.2.2.2-7.

① Zabda-Houfa-Zatary Transfer Line
This transfer line is the line from Zabda pump station in Irbid Governorate to Zatary pump station in Mafraq Governorate by way of Houfa pump station as shown in Fig. 6.2.2.2-2.

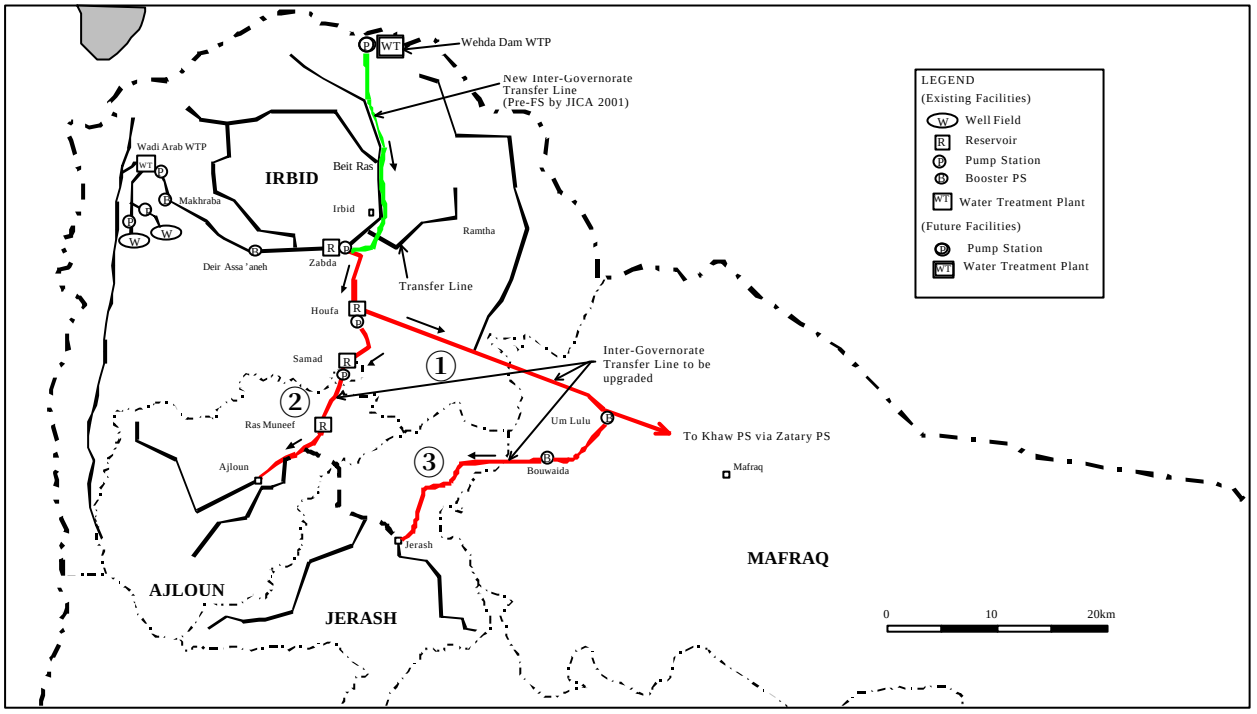

Fig. 6.2.2.2-2 Zabda-Houfa-Zatary Transfer Line

② Houfa-Ajloun Transfer Line
This transfer line is the line from Houfa pump station in Irbid Governorate to Ajloun City of Ajloun Governorate as shown in Fig. 6.2.2.2-2.

③ Um Lulu-Jerash Transfer Line
This transfer line is the line from Um Lulu pump station in Mafraq Governorate to Jerash City of Jerash Governorate as shown in Fig. 6.2.2.2-2.

④ KM124-Zatary Transfer Line
This transfer line is the line from KM124 pump station in Mafraq Governorate to Zatary pump station of the same Governorate as shown in Fig. 6.2.2.2-3.

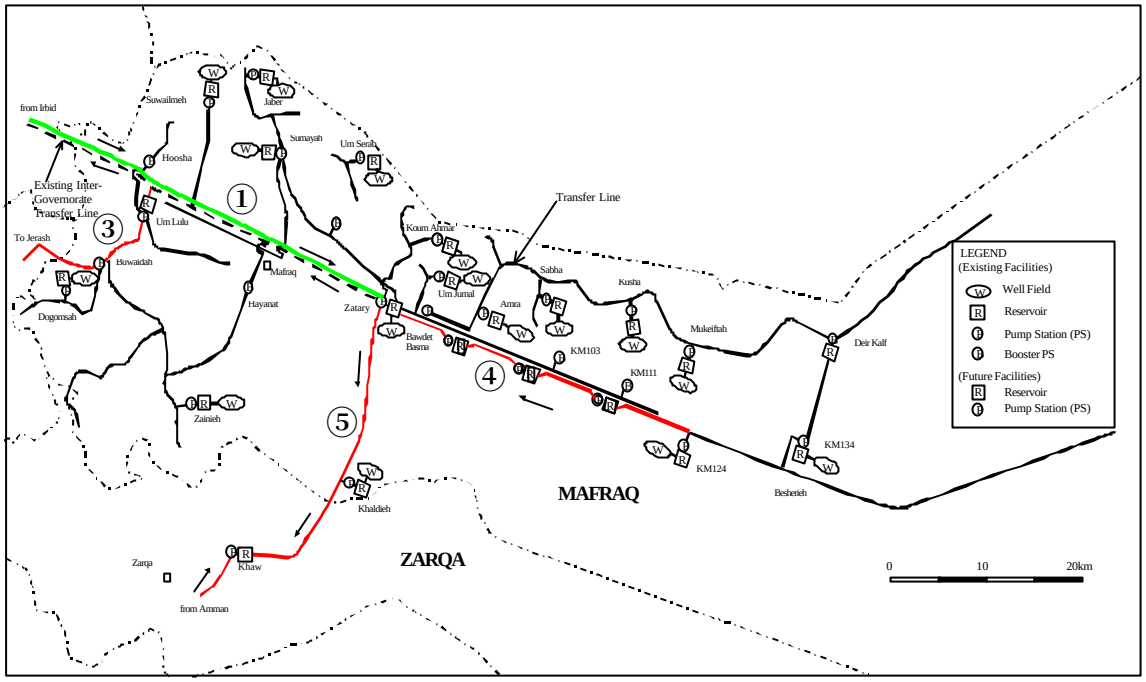

Fig. 6.2.2.2-3 KM124-Zatary Transfer Line

⑤ Zatary-Khaw Transfer Line
This transfer line is the line from Zatary pump station in Mafraq Governorate to Khaw pump station of Zarqa Governorate as shown in Fig. 6.2.2.2-3.

⑥ Abu Alanda-Khaw Transfer Line
This transfer line is the line from Abu Alanda reservoir to Khaw pump station as shown in Fig 6.2.2.2-4.

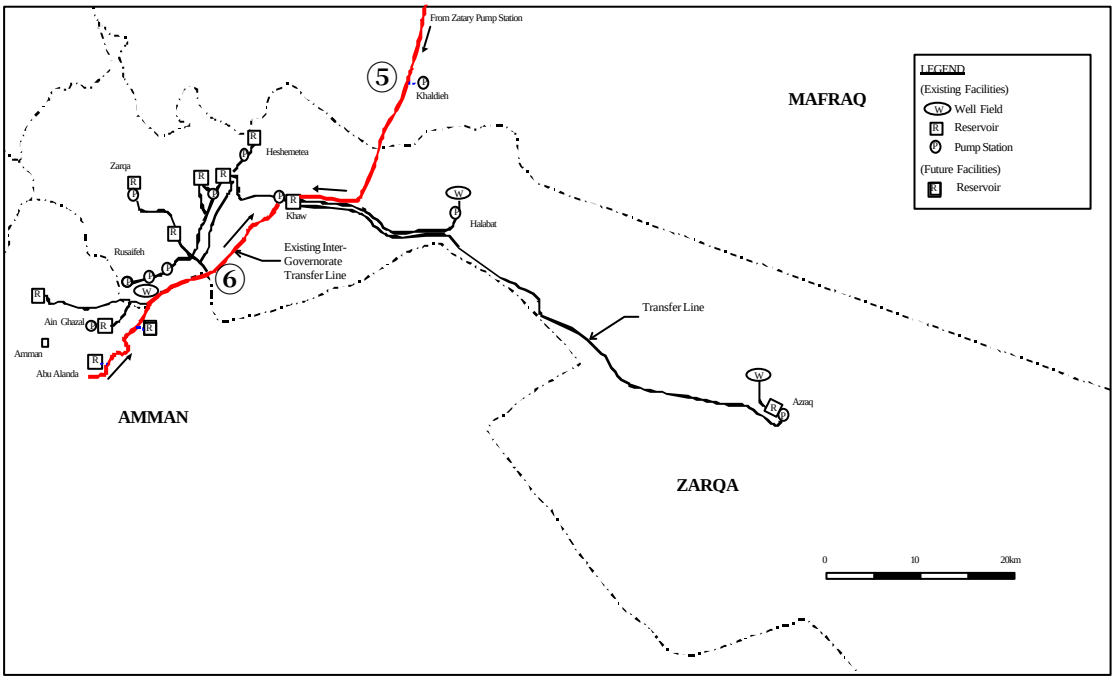

Fig. 6.2.2.2-4 Abu Alanda-Khaw Transfer Line

⑦ Disi-Madaba Branch

This transfer line is the line branched from the Disi-Amman Water Conveyor to Madaba City. The location of the line is shown in Fig. 6.2.2.2-5.

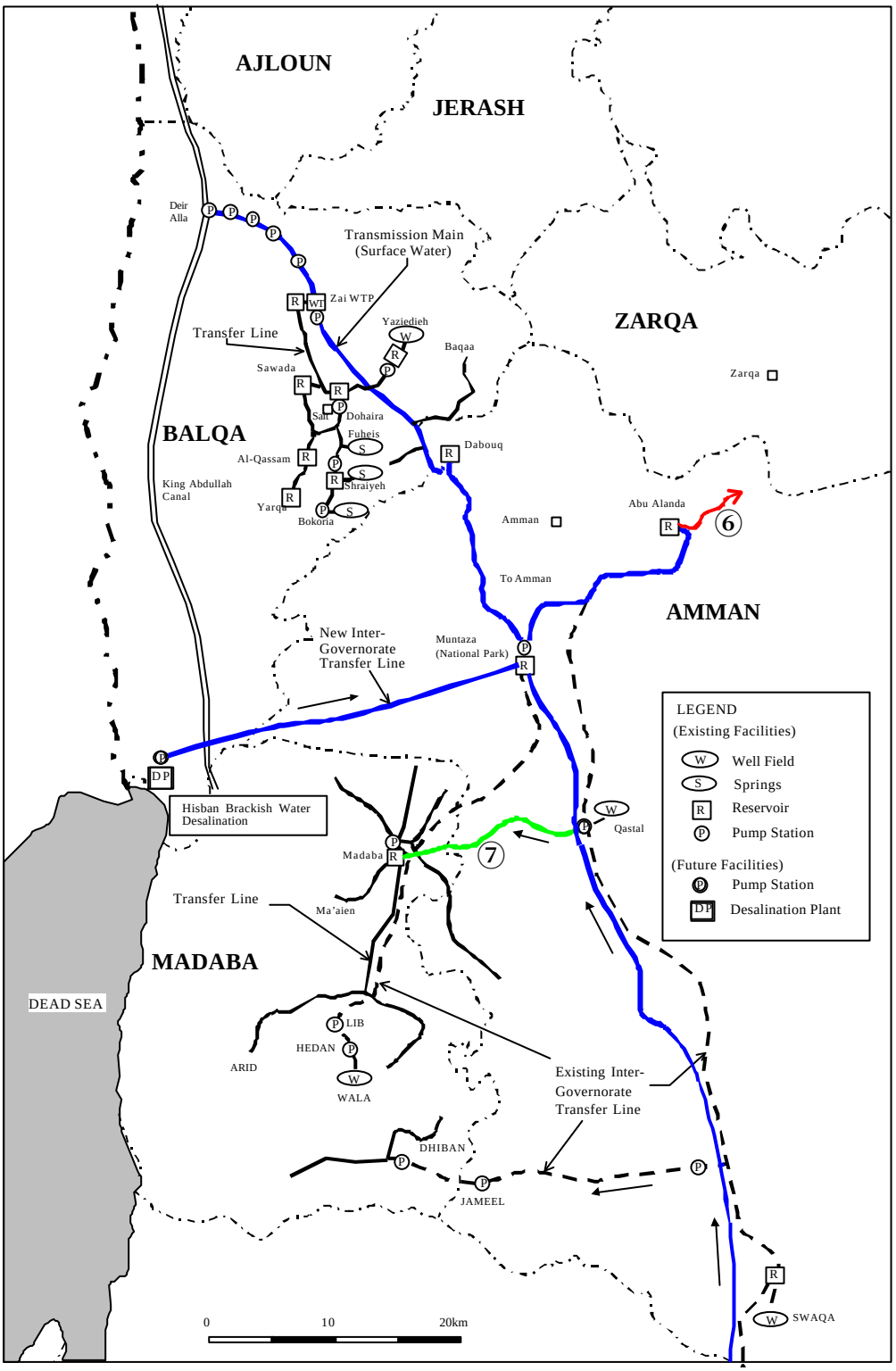

Fig. 6.2.2.2-5 Disi-Madaba Branch

⑧ Disi-Karak Branch

This transfer line is the line branched from the Disi-Amman Water Conveyor to Karak City. The location of the line is shown in Fig. 6.2.2.2-6.

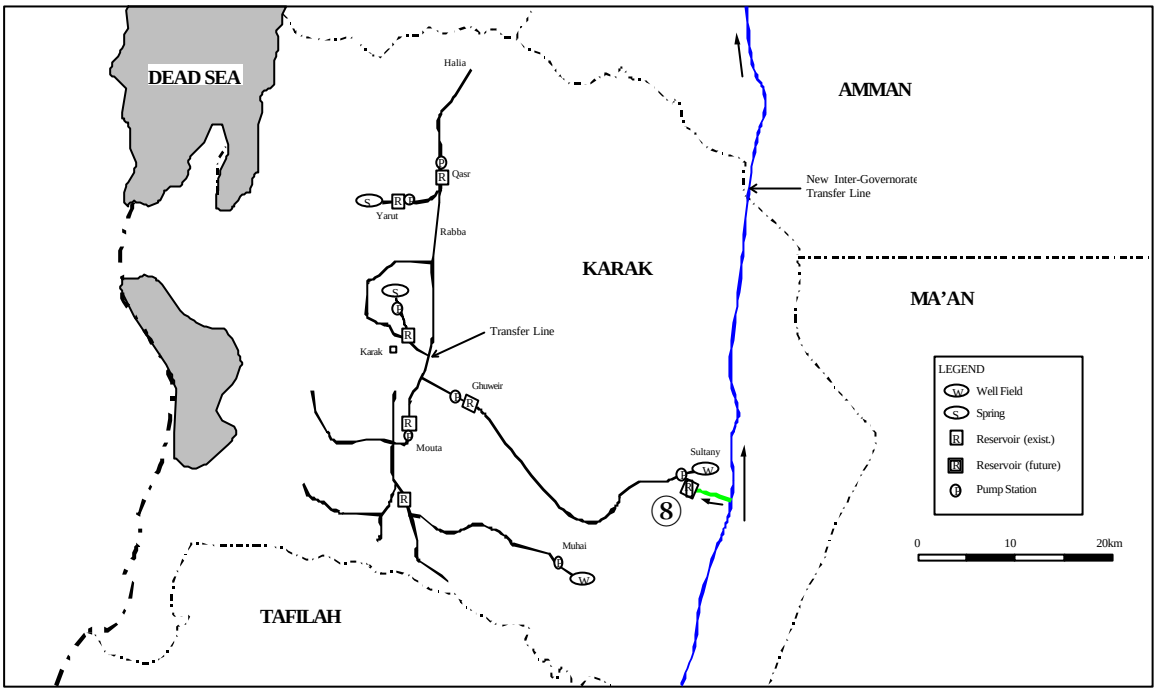

Fig. 6.2.2.2-6 Disi-Karak Branch

⑨ Disi-Ma'an Branch

This transfer line is the line branching from the Disi-Amman Water Conveyor to Ma'an City. The location of the line is shown in Fig. 6.2.2.2-7.

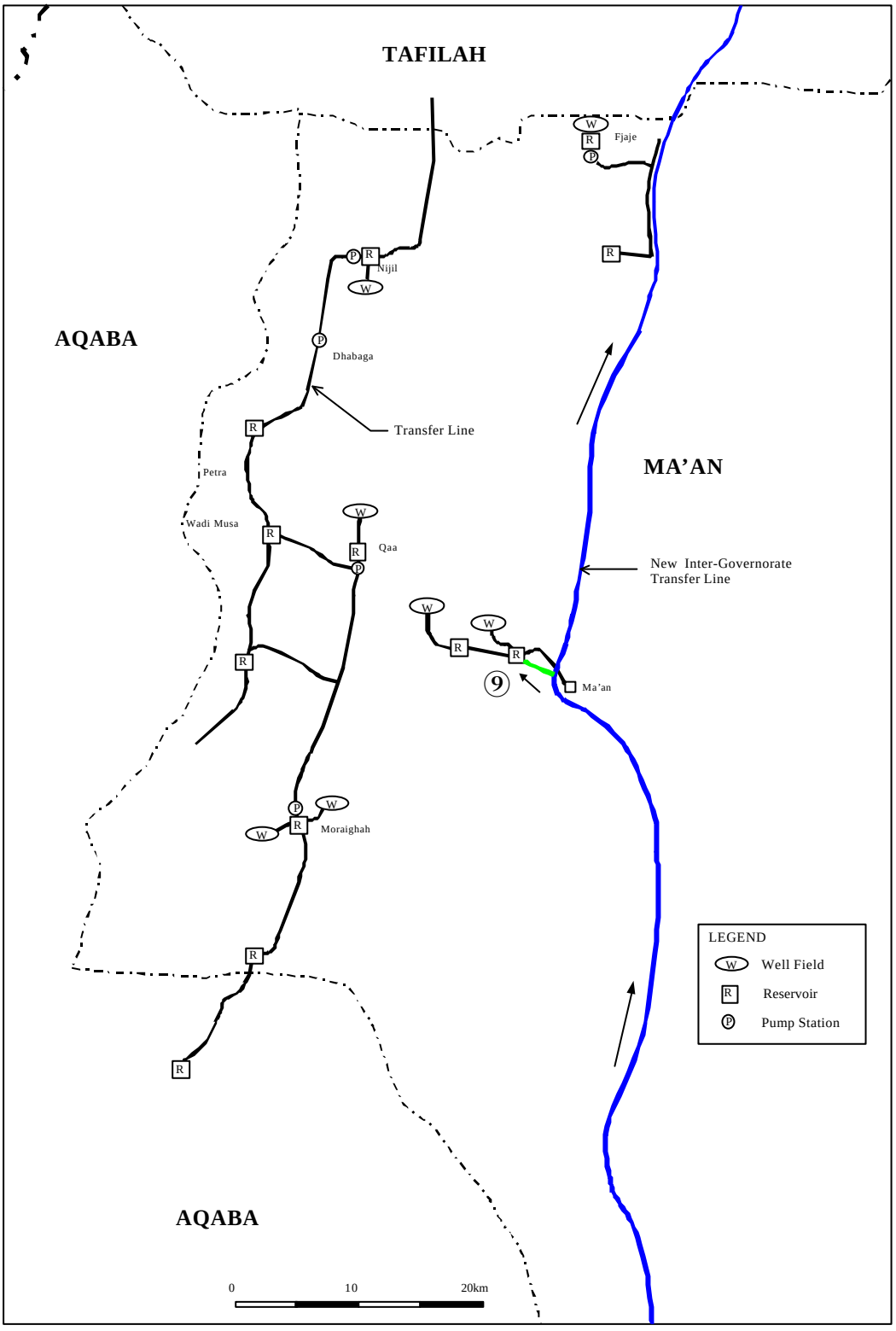

Fig. 6.2.2.2-7 Disi-Ma'an Branch

6.2.2.3 Hydraulic Analysis on Proposed Transfer Lines

Hydraulic analysis has been carried out for the optimum design of the proposed transfer lines. The results of the analysis are shown in Fig. 6.2-A1 to Fig. 6.2-A7 and the calculation results are shown in Table 6.2-A1 to Table 6.2-A7 in Annex 6.2.

The transfer volumes of the transfer line are shown in Table 6.2.2.3-1 and 6.2.2.3-2, which have been applied as the bases of the hydraulic analysis.

Table 6.2.2.3-1 Transfer Volume for Each Transfer Line (Exported/Locally Used)

(unit : MCM/year)

No.	Transfer Line	From/To		Target Year			
				2005	2010	2015	2020
①	Zabda - Houfa - Zatary	Zabda PS→Zatary PS	Exported	---	---	10	15
			Locally Used	---	---	0	0
			Total	0	0	10	15
			(m3/hr)			(1,142)	(1,681)
②	Houfa - Ajloun	Houfa PS→Ajloun	Exported	1	3	5	10
			Locally Used	0	0	0	0
			Total	1	3	5	10
			(m3/hr)	(114)	(342)	(571)	(1,142)
③	Um Lulu - Jerash	Um Lulu PS→Jerash	Exported	1	3	5	6
			Locally Used	0	0	0	0
			Total	1	3	5	6
			(m3/hr)	(114)	(342)	(571)	(685)
④	KM124 - Zatary	KM124 PS→Zatary PS	Exported	11	13	16	20
			Locally Used	0	0	0	0
			Total	11	13	16	20
			(m3/hr)	(1,207)	(1,435)	(1,777)	(2,234)
⑤	Zatary - Khaw	Zatary PS→Khaw PS	Exported	17	13	26	32
			Locally Used	0	0	0	0
			Total	17	13	26	32
			(m3/hr)	(1,941)	(1,484)	(2,968)	(3,653)
⑥	Abu Alanda - Khaw	Abu Alanda res.→Khaw PS	Exported	---	18	19	21
			Locally Used	---	0	0	0
			Total	0	18	19	21
			(m3/hr)		(2,055)	(2,169)	(2,397)
⑦	Disi - Madaba branch	Qastal PS→Madaba PS	Exported	---	0	5	5
			Locally Used	---	0	0	0
			Total	0	0	5	5
			(m3/hr)			(571)	(571)
⑧	Disi - Karak branch	PS→Sultany PS	Exported	---	0	9	15
			Locally Used	---	0	0	0
			Total	0	0	9	15
			(m3/hr)			(1,027)	(1,712)
⑨	Disi - Ma'an branch	PS→Ma'an reservoir	Exported	---	0	0	0
			Locally Used	---	9	11	13
			Total	0	9	11	13
			(m3/hr)		(1,027)	(1,256)	(1,486)

Table 6.2.2.3-2 Transfer Volume for Each Transfer Line (Municipal/Industrial/Touristic)

(unit : MCM/year)

No.	Transfer Line	From/To		Target Year			
				2005	2010	2015	2020
①	Zabda - Houfa - Zatary	Zabda PS→Zatary PS	Municipal	0	0	10	15
			Industrial	0	0	0	0
			Touristic	0	0	0	0
			Total	0	0	10	15
②	Houfa - Ajloun	Houfa PS→Ajloun	Municipal	1	3	5	10
			Industrial	0	0	0	0
			Touristic	0	0	0	0
			Total	1	3	5	10
③	Um Lulu - Jerash	Um Lulu PS→Jerash	Municipal	1	3	5	6
			Industrial	0	0	0	0
			Touristic	0	0	0	0
			Total	1	3	5	6
④	KM124 - Zatary	KM124 PS→Zatary PS	Municipal	11	13	16	20
			Industrial	0	0	0	0
			Touristic	0	0	0	0
			Total	11	13	16	20
⑤	Zatary - Khaw	Zatary PS→Khaw PS	Municipal	17	13	26	32
			Industrial	0	0	0	0
			Touristic	0	0	0	0
			Total	17	13	26	32
⑥	Abu Alanda - Khaw	Abu Alanda res.→Khaw PS	Municipal	0	18	19	21
			Industrial	0	0	0	0
			Touristic	0	0	0	0
			Total	0	18	19	21
⑦	Disi - Madaba branch	Qastal PS→Madaba PS	Municipal	0	0	5	5
			Industrial	0	0	0	0
			Touristic	0	0	0	0
			Total	0	0	5	5
⑧	Disi - Karak branch	PS→Sultany PS	Municipal	0	0	4	6
			Industrial	0	0	5	9
			Touristic	0	0	0	0
			Total	0	0	9	15
⑨	Disi - Ma'an branch	PS→Ma'an reservoir	Municipal	0	3	4	4
			Industrial	0	6	7	9
			Touristic	0	0	0	0
			Total	0	9	11	13

6.2.2.4 Implementation Schedule for Proposed Water Transfer/Supply Facilities

The implementation schedule for the proposed water transfer/supply facilities is shown in Fig. 6.2.2.4-1.

Fig. 6.2.2.4-1 Implementation Schedule for Proposed Water Transfer/Supply Facilities

Transfer Line	Target Years																			
					2005					2010					2015					2020
①Zabda→Houfa→Zatary (New construction& replacement)										Construction for Replacement (48 months)					**10**		Operation			**15**
②Houfa→Ajloun (Replacement)					**1**	Operated by existing system				**3**					**5**		Operation			**7**
													Construction for Replacement (12 months)							
③Um Lulu→Jerash (Replacement)					**1**	Operated by existing system				**3**					**4**		Operation			**6**
												Construction for Replacement (24 months)								
④KM124→Zatary (Replacement)					**11**	Operated by existing system				**13**					**16**			Operation		**20**
														Construction for Replacement (24 months)						
⑤Zatary→Khaw (Replacement)					**11**	Operated by existing system				**13**					**16**			Operation		**35**
														Construction for Replacement (24 months)						
⑥Abu Alanda→Khaw (Replacement)					Operated by existing system					**18**					**19**			Operation		**21**
													Construction for Replacement (18 months)							
⑦Disi→Madaba branch (New construction)															**2**		Operation			**1**
												Construction (12 months)								
⑥Disi→Karak branch (New construction)															**9**		Operation			**15**
												Construction (12 months)								
⑨Disi→Ma'an branch (New construction)										**8**			Operation		**10**					**13**
								Construction (12 months)												

Remarks
1. Bolded figures show the expected transfer volume (MCM/year) of fresh water between Governorates.

6.3 Proposed National Water Supply Control System

6.3.1 Establishment of National Water Supply Control System (NWSCS)

6.3.1.1 Purpose of System Introduction

The national Water Supply Control System (hereinafter referred to as "NWSCS") shall be established in order to realize an efficient distribution of limited water resources in Jordan through integrated operation and maintenance of water supply facilities located throughout the country.

A computerized supervision and control system will be applied in the Center to enable "efficient usage of water resources" or "reciprocal utilization among water supply facilities."

A stable water supply, reliable water quality, and the efficient management of water facilities can all be realized through this system.

6.3.1.2 Implementation Plan

The plan for establishing NWSCS shall be implemented in two stages, that is, Phase-1 and Phase-2 as shown in Table 6.3.1.2-1.

Phase-1 shall cover the construction of the Main Control Center to be located in the head office of WAJ in Amman for supervising and controlling the water transmission volume among the related Governorates. Phase-1 shall also include the construction of a Sub-Center for the 4 Governorates with the biggest water supply (Amman, Zarqa, Irbid and Mafraq) whose water supply accounts for about 70% of Jordan's total water supply.

Phase-2 shall cover the construction of a Sub-Center for the remaining 8 Governorates.

Table 6.3.1.2-1 Implementation Plan

Project Name	Outline	Expected Schedule
Project for the Establishment of a National Water Supply Control System (Phase-1) **[Short Term Plan]**	• Construction of a Main Control Center • Construction of Sub-Centers of 4 northern Governorates (Amman, Zarqa, Irbid and Mafraq) • Establishment of the SCADA system including installation of flow meters	Year 2003～2004
Project for the Establishment of a National Water Supply Control System (Phase-1) **[Mid Term Plan]**	• Construction of Sub-Centers of 8 southern Governorates. • Establishment of the SCADA system including installation of flow meters.	Year 2006～2008

6.3.1.3 Components of the Project

The components of the projects (Phase 1 and 2) are as shown in Table 6.3.1.3-1.

Table 6.3.1.3-1 Components of the Projects

	Component		Unit	Quantity
Phase 1	Main Control Center (MCC)		Lot	1
	Sub-Center (SC)		Lot	4
	SCADA system		Lot	1
	Flow meter for MCC	main pump stations	nos.	34
	Flow meter for SC	Zarqa	nos.	8
		Irbid	nos.	26
		Mafraq	nos.	15
Phase 2	Sub-Center (SC)		Lot	8
	SCADA system		Lot	1
	Flow meter for SC	Ajloun	nos.	8
		Jerash	nos.	8
		Balqa	nos.	8
		Madaba	nos.	6
		Karak	nos.	9
		Tafilah	nos.	11
		Ma'an	nos.	12
		Aqaba	nos.	9

6.3.2 Outline of NWSCS

6.3.2.1 General

The conceptual drawing of the computerized supervisory control system for the NWSCS is shown in Fig. 6.3.2.1-1.

As shown in the figure, the system shall use the available data from the existing SCADA system that has already been established in the Dirar Control Center of King Abdullah Canal, the Early Warning System of the Zai Water Treatment Plant and the LEMA control center.

Water supply facilities throughout the country will be divided into 12 groups. Each group will have a sub-center to be located in the representative WAJ office or a main pump station in each Governorate where the water supply facilities are supervised and controlled by wire or wireless communication.

A wire or wireless communication will also connect the 12 sub-centers to the Center of the NWSCS to be located in the WAJ head office in Amman. The Center will consist of a web server, a data base server, a mail server, communication devices, a water supply supporting system, a facility management supporting system, a large screen projector, printers, a voice alarm system, PC terminals, firewall, router, etc.

6.3.2.2 Function of Main Control Center

The functions of the Center will be:

- To enable centralized supervision of water supply facilities located widely throughout the country.
- To support the formulation of an optimum water supply plan, including daily water-demand forecasts, optimum water transmission and distribution, and simulated action planning for emergency scenarios.
- To develop a database for operation and maintenance records of existing water supply facilities, including transmission and distribution pipeline drawings and to execute efficient operation and maintenance for water supply facilities.

The introduction of remote supervision and control of the water supply facilities and the mechanization of the routine work will provide a centralized management of the information from the water supply facilities, realize prompt action to emergency cases and enable the operation work to be more efficient.

The control function of the equipment will be established in the future when the valves and pumps with remote control function are installed. However, the Main Control Center, the Sub-Centers and the RTUs shall have a system ready for the extension of the functions to the controlling equipment.

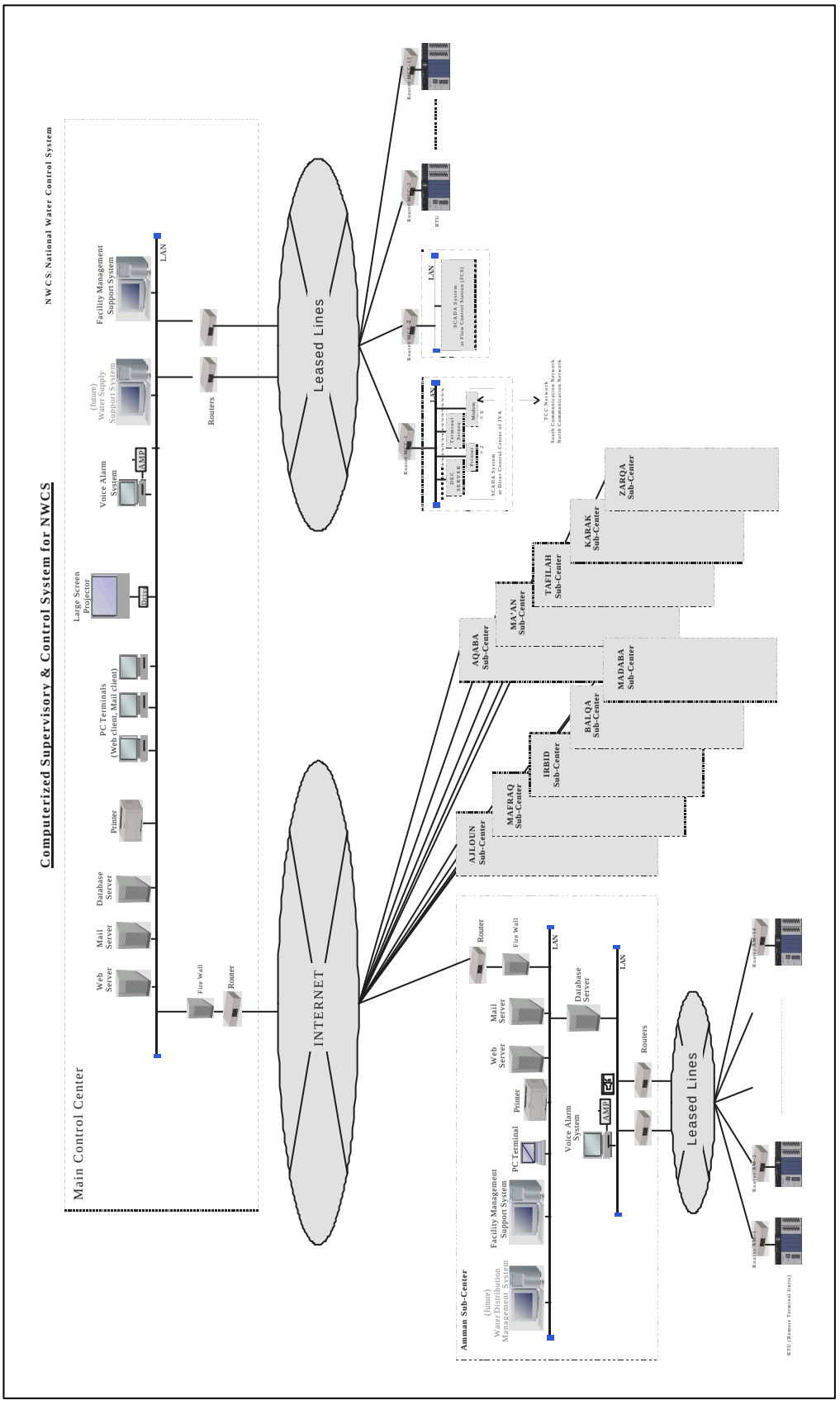

Fig. 6.3.2.1-1 Computerize Supervisory & Control System for NWSCS

6.3.3 Contents of Each Phase for the Project

6.3.3.1 Phase-1 : NWSCS for Inter-Governorate Transfer System

NWSCS shall be established in Phase-1 for supervising and controlling transferred water volume among the related Governorates. In Phase-1, the Main Control Center will be constructed in the head office of WAJ in Amman and a Sub-Center will be set up in 3 Governorates (Zarqa, Irbid and Mafraq). The Main Control Center will function for the Sub-Center in Amman.

The conceptual drawing for Phase-1 is shown in Fig. 6.3.3.1-1 and NWSCS for Inter-Governorate Transfer System is shown in Fig. 6.3.3.1-2.

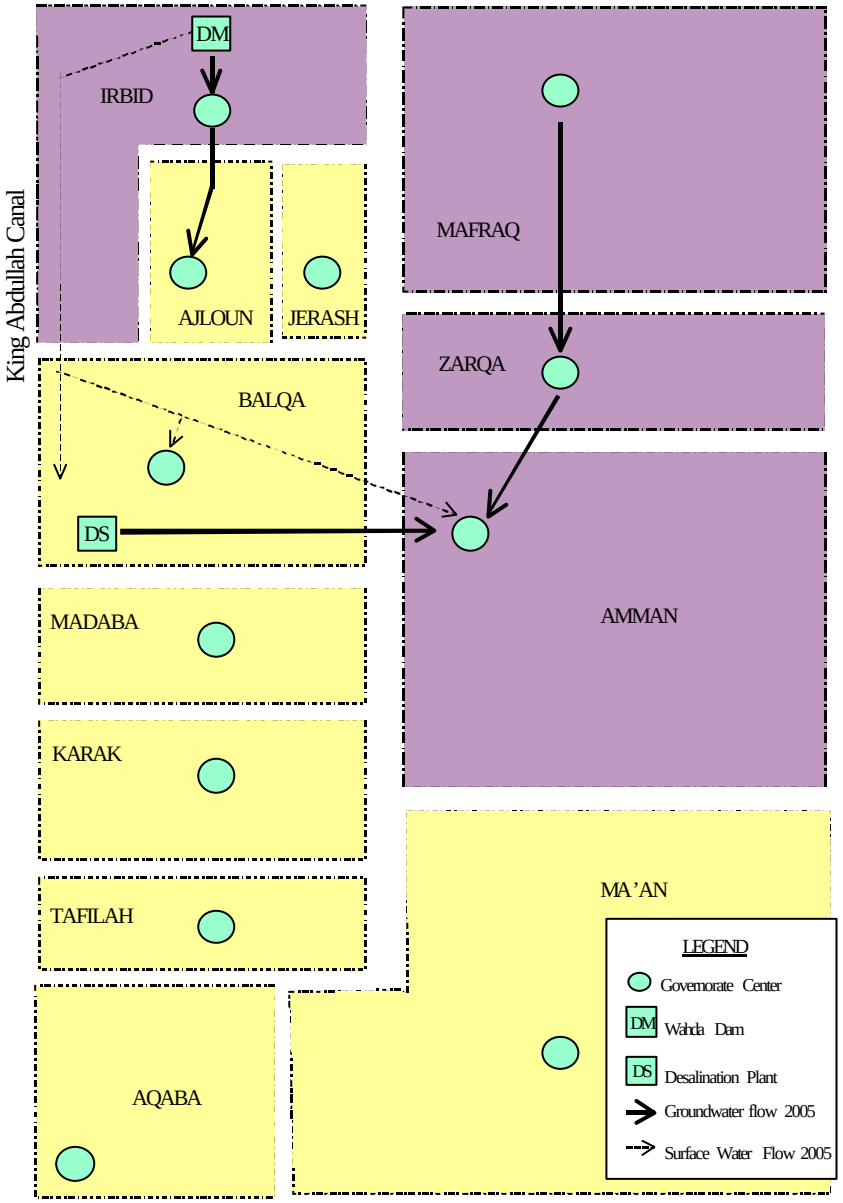

Fig. 6.3.3.1-1 Conceptual Drawing for Phase-1 of NWSCW

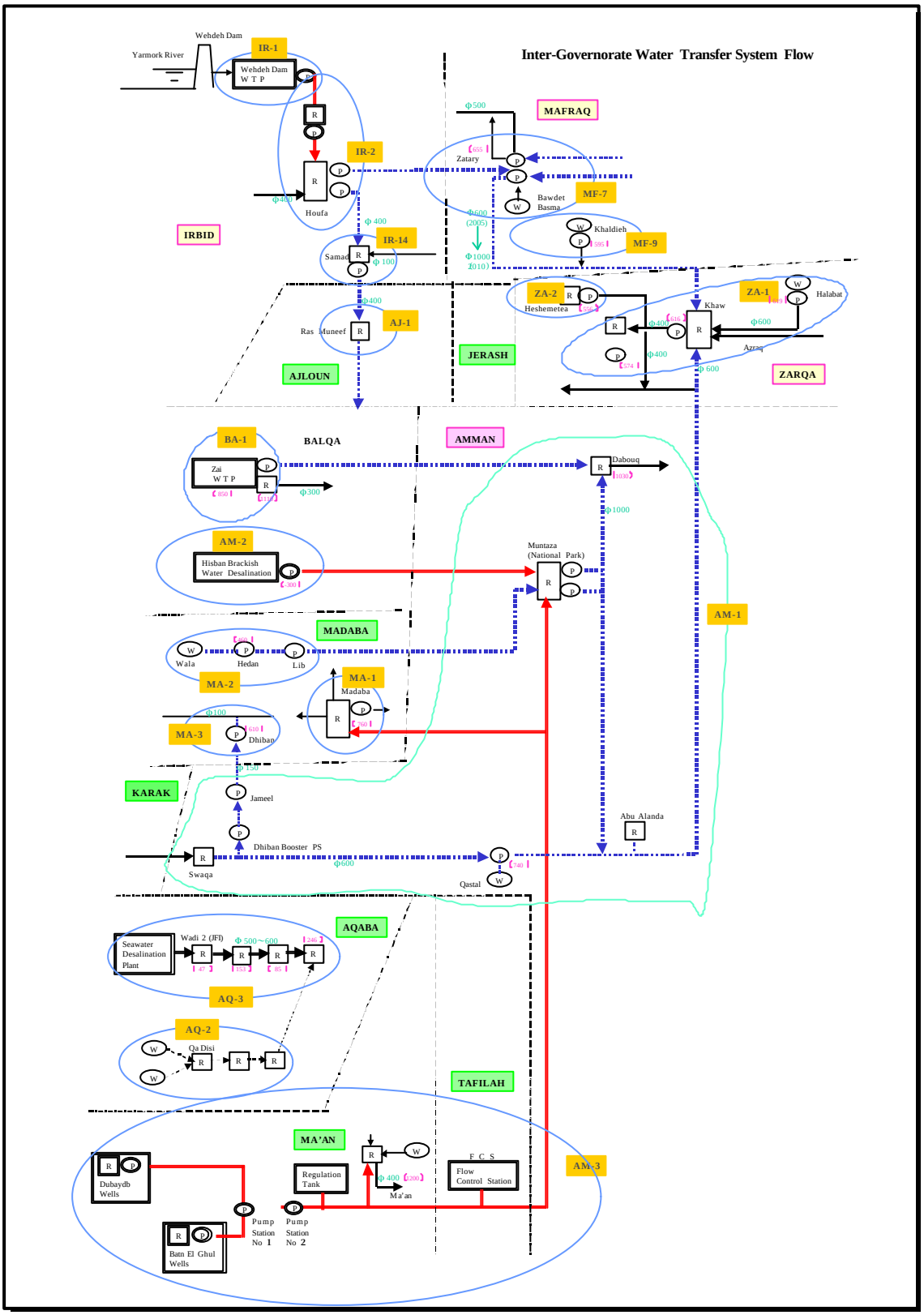

Fig. 6.3.3.1-2 NWSCS for Inter-Governorate Water Transfer System

6.3.3.2 Phase-2 : NWSCS for Internal Transfer Systems in Each Governorate

The NWSCS for the internal transfer lines in the Governorate shall be set up at Phase-2. The conceptual drawing for Phase-2 and the typical drawing for NWSCS for the internal transfer lines including the Sub-Center are shown in Fig. 6.3.3.2-1 and Fig. 6.3.3.2-2 respectively.

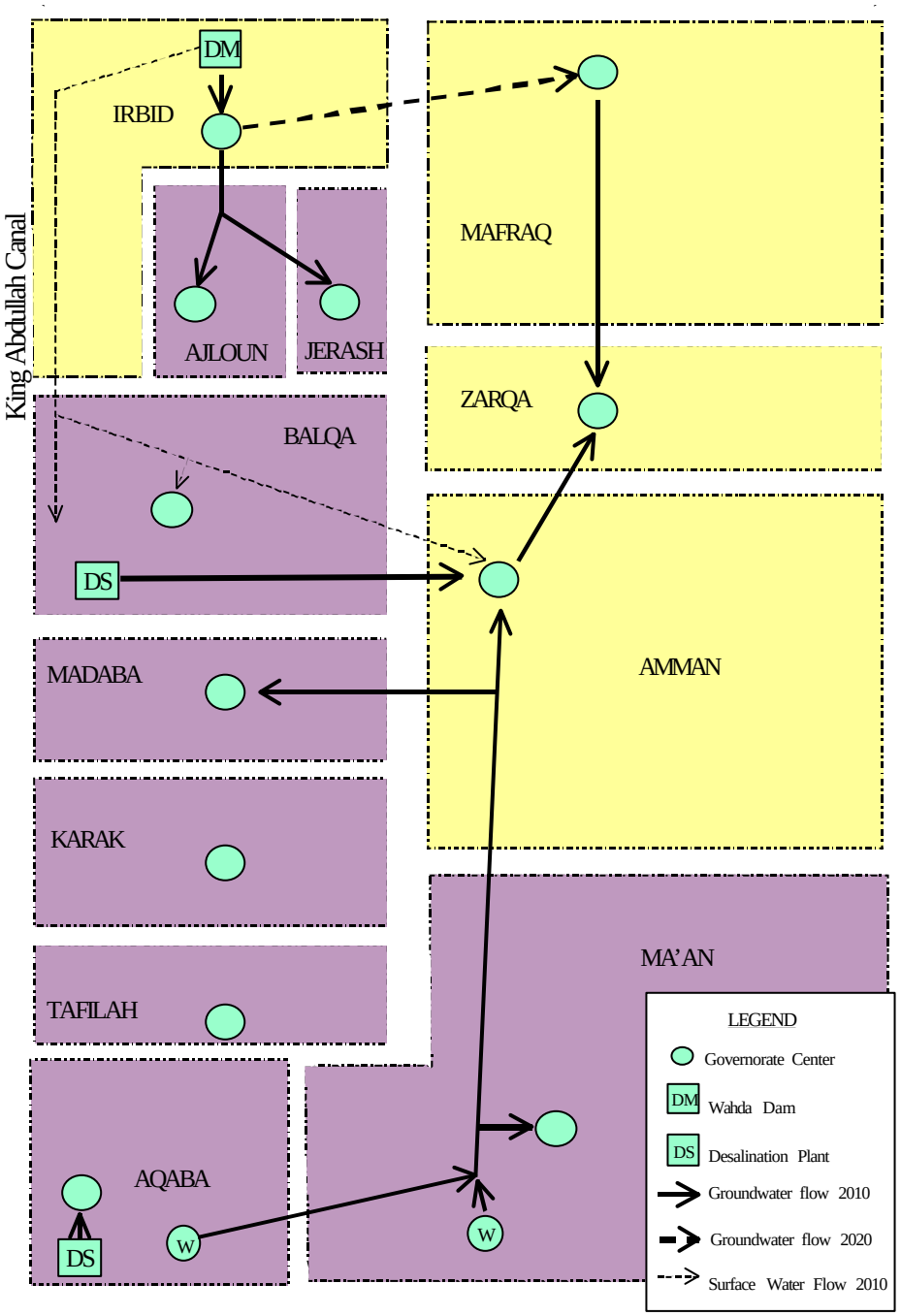

Fig. 6.3.3.2-1 Conceptual Drawing for Phase-2 of NWSCS

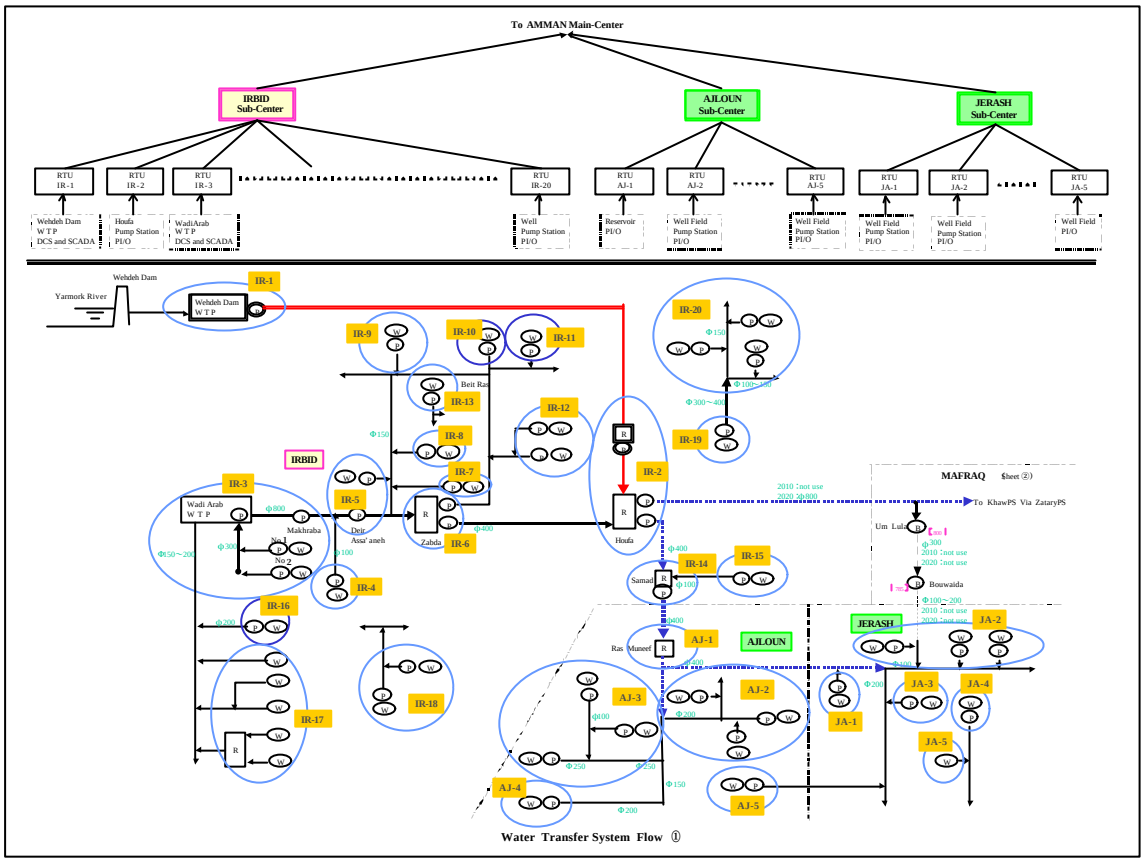

Fig. 6.3.3.2-2 Typical Drawing for NWSCS for Internal Transfer Lines (Irbid/Ajloun/Jerash)

6.3.3.3 Contents of Facilities for NWSCS

The Main Control Center and Sub-Centers will include the required hardware and software as shown in Tables 6.3.3.3-1 and 6.3.3.3-2 respectively.

Table 6.3.3.3-1 Hardware and Software for Main Control Center

	Name of Equipment
Hardware	
1	Web server
2	Mail server
3	Database server
4	Printer
5	Voice alarm system
6	Large area display projector & projector drive
7	LAN equipment
8	Firewall
9	Router
10	GPS
11	UPS (1.5kVA)
12	Water supply supporting system (to be installed in the future)
13	Facility management supporting system
Software	
1	SCADA system software
2	Water supply supporting system software (to be installed in the future)
3	Facility management supporting system software

Table 6.3.3.3-2 Hardware and Software for Sub-Center

	Name of Equipment
Hardware	
1	Web server
2	Mail server
3	Database server
4	Printer
5	PC terminal
6	Voice alarm system
7	LAN equipment
8	Firewall
9	Router (to Leased Line)
10	Router (to Internet)
10	GPS
11	UPS (1.5kVA)
12	Facility management supporting system
Software	
1	SCADA system software
2	Facility management supporting system software

In order to transmit data from the local stations such as pump stations, water reservoirs, etc., the hardware and software shown in Table 6.3.3.3-3 will be required.

Table 6.3.3.3-3 Hardware and Software for Data Transmission from Local Stations

	Content
Hardware	
1	Router (to Leased Line)
2	Remote terminal unit (RTU)
3	PI/O station
4	PI/O modules (DI)
5	PI/O modules (AI)
6	Station box
Software	
1	System software (to PI/O)
2	System software (to SCADA)

Notes :
1. Local station means pump station, water reservoir, etc.
2. PI/O : Process Input/Output
3. DI : Digital Input
4. AI : Analog Input
5. SCADA : Supervisory Control and Data Acquisition System

6.3.4 Proposed Implementation Schedule

The proposed implementation schedule for the National Water Supply Control System is shown in Fig. 6.3.4-1.

Project Name	2005	2010	2015	2020
Project for Establishment of National Water Supply Control System (Phase-1)				
Project for Establishment of National Water Supply Control System (Phase-2)				

Fig. 6.3.4-1 Proposed Implementation Schedule for NWSCS