CHAPTER 4 ALLOCATED WATER TO IRBID AND RAMTHA

With fixed available water resource for the northern governorates in future, allocated water to the Study Area (Irbid and Ramtha) is estimated in this Chapter. Allocation is made based on sub-transmission zones first and then to the Study Area because water transfer based on water allocation will be made through main transmission line and sub-transmission line. Population and water demand in the northern governorates is estimated and distributed to each locality in the northern governorates. Then, allocated water to the Study Area is estimated. Based on allocated water, distribution facilities in the Study Area are planned in the following Chapters.

The sub-transmission lines are defined as branch lines from the main transmission line. Sub-transmission zones are defined as water supply zones to which water is supplied from sub-transmission lines.

4.1 Water Demand Estimation in Northern Governorates

4.1.1 Population

(1) Population by Governorate
Population estimated by Department of Statistics (DOS) is used in this Study. DOS estimates governorate population with different growth rates; low growth rate in Amman and Irbid governorates and high growth rates in Mafraq, Jerash and Ajloun governorates. The estimated population for the northern governorates up to 2035 is shown in Table 4.1 and Figure 4.1. The estimated populations in the governorates are almost the same as used in the Water Reallocation Strategy 2010 where estimated populations in 2035 are 1.81 million in Irbid, 0.23 million in Ajloun, 0.31 million in Jerash and 0.48 million in Mafraq, totaling to 2.83 million. Therefore, this is in line with on-going water reallocation strategy.

Table 4.1 Governorate Population

(Unit: persons)

Year/ Governorate	1994 Census (persons)	2004 Census (persons)	2012 Estimate (persons)	2035 Projection (persons)	% increase of 23 years	Avg. Growth Rate
Irbid	751,634	927,892	1,137,100	1,801,256	55.1 %	2.00 %
Mafraq	178,634	244,188	300,300	486,763	61.6 %	2.10 %
Jerash	123,190	153,602	191,700	336,780	75.7 %	2.45 %
Ajloun	94,548	118,725	146,900	240,869	63.6 %	2.15 %
4 Governorates	1,148,006	1,444,407	1,776,000	2,865,668	59.2 %	2.10 %
Amman			2,473,400	3,681,579	48.9 %	1.70 %
Jordan	4,139,458	5,103,639	6,388,000	9,767,149	52.9 %	1.90 %

Source: Department of Statistics (DOS)

(2) Population by Sub-transmission Zones
Population is estimated for each locality in governorates. Locality is “census unit” used by DOS and the boundary of locality is slightly different from that of city and village with the same names. However, accurate data on population and locality boundaries are available from DOS; and are used in this Study. Name and location of locality in Irbid, Ajloun, Jerash and Mafraq Governorates are shown in figures in Appendix 3B. Localities are grouped into “Sub-transmission zones” for water balance estimation. Population of each locality according to sub-transmission zone is shown in Appendix 3B.

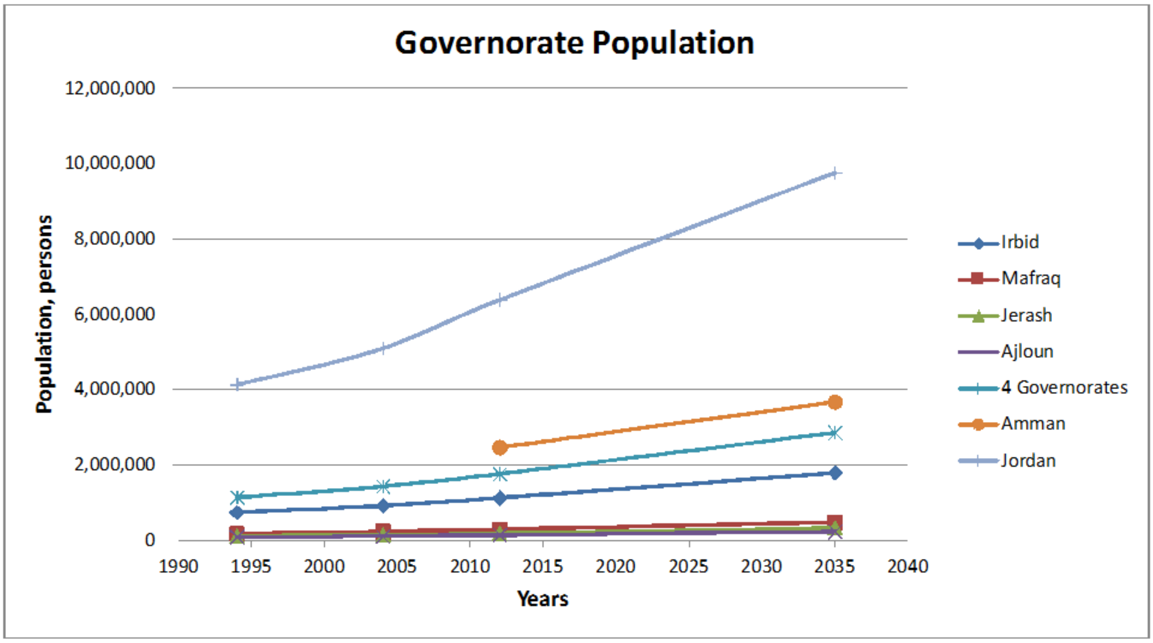


Figure 4.1 Governorate Population

Table 4.2 Population in Sub-Transmission Zones

Sub-transmission zone	2012 (Current Estimate)	2035 (Planned)
North Shooneh	107,421	170,163
Deir Al Sina	147,210	233,193
Kufur Youba	120,645	191,111
Zebdat	501,347	794,174
Badia	108,800	176,357
Mafraq	136,470	221,208
Um El Lulu	239,723	413,668
Ramtha	133,690	211,775
Hofa	280,694	454,019
Total	**1,776,000**	**2,865,668**

Note: See Figure 3.2 for sub-transmission zones.
Source: JICA Study Team

(3) Population of Syrian Refugees

Population of Syrian refugees are not taken into consideration explicitly in Chapters 4 to 6, dealing with water allocation to the Study Area and improvement plans in the Study Area. The target year is set as 2035 for Jordanian population only, but it is practically 2028 if refugee's population is counted (refer to section 2.1.3 (2)). Basic assumptions on the numbers of Syrian refugees in the Study are as follows;

- Nobody can predict number of Syrian refugees in the Study Area and each locality within the Study Area.
- Therefore, it is assumed that the number of the refugees will be settled in proportion to the Jordanian population, more or less because refugees are settled in the built-up houses and apartments except in the refugees' camps.
- The Ministry of Interior issued the number of each governorate as of July 2013.
- It is used in the Study for water allocation and improvement plans assuming that the above number will not change in the Study.
- When this unchanged refugees' population is added to the estimated Jordanian population in 2028, total population becomes equal to the Jordanian population in 2035. Therefore, the target year of 2035 for the Jordanian population is regarded as target year of 2028 for the

population of Jordanian and the refugees.

The refugees' population may change in future, different from the above unchanged population. In such a case, implementation schedule should be adjusted: If increased, the target year should come earlier.

4.1.2 Planned Per Capita Consumption

The non-revenue water (NRW) ratio of Irbid governorate in 2012 is estimated at 36.8 % by YWC and 45.1 % by WAJ. Assuming average of these values, the current NRW is estimated as 40 % and half of the NRW ratio (20 %) is assumed as leakage. The target value of NRW ratio of this Study is set as 30 %, same value as recommended in "Water Reallocation Strategy 2010" and the leakage ratio is planned as 15 %. The values of the national target are adopted in this Study. As planned in Chapter 5, leakage ratio will be 20 % up to 2020 and 15 % in and after 2025.

Per capita consumption and leakage applied in this Study is shown in Table 4.3. These values are the recommended ones in "Water Reallocation Strategy 2010" to rectify the problem of unequitable water allocation among the governorates and to pursue equitable water allocation to each governorate. And even this minimum requirement is difficult to achieve due to scarce water resources.

Table 4.3 Per Capita Consumption and Demand

(lpcd)

Area	Basic	Commercial	Industrial	Tourism	Contingency	Consumption	Leakage	Average Demand		Maximum Demand	
								Leakage 20 %	Leakage 15 %	Leakage 20 %	Leakage 15 %
Urban	100	3	5	3	5	116	21	145	137	168	159
Rural	80	2.4	1.6	-	4	88	16	110	104	128	121

Note: 1. Cities of Irbid, Ramtha, Mafraq, Jerash and Ajloun are Urban while others are Rural areas.
2. Compiled by JICA Study Team based on values recommended in Water Reallocation Strategy 2010

4.1.3 Water Demand Estimation

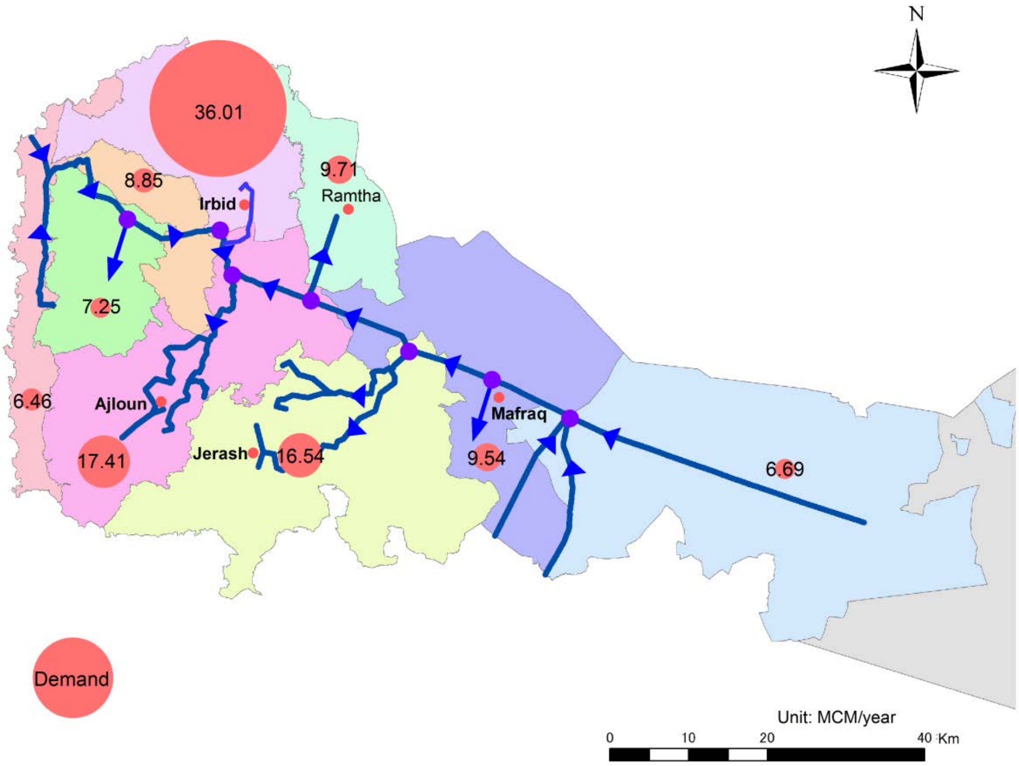
Water demand for each sub-transmission zones have been estimated considering population and per capita average demand. Average demand in 2035 will be about 118 MCM/year and, demand in sub-transmission zones are shown in Table 4.4 and Figure 4.2. Details are given in Appendix 3B.

Table 4.4 Average Water Demand in Sub-Transmission Zone

(MCM/y)

Sub-transmission zone	2012	2035
North Shooneh	4.313	6.459
Deir Al Sina	5.910	8.852
Kufur Youba	4.844	7.255
Zebdat	24.051	36.005
Badiah	4.368	6.695
Mafraq	6.230	9.544
Um El Lulu	10.130	16.539
Ramtha	6.485	9.708
Hofa	11.385	17.413
Total	77.716	118.470

Note: see Figure 3.2 for sub-transmission zone.
Source: JICA Study Team



Source: JICA Study Team

Figure 4.2 Annual Water Demand in 2035 by Sub-Transmission Zone

4.2 Water Sources

4.2.1 Existing Water Sources

Groundwater level of each well field in the northern governments is lowering as shown in section 3.1.1(3). It indicates excessive pumping. However, YWC cannot reduce pumping volume but needs to maintain the current water supply amount at minimum. Unless YWC secures alternative water source, it is not possible to reduce pumping volume.

Wells' production in the northern governorates in three years (2011-2013) is almost constant (71 to 73 MCM per year). To maintain the production volume, YWC has been trying to rehabilitate old wells and install new wells. In this Study, based on discussion with YWC, the water amount from wells in the future is assumed to be same as the current level.

4.2.2 Water Resources Augmentation Plan

Water resources development has been continuously conducted in Jordan. Development of two additional water resources in the foreseeable future is considered in this Study. One is additional 19 MCM/year (10 MCM/year from Disi project and 9 MCM/year from rehabilitation of eastern wells) and the other is further addition of 30 MCM/year from western sources in Wadi Al-Arab, as explained in the section 3.1.2.

In the former case (A), available water resources in the northern governorates will be 91 MCM/year (existing production amount 72 MCM/year plus 19 MCM/year). In the latter case (B), the total amount will be 121 MCM/year, which would be almost equal to 118 MCM/year; daily average demand in 2035. The former project can be materialized in 2017 while the latter is not certain but in 2020 at the earliest.

Table 4.5 Water Resources in Northern Governorates

(Unit: MCM/y)

Source	**Current***	**Case A**	**Case B**	**Commissioning Year**
Existing Wells	72	72	72	Present
Eastern well improvement	-	9	9	2014
Disi water allocation	-	10	10	2017
Wadi Al-Arab Extension	-	-	30	early 2020's (Uncertain)
Total	**72**	**91**	**121**	

* Breakdown of wells is shown in Appendix 3A and 3B.
Source: Yarmouk Water Company

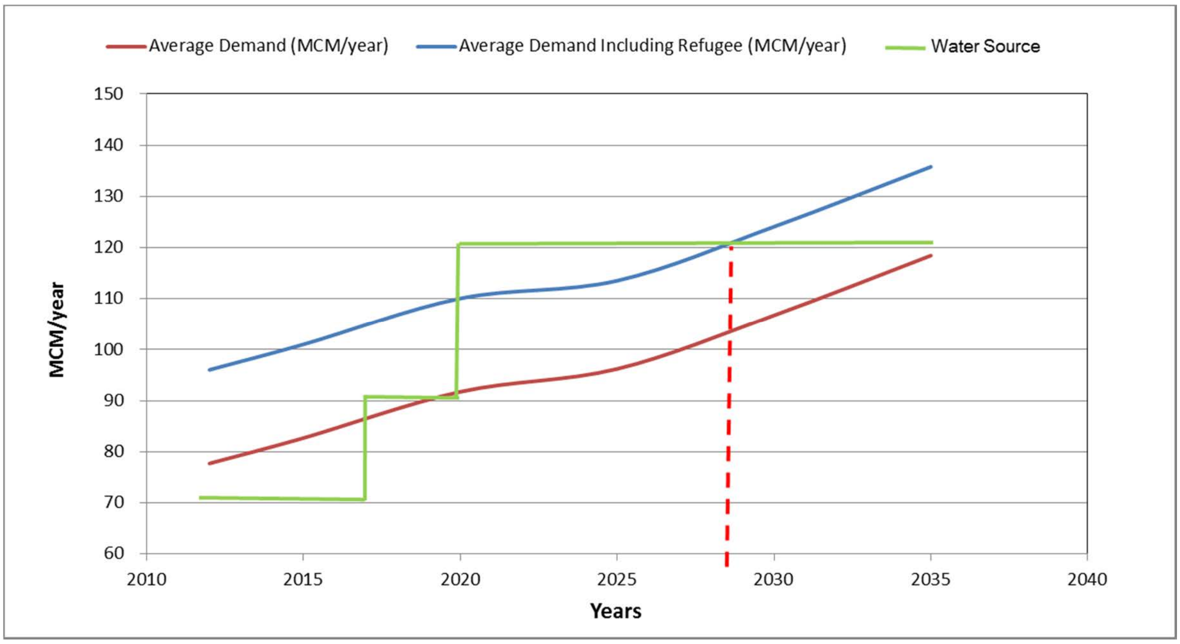
4.3 Water Allocation

Daily average water demand is calculated based on estimated population of all localities within each sub-transmission zone in the northern governorates and production of water sources located in corresponding sub-transmission zones is summed up. Based on this result, water balance in two cases of future water source development of 91 MCM/year and 121 MCM/year is studied and water allocation plan to Irbid and Ramtha is prepared.

4.3.1 Water Balance in Northern Governorates

Estimation of population and water demand in the northern governorates is shown in Table 4.6 and water supply and demand balance for the northern governorates is shown in Figure 4.3. In the case A, when available water for northern governorates is 91 MCM/year, the supply can meet the demand until 2019 but the supply is much lower than the demand if the demand of Syrian refugees is counted.

In the case B, when available water for the northern governorates becomes 121 MCM/year, the supply can meet the demand of up to year 2035 and beyond but the supply can meet the demand of only up to year 2028 if the demand of Syrian refugees is counted.



Note: Year 2020 is the earliest year when additional water source of 30 MCM/y is available.

Figure 4.3 Water Supply and Demand Balance for the Northern Governorates

Table 4.6 Estimation of Population and Water Demand in Northern Governorates

Year	Jordanian Population	Average Demand (MCM/year)	Expected Water Availability (MCM/year)	Population Including Refugees	Demand of Refugee (MCM/year)	Average Demand Including Refugee (MCM/year)
2012	1,776,000	77.717	72	2,169,934	18.333	96.049
2015	1,890,248	82.710	72	2,284,182	18.333	101.043
2020	2,097,312	91.760	121	2,491,246	18.333	110.093
2025	2,327,175	96.230	121	2,721,109	17.326	113.556
2030	2,582,356	106.770	121	2,976,290	17.326	124.096
2035	2,865,668	118.469	121	3,259,602	17.326	135.796

Source: JICA Study Team

Without two water resource projects, the deficiency of the supply in the northern governorates is getting considerably large, especially if Syrian refugee's demand is counted. Therefore, facilities for 91 MCM/y are urgently required and successively additional 30 MCM/y is required to meet the demand of 2035 for Jordanian population or 2028 for the population including Syrian refugees.

4.3.2 Water Allocation by Sub-Transmission Zone

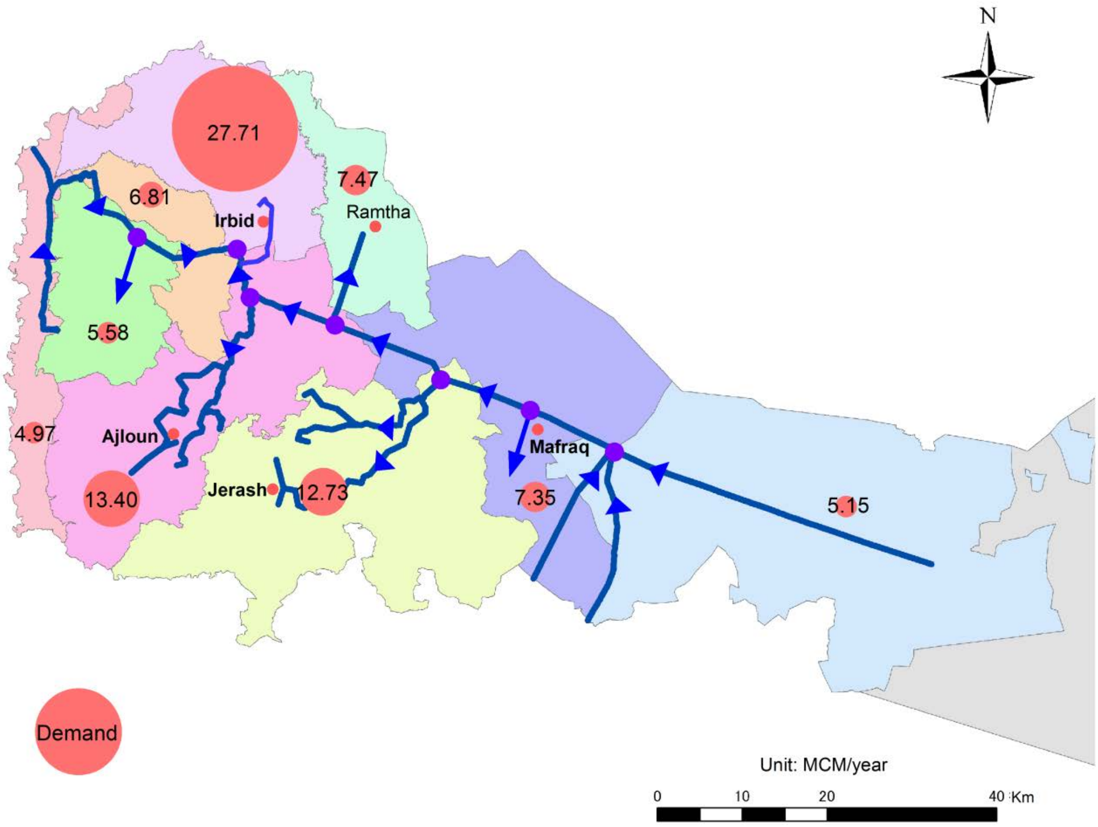
(1) Case A (91 MCM/y)

The water allocation to each sub-transmission zone in the case A (91 MCM/y) is shown in Figure 4.4. Total available water of 91 MCM/year is distributed to each sub-transmission zone in proportion to the water demand of each sub-transmission zone in 2035. Twenty seven point seven (27.7) MCM/year is allocated to the area covered by Zebdat sub-transmission zone and 7.47 MCM/year to Ramtha sub-transmission zone. This allocated water is total water availability of both internal and external sources. Figure 4.5 shows the amounts of internal and external sources separately. In addition, water transfer for this water allocation (91 MCM/y) on the transmission lines is shown in Figure 4.6.

(2) Case B (121 MCM/y)

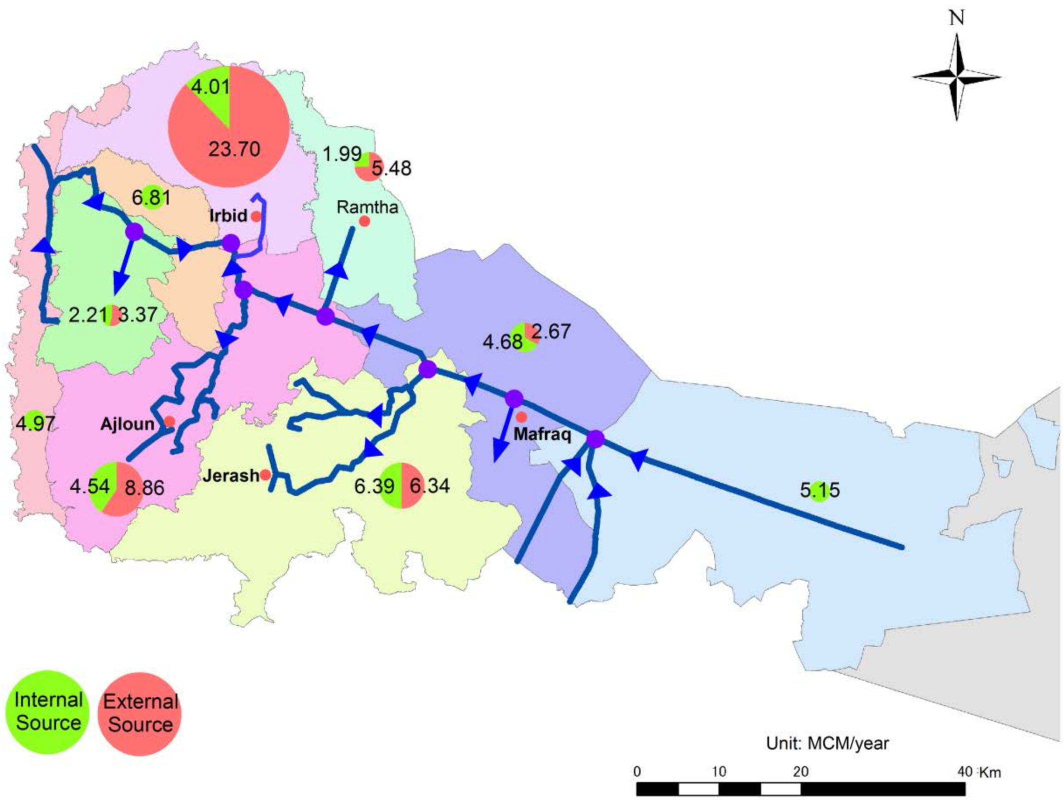
The water allocation to each sub-transmission zone in the case B (121 MCM/y) by source type is shown in Figure 4.7. In this case, 121 MCM/year is more than the water demand in 2035. Therefore, water allocation is made using the water demand in 2035, total of which is 118 MCM/year.

Thirty six (36) MCM/year is allocated to the area covered by Zebdat sub-transmission zone and 9.71 MCM/year to Ramtha sub-transmission zone. Water transfer for this water allocation on the transmission lines is shown in Figure 4.8.



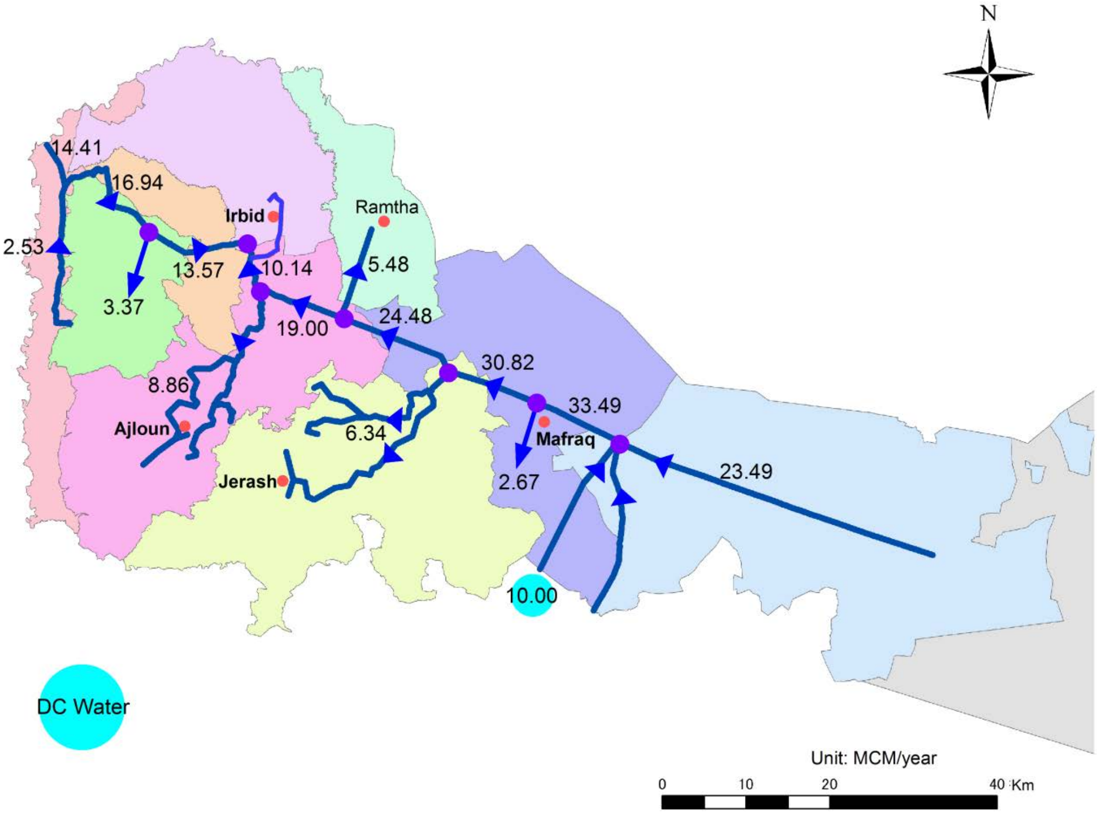
Source: JICA Study Team

Figure 4.4 Water Allocation (91 MCM/y) to Sub-Transmission Zones



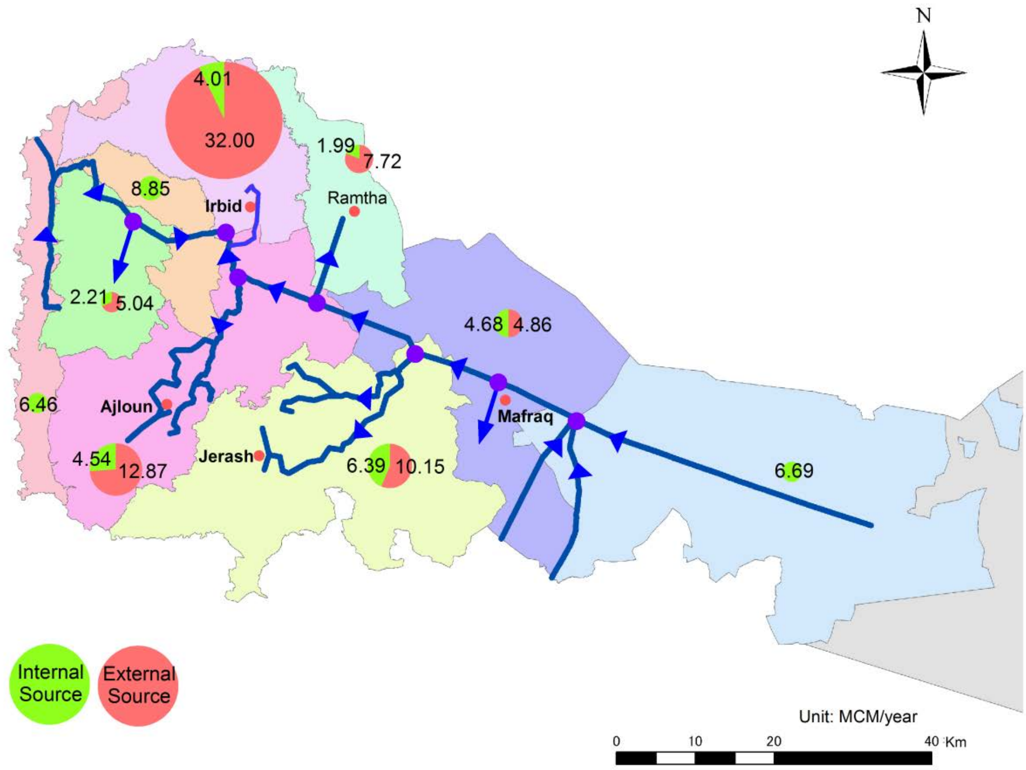
Source: JICA Study Team

Figure 4.5 Water Allocation by Source Type (91 MCM/y) to Sub-Transmission Zones



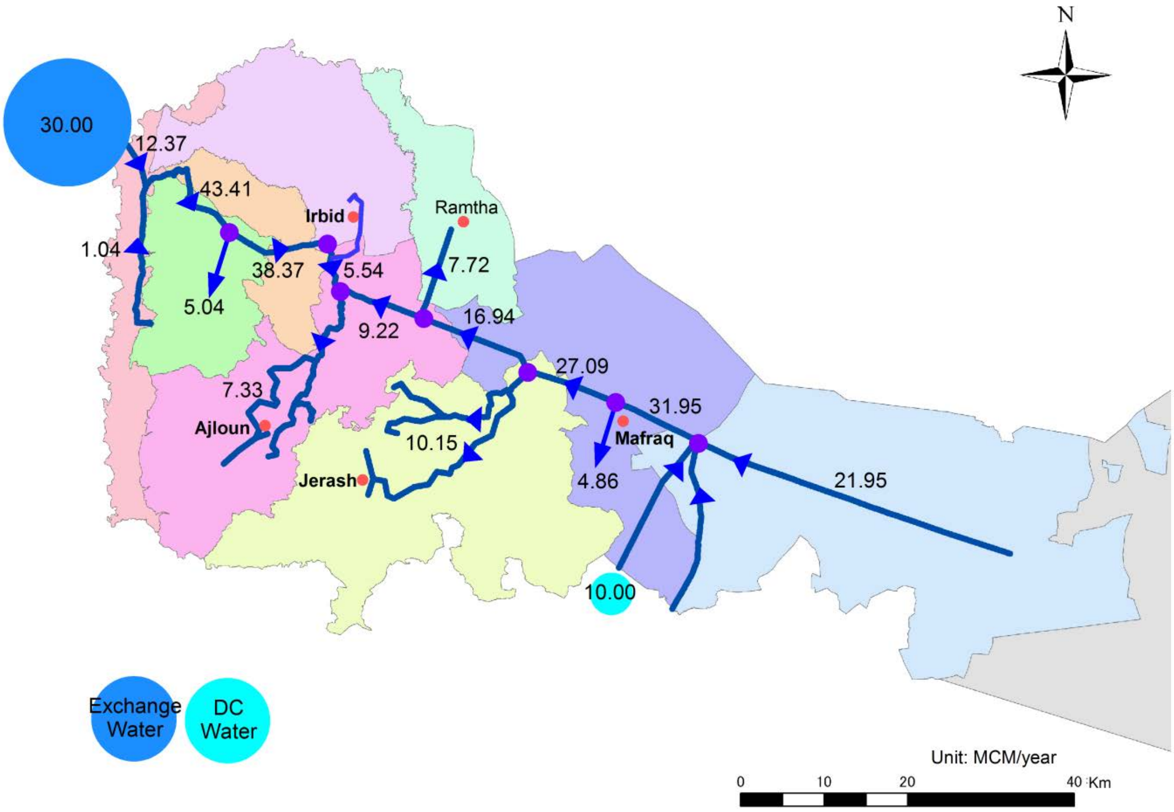
Source: JICA Study Team

Figure 4.6 Water Transfer for Water Allocation (91 MCM/y)



Source: JICA Study Team

Figure 4.7 Water Source for Each Sub-transmission Zone for Water Demand (121 MCM/y) in 2035



Source: JICA Study Team

Figure 4.8 Water Transfer for Water Demand in 2035 (121 MCM/y)

4.3.3 Water Allocation to Irbid and Ramtha Study Area

Allocated water to the Study Area of Irbid and Ramtha is summarized in Table 4.7. The water allocated to Irbid area in this table includes water allocated to Bani Kinana district, to which water is transferred from Zebdat and/or Hofa.

Table 4.7 Allocated Water to the Study Area in Irbid and Ramtha

Case	Irbid*			Ramtha		
	Total	Internal Sources	External sources	Total	Internal Sources	External sources
2012 (present)	17.85	4.01	13.84	3.83	1.99	1.84
91 MCM/year	31.98	4.01	27.97	7.47	1.99	5.48
121 MCM/year	42.38	4.01	38.37	9.71	1.99	7.72

Note: * The value includes water allocated to Bani Kinana district.
Source: JICA Study Team

CHAPTER 5 IMPROVEMENT PLAN IN IRBID AND ITS SUBURBS

5.1 Water Demand Estimation

5.1.1 Design Population

Population of the Study Area (Irbid city and its suburbs) is estimated using the governorates' growth rates of DOS and presented in Appendices 2A and 3B. Irbid city occupies large area with marked difference in the development levels within the city. The Study area includes Irbid city, Irbid suburbs within urban growth area (including localities of Aidoon, Aliah, Bait Ras, etc.), and Irbid suburbs outside of urban growth area (including localities of Al'al, As'ara, etc.). The population has also been estimated for localities of Bani Kinana Area in order to consider their demand in future, although they are out of the Study Area. The location of Irbid city and localities is shown in Figure 5.1.

(1) Population Density in Irbid City and Suburbs
As a first step, population of neighborhoods within Irbid city is estimated up to 2035 using the growth rate of Irbid Governorate, which is same for both Irbid city and its suburban localities. Locations of neighborhood within Irbid city is shown in Figure 5.2. The population densities in 2012 and 2035 based on DOS estimates are calculated and presented in Appendix 2A. It is apparent that population densities in 10 neighborhoods located in the central part of Irbid city range from 105 to 391 persons per hectare, and are exceeding healthy environment levels considering the available infrastructures. Such abnormally high density of population in the central part of Irbid will not take place causing increased load on limited infrastructures and consequently leading to unhealthy living environments.

(2) Population Reallocation within Irbid City
Therefore, it is considered that the central area of Irbid would not be able to accept additional population and hence increased population will diffuse to suburban parts of Irbid guided by factors such as availability of infrastructure, lower prices of land, etc. The "Irbid 2030: Greater Irbid Area plan" prepared by the Ministry of Municipal Affairs (hereinafter called as city master plan) includes planned population density in Irbid city and its suburbs which has been set considering sound living environment and development of city and its suburbs. The city master plan is used as a guide for future population distribution in the Irbid city and its suburbs. Ten (10) neighborhoods located in the central part of Irbid are defined as "residential stable" areas in the city master plan. Population growth in these 10 neighborhoods is not encouraged and, consequently, future population in these neighborhoods is considered same as the existing population.

Population in the remaining 35 neighborhoods, defined as "residential intensification" area, is estimated using the population density in the city master plan. As a result, the adopted population in Irbid city in 2035 is 389,310, which is lower than DOS population (486,360). This is shown in Table 5.1 and Figure 5.2.

(3) Population Reallocation to Irbid Suburbs
The remaining population of the DOS estimates of Irbid city for 2035 is re-allocated to peri-urban or suburban localities within Greater Irbid "urban growth area" (shown in section 2.1.1) such as localities of Hawwara, Sarieh, Aidoon, Hoson, Bait Ras, etc. The infrastructure in these suburban localities are developing at fast pace and existing population density is still very low, thus capable of accommodating increased population in sustainable manner. The total of the DOS population in 2035 of these suburban localities (229,273) and the remaining population from Irbid city (97,050) is redistributed to these suburban localities in proportion of their calculated population using city master plan density. Consequently, the population in these suburban localities is a) corresponding DOS population (using population growth rate of 2.0 %) plus b) re-allocated population from Irbid city. Hence, the total population of Irbid and its suburbs calculated in this Study remains same as in case of DOS estimates and the population distribution gets fairer with due consideration to avoiding population overload in central Irbid.

The calculated population and population density of each neighborhood in Irbid city, its suburban localities and a Bani Kinana and outside of urban growth area is shown in Table 5.1.

5.1.2 Water Demand Estimation

Estimated demand in all localities and neighborhoods in the Study Area (Irbid and its suburbs) including Bani Kinana is shown in Table 5.1 based on estimated population and the per capita consumption mentioned in section 4.1.2.

5.2 Water Sources and Supplemented Water

Networks in the Zebdat system is connected with networks in Bani Kinana district as shown in Figure 5.3. Therefore, in order to plan the distribution facilities in Irbid and its suburbs, Bani Kinana district shall be included and supplemented water amount from external sources are calculated by locality using local (internal) water sources and estimated water demand in each locality.

The estimated average water demand for Case A and Case B (in 2035) and fixed amount of internal sources same as current amount in each locality are shown in Table 5.2 and required supplemented water supplied to Irbid city and its suburbs and localities in Bani Kinana district are calculated in the same table. The estimated average water demand and external source allocation to localities are shown in Figure 5.3 (Case A for reduced water demand) and Figure 5.4 (Case B for water demand in 2035). In addition, water transfer amount to each locality in Case A and Case B are presented in Figure 5.5 and Figure 5.6, respectively.

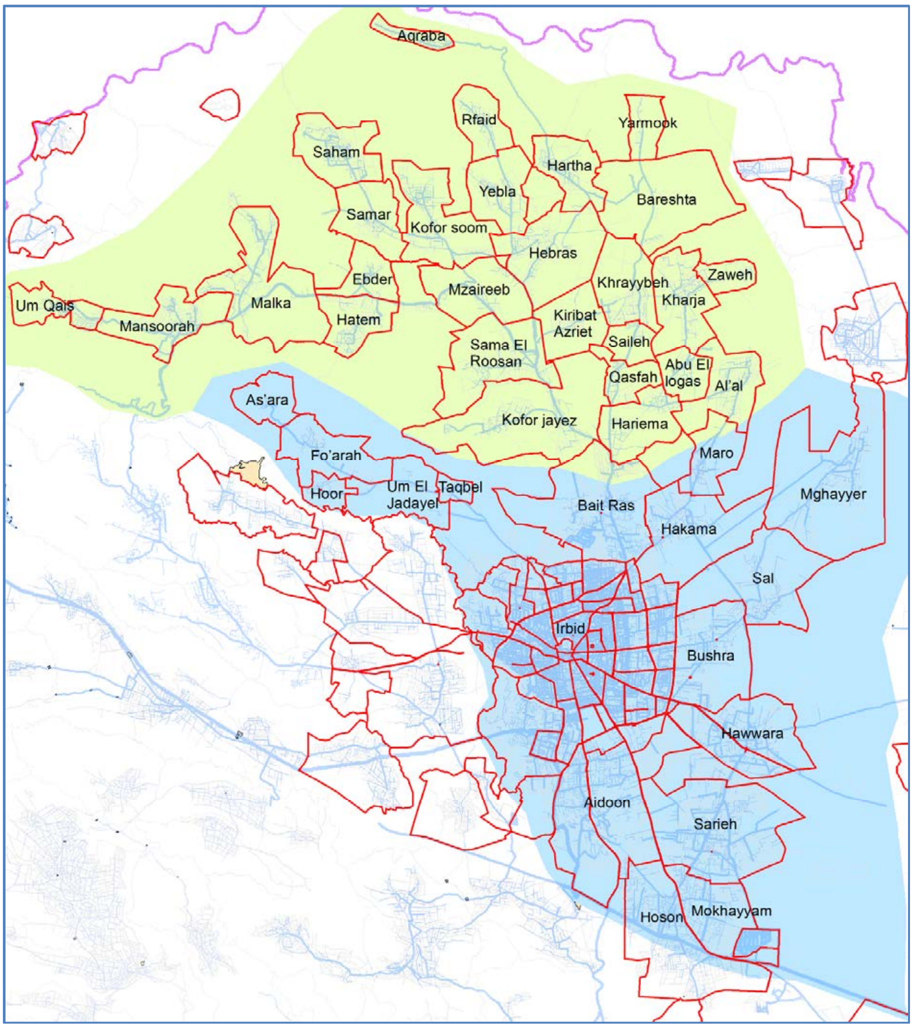


Figure 5.1 Irbid City and Localities in Its Suburbs (Study Area) and Bani Kinana District

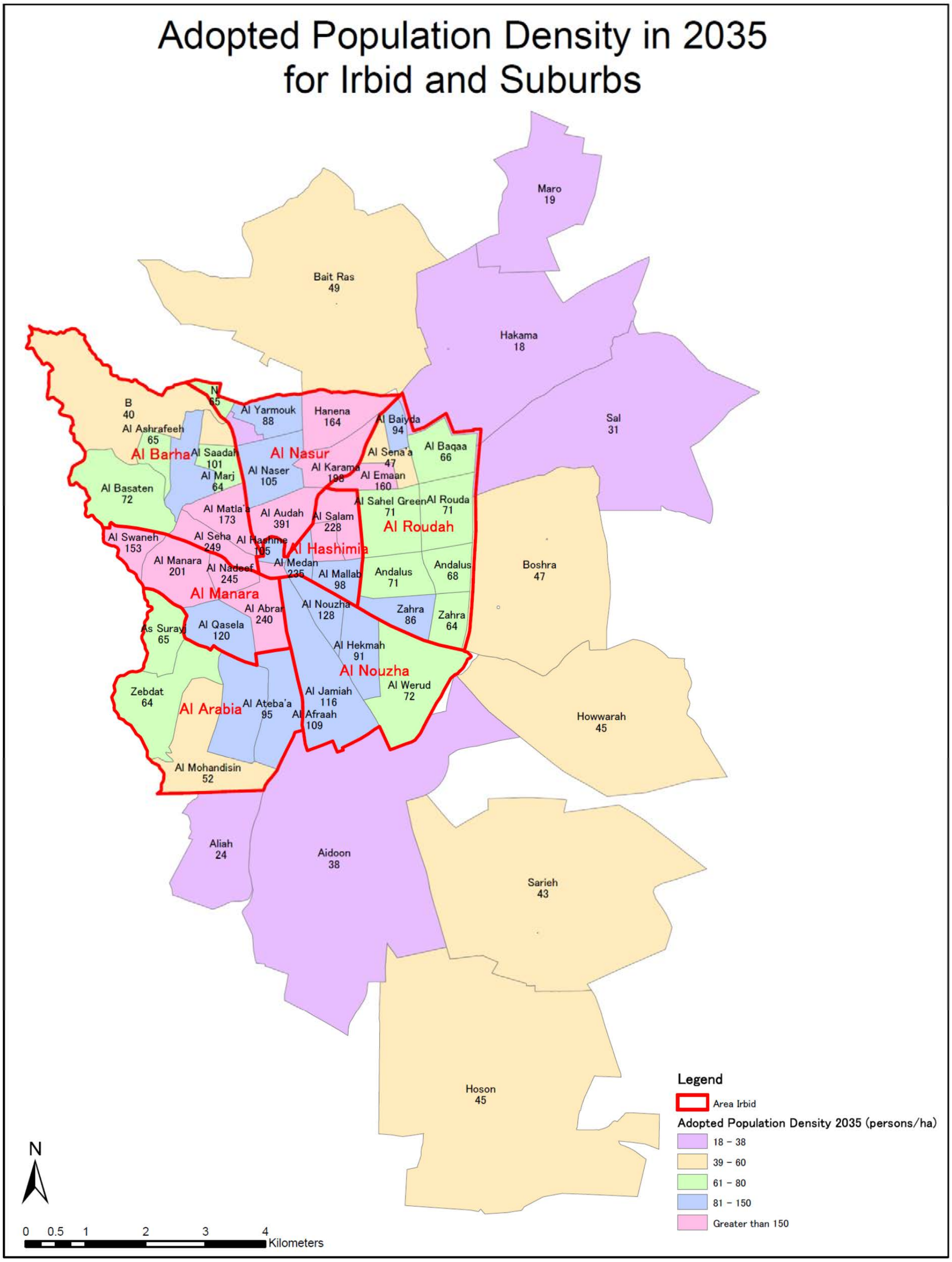
Table 5.1 Population and Average Water Demand in Irbid City, Suburbs and Bani Kinana District

Area/Locality	Neighborhood	2012 Population (person)	2035 Population (person)	2012 (MCM/y)	2035 (MCM/y)
Irbid City					
Al Arabia, Irbid City	Al Afraah	11,917	11,917	0.63	0.60
	Al Ateba'a	5,730	11,868	0.30	0.59
	Al Mohandisin	6,300	9,717	0.33	0.49
	As Surayj	217	4,992	0.01	0.25
	Zebdat	3,585	10,561	0.19	0.53
	Sub-total	**27,752**	**49,055**	1.47	**2.46**
Al Barha, Irbid City	Al Ashrafeeh	2,196	2,308	0.12	0.12
	Al Basaten	4,498	11,768	0.24	0.59
	Al Herafeyeen West	158	997	0.01	0.05
	Al Marj	1,610	2,687	0.09	0.13
	Al Matla'a	12,990	12,990	0.69	0.65
	Al Saadah	7,497	8,446	0.40	0.42
	Al Seha	13,147	13,147	0.70	0.66
	No Name	--	12,453	-	0.62
	Sub-total	**42,096**	**64,796**	2.23	**3.24**
Al Hashme, Irbid City	Al Hashme	2,732	2,732	0.14	0.14
	Al Jamee	1,433	1,730	0.08	0.09
	Al Mallab	3,895	4,512	0.21	0.23
	Al Medan	6,822	6,920	0.36	0.35
	Al Salam	13,977	14,272	0.74	0.71
	Al Tall	1,044	1,908	0.06	0.10
	Sub-total	**29,903**	**32,074**	1.58	**1.62**
Al Manara, Irbid City	Al Abrar	19,224	19,224	1.02	0.96
	Al Manara	21,481	21,481	1.14	1.07
	Al Nadeef	8,904	8,904	0.47	0.45
	Al Qasela	10,212	10,397	0.54	0.52
	Al Swaneh	5,191	7,201	0.27	0.36
	Sub-total	**65,012**	**67,207**	3.44	**3.36**
Al Nasur, Irbid City	Al Audah	32,581	32,581	1.72	1.63
	Hanena	15,617	17,089	0.83	0.85
	Al Herafeyeen East	486	648	0.03	0.03
	Al Karama	13,256	13,814	0.70	0.69
	Al Naser	10,871	10,871	0.58	0.54
	Al Yarmouk	4,242	5,511	0.22	0.28
	No Name	-	1,206	-	0.06
	Sub-total	**77,053**	**81,720**	4.08	**4.08**
Al Nouzha, Irbid City	Al Jamiah	12,025	13,591	0.64	0.68
	Al Nouzha	6,896	6,896	0.36	0.34
	Al Hekmah	6,784	7,562	0.36	0.38
	Al Werud	6,525	14,292	0.35	0.71
	Sub-total	**32,230**	**42,341**	1.71	**2.11**
Al Roudah, Irbid City	Andalus	-	4,015	-	0.20
	Andalus	5,532	5,643	0.29	0.28
	Al Baqaa	2,413	6,340	0.13	0.32
	Al Baiyda	2,844	2,943	0.15	0.15
	Al Emaan	4,982	6,215	0.26	0.31
	Al Rouda	5,009	7,684	0.27	0.38
	Al Sahel Green	6,028	8,011	0.32	0.40
	Al Sena'a	796	2,174	0.04	0.11
	Zahra	-	3,707	-	0.19
	Zahra	5,374	5,385	0.28	0.27
	Sub-total	**32,978**	**52,117**	**1.75**	**2.61**
Sub-total		**307,024**	**389,310**	**16.25**	**19.47**
Irbid Suburbs within Urban Growth Area					
Greater Irbid Municipality	Aidoon	22,767	48,819	0.92	1.85
	Aliah	532	5,197	0.02	0.20
	Bait Ras	22,078	50,036	0.89	1.90
	Bushra	13,936	32,175	0.56	1.22
	Hakama	9,093	14,404	0.37	0.55
	Hawwara	15,622	31,955	0.63	1.21
	Hoson	25,093	65,633	1.02	2.49
	Maro	3,578	6,046	0.14	0.23
	Sal	8,505	24,699	0.34	0.94
	Sarieh	23,532	47,359	0.95	1.80
Sub-total		**144,736**	**326,323**	**5.86**	**12.39**
Total		**451,760**	**715,633**	**22.11**	**31.86**

Area	Locality	2012 Population (person)	2035 Population (person)	2012 (MCM/y)	2035 (MCM/y)
Irbid Suburbs outside of Urban Growth Area					
Greater Irbid Municipality	Locality				
	Al'al	5,343	8,464	0.22	0.32
	As'ara	1,188	1,882	0.05	0.07
	Fo'arah	4,062	6,435	0.16	0.24
	Kofor Jayez	3,818	6,048	0.15	0.23
	Mghayyer	10,625	16,831	0.43	0.64
	Mokhayyam Azmi Mufte (Hoson camp)	20,353	32,241	0.82	1.22
	Teqbel	612	969	0.02	0.04
	Um El-Jadayel	1,083	1,716	0.04	0.07
	Sub-total	**47,084**	**74,586**	**1.89**	**2.83**
Bani Kinana District					
Bani Kinana District	Hariema	4,522	7,163	0.18	0.27
	Kharja	5,283	8,369	0.21	0.32
	Abu El-Loqas	1,549	2,454	0.06	0.09
	Aqraba	3,070	4,863	0.12	0.19
	Bareshta	214	339	0.01	0.01
	Ebder	2,838	4,496	0.11	0.17
	Hartha	4,916	7,787	0.20	0.30
	Hatem	6,629	10,501	0.27	0.40
	Hebras	4,374	6,929	0.18	0.26
	Hoor	2,432	3,852	0.10	0.15
	Kherbit Azrit	930	1,473	0.04	0.06
	Khrayybeh	1,747	2,767	0.07	0.11
	Kofor Soom	8,377	13,270	0.34	0.50
	Malka	7,784	12,330	0.32	0.47
	Mansoorah	4,404	6,976	0.18	0.26
	Mzaireeb	1,466	2,322	0.06	0.09
	Rfaid	2,532	4,011	0.10	0.15
	Saham	7,226	11,447	0.29	0.43
	Saidoor	1,810	2,867	0.07	0.11
	Samar	3,852	6,102	0.16	0.23
	Soom	6,311	9,997	0.24	0.38
	Qasfah	882	1,397	0.04	0.05
	Saileh	871	1,380	0.04	0.05
	Sama El-Roosan	3,487	5,524	0.14	0.21
	Um Qais	4,811	7,621	0.19	0.29
	Yarmook	1,034	1,638	0.04	0.06
	Yebla	4,564	7,230	0.18	0.28
	Zaweh	1,047	1,659	0.04	0.06
	Sub-Total	**98,962**	**156,764**	**3.98**	**5.95**
Total Outside of Urban Growth Area and Bani Kinana District		146,046	231,350	5.87	8.78
Grand Total		597,806	946,983	27.98	40.64
Summary					
Study Area					
Irbid City		**307,024**	**389,310**	**16.25**	**19.47**
Within Urban growth area		**144,736**	**326,323**	**5.86**	**12.39**
Outside of Urban Growth Area		**47,084**	**74,586**	1.89	2.83
Sub-total		**498,844**	**790,219**	**24.00**	**34.69**
Outside of Study Area					
Bani Kinana		**98,962**	**156,764**	**3.98**	**5.95**
Total		**597,806**	**946,983**	**27.98**	**40.64**

Note:

1. Irbid city and its suburbs within and outside of Urban Growth Area in Greater Irbid Municipality are the Study Area. Bani Kinana District is outside of Study Area but connected with distribution network of the Study Area.
2. Andalus and Zahra are each divided into 2 with the same names based on the map received from the Irbid Municipality office.
3. One area each in Al Barha and Al Naser are with "No Name". These areas are located in the north-western corner of Irbid city and in the map provided by both the Irbid Municipality and DOS, there does not exist any name for this area. Also, DOS did not have population estimate for this area.
4. Source: Prepared by JICA Study Team



Source: JICA Study Team

Note: Number in cells (locality and neighborhood) is population density in persons per hectare.

Figure 5.2 Population Density in Irbid City and Suburbs in 2035

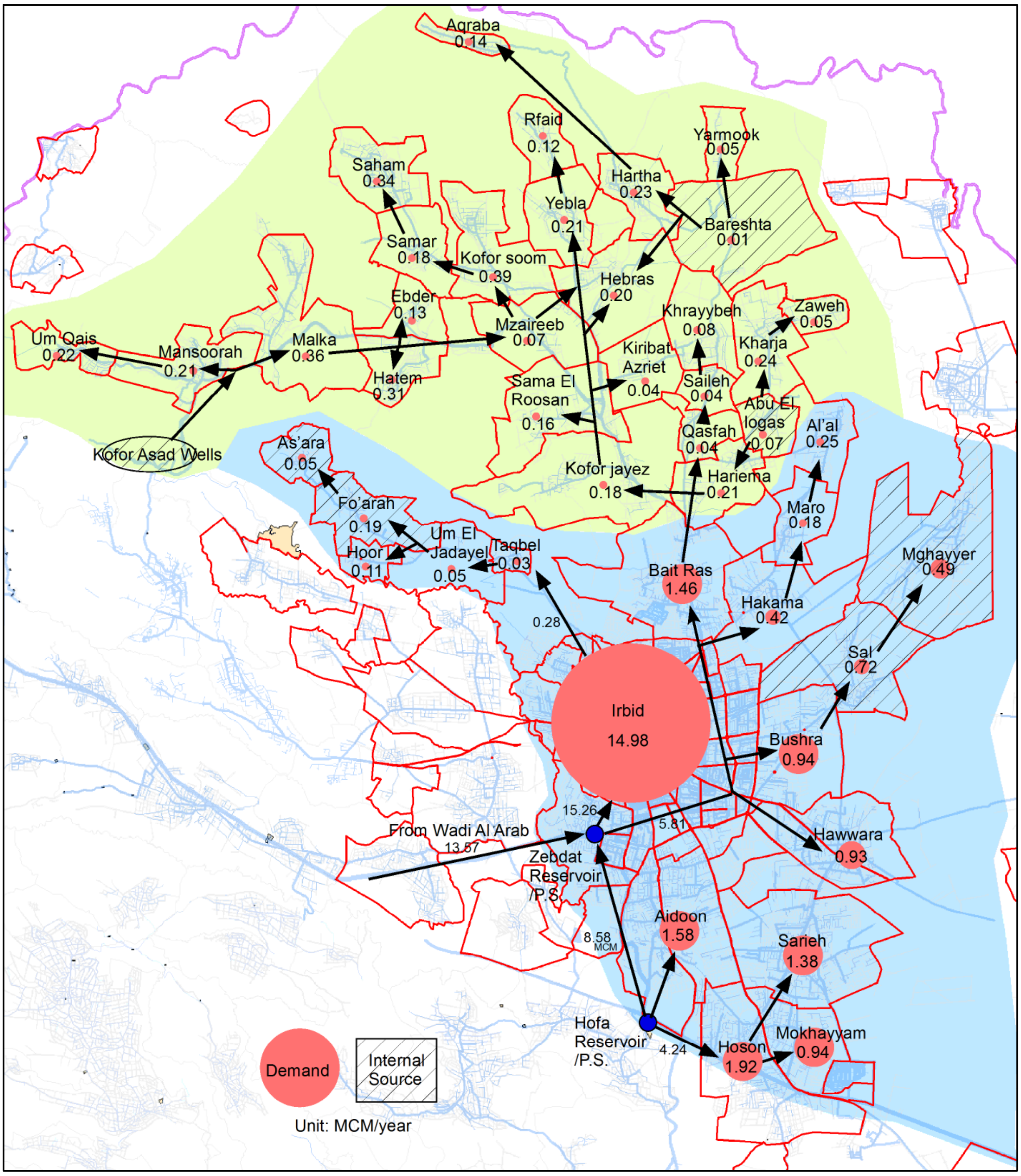
Table 5.2 Average Water Demand, Internal Water Sources and Required Supplemented Water from External Sources for Case A and B in Irbid Area

Unit: (MCM/year)

Area	Locality	Both Cases	Allocation in 91 MCM/y (Case A)		Allocation in 121 MCM/y (Case B)	
		Internal source	Water Allocation (reduced average water demand)	Supplemented from External Sources	Average Water Demand in 2035	Supplemented from External Sources
Irbid City	**Irbid City**	**0.00**	**14.98**	**14.98**	**19.47**	**19.47**
Irbid Suburbs within Urban Growth Area	Aidoon	0.00	1.43	1.43	1.85	1.85
	Aliah	0.00	0.15	0.15	0.20	0.20
	Bait Ras	0.00	1.46	1.46	1.90	1.90
	Bushra	0.00	0.94	0.94	1.22	1.22
	Hakama	0.00	0.42	0.42	0.55	0.55
	Hawwara	0.00	0.93	0.93	1.21	1.21
	Hoson	0.00	1.92	1.92	2.49	2.49
	Maro	0.00	0.18	0.18	0.23	0.23
	Sal	0.30	0.72	0.42	0.94	0.64
	Sarieh	0.00	1.38	1.38	1.80	1.80
	Suburb-total	**0.30**	**9.53**	**9.23**	**12.39**	**12.09**
Irbid Suburbs Outside of Urban Growth Area	Al'al	0.00	0.25	0.25	0.32	0.32
	As'ara	0.02	0.05	0.03	0.07	0.05
	Fo'arah	0.13	0.19	0.06	0.24	0.11
	Kofor Jayez	0.00	0.18	0.18	0.23	0.23
	Mghayyer	0.02	0.49	0.47	0.64	0.62
	Mokhayyam Azmi Mufte	0.00	0.94	0.94	1.22	1.22
	Um El-Jadayel	0.00	0.05	0.05	0.07	0.07
	Teqbel	0.00	0.03	0.03	0.04	0.04
	Sub-Total	**0.17**	**2.18**	**2.01**	**2.83**	**2.66**
Bani Kinana District	Hariema	0.00	0.21	0.21	0.27	0.27
	Kharja	0.00	0.24	0.24	0.32	0.32
	Abu El-Loqas	0.72	0.07	-0.65	0.09	-0.63
	Aqraba	0.00	0.14	0.14	0.19	0.19
	Bareshta	0.61	0.01	-0.60	0.01	-0.60
	Ebder	0.00	0.13	0.13	0.17	0.17
	Hartha	0.00	0.23	0.23	0.30	0.30
	Hatem	0.00	0.31	0.31	0.40	0.40
	Hebras	0.00	0.20	0.20	0.26	0.26
	Hoor	0.00	0.11	0.11	0.15	0.15
	Kherbit Azrit	0.00	0.04	0.04	0.06	0.06
	Khrayybeh	0.00	0.08	0.08	0.11	0.11
	Kofor Soom	0.00	0.39	0.39	0.50	0.50
	Malka	0.00	0.36	0.36	0.47	0.47
	Mansoorah	0.00	0.21	0.21	0.26	0.26
	Mzaireeb	0.00	0.07	0.07	0.09	0.09
	Rfaid	0.00	0.12	0.12	0.15	0.15
	Saham	0.00	0.34	0.34	0.43	0.43
	Saidoor	2.21	0.08	-2.13	0.11	-2.10
	Samar	0.00	0.18	0.18	0.23	0.23
	Soom	0.00	0.29	0.29	0.38	0.38
	Qasfah	0.00	0.04	0.04	0.05	0.05
	Saileh	0.00	0.04	0.04	0.05	0.05
	Sama El-Roosan	0.00	0.16	0.16	0.21	0.21
	Um Qais	0.00	0.22	0.22	0.29	0.29
	Yarmook	0.00	0.05	0.05	0.06	0.06
	Yebla	0.00	0.21	0.21	0.28	0.28
	Zaweh	0.00	0.05	0.05	0.06	0.06
	Sub-Total	**3.54**	**4.58**	**1.04**	**95**	**2.41**
		4.01	**31.27**	**27.26**	**40.64**	**36.63**
Total						

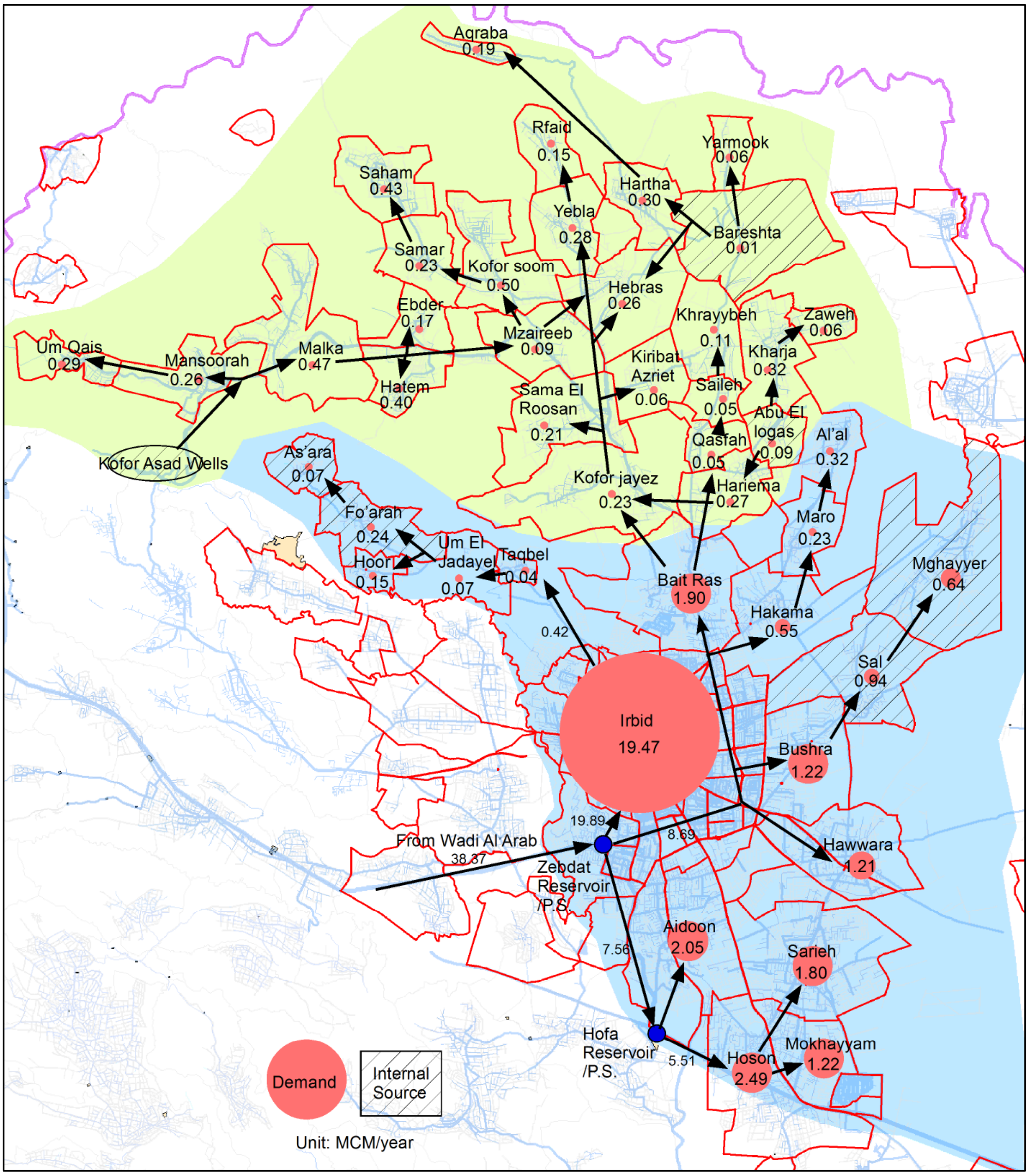
Note: Total external source amounts in this Table and Table 4.7 do not match because the values of this Table are demand based but Table 4.7 is water availability based.

Source: JICA Study Team



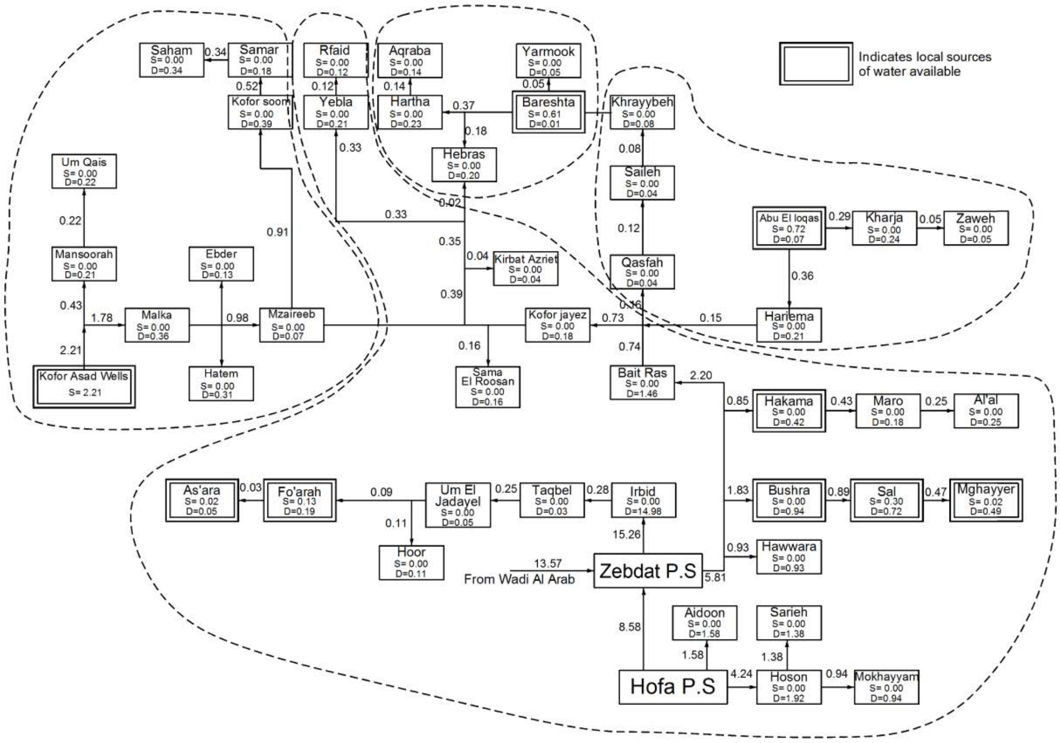
Source: JICA Study Team

Figure 5.3 Water Demand in Localities in Case A (91 MCM/y)



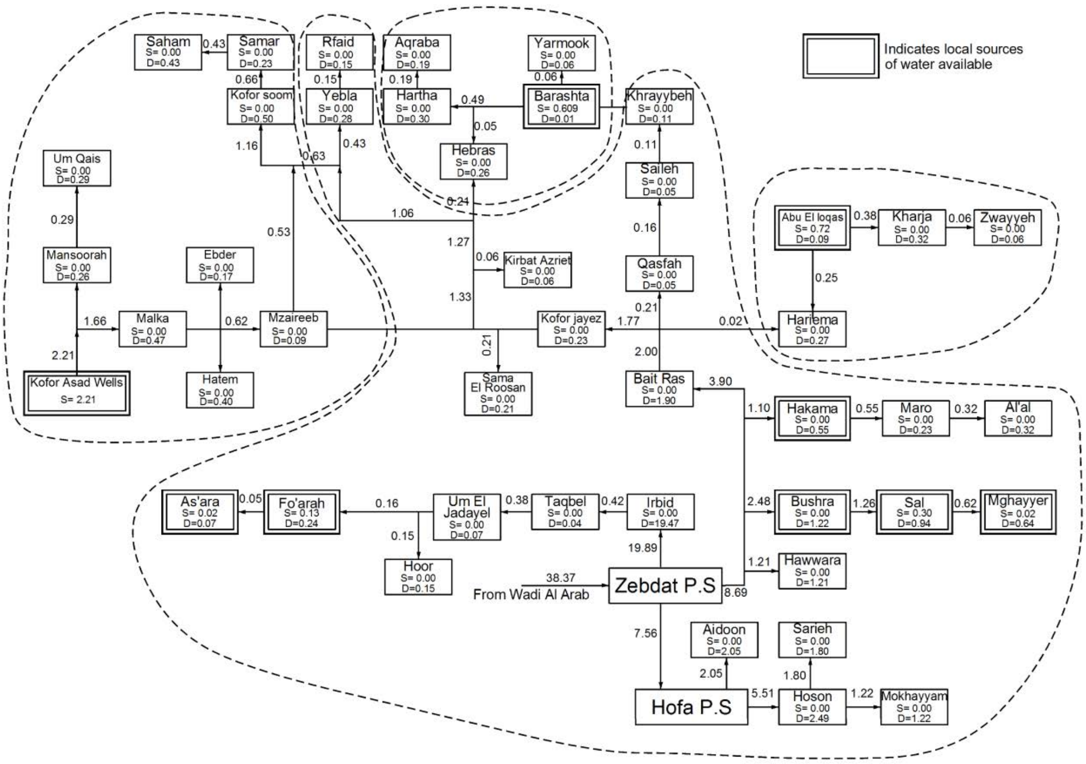
Source: JICA Study Team

Figure 5.4 Water Demand in Localities in 2035 (121 MCM/y)



Note: S=Local Supply, D=Demand in Locality, Unit=MCM/year

Figure 5.5 Internal Source (Local Supply) and Water Transfer in Reduced Demand (91 MCM/y) in Irbid



Note: S=Local Supply, D=Demand in Locality, Unit=MCM/year

Figure 5.6 Internal Source (Local Supply) and Water Transfer in 2035 for Full Demand (121 MCM/y)

5.3 Conditions of Distribution Network in Irbid Study Area

Transmission facilities will be ready in 2017 as shown in Figure 3.6, Chapter 3, bringing additional water to Hofa reservoir for Irbid and its suburbs from the eastern transmission line. Further, additional transmission facilities from the western sources for additional 30 MCM/year supply are now under study. Its operation year is not certain but it will be materialized sooner or later so that the proposed distribution facilities need to be planned for the two cases.

The supplied amount to the Irbid Study Area from the two existing reservoirs will increase by more than double in 2035. To accommodate the increased flow, restructuring of the distribution system as well as increase in pipe sizes is required. Therefore, water supply conditions are checked with the existing network when 121 MCM/year water amount becomes available. Estimated water pressures in Irbid in case of water demand in 2035 is presented in Figure 5.7. It is observed that variation in pressure is significant from negative pressure to more than 7 bars. This indicates insufficiency of network in terms of its carrying capacity for the demand in 2035, particularly in the north and east Irbid city.

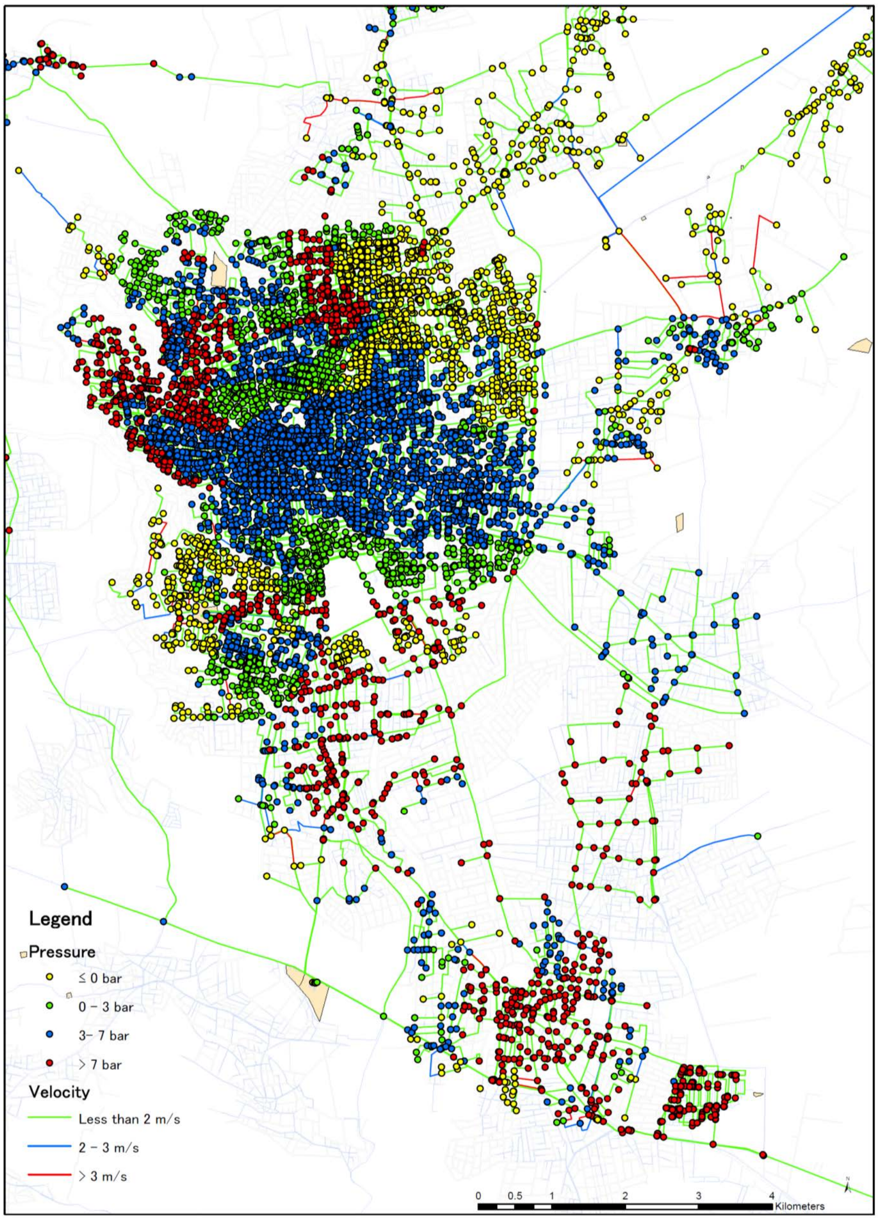


Figure 5.7 Simulated Water Pressure with Existing Network in Case of Water Demand in 2035

5.4 Improvement Concept

5.4.1 Planning Target and Objectives

(1) Planning Target

The planning target is to alleviate "no-water" condition for Syrian refugees as well as Jordanian people with equitable supply to all customers with limited water resources. The issues and problems are summarized in section 3.10 and the main and most significant problem is identified as "No Water". Therefore, no-water condition should be alleviated. In anyway, even though water resource development is implemented, water supply amount is very limited so that equitable distribution should be worked out with available water supply amount.

(2) Planning Objectives

The following three planning objectives are identified:

1. Improvement of inadequate distribution system (strengthening and restructuring)
2. Reduction of leakage through replacement of inferior pipes and adequate maintenance of pipes
3. Improvement of distribution management and technical capacity for equitable supply

Note: Improvement of inadequate distribution system, reduction of leakage through replacement of inferior pipes and improvement of distribution management equipment are dealt in this Chapter and reduction of leakage through improvement in maintenance of pipes and improvement of distribution management technical capacity are planned in Chapter 7.

(3) Planning Preposition

The planning prepositions are identified as follows:

1. Unchanged future population of Syrian refugees (393,000 in the northern governorates) and unchanged water demand of the refugees
2. Water resource development (19 MCM/year plus 30 MCM/year in the northern governorates) and construction of transmission lines

In the section 3.10, the main causes of problems are also identified as follows:

- Increased water demand by rapid influx of Syrian refugees
- Limited water resources
- Insufficient transmission facilities
- Inadequate distribution system
- Low distribution management capacity
- Leakage due to inferior pipes and inadequate maintenance of pipes

Population of Syrian refugees cannot be controlled in this plan so that this must be regarded as a given condition. In discussion with Jordanian side, future refugee population is fixed as the 2013 figure; 393,000 in the northern governorates.

In the study area, water resources are limited but now several water resource development projects in and out of the Study Area are completed and under way including construction of transmission line by which developed water resources will be conveyed to the Study Area. Additional water sources of 19 MCM/year in 2017 and further addition of 30 MCM/year will be available for the northern governorates. Therefore, available water to the Study Area will be increased in near future. Therefore, improvement of limited water resources and insufficient transmission facilities are preposition of this plan. On the other hand, the latter three causes shall be improved through implementation of this plan to achieve the planning target.

5.4.2 Target Values

The current water supply service conditions related with "No water" along with planning target values are summarized in the table below.

Table 5.3 Target Values for Improvement of Service in Irbid and Its Suburbs

Indicators for Improvement		Current (2013)	Target Values in 2035	Required main measures
Number of "No water" complaints (equitable supply)		20,801	1,000	• Distribution management for equitable supply • All measures below
Water supply pressure		0 to more than 7.5 bar	2.5 – 7.5 bar	• Strengthening and restructuring of distribution main system • Distribution management
Per capita supply *		82	123	• Strengthening of distribution main system
Per capita consumption *		65	104	• Strengthening of distribution main system • Leakage reduction measures
Leakage ratio	Assumption	20 %	15 %	• Replacement of inferior pipes
Leakage	Complaints	4,439	1,000	
Service population		498,800	790,200	• Distribution management for equitable supply

Note: * Per capita supply and consumption are calculated based on available water supply.

5.4.3 Facility Planning Concepts

The facility plan is prepared to achieve the planning target and following measures are required for this purpose.

1. Strengthening and restructuring of distribution system
   - Rezoning of reservoir zones including Zebdat and Hofa reservoir zones
   - Strengthening of network including increase in pipe size and addition of mains
2. Rehabilitation of inferior pipe (GI and old pipes)
3. Distribution management for equitable supply
   - Establishment of district metered area (DMA)
   - Supervisory Control and Data Acquisition (SCADA)

These measures correspond to improved water supply service as shown in Table 5.4.

Table 5.4 Corresponding Measures for Improvement of Water Supply Service

Water supply service	Source increase	Restructuring of distribution system		Rehabilitation of network	Distribution management	
	Increase of water allocation	Rezoning of reservoir zone	Strengthening of network		DMA	SCADA
1. No water	High	High	High	-	High	High
2. Insufficient water supply per capita	High	High	High	Medium	Medium	Medium
3. Inadequate pressure	High	High	High	-	Medium	Medium
4. High leakage	-	-	-	High	Medium	Medium

Note: High: High contribution to service improvement; Medium: Medium contribution to service improvement

Out of these measures, restructuring of distribution system is definitely required with the additional water allocation projects to supply increased water to the customer equitably. Rehabilitation of networks will reduce leakage and increase water supply amount. Distribution management through DMA and SCADA will further improve all water supply services including equitable supply. In the area like Irbid which has water scarcity and a large variation in elevation, serious water distribution management using tools like DMA and SCADA is required. This will help, by monitoring and control of water pressure and water flow, reduce leakage and supply water more equitably.

5.5 Design and Planning Conditions

(1) Design Population
The estimated Jordanian population in 2035 excluding the refugees is used as the design population of the Study Area. If the refugees are included, the target year becomes 2028.

(2) Water Sources and Water Demand
The existing internal and external water sources will be continuously used in future and the additional water allocation to the northern governorates described in Chapter 4 is used in planning.

Table 5.5 Water Allocation to Study Area

MCM/year

Item	Present in 2013	Case A	Case B (in 2035)
1. Northern governorates			
1.1Exsiting supply	72	72	72
1.2 Additional supply (Disi+well rehab.)	0	19	19
1.3 Additional supply (Wadi Al Arab)	0	0	30
Total	72	91	121
2. Irbid and Suburbs including Bani Kinana			
2.1 Existing supply (Internal)	4.01	4.01	4.01
2.2 Existing supply (External)	13.84	13.57	13.84
2.3 Additional supply (Disi+well rehab.)	0	14.40	0
3.4 Additional supply (Wadi Al Arab)	0	0	24.53
Total	17.85	31.98	42.38

(3) Facility Design Criteria
The main design criteria for distribution facilities are shown in Table 5.6.

Table 5.6 Design Criteria for Distribution Facilities

Facility	Design criteria
Reservoir	Required minimum capacity is 12 hours of daily maximum water demand; 24 hours capacity is preferable considering the current supply conditions where the transferred water is firstly stored in a reservoir and then distributed with rationing by controlling valves.
Distribution pump	Required capacity is peak hourly flow rate. Peak factor: 1.8
Distribution pipe	Required diameter is calculated using peak hourly flow rate Maximum static pressure: 7.5 bars in principle (there are exceptional areas) Minimum effective pressure: 2.5 bars in principle Design is prepared using Hazen-Williams Formula

(4) Adopted water demand for facility design
Transmission and distribution pipes are designed based on the water demand in 2035. The water supply facilities required for the 91 MCM/y system are selected from the water supply facilities in 2035. Therefore, the selected pipe size for the 91 MCM/y system is larger than the required size for the 91 MCM/y system.

(5) Rehabilitation criteria
Pipe rehabilitation criteria are as follows:
1. All galvanized iron (GI) pipes are to be replaced, regardless of pipe age.
2. Steel pipes that are 40 years or older are to be replaced.

As mentioned in Chapter 3, GI pipe is easily corroded and steel pipes are easily damaged. Therefore, both materials are prone to leakage and are being replaced in Jordan to reduce leakage. In addition following concept is adopted for replacement of GI pipe.

- The normal lifetime of GI is 10 to 20 years and 80 % of GI pipes are older than the lifetime in the Study Area. These pipes will be replaced earlier as possible.
- Possibly, GI pipes in the Study Area are easily corroded due to exposure to air in rationing supply

so that lifetime of GI pipe is much shorter than expected. Therefore, it is assumed that the lifetime of GI pipe in the Study Area is 10 years more or less.

- In the target year of this Project, all GI pipes should be replaced.
- The replacement of GI pipe will be prioritized by age of pipe.

5.6 Transmission and Distribution System in Irbid and Its Suburbs

5.6.1 Zoning Concept

Water naturally flows down to lower sites and, if water amount is not adequate, water does not reach to downstream higher sites. Therefore, distribution zones are proposed for equitable water distribution or allocation; to control water flow to lower sites and divert it to higher sites artificially.

Zoning system will be established with 3 tier systems in Irbid and its suburbs as follows:

- Reservoir zone: largest zone system which is covered with reservoirs (Hofa and Zebdat)
- Sub-zone: zone by pumping or gravity flow under reservoir zone
- District metered area (DMA): smallest component of zone under sub-zone, by which NRW reduction activities will be carried out

The proposed zones are generated primarily based on elevation range and existing pipe alignment and secondarily by road. The International Water Association recommends about 1,500 connections on average for the size of DMA as a basic standard. However, if we adopt this standard, there will be a large number of DMAs; around 120 in Irbid city only, which is not manageable for the YWC. Therefore, the number of DMA is reduced at the minimum, mainly considering difference in elevation and localities.

5.6.2 Existing Zoning

There are two reservoir zones: Hofa and Zebdat zones. Zebdat reservoir zone is composed of 3 pump sub-zones and 3 gravity sub-zones and Hofa reservoir zone has one gravity zone only. The current zoning system, which is mainly used for rationing, is shown in Figure 5.9 with elevation and Figure 5.8 with areal extent.

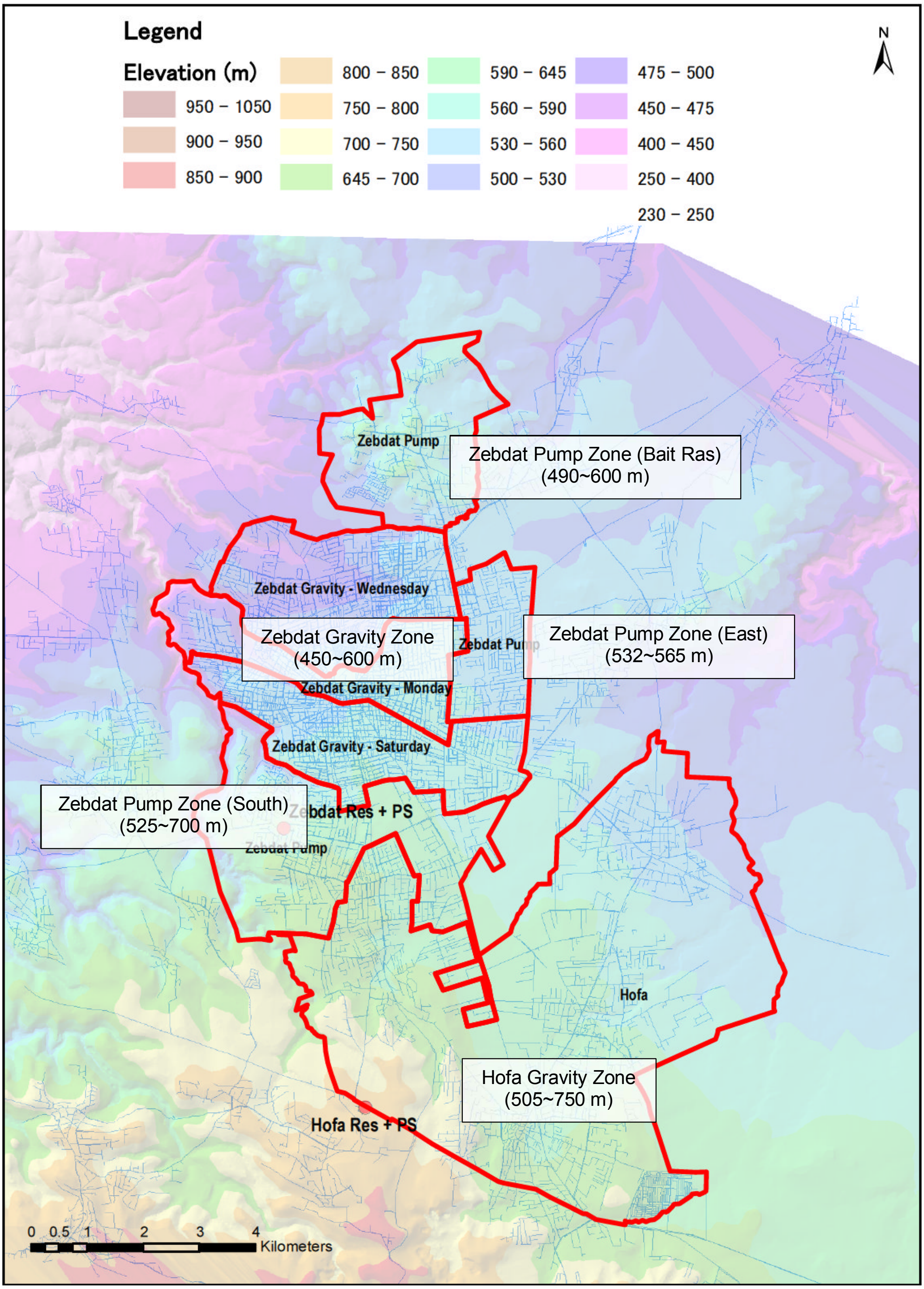


Figure 5.8 Existing Sub-Zones in Irbid and Its Suburbs

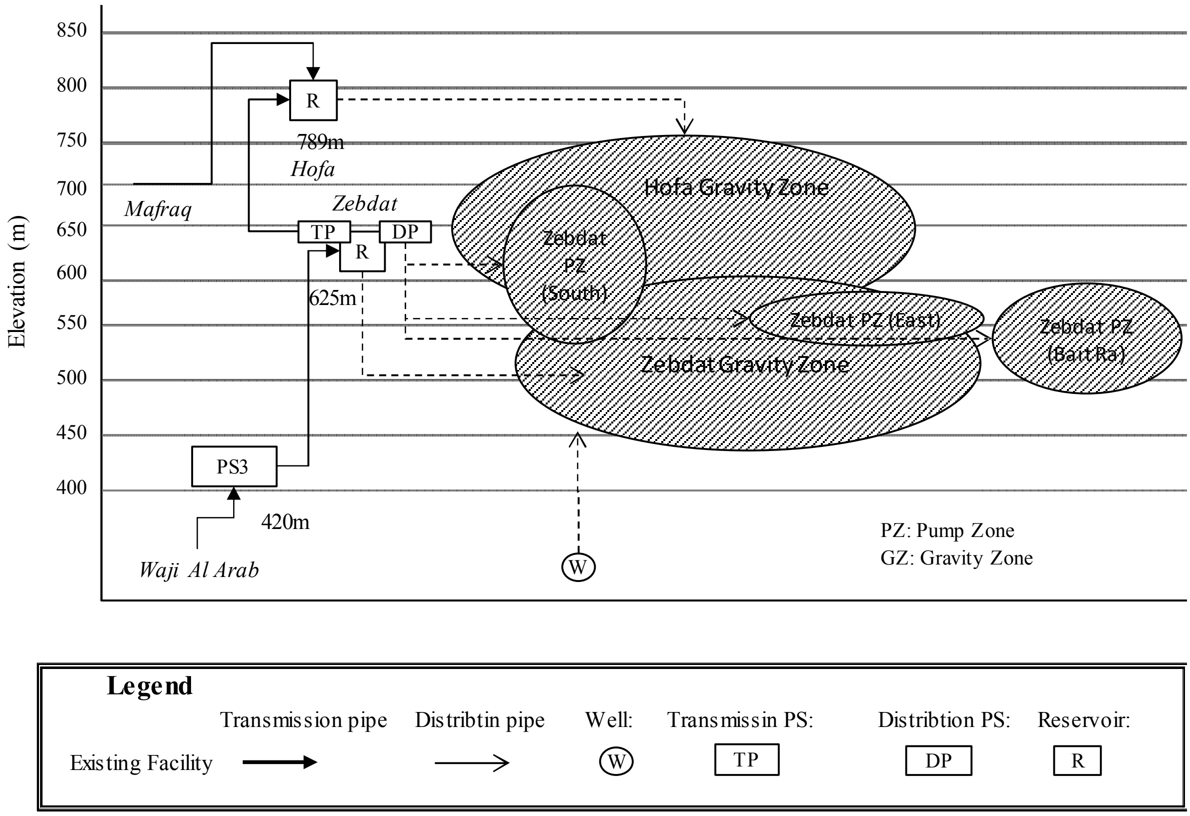
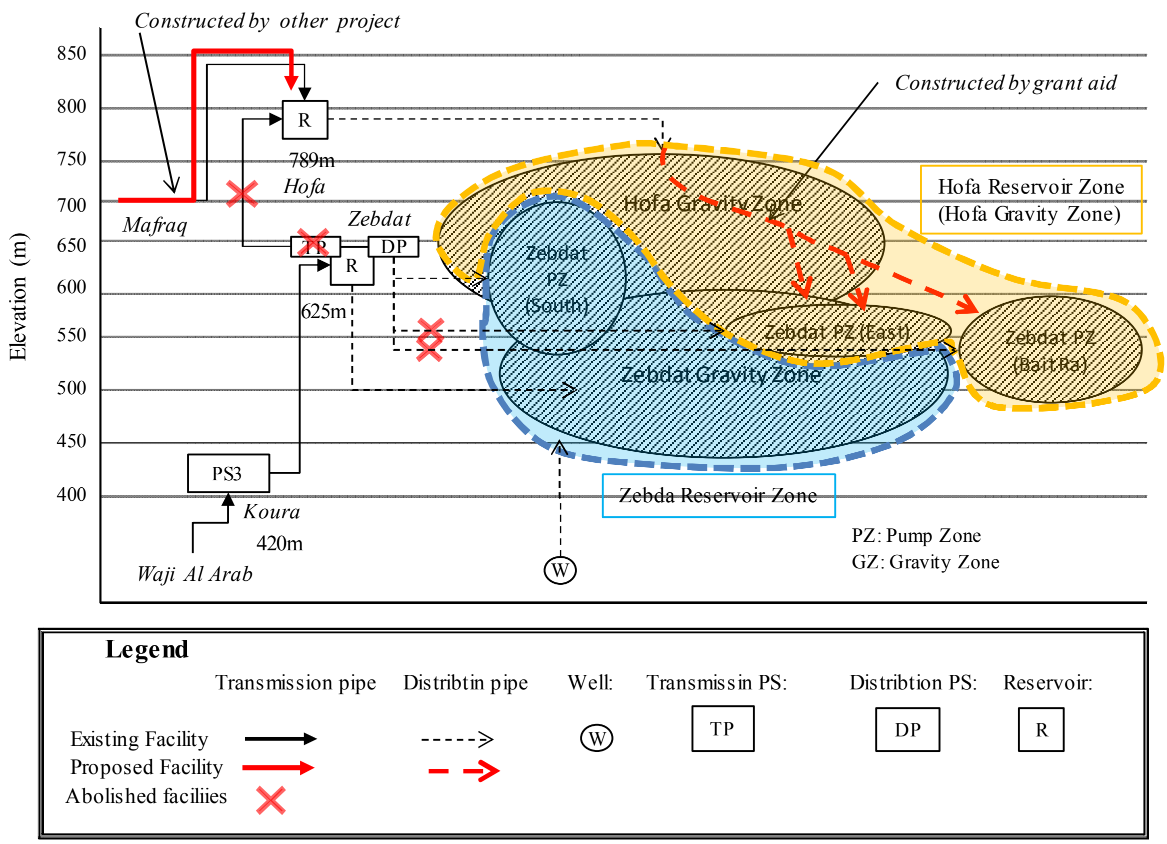


Figure 5.9 Existing Zoning with Elevation in Irbid and Its Suburbs

5.6.3 Transmission and Zoning System for Case A

Grant Aid scheme of Japanese government will be implemented and distribution mains from Hofa reservoir to Bait Ras and connection mains to the existing networks will be constructed. At this stage, one pump supply zone will be kept in Zebdat reservoir zone.

As for Case A, when 91 MCM of water will be available in the northern governorates, 10.14 MCM/year water will be available at Hofa from eastern sources, and 13.57 MCM/year water will be available at Zebdat. Reservoir zoning in Case A is rather simple, as large amount of additional water will be available at the Hofa reservoir, the highest place in the Study Area, from which water is currently being supplied to the existing Hofa gravity zone. With the additional water amount from Hofa reservoir, the existing 2 pump zones and part of gravity flow area in Zebdat reservoir zone will be covered by gravity flow from Hofa reservoir. In this case, entire planning area except 1 pump zone will be covered by gravity flow either from Zebdat or Hofa reservoir. The schematic layout of proposed water supply facilities with zoning in elevation is shown in Figure 5.10 and proposed two reservoir zones in Case A are shown in Figure 5.11.



Note: Transmission line between Mafraq and Hofa has been constructed except sub-mains.

Figure 5.10 Schematic Layout of Proposed Water Supply Facilities in Elevation (Case A) in Irbid and Its Suburbs

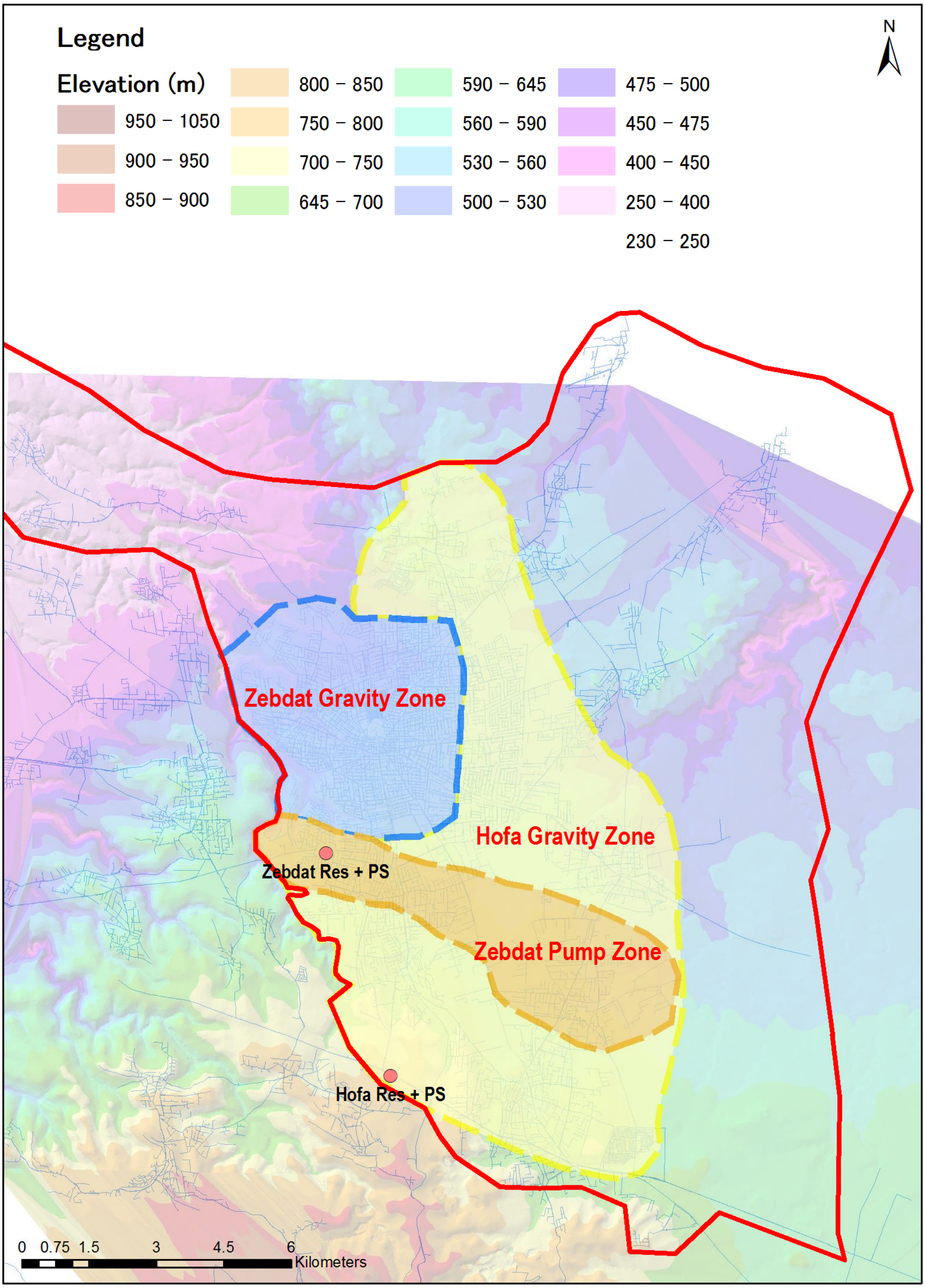


Figure 5.11 Proposed Reservoir Zones for Both Reservoirs (Case A: 91MCM/y) in Irbid and Its Suburbs

5.6.4 Transmission and Zoning System for Case B

(1) Zoning Basis

In Case B, 121 MCM/year water available in northern governorates, water from the Za'atary wells etc. through the eastern transmission line will not be allocated to the Study Area even though water will reach to Hofa reservoir for the demand of the Jerash governorate. 38.37 MCM/year water will be available at Zebdat from Wadi Al Arab wells through the western transmission line. This quantity can meet the required demand of the Irbid Study Area for 2035. Of this amount, 5.54 MCM/year will be required for localities of Aliah, Aidoon, Sarieh, Hoson and others, which are mainly located in the areas higher than Zebdat and lower than Hofa.

In this case, there are several alternatives of zoning along with those of transmission system as water from Wadi Al Arab can be transferred to not only Zebdat reservoir but also Hofa reservoir. To transfer water to Hofa, the following routes are possible.

1. Water is transferred through Zebdat reservoir/ pumping station to Hofa from PS3 in Wadi Al Arab system
2. Water is transferred to Hofa reservoir directly from PS3 in Wadi Al Arab system

Water quantity to be transferred to each reservoir can be changed according to water demand of reservoir zones or sub-zones. To evaluate efficient transfer of water quantity to each reservoir, alternatives of reservoir zones and sub-zones along with alternatives of transmission route are considered. The following are important notions in zoning.

1. To achieve energy efficient water supply system, at first, water from Zebdat reservoir should be supplied to the area where water can be supplied by gravity from Zebdat reservoir. This zone will be Zebdat reservoir (gravity) zone.
2. For the same reason, the area near Hofa reservoir will be supplied from Hofa reservoir by gravity. This zone will be Hofa reservoir (gravity) zone.
3. The remaining area will be supplied either from Zebdat by pumping or Hofa by gravity.

With this notion, following 4 sub-zones are prepared for comparison, mainly considering elevation range. The sub-zones are shown in Figure 5.12.

- Zebdat gravity zone (fixed zone)
- 2 sub-zones (not fixed)
- Hofa gravity zone (fixed zone)

In all systems for comparison, the following are common facilities so that these facilities are not included in comparison.

- Wadi Al Arab intake and treatment facilities
- Additional transmission line to PS3

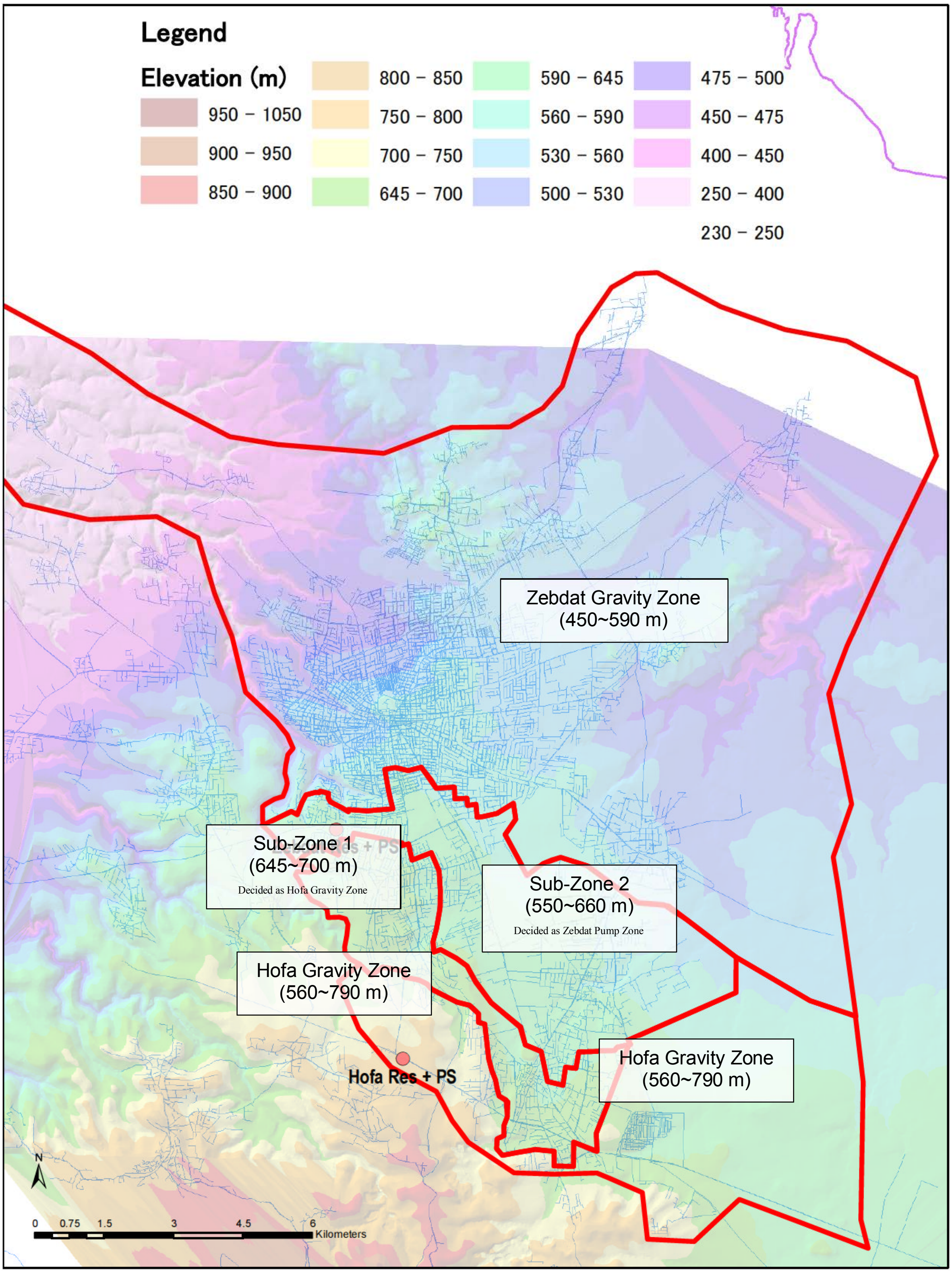


Figure 5.12 Zoning System in Case B (121 MCM/y) System for Alternatives in Irbid and Its Suburbs

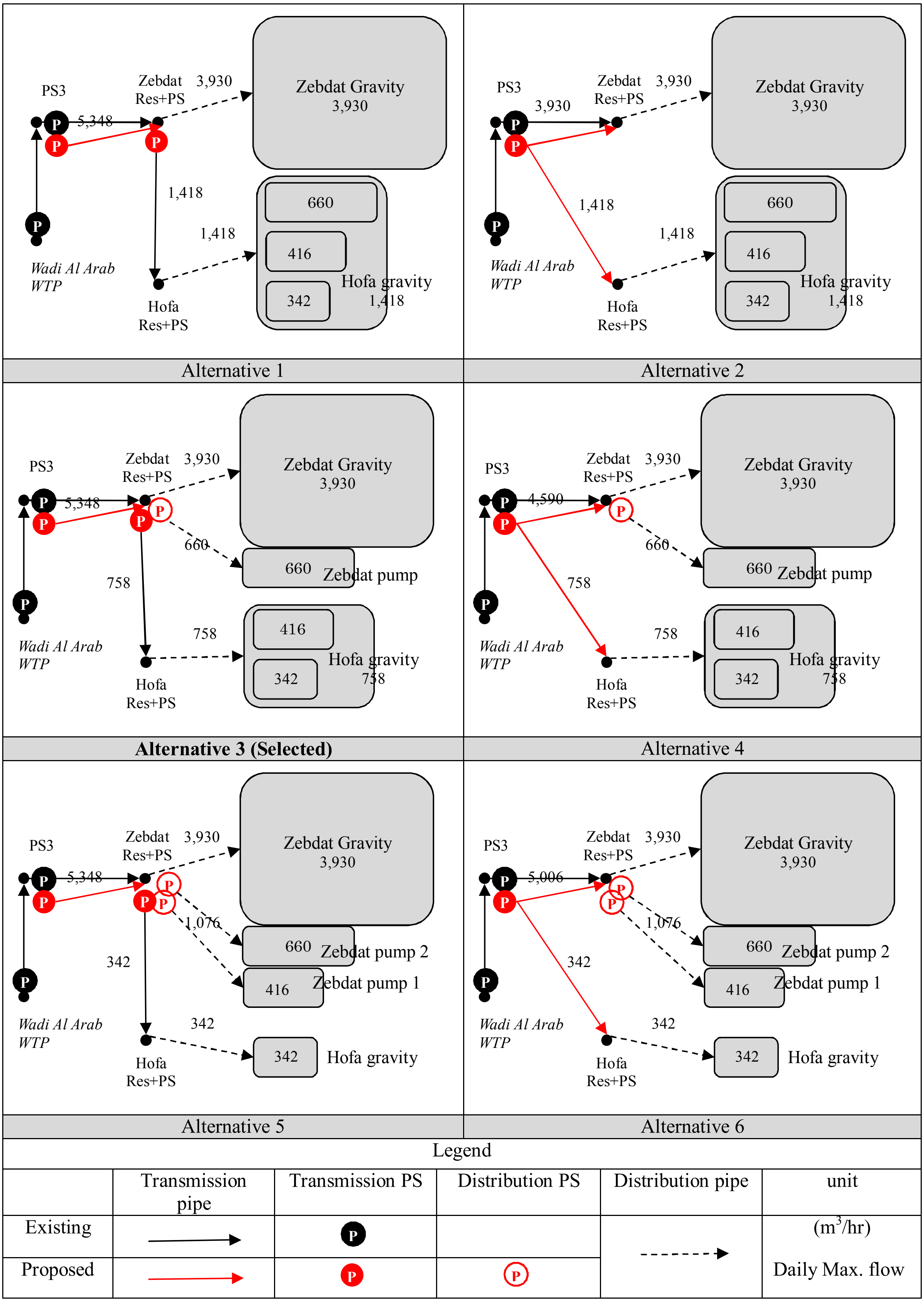


Figure 5.13 Alternatives of Transmission and Zoning System (Plane Schematic) in Irbid and Its Suburbs

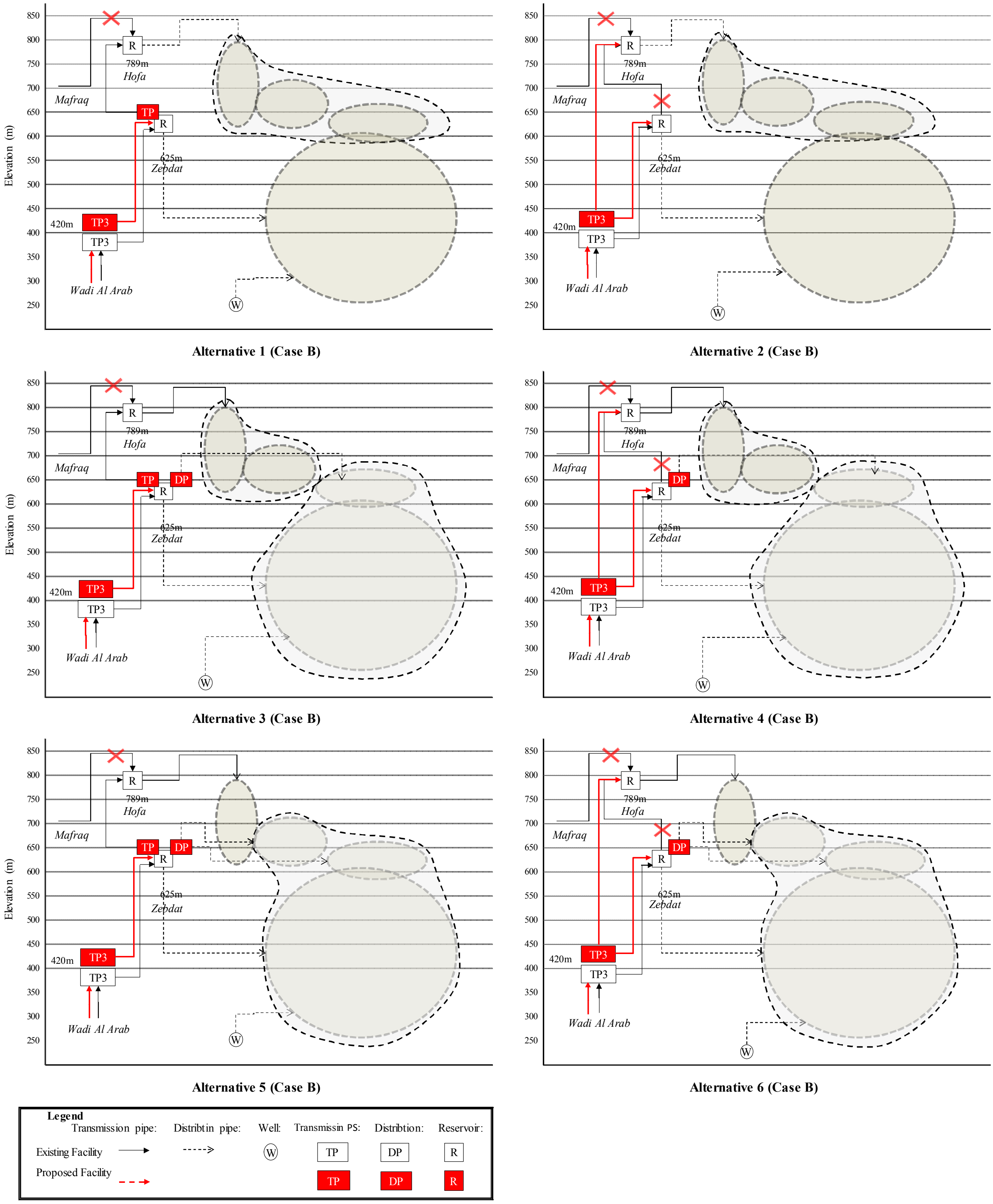


Figure 5.14 Alternatives of Transmission and Zoning System (Elevation Schematic) in Irbid and Its Suburbs

(2) Selection of Transmission and Zoning System

The comparison of alternatives is summarized in Table 5.7 in terms of initial and operation (electricity) costs. As a result of evaluation, Alternative 2 is the least cost alternative but Alternative 3 is almost same as the least cost with only 3 % higher cost than Alternative 2. The cost comparison is given in Appendix 5A.

However, with these alternatives, WAJ and the Study Team discussed and concluded to select Alternative 3 for future water supply system with following reasons.

- WAJ is planning to augment water of Wadi Arab system and transfer all augmented water of the Wadi Al Arab system to Zebdat reservoir.
- Based on this plan, a preliminary design is being prepared as of October 2014.
- The design change and corresponding delay of construction is to be avoided for early augmentation of water.
- In addition, the difference in costs between both alternatives is negligibly small.

It is noted that additional storage capacity to the existing reservoirs is not required; they are 22 to 28 hours storage volume in Zebdat reservoir while they are 12 to 50 hours volume in Hofa reservoir as shown in the same table.

Table 5.7 Evaluation of Alternatives for Transmission and Distribution Zoning System in Irbid and Its Suburbs

Alt	Cost (Million JD)			Storage capacity (hours)		Operation and Maintenance
	Initial Cost	Operation cost (Electricity)	Initial and Operation cost	Zebdat	Hofa	
1	28.23	0.40	31.23	28	12	There is no distribution pump station in the Study Area. Only 2 gravity flow systems exist. The operation and maintenance are easiest. However, this system requires transmission pump station at Zebdat to transfer water to Hofa reservoir.
2	22.93	0.42	26.09	28	12	There is no distribution pump station in the Study Area. Only 2 gravity flow systems exist. Operation and maintenance are easiest. Also, this system does not require transmission pump station at Zebdat.
3	24.10	0.37	26.89	24	22	One pump flow zone exists in Zebdat zone and one transmission pump station at Zebdat is required to transfer water to Hofa reservoir. O&M of these pump stations are troublesome.
4	24.10	0.44	27.48	24	22	One pump flow zone exists in Zebdat zone. O&M of these pump stations are troublesome.
5	29.84	0.43	33.08	22	50	Two pump flow zones exist in Zebdat zone and one transmission pump station at Zebdat is required to transfer water to Hofa reservoir. This alterative has the most number of pump stations and O&M of these pump stations are most troublesome.
6	23.48	0.47	27.02	22	50	Two pump flow zones exist in Zebdat zone, O&M of these pump stations are troublesome.

Note: Initial and operation cost is calculated as initial cost + O&M cost discounted by 10 % for 15 years.

5.6.5 Proposed Distribution System

In the selected alternative 3, all water of the Wadi Al Arab system is at first transferred to the Zebdat reservoir, from where water is distributed to one sub-distribution zone by pump and one sub-distribution zone by gravity, and transferred to the Hofa reservoir to distribute water to one gravity zone. Within sub-distribution zone, district metered area (DMA) is planned. Table 5.8 shows summary of water distribution amount by zones.

Table 5.8 Summary of Water Distribution Zones in Irbid and Its Suburbs

Zone	Sub Zone	No. of DMA*	Elevation (m)			Daily Average Water Demand in 2035 (m^3/day)	
			Max	Min	Difference		
Zebdat	Gravity zone	1	590	432	158	14,054	80,611
		2	622	494	127	28,553	
		3	588	544	44	5,764	
		4	576	420	156	10,621	
		5	600	299	301	6,453	
		Bani Kinana	570	71	499	15,166	
	Pump zone	1	659	556	103	7,524	13,746
		2	646	558	88	6,222	
					Sub-Total	94,357	94,357
Hofa	Gravity zone	1	678	609	69	2,310	15,035
		2	789	628	161	8,797	
		3	722	622	99	3,928	
					Sub-Total	15,035	15,035
					Total	109,392	109,392

Note: * Refer to Figure 5.16 for DMAs.

5.7 Proposed Transmission and Distribution Facility

5.7.1 Transmission Pump Station and Pipeline

Transmission pump and pipeline to transfer water from Zebdat pumping station to Hofa reservoir are proposed for the 121 MCM/y water supply system as shown in table below.

Table 5.9 Transmission Pump and Pipe from Zebdat to Hofa (Case B: 121 MCM /year)

Description	Specification
Zebdat Transmission Pump	Q=732 m^3/h, H=180m 2 numbers (1 duty and 1 stand-by)
Transmission pipe from Zebdat to Hofa	DI Pipe, Diameter 500 mm x 3,700 m

5.7.2 Distribution Pump Station

Distribution pump for the 91 MCM/y water supply system is proposed to distribute water from Zebdat pumping station as shown in the table below. This pump will also be used for the 121 MCM/y system. The specification of distribution pump differs from the existing pumps in head and flow rate.

Table 5.10 Distribution Pump at Zebdat (Case A and B: 91 and 121 /year system)

Description	Specification
Zebdat Distribution Pump	1,206 m^3/h, H=80m, 2 numbers (1 duty and 1 stand-by)

5.7.3 Distribution Reservoir

Reservoir capacities are sufficient for the increased water volume and no additional reservoir is required.

5.7.4 Strengthening of Distribution Network

The distribution network is analyzed using network analysis software, based on the selected alternatives of transmission and distribution zoning system in the previous section. The proposed distribution pipelines with diameter, material and length for strengthening of network are shown in

Table 5.11 and Figure 5.15. Refer to Appendix 5C for detail map on proposed pipes.
The transmission and distribution pipelines between Hofa reservoir and Bait Ras (refer to section 3.1.2), will be constructed in the Japan's grant aid scheme. This will satisfy distribution of the increased water for Case A (91 MCM/year of water allocation) so that new facilities are not required for Case A and the proposed pipelines for strengthening of network shown in Table 5.11 are all for the Case B (121 MCM/y of water allocation).

5.7.5 Rehabilitation of Distribution Network

Based on the criteria for replacement of GI and steel pipes, rehabilitation pipes with material and length are proposed in Table 5.11 and Figure 5.15.

Table 5.11 Proposed Strengthening of Network and Rehabilitation of GI and Steel Pipes in Irbid and Its Suburbs

(m)

Diameter and Material	Strengthening for Case B (121 MCM/y) *	Rehabilitation
HDPE 25 mm	-	3,606
HDPE 32 mm	-	193
HDPE 50 mm	1,546	245,676
HDPE 63 mm	434	65
HDPE 75 mm	-	12,230
HDPE 100 mm	46,171	30,511
HDPE 150 mm	8,249	3,646
DI 200 mm	23,254	6,180
DI 300 mm	42,146	2,839
DI 400 mm	18,276	-
DI 600 mm	16,494	-
DI 800 mm	25,691	-
DI 1000 mm	1,971	-
Total	184,230	304,946

Note: DI: Ductile Iron, HDPE: High density polyethylene

5.7.6 Service Pipe and House Connection

Increase of the number of house connections between 2014 and 2035 is estimated using estimated population and population per connection as shown in the table below. Approximately 40,400 new house connections will be required to cater to the needs of increased service population up to 2035. Also, 13,500 house connections will require to be replaced for the consumers along the distribution networks proposed to be rehabilitated. In total 53,900 house connections will be required up to 2035 and these connections will be added in this plan.

Table 5.12 Estimated Number of House Connections in Irbid and Its Suburbs

Item	Value (Number)	Note
1. House connection requirements to cater to needs of increased service population		
Population in 2014 (person)	518,997	Estimated based on design population in section 5.1.1
Population in 2035 (person)	790,219	Estimated based on design population in section 5.1.1
Increased population (person)	271,222	
Average number of persons per connection	6.72	Assumed based on estimated population of 2014 in northern governorates and number of subscribers (connections) (refer to Table 7.7)
Increased number of connection	40,400	
2. House connection replacement to cater to needs of consumers along rehabilitated distribution networks		
Number of connection	13,500	Estimated based on the length of distribution pipe to be rehabilitated and number of house connections per unit length of distribution pipes (44 connections/km) in 2014
Total number of house connections to be replaced	**53,900**	

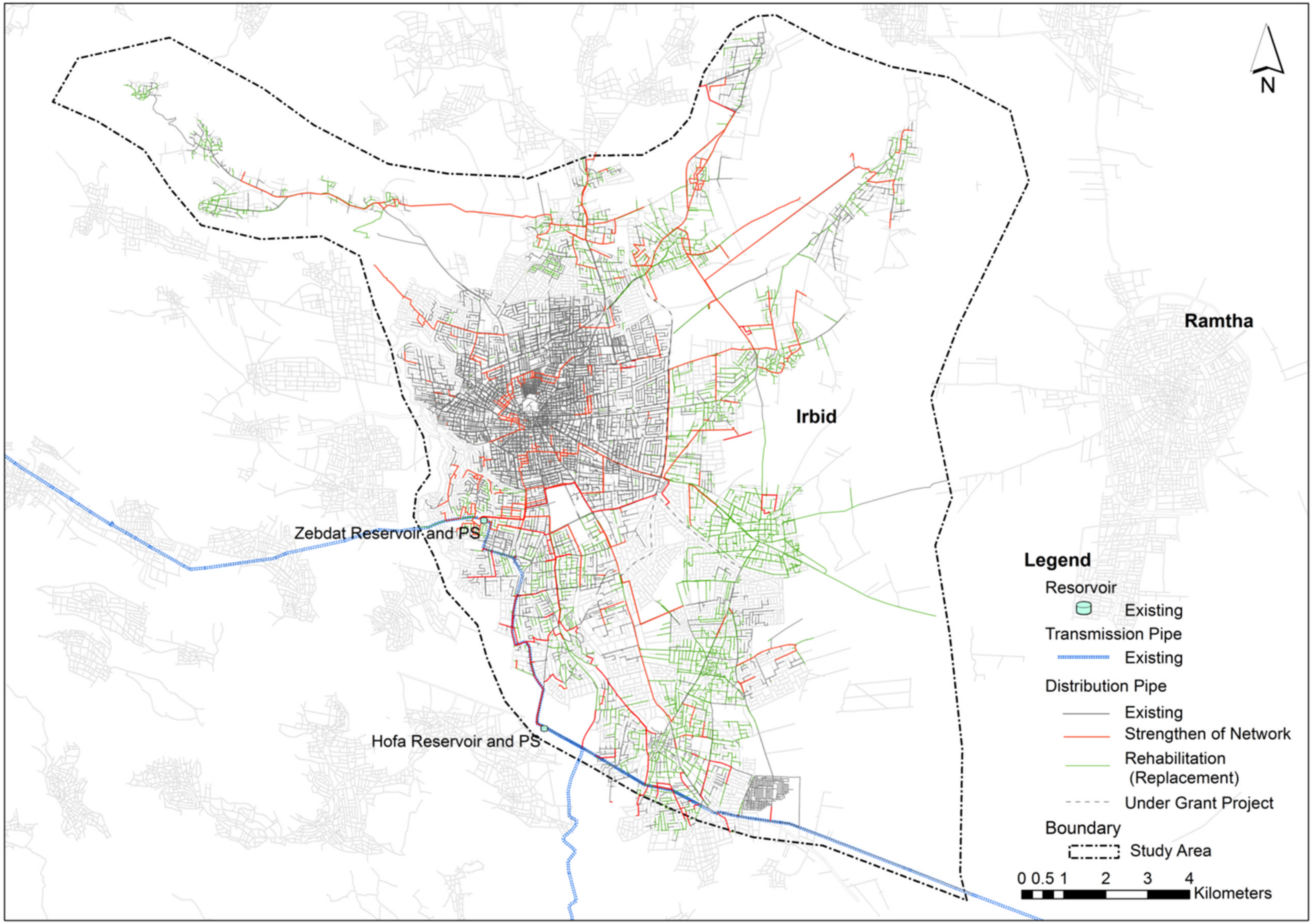


Figure 5.15 Proposed Distribution Pipe for Strengthening and Rehabilitation up to 2035 (121 MCM/y) in Irbid and Its Suburbs

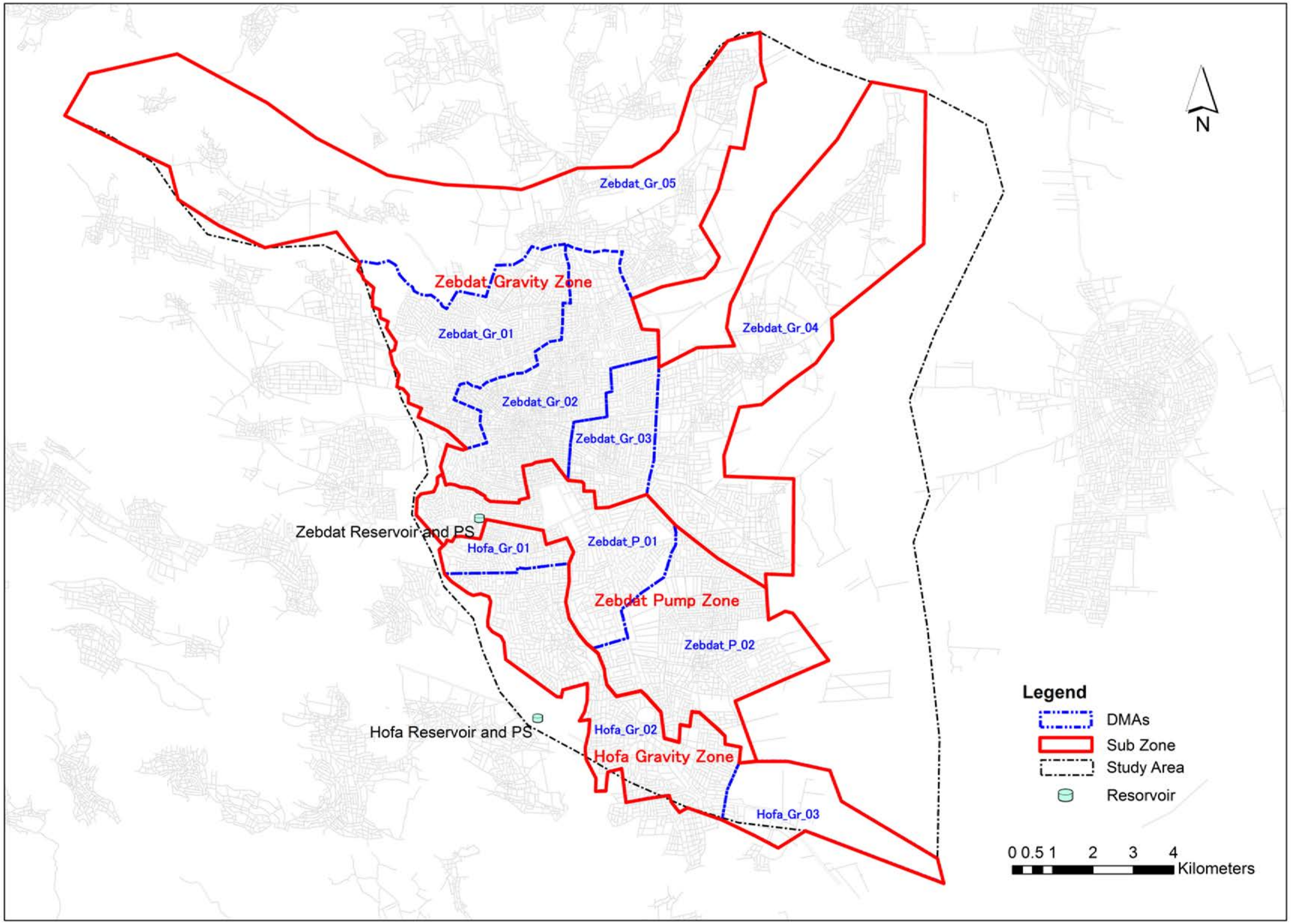


Figure 5.16 Proposed DMA in Irbid and Its Suburbs

5.7.7 DMA and SCADA

(1) Necessity and purpose of DMA and SCADA

Supervisory control and data acquisition (SCADA) is to monitor and control flow and pressure to each distribution zone for equitable water distribution and reduction of leakage. For this purpose, sub-zones or DMA are proposed within the reservoir zones since some reservoir zones are still quite large.

(2) Proposed DMA

DMA is created mainly based on the elevation range. As explained in design criteria, DMA will be created so that the static pressure should be less than 7.5 bar. The planned DMA is shown in Figure 5.16; 3 DMAs in Hofa reservoir zone and 7 DMAs in Zebdat reservoir zone for 2035.

(3) Effect of SCADA System

Subject to the development of appropriate DMA, following effects can be expected by introduction of SCADA.

1) Monitoring for the conditions of the water distribution
   By monitoring flow and pressure at inlet for each DMA and outlet flow of pumping station and reservoir, YWC can understand the conditions of water distribution.
2) Achievement of equivalent water distribution
   To distribute the limited water amount evenly, water flow for each distribution area should be controlled to the appropriate value calculated in advance. By flow control for the inlet valve of DMA, it is possible to carry out the equitable or even water distribution.
3) Reduction of leakage
   Depending on the location and elevation, some areas have high pressure, which may cause leakage. In such areas, it is possible to reduce water leakage by pressure control through the inlet valve of DMA.
4) Reduction of the labor intensive load of manual valve operation
   To carry out rational water distribution YWC currently operates manually about 100 valves twice a day in Irbid city. This is a substantial work for YWC. By motorizing valves and using remote control by SCADA system, YWC will be able to operate the valves from SCADA center. This will reduce the load of manual valve operation and achieve rational, even water distribution.
5) Efficient management of water distribution
   SCADA system is a tool for comprehensive data acquisition, by which important decisions for flow and pressure control can be made. SCADA system can collect data on flow, pressure, valve status, pump status, pump energy consumption, etc. After analysis of these gathered data, engineers will be able to improve the operation of the water distribution facilities to achieve an equitable distribution, energy saving, NRW reduction, and so on.

(4) DMA Implementation Effect

The following effects by DMA implementation are estimated.

- Reduction in amount of leakage volume
- Reduction in O&M Cost (Electricity)

The relation between water pressure and leakage volume is used for calculation of leakage volume and reduction in leakage as expressed in the following formula.

$Q=C\times A\times\sqrt{P}$

where,

Q: Leakage volume of water

C: Discharge coefficient which depends upon the form of leaking hole

A: Cross-sectional area of the leaking hole

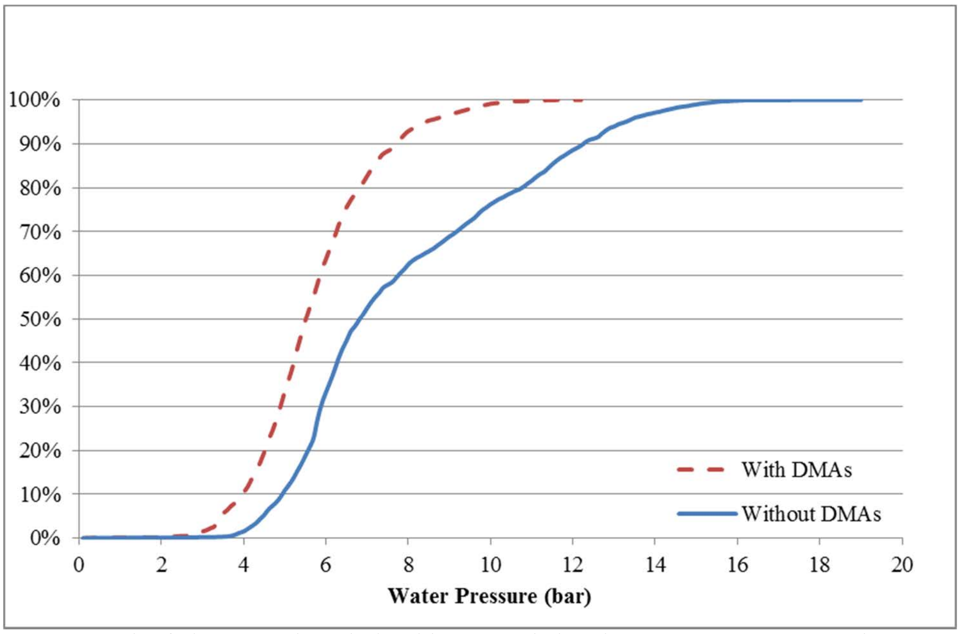
P: Water pressure in the pipe

This formula expresses that the leakage volume increases if the water pressure increases. The effects by DMA implementation are estimated as shown in Table 5.13 based on the result of pipe network analysis with proposed pipes in 2035 as given in Figure 5.18.

The average water pressure before construction is 8.1 bar which becomes 6.0 bar after DMA creation. The simulation result of water pressure with and without DMA for Zebdat gravity zone as a sample is shown in Figure 5.18. This pressure reduction reduces leakage volume by 13.9 %, as shown in Figure 5.17. With 34.60 MCM/year of water supply amount and 20 % of current leakage ratio, the leakage volume is estimated as 6.94 MCM/year. By reduction of water pressure by 2.1 bar, 0.97 MCM/year of leakage volume can be saved. It is estimated that 1.24 million JD/year can be saved in terms of electricity cost by this water saving based on 0.257 JD/m^3 of the estimated average electricity cost per unit water supply of YWC.

Table 5.13 Estimate of DMA Implementation Effect in Irbid and Its Suburbs

Item	Value	Remarks
Average pressure in pipe network without DMA:P1(bar)	8.1	
Average pressure in pipe network with DMA:P2(bar)	6.0	
Theoretical Leakage-of-water reduction rate by proper management of water supply pressure (%)	13.9	1-(P2/P1)^0.5
Amount of water supply (MCM/year)	34.69	In 2035
Leakage rate (%)	20.00	As Current value
Amount of water leakage (MCM/year)	6.94	
Amount of leakage reduction (MCM/year)	0.97	
Reduction in O&M (electricity) Cost (million JD/year)	1.24	as 0.257 JD/m^3



Note: Result of pipe network analysis with proposed pipes in 2035. Water pressures shown are weighted average pressures.

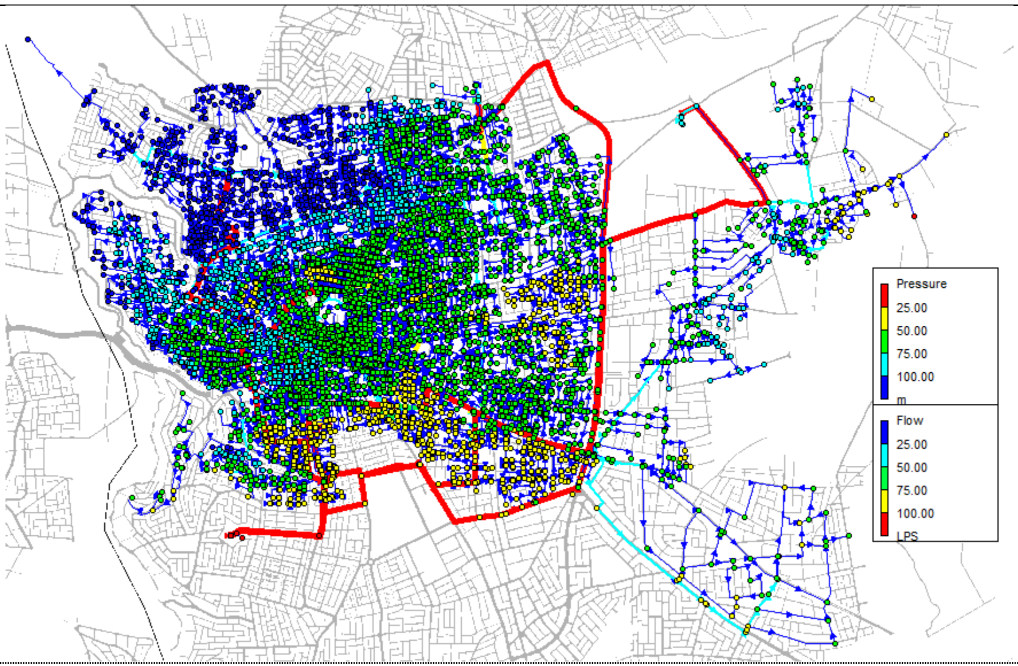
Figure 5.17 Distribution of Water Pressure in Irbid (Including Zebdat Gravity Zone, Zebdat Pumping Zone and Hofa Gravity Zone)

(5) Composition of SCADA

SCADA system is comprised of SCADA center and remote stations. Remote station is placed near the local facilities and handles input signal from process equipment and output the control signal to the local facilities. Therefore, basically remote stations are placed in each DMA and in Zebdat and Hofa reservoirs/pump stations. SCADA center should be placed in the office where operation and maintenance crews for the distribution facilities are stationed. Therefore it will be preferable that

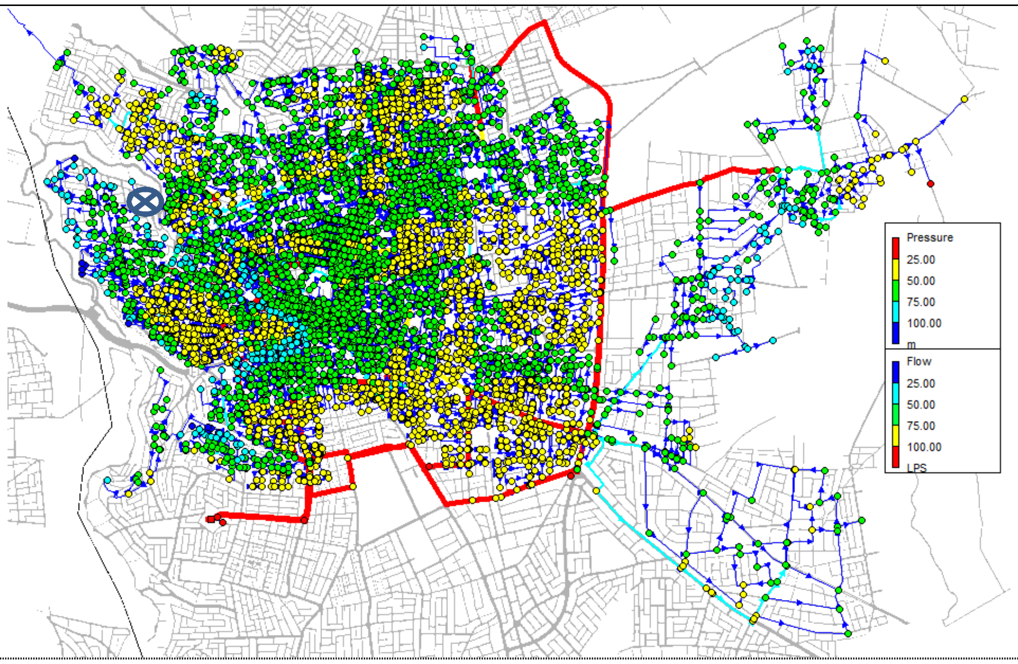
SCADA center is placed in Irbid ROU of YWC.

Effective Pressure Without DMA



Zebdat Gravity Distribution Zone With Proposed Pipe Network for 121 MCM/year Case

Effective Pressure With DMA



Zebdat Gravity Distribution Zone With Proposed Pipe Network for 121 MCM/year Case

Source: JICA Study Team

Figure 5.18 Effective Water Pressures in Irbid and Its Suburbs With and Without DMA

CHAPTER 6 IMPROVEMENT PLAN IN RAMTHA AND ITS SUBURBS

6.1 Water Demand Estimation

6.1.1 Design Population

Population in Ramtha city and its suburbs (Ramtha Study Area) are estimated using the governorates' growth rates of DOS and is given in Table 6.1. The location of localities and neighborhood is shown in Figure 6.1. Bwaidhah locality is out of the scope of this Study since water to this area is supplied from the eastern transmission line other than the eastern transmission line for other 5 localities.

The population in Ramtha city is expected to increase from 87,499 in 2012 to 138,605 in 2035 while the total population of the Study Area is expected to increase from 127,013 in 2012 to 201,198 in 2035.

Table 6.1 Population Estimation in Ramtha City and Its Suburbs in 2012 and 2035

Locality/ Year	2012	2035
Ramtha (City)	87,499	138,605
Torrah	18,183	28,803
Shajarah	14,115	22,359
Emrawah	4,622	7,322
Dnaibeh	2,594	4,109
Sub-total (Study Area)	127,013	201,198
Bwaidhah*	6,677	10,577
Total	133,690	211,775

Source: JICA Study Team based on DOS population growth rates
*Bwaidhah is separately supplied water from the eastern transmission system and out of scope

The information on population distribution within Ramtha city is available only for 2004. Ramtha city (locality) comprises of several neighborhoods and each neighborhood is divided into blocks by DOS for preparing population data. Population of neighborhoods is calculated considering the population density in blocks. The calculated population and density for each neighborhoods of Ramtha for 2012 and 2035 considering the DOS growth rate is presented in Appendix 2B.

Employing the same concept of maintaining sound living environment, as in case of Irbid, population is estimated using the maximum population density of 100 pph for neighborhoods in the central Ramtha city, except for the neighborhood that has existing population density of over 100 pph already in 2012. Then, excess population has been distributed to peripheral neighborhoods in proportion to their projected population using DOS population growth rate. Accordingly, the population to be adopted for each neighborhood has been calculated for year 2035 and is presented in Table 6.2.

6.1.2 Water Demand Estimation

Estimated water demand in Ramtha and its suburbs is shown in Table 6.2. The estimate is based on estimated population and the per capita consumption mentioned in section 4.1.2. Total annual water demand is 6.50 MCM and 9.71 MCM in 2012 and 2035, respectively.

6.2 Water Sources and Supplemented Water

Table 6.3 presents the water demand in Ramtha and its suburbs, and internal and external sources to Ramtha and its suburbs in 2035 in case of 121 MCM/year. The existing internal source of 1.99 MCM/year will remain same in 2035. Internal sources are located in eastern (Jaber wells) and western (Abu Al-Basal wells) areas and Mahasi of Ramtha, from which water is pumped up by Hodod PS, Abu

Al Basal PS and Mahasi PS, respectively and supplied to the Study Area. External sources of 7.72 MCM/year will come from the eastern transmission line in 2035 (refer to Figures 4.7 and 4.8).

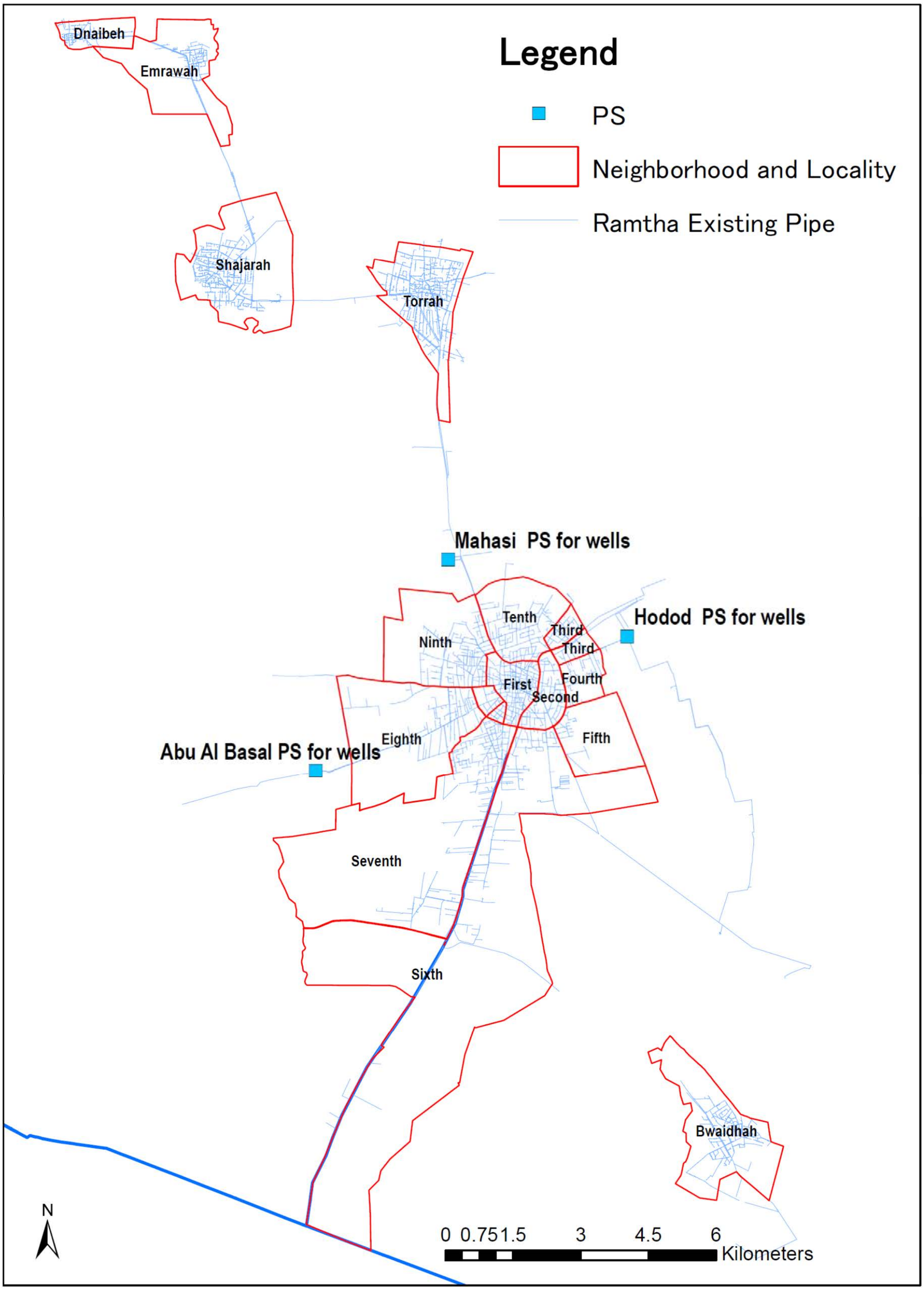


Figure 6.1 Location of Localities and Neighborhood in Ramtha and Its Suburbs

Table 6.2 Population and Water Demand Estimation in Ramtha City and Localities

Neighborhood Arabic (English)	2012 Population	2035 Population	2012 (MCM/y)	2035 (MCM/y)
Aowl (1st)	21,950	21,950	1.16	1.10
Aththani (2nd)	8,299	10,506	0.44	0.52
Aththalth (3rd)	4,961	8,253	0.26	0.41
Arraba (4th)	1,910	3,861	0.10	0.19
Khames (5th)	1,292	2,612	0.07	0.13
Sades-A (6th-A)	6,133	12,398	0.32	0.62
Sades-B (6th-B)	5,186	10,485	0.27	0.52
Sabea-A (7th-A)	11,512	20,012	0.61	1.00
Sabea-B (7th-B)	948	1,917	0.05	0.10
Thamen (8th)	6,792	13,731	0.36	0.69
Tasea-A (9th-A)	8,692	13,020	0.46	0.65
Tasea-B (9th-B)	1,453	2,937	0.08	0.15
Aasher (10th)	8,371	16,923	0.44	0.85
Sub-total (Ramtha City)	**87,499**	**138,605**	**4.62**	**6.93**
Locality	2012 Population	2035 Population	2012 (MCM/y)	2035 (MCM/y)
Torrah	18,183	28,803	0.74	1.09
Shajarah	14,115	22,359	0.57	0.85
Emrawah	4,622	7,322	0.19	0.28
Dnaibeh	2,594	4,109	0.11	0.16
Sub-total (Locality)	**39,514**	**62,593**	**1.61**	**2.38**
Bwaidhah	6,677	10,577	0.27	0.40
Sub-total (Locality)	46,191	73,170	**1.88**	**2.78**
Total	**133,690**	**211,775**	**6.50**	**9.71**
Total (Study Area)	**127,013**	**201,198**	**6.23**	**9.31**

Source: JICA Study Team
Note: Water to Bwaidhah is separately supplied from the eastern transmission system.

Table 6.3 Water Source for 2035 in Ramtha (Water Allocation of Case B: 121 MCM/y)

Area	Locality	Water Demand in 2035 (MCM/y)	Source (MCM/y)		
			Internal source	Supplemented from External Sources	Total
Ramtha (City)	Aowl (1st)	1.10	1.99 Jaber wells (eastern): 1.31 Abu Al-Basal well (western): 0.5 Mahasi wells:0.18	1.10	1.10
	Aththani (2nd)	0.52		0.52	0.52
	Aththalth (3rd)	0.41		0.41	0.41
	Arraba (4th)	0.19		0.19	0.19
	Khames (5th)	0.13		0.13	0.13
	Sades-A (6th-A)	0.62		0.62	0.62
	Sades-B (6th-B)	0.52		0.52	0.52
	Sabea-A (7th-A)	1.00		1.00	1.00
	Sabea-B (7th-B)	0.10		0.10	0.10
	Thamen (8th)	0.69		0.69	0.69
	Tasea-A (9th-A)	0.65		0.65	0.65
	Tasea-B (9th-B)	0.15		0.15	0.15
	Aasher (10th)	0.85		0.85	0.85
	Sub Total	**6.93**	**0.00**	**6.93**	**6.93**
Sahel Horan City	Torrah	1.09	0.00	0.79	2.78
Sahel Horan City	Shajarah	0.85			
Sahel Horan City	Emrawah	0.28			
Sahel Horan City	Dnaibeh	0.16			
Ramtha City	Bwaidhah*	0.40			
	Sub Total	**2.78**	**1.99**	**0.79**	**2.78**
Total		**9.71**	**1.99**	**7.72**	**9.71**
Total Study Area		**9.31**	**1.59**	**7.72**	**9.31**

Source:JICA Study Team * Water to Bwaidhah is separately supplied from the eastern transmission system.

6.3 Improvement Concept

6.3.1 Planning Target and Objectives

The planning target and objectives are same as in section 5.4.1.

6.3.2 Target Values

The current water supply service conditions related with “No water” along with planning target values are summarized in the Table 6.4 below.

Table 6.4 Target Values for Improvement of Service

Indicators for Improvement		Current (2013)	Target Values in 2035	Required main measures
Number of “No water” complaints (equitable supply)		1,630	100	• Distribution management for equitable supply • All measures below.
Water supply pressure		0 to more than 7.5 bar	2.5 – 7.5 bar	• Strengthening and restructuring of distribution main system • Distribution management
Per capita supply		79	126	• Strengthening of distribution main system
Per capita consumption		63	107	• Strengthening of distribution main system • Leakage reduction measures
Leakage ratio	Assumption	20 %	15 %	• Replacement of inferior pipes
Leakage	Complaints	433	100	
Service population		127,000	228,000	• Distribution management for equitable supply

6.3.3 Facility Planning Concepts

Facility planning concept is same as in section 5.4.3.

6.4 Design and Planning Conditions

(1) Design Population
The estimated Jordanian population in 2035 excluding the refugees is used as the design population of the Study Area. If the refugees are included, the target year becomes 2028.

(2) Water Sources and Water Demand
The existing internal and external water sources will be continuously used in future and the additional water allocation to the northern governorates described in Chapter 4 is used for planning.

Table 6.5 Water Allocation to Study Area

MCM/year

Item	Present in 2013	Case A	Case B (in 2035)
1. Northern governorates			
1.1Exsiting supply	72	72	72
1.2 Additional supply (Disi + well rehab.	0	19	19
1.3 Additional supply (Wadi Al Arab)	0	0	30
Total	72	91	121
2. Ramtha and Suburbs			
2.1 Existing supply (Internal)	**1.99**	**1.99**	**1.99**
2.2 Existing supply	**1.84**	**1.84**	**1.84**
2.3 Additional supply (Disi + well rehab.)	**0.00**	**3.64**	**5.88**
Total	**3.83**	**7.47**	**9.71**

(3) Facility Design Criteria
The facility design criteria for flow and pressure is same as (3) in section 5.5.

(4) Rehabilitation criteria
The rehabilitation criteria is same as (5) in section 5.5.

6.5 Transmission and Distribution System in Ramtha and Its Suburbs

6.5.1 Transmission and Distribution Concept

The proposed distribution method is same as the existing method, in which water is supplied directly from the eastern transmission line and local (internal) wells. In the former method, residual water pressure of the eastern transmission line is efficiently utilized. Another distribution method is to supply through a reservoir but it loses residual pressure of mains and again water needs to be pumped up for distribution. It requires new reservoir and operation cost of pumps. Therefore, water supply method is direct distribution from the eastern transmission line, which is supplemented by the existing local wells.

6.5.2 Distribution Zone

The existing distribution network in Ramtha and suburbs is rather simple and small. Only one distribution main runs through the Study Area supplying water along the main pipeline route. In this simple and small network system, only one tier zoning system, DMA, is sufficient.

The proposed zones (DMAs) are generated based on elevation range, existing pipe alignment and unit of locality. The proposed zoning system of DMA with elevation range is shown in Figure 6.2. The hydraulic profile of existing and proposed water supply systems is presented in Figure 6.3.

6.5.3 Transmission and Distribution Method of Existing Local Wells and Transmission Water from Za'atary

Three existing wells will be used in the transmission and distribution concept as shown in Table 6.6 considering the amount of water sources and locations.

The transmission water from Za'atary will be utilized mainly for the central and eastern areas in Ramtha city and the area along the transmission and distribution line between the branch of the eastern transmission line and Ramtha city. In addition, it will be transferred to the northern localities to supplement the deficit of local wells (Jaber wells and Mahasi wells.)

Table 6.6 Transmission and Distribution Method of Existing Local Wells

Wells	Source amount (MCM/y)	Transmission and Distribution method for Local Wells	
		Existing	Proposed
Jaber wells (eastern)	1.31	• Groundwater in the Jaber wells is transferred to Hodod PS first. • Then, collected water is distributed directly from Hodod PS to the Ramtha city or transferred to Mahasi PS for further transmission to the northern localities.	• Collected water will be transferred to the Mahasi PS and injected to transmission line to supply the northern localities. • The existing distribution pumps in Hodod PS are all new and will be utilized for transmission pump. • A transmission pipe is required between Hodod PS and Mahasi PS.
Abu Al-Basal well (western)	0.50	• Water is distributed directly by Abu Al-Basal PS.	• Same as existing. No change is required. Water is injected directly in distribution network in the western Ramtha city since the well flow is small so that it is used for only local supply.
Mahasi wells:	0.18	• Water is injected to the transmission pipe to Torrah and the northern localities.	• Same as existing. No change is required.

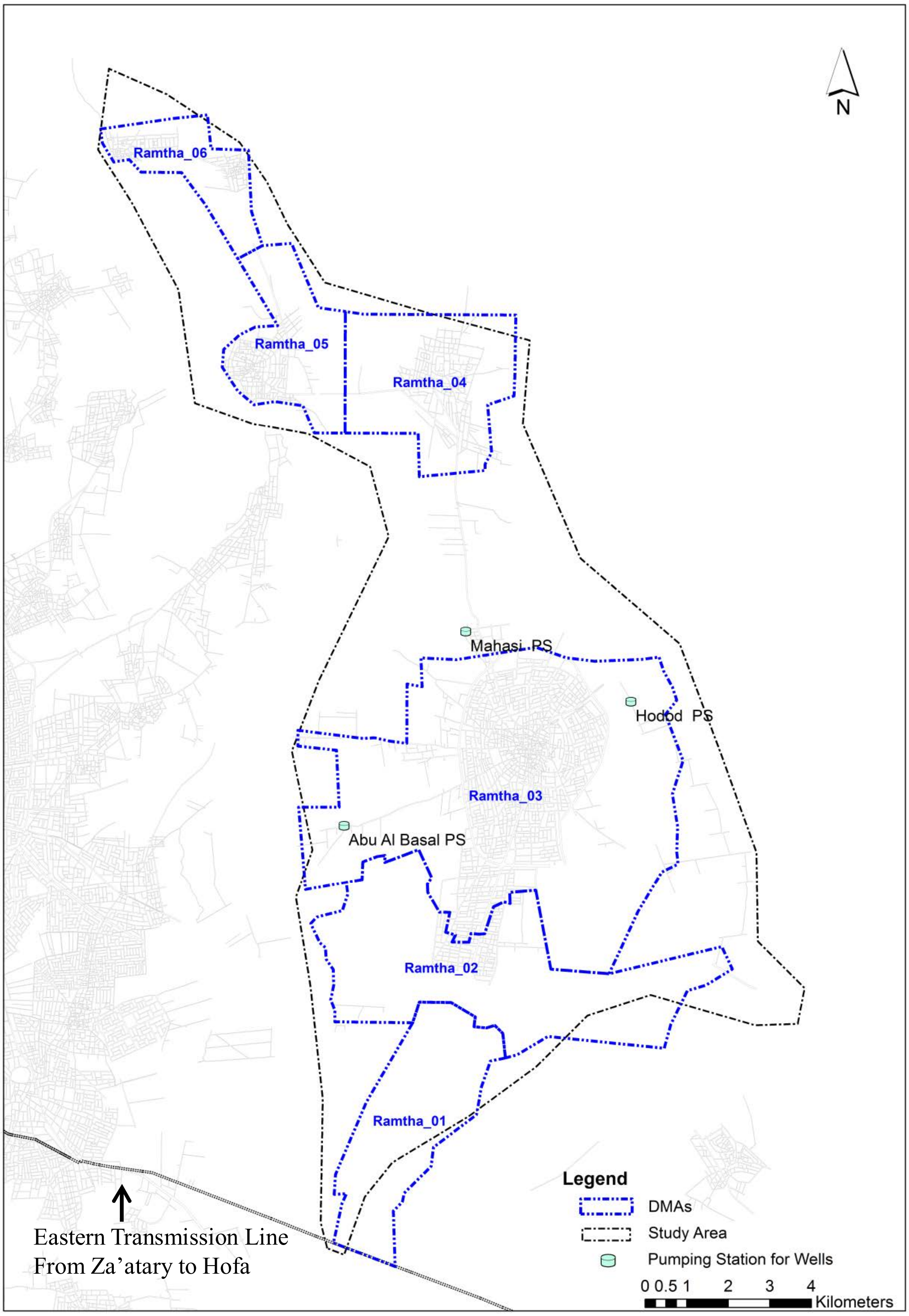
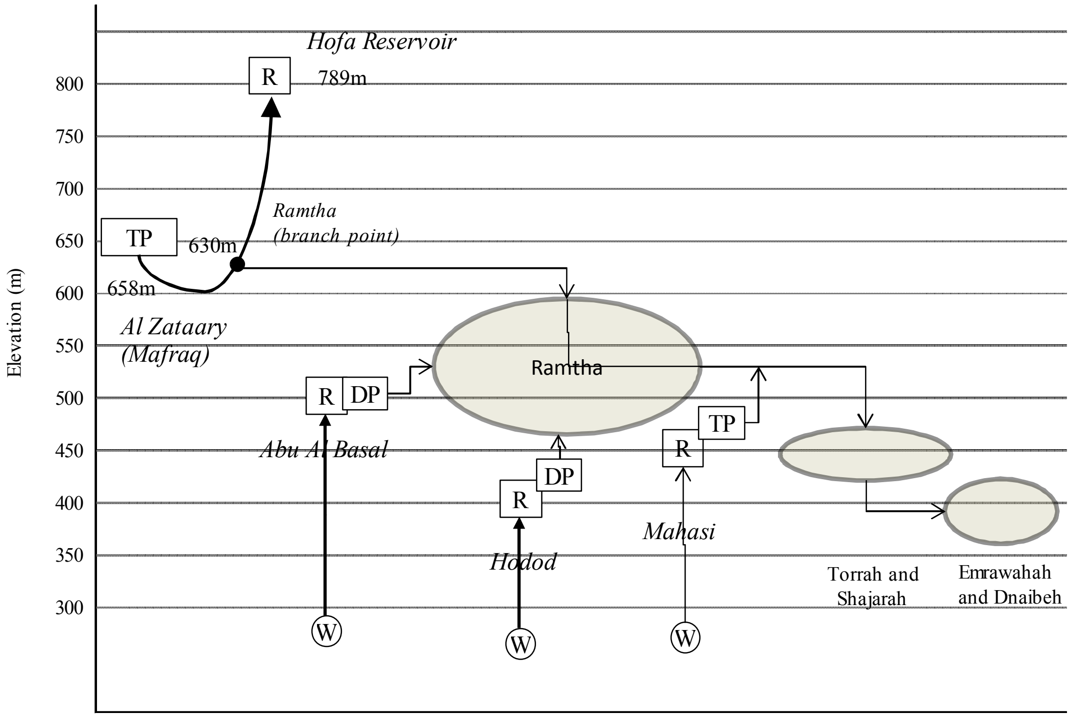
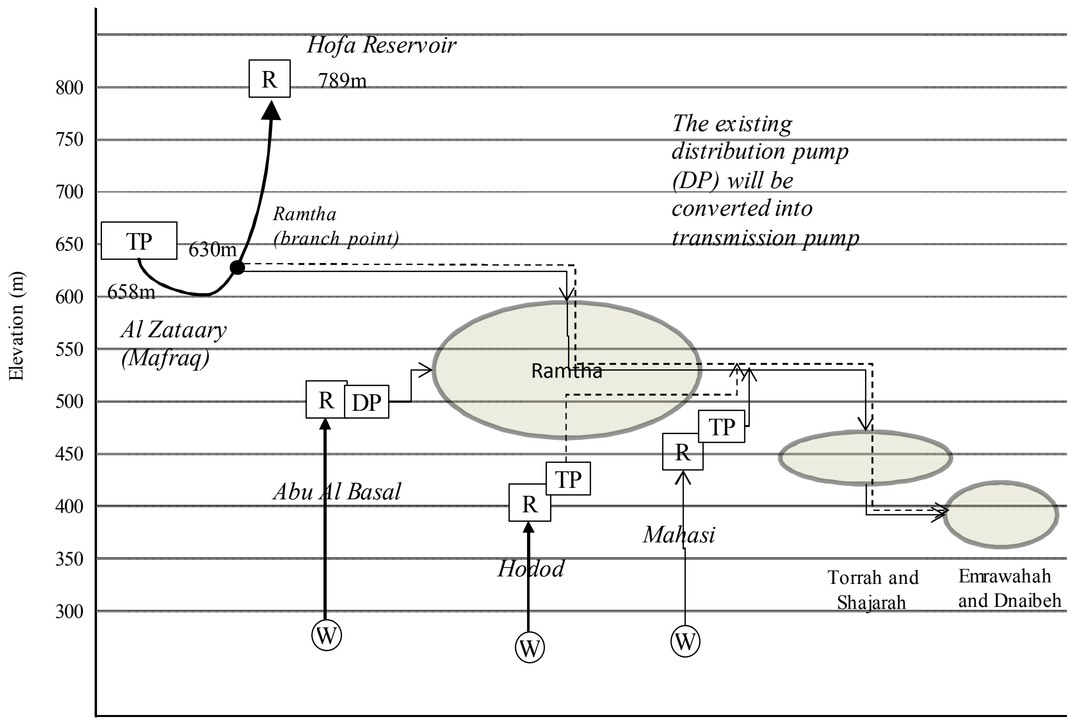


Figure 6.2 Proposed Zoning System of DMA in Ramtha and Its Suburbs



Existing water supply system



(Planned water supply system)

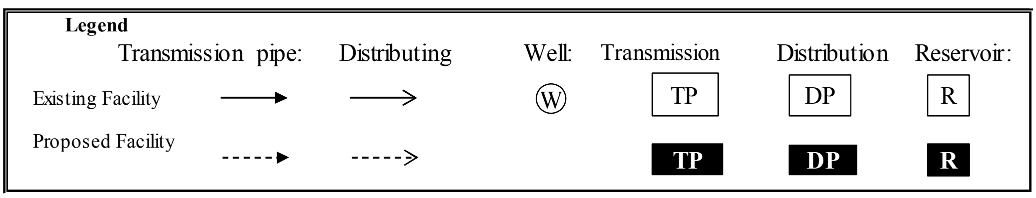


Figure 6.3 Hydraulic Profile of Existing and Planned Water Supply System in Ramtha and Its Suburbs

6.5.4 Proposed Distribution System

Salient features of proposed distribution zones in Ramtha and its suburbs are given in Table 6.7.

Table 6.7 Summary of Water Distribution Zones in 2035 in Ramtha and Its Suburbs

Zone	S. No. of DMA	Elevation (m)			Daily Average Water Demand in 2035 (m^3/day)
		Max	Min	Difference	
Ramtha	1	591	587	5	285
	2	545	530	15	848
	3	546	470	76	13,206
	4	481	440	41	3,804
	5	448	371	77	2,853
	6	419	391	28	1,488
Total					22,484

6.6 Proposed Transmission and Distribution Facility

6.6.1 Transmission Pipe

Transmission pipe of 300 mm diameter and 5,900 m length is required to transfer water from Hodod pumping station to the transmission line at Mahasi pumping station to supply water to the northern localities.

6.6.2 Reservoir

Reservoir is not proposed since water is directly supplied to the area using the residual pressure of the eastern transmission line.

6.6.3 Distribution Pump

All distribution pumps in existing pump stations are very new so that all these pumps will be utilized in the plan.

6.6.4 Strengthening of Distribution Network

The distribution network is analyzed using network analysis software. The proposed distribution pipelines with diameter, material and length for strengthening of network are shown in Table 6.8 and Figure 6.4. The total length for proposed strengthening of network is 47 km with pipe length of 20 km for 91 MCM/y of water and 27 km for 121 MCM/y of water. Refer to Appendix 6A for detail map on proposed pipes.

6.6.5 Rehabilitation of Distribution Network

Rehabilitation pipes with material and length are proposed in Table 6.8 and Figure 6.4. The total length for proposed rehabilitation of network is 80 km.

6.6.6 Service Pipe and House Connection

Increase of the number of house connections between 2014 and 2035 is estimated using estimated population and population per connection as shown in the Table 6.9. Approximately 10,200 new house connections will be required to cater to the needs of increased service population up to 2035. Also, for the consumers along the distribution networks proposed to be rehabilitated, 3300 house connections will require to be replaced. In total 13,500 house connections will be required up to 2035 and these connections will be added in this plan.

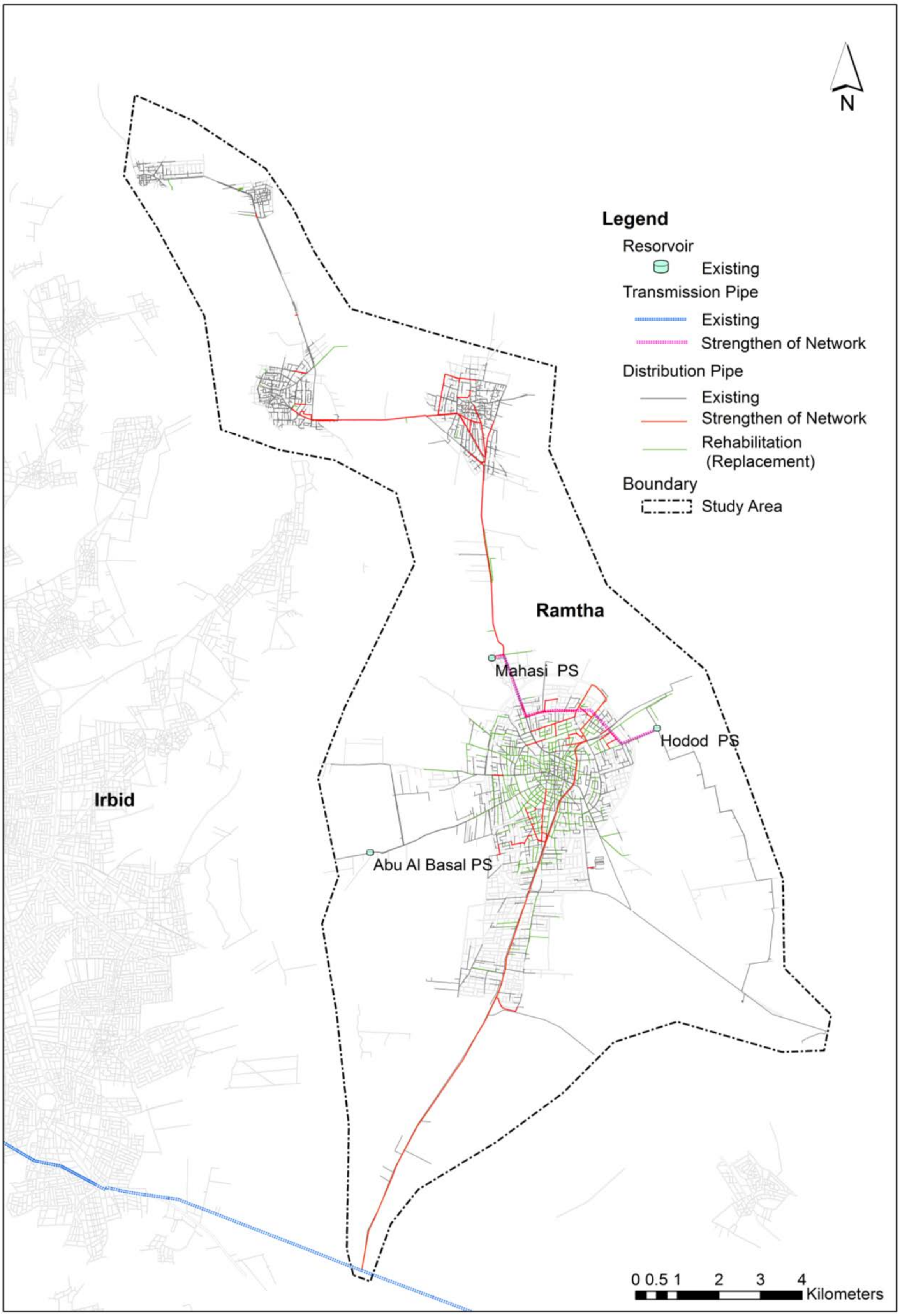


Figure 6.4 Proposed Pipe for Strengthening and Rehabilitation in Ramtha and Its Suburbs (Diameter more than 100 mm)

Table 6.8 Proposed Strengthening of Network and Rehabilitation

Pipe Material and Diameter	Length (m)		
	Strengthening		Rehabilitation (Replacement)
	91 MCM/y	121 MCM/y	
HDPE 20 mm			722
HDPE 25 mm			289
HDPE 50 mm			19,652
HDPE 75 mm			56,686
HDPE 100 mm		7,858	2,107
HDPE 150 mm		4,463	246
DI 200 mm		3,795	
DI 250 mm			9
DI 300 mm		4,654	
DI 400 mm		5,824	
DI 500 mm	5,094		
DI 600 mm	14,794		
Sub-Total	19,888	26,594	-
Total	46,482		79,711

Table 6.9 Estimated Number of House Connections

(Number)

Item	Value	Note
1. House connection requirements to cater to needs of increased service population		
Population in 2014 (person)	132,746	Population estimated for 2014
Population in 2035 (person)	201,198	Design population in Section 6.1.1
Increased population (person)	68,452	
Average number of persons per connection	6.72	Assumed based on estimated population of 2014 in northern governorates and the number of subscribers (connections) (refer to Table 7.7)
Increased number of connection	10,200	
2. House connection replacement to cater to needs of consumers along rehabilitated distribution networks		
Number of connection	3,300	Estimated based on the length of distribution pipe to be rehabilitated and number of house connections per unit length of distribution pipes (41 connections/km) in 2014
Total number of house connections to be replaced	**13,500**	

6.6.7 DMA and SCADA

(1) Necessity and Purpose of DMA and SCADA

Supervisory control and data acquisition (SCADA) is to monitor and control flow and pressure to each distribution zone for equitable water distribution and reduction of leakage. Zoning (DMA) and SCADA are proposed for this purpose.

(2) Proposed DMA

Ramtha and its suburbs are large in area. The area slopes down gently from north to south but due to large area the difference in elevation is significant. The highest elevation in the north is 590 m and the lowest elevation in the south is 370 m. In order to control supply pressures in the areas ranging from 590 m to 370 m, 6 DMAs are proposed as shown in Figure 6.2.

(3) Effect of DMA and SCADA System

This section is same as (3) in section 5.7.7.

(4) DMA Implementation Effect

The effects are estimated similarly as in (4) in section 5.7.7. The effects by DMA implementation are estimated as shown in Table 6.10 based on the result of pipe network analysis with proposed pipes in

2035 as given in Figure 6.4.

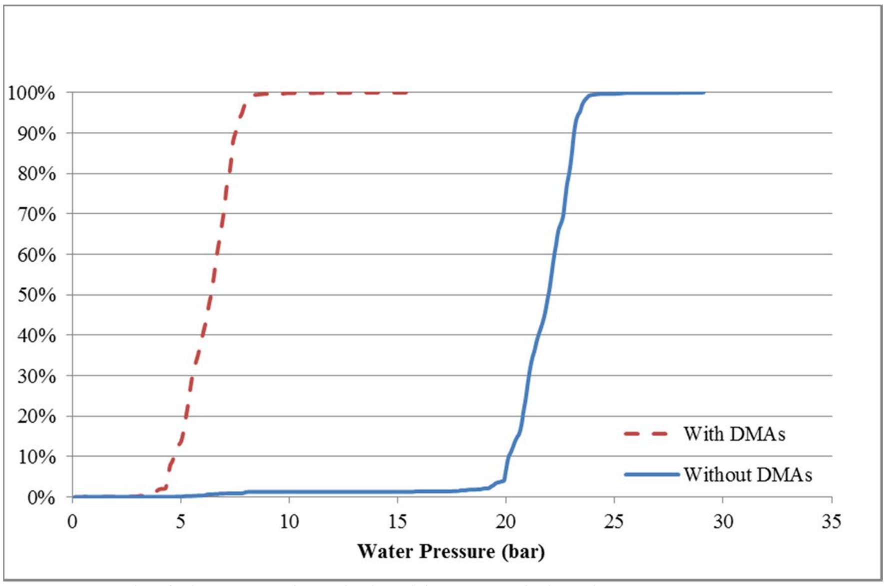
The average water pressure before construction is 21.2 bar which becomes 6.1 bar after DMA creation. The simulation result of water pressure with and without DMA is shown in Figures 6.5 and 6.6. This pressure reduction reduces leakage volume by 46.4 %, as shown in Figure 6.5. With 9.31 MCM/year of water supply amount and 20 % of current leakage ratio, the leakage volume is estimated as 1.86 MCM/year. By reduction of water pressure by 15.1 bar, 0.86 MCM/year of leakage volume can be saved. It is estimated that 1.11 million JD/year can be saved in terms of electricity cost by this water saving based on 0.257 JD/m^3 of the estimated average electricity cost per unit water supply of YWC.

Table 6.10 Estimate of DMA Implementation Effect

Item	Value	Remarks
Average pressure in pipe network without DMA:P1(bar)	21.2	
Average pressure in pipe network with DMA:P2(bar)	6.1	
Theoretical Leakage-of-water reduction rate by proper management of water supply pressure (%)	46.4	1-(P2/P1)^0.5
Amount of water supply (MCM/year)	9.31	In 2035
Leakage-of-water rate (%)	20.00	As Current value
Amount of water leakage (MCM/year)	1.86	
Amount of leakage reduction (MCM/year)	0.86	
Reduction in O&M (electricity) Cost (million JD/year)	1.11	as 0.257 JD/m^3

(5) Composition of SCADA

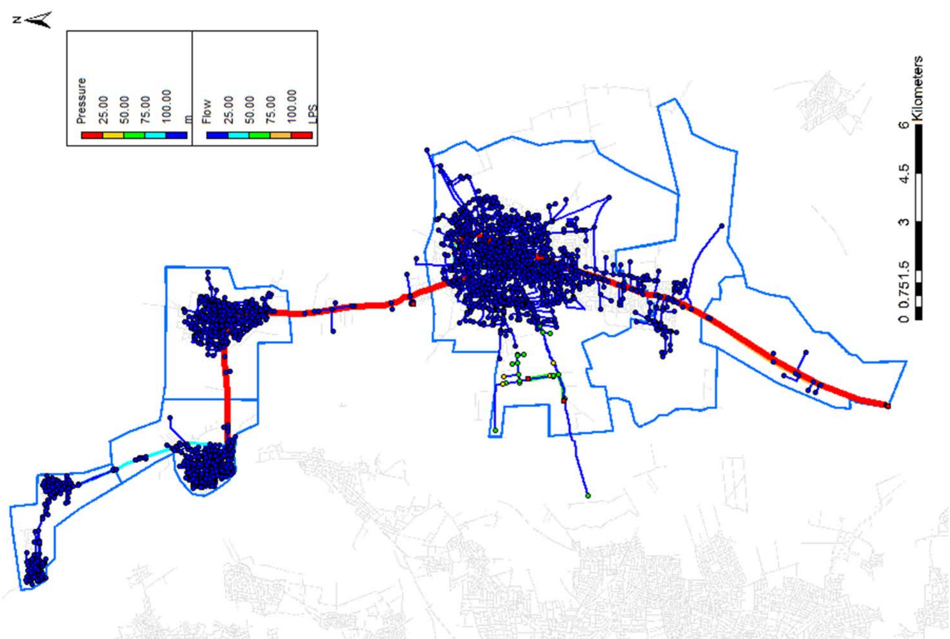
Remote stations are placed in each DMA and in the branch point from the transmission line, and the three pumping stations. Well pumps which supply to the distribution area directly are not included in the main distributing line, so well pumps can be out of scope in the SCADA system. SCADA center should be placed in the office where operation and maintenance crews for the distribution facilities are stationed. Therefore it will be preferable that SCADA center is placed in Ramtha ROU.



Note: Result of pipe network analysis with proposed pipes in 2035.
Water pressure shows weighted average pressure.

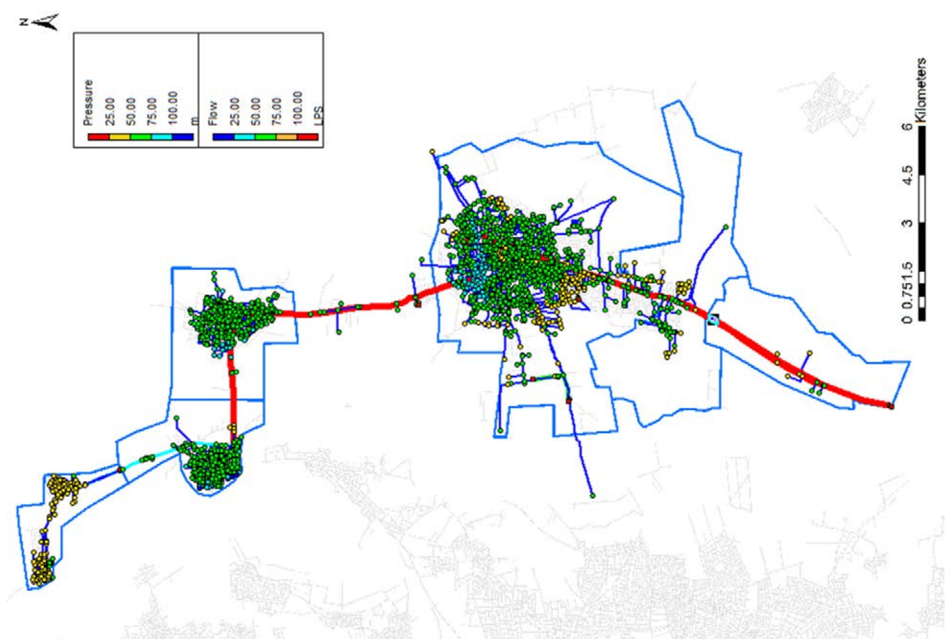
Figure 6.5 Distribution of Water Pressure in Ramtha

Effective Pressure Without DMA



Ramtha Distribution Zone With Proposed Pipe Network

Effective Pressure With DMA



Ramtha Distribution Zone With Proposed Pipe Network

Figure 6.6 Effective Water Pressures With and Without DMA

CHAPTER 7 CONSIDERATIONS ON OPERATION / MAINTENANCE, INSTITUTION AND CAPACITY DEVELOPMENT

In the first two sections, brief suggestions are made on water distribution management and leakage control noticed during the Study. In the following section, suggestion is made on some re-organization as well as required staff number for the increased capacity of the distribution system though not large. Then, in the last section, capacity development is explained for better water management.

7.1 Water Distribution Management

YWC has been conducting the following activities on water distribution management;

- Various water distribution data are collected and stored in ICT directorate of YWC.
- There is GIS system on pipe networks as well as facilities.
- Location of no water, leakage, etc. is stored in GIS format.

For strengthening and improvement of the O&M system and reduce complaints, the following measures are suggested:

- Collected and stored various data in ICT directorate are effectively to be analyzed and utilized for more efficient planning and operation/ maintenance.
- Systematic repair plan based on analysis and storage of maintenance and check/repair record is required.
- O&M manuals are required to be updated, based on which systematic O&M is to be carried out.
- Training for the technical skills on operation and maintenance is to be carried out more actively.

In order to effectively use water and to reduce non-revenue water, leakage detection and repair is strengthened as follows.

- Leakage detection is continued, however, more actively.
- Equipment required for leakage detection and repair is obtained.
- Training for leakage detection and repair is carried out more actively.
- Water balance study is to be conducted.
- DMA creation will help water balance study.

The issue on leakage control, which is one of the most important O&M activities for YWC, is further discussed in the following section.

7.2 Leakage Control

It is understood and generally accepted that about half of the NRW in Jordan is due to leakage. Controlling leakage not only reduces NRW but also generates additional water resource which is very much important in a water scarce country like Jordan.

7.2.1 Leakage Control Methods and Current Practice in YWC

The methods of controlling leakage can be lumped into 4 groups; (i) speed and quality of repairs, (ii) pipe line and asset management, (iii) active leakage control, and (iv) pressure management. They are briefly outlined hereafter in the context of this plan.

(1) Speed and quality of repairs
Repairing leaks in a timely and efficient manner following a set work standard and using quality materials is essential in order to reduce NRW. A bad quality repair invites more leaks either from the

same place or in its vicinity because of the disturbance to the surrounding ground and bedding caused by both the initial failure and its subsequent repair.

YWC practices computer based maintenance management system which tracks the process of leakage repair from the initial reporting of leak event until the completion of repair. Keeping leak repair team(s) standby 24 hours-a-day and maintaining stocks of essential leak repair materials should be emphasized.

YWC should also make sure that the repair works are done following due quality control process. Using inferior materials and methods are acceptable to stop water wastage for a short period in emergency cases but they should be replaced with quality materials and standard repair method once the emergency is over.

Leakage from valve glands in pumping stations and air valves in transmission lines are common sight in Jordan. YWC should strive to minimize such leaks by timely replacing the glands or sealing the leaks appropriately.

(2) Pipeline and assets management
Proper selection, installation, maintenance, renewal, and replacement of pipe and other assets come under this component. The main goal of this component is to manage network rehabilitation in an economical manner to reduce the need for corrective maintenance.

GI pipes are easily corroded and are the main source of leakage. This has been well understood in Jordan and use of GI pipe is decreasing. But due to rocky terrain where burying plastic pipe becomes difficult GI pipes of small diameter are still in use. Use of GI pipe is more prevalent in house connection. Existing GI pipes should be replaced in phases by PE pipe for smaller diameter and by DI pipe for bigger diameter. All new house connections should be of PE pipe.

WAJ, with the help of JICA assisted capacity development project for NRW reduction, has introduced plumbers' licensing system for house connection installation. This will help reduce water leakage from the house connections. Its enforcement should be continued.

(3) Active leakage control
The frequency at which new bursts and leaks occur depends upon the overall condition of the infrastructure and how well the pressure is managed. Dependent upon the specific ground type, there will always be some proportion of leaks and bursts that do not appear on the surface, i.e. non-visible leaks, and these need to be detected. Active Leakage Control (ALC) is a proactive strategy to reduce water loss by the detection of non-visible leaks using trained engineers and technicians with specialized equipment followed by the prompt repair of leaks. Alternatively, we can say that ALC is practiced when competent persons (company staff or hired) are deployed to find leaks, which have not been reported, by customers or other means. The main methods of ALC are regular survey and leakage monitoring.

1) Regular survey – This is a method of starting at one side of the distribution system and proceeding to the other using one of the following techniques:
    - Listening for leaks on pipe work and fittings
    - Reading metered flows into temporarily-zoned areas to identify high-volume night flows
    - Using clusters of noise loggers (leak localizing)

2) Leakage monitoring – This is flow monitoring into zones or districts (DMAs) to measure leakage and to prioritize leak detection activities.

Due to various reasons such as lack of adequate trained staff, proper equipment, and motivation of staff ALC is not practiced currently in YWC. The leak repair works in YWC are almost all 'reactive' rather than 'preventive'. This situation should be reversed gradually and provisions have been made in this MP for training, equipment, and capacity building for the ALC.

(4) Pressure management
Pressure management for leakage control is the practice of managing system pressures to the optimum levels of service ensuring sufficient and efficient supply to legitimate uses and customers, while reducing unnecessary or excess pressures and eliminating transients, which cause the distribution system leak unnecessarily. Pressure management reduces the frequency of new breaks as well as the flow rates from all breaks and background losses.

Due to highly undulating terrain managing pressure is a challenge in Irbid area. Nevertheless, pressure management will be accomplished through distribution zoning, DMA implementation, and installation of PRVs at appropriate locations. The capacity building component of this MP will address the needs of training for proper operation and maintenance of the pressure management facilities.

7.2.2 Consideration for Leakage Control

Based on the available leakage control methods and current practice in YWC, the following should be considered to control leakage:

- Continue using, and improve upon as necessary, the current practice of computerized Maintenance Management system. Put more effort and resources as required to reduce response time for leak repair to the practically possible minimum,
- Continue and enforce the policy of not using GI pipe,
- Enforce quality control methods in selection of materials and installation of pipe lines, valves, pumping stations and so on,
- Provide trainings to untrained staffs and refresher trainings to already trained staffs on leakage control. Establish incentive mechanism, not necessarily in the monitory term, to staffs working in the leakage control section which often requires working at odd hours,
- And more importantly, make leakage reduction as a regular activity and not a work to be taken up during free time. Possibly include plan and target of leak survey in annual work plan and make its progress as one of the performance evaluation criteria of the staffs.

7.3 Institutional Development Plan

7.3.1 Key Issues for Institutional Development

(1) Cultural Change toward Service Provider with Business Awareness
It is important to nurture corporate culture through business awareness and customer focus as a service provider from governmental institutions.

Change to an administrative organization with technical specialization is required. The first step for this change could be started from the change of employee’s mind and awareness at the individual level. In order to do that, strong leadership needs to be taken by the upper management class.

(2) Efficient Usage of Performance Indicators (PIs)
Performance indicators for water services should be effectively utilized in the business operation of waterworks. PIs are an effective tool for evaluation of performance quantitatively. It enables to compare the utility’s performance of the past, present and future periodically, and also to set up quantitative targets for future improvement. The state of existing business operation and target achievement status of water services should be always monitored. It makes current management situation and achievement visible. Key data is collected and some performance indicators are currently compiled by YWC, however, effective analysis to clarify issues and improvement points is not fully done. The results should be practiced and be reflected in development of strategy and plan of YWC.

(3) Setting Targets for Waterworks
Performance targets and achievement standards of water services should be clearly established.

Business Management and Planning Division should set up the key performance indicators and the achievement targets, and do their best for achievement of these targets. Then the performance results need to be reviewed and the results should be made best use for feedback to the development of strategy setting and target setting.

(4) Clear Job Description and Standard Operating Procedures
Limited job description and Standard Operating Procedure (SOP) was created. In order to raise the level of staff's performance, job description and SOP need to be defined and delegation of responsibility should be clearly established in each section. Authority should also be delegated to the lower level in the hierarchy thereby increasing self-awareness and self-reliance of the employees.

(5) Building Up the Human Resource Management System
YWC should well-understand internal human resources by establishing human resource management system which enables efficient use of human resources and their proper appointment. Evaluation standards need to be set up so as to objectively evaluate the performance of the employees. Incentive mechanism and promotion system needs to be formulated and employee's motivation should be enhanced.

(6) Enhancement of People's Awareness through Information, Education and Communication (IEC) Activities
Commercial directorate is the responsible section for promoting IEC activity, however its activities are not getting on the track sufficiently due to lack of budget. Also, the department is basically busy for responses to customer's claim rather than IEC activities on water saving, leakage reduction and so on. Hence, establishment of IEC activity programs, development of IEC materials in cooperation with outside institutions and experts, and its implementation need to be strengthened. People's education and awareness-raising using media, publications and schools should also be proactively promoted. Intensive trainings for the staffs need to be carried out to implement the programs appropriately.

7.3.2 Organizational Arrangement

Based on the analysis of the existing organization set-up, it is proposed that some key arrangements be made in the YWC organization structure in the view of incremental responsibilities and workload arising from the extra facilities in the Master Plan and optimization of the structure is suggested as a water and wastewater utility. Such arrangements are described below.

(1) Business Management and Quality Management Section
This section is suggested to be newly established directly under the General Manager to ensure its independent function. The main functions shall be: 1) to prepare high level policies, plans and strategies, and to manage investment considering urgency, priority, weakness and development goals, 2) to regularly monitor the business performance of waterworks and wastewater works as a whole by using Performance Indicators (PIs), and 3) to initiate and enhance continuous improvement in the quality of services as a whole and, to increase customer satisfaction as a service provider.

The consistency among the corporate plan, operational plan and development plan will be secured by initiative taken by this section. Furthermore, this section will enhance the inter-directorate decision-making from the aspects of not only public services but also business activities. Hence, sustainability view point will be expected to be nurtured by this institutional arrangement.

YWC has been engaged with various donor-funded projects for many years since it was NGWA. These projects sometime tend to be patchworks without the consideration of a comprehensive planning and a middle- and long-term goal for development. Thus the function of this section for keeping its consistency shall be strengthened.

In addition, quality management system does not exist in YWC currently and the awareness on this concept is scarcely shared among the employees. Initially, an understanding of the concept needs to be promoted and awareness on the concept should be shared by all employees. Presumably the next step may be to obtain and translate ISO9001 and ISO24512, related to the management of drinking water utilities and for the assessment of drinking water services, and bring into practice in stages.

(2) Technical Planning Division

This section is suggested to be newly established under the Technical Directorate. The expected functions of the section are 1) to develop, lead and coordinate the engineering plan and the design of water supply facilities, mechanical and electrical equipment, water engineering, and 2) to monitor and assess water demands and technical functionality of overall existing water supply system and development projects. This section is also responsible for overall management of network and distribution planning, hydraulic and pressure analysis, and planning coordination.

(3) Irbid ROU Operation Section

This section is suggested to be rearranged in accordance with the need of SCADA system application. The rearrangement could be thought to be divided into 2 stages, before and after the installation of SCADA system.

1) Before application of SCADA system

Daily water distribution to Irbid city is currently managed and operated on 24 hours-basis by only 2 valve operators. The operators go to the valve points around the city and manually open and close 65-150 valves per day. It seems to be a huge task, and there is higher possibility of occurrence of error or missing to open/close the valves especially in the absence of experienced senior operator. Hence it is recommended to increase the number of operators; at least 2 additional operators making each team of 2 persons, and to establish a more systematic operation by using a map and a check sheet rather than the current practice of experimental operation.

2) After application of SCADA system

When the SCADA system for rationalized distribution management is installed, this section needs to be reorganized. Valve operators may be transferred to distribution section, maintenance section within the Irbid ROU, or other section such as leakage section in Technical and Maintenance Service Division, or pumping stations under Production Division.

(4) Irbid ROU Maintenance Section

This section is suggested to be strengthened by increasing staffs for pipeline maintenance. Currently 3 teams, composed of 2 teams for daytime and 1 teams for nighttime, are handling maintenance of pipeline, usually in response to customer claims on “leakage”, “blockage”, “replacement of valves”, “clogged pipes” and so on. This section is absolutely busy and current staffing appears to be insufficient for responding to more than 5,000 claims per year on pipeline maintenance. At least one additional team consisting of 3 members needs to be allocated to this section.

Furthermore, it is recommended that their daily maintenance activities are systematically managed with appropriate maintenance records and reporting to the section head. Staff’s insufficient competence and skills in pipeline works is one factor of endless maintenance works. It should be improved at individual level. Tools and pipe materials for repair needs to be arranged and stocked.

(5) Technical Support and Maintenance Division

Maintenance section in Technical Support and Maintenance Division needs to be strengthened by increasing the number of staffs and by providing more advanced training.

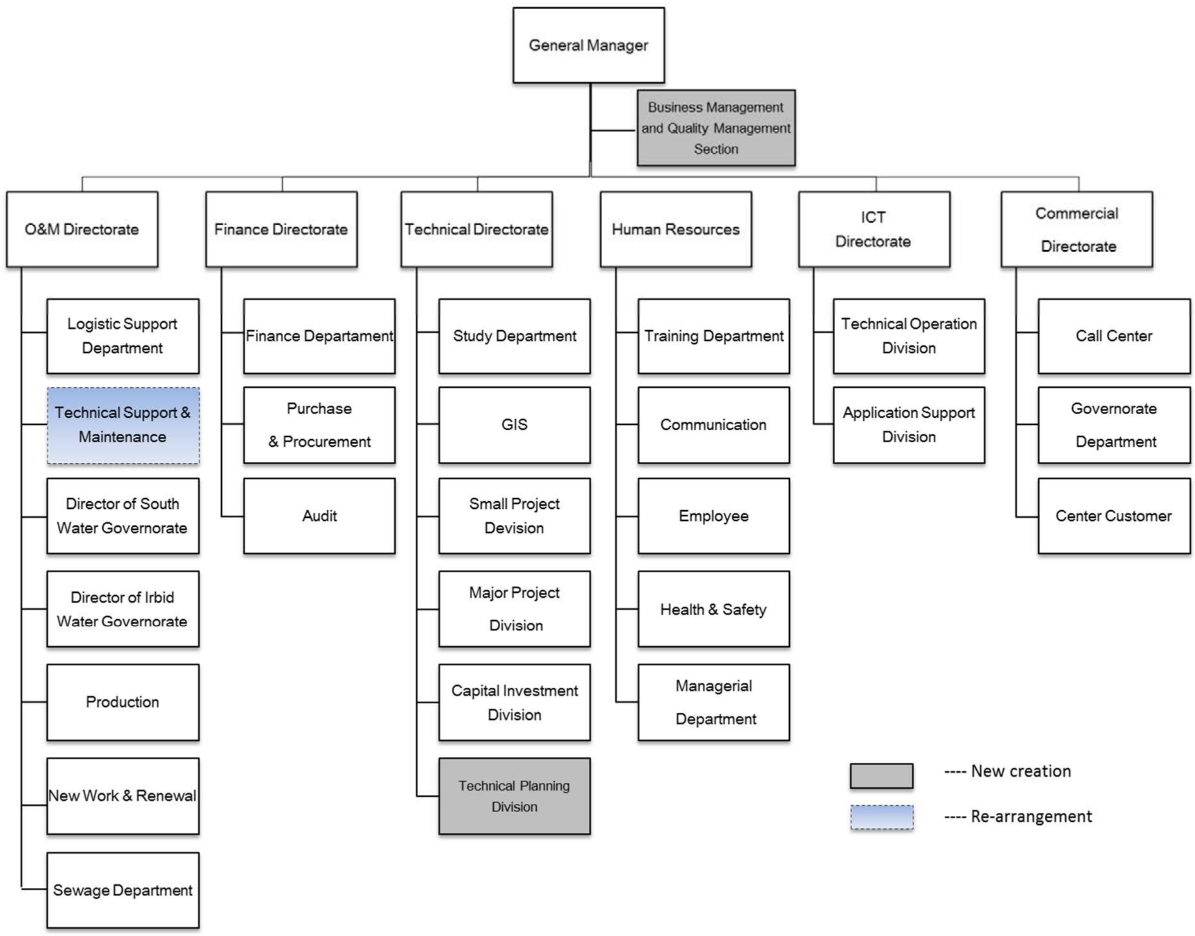
Currently, only 3 persons, i.e., section head, mechanical engineer and electrical engineer exist in this section and cover technical service and maintenance of all pumping stations and treatment plants except for pipeline. Preventive maintenance was carried out under the YWC operation by the private contractor; however this is not functioning due to the reduction of staffs and availability of only one vehicle after the contractor left.

Maintenance activities are very crucial to extend the lifetime of mechanical and electrical equipment, to minimize maintenance downtime and to contribute to sustain utility's management by deferring rehabilitation and replacement investments. Since the maintenance downtime of well pumps directly linked to the reduction of well production, the preventive maintenance is essential. Hence, additional 3 engineers and at least one vehicle should be allocated in this division. Current staff's motivation to learn advanced technique and technology should also be respected.

In addition, leakage section which was established recently in February 2014 needs to be strengthened. This section launched the activities of detection of leak location and reporting the information to ROU for repair works. Considering current number of customer claims on water leakage of nearly 5,000 per year, the number of staffs, tools and devices and their competence seems to be insufficient. The activities related to preventive maintenance should be enhanced together with routine maintenance activity.

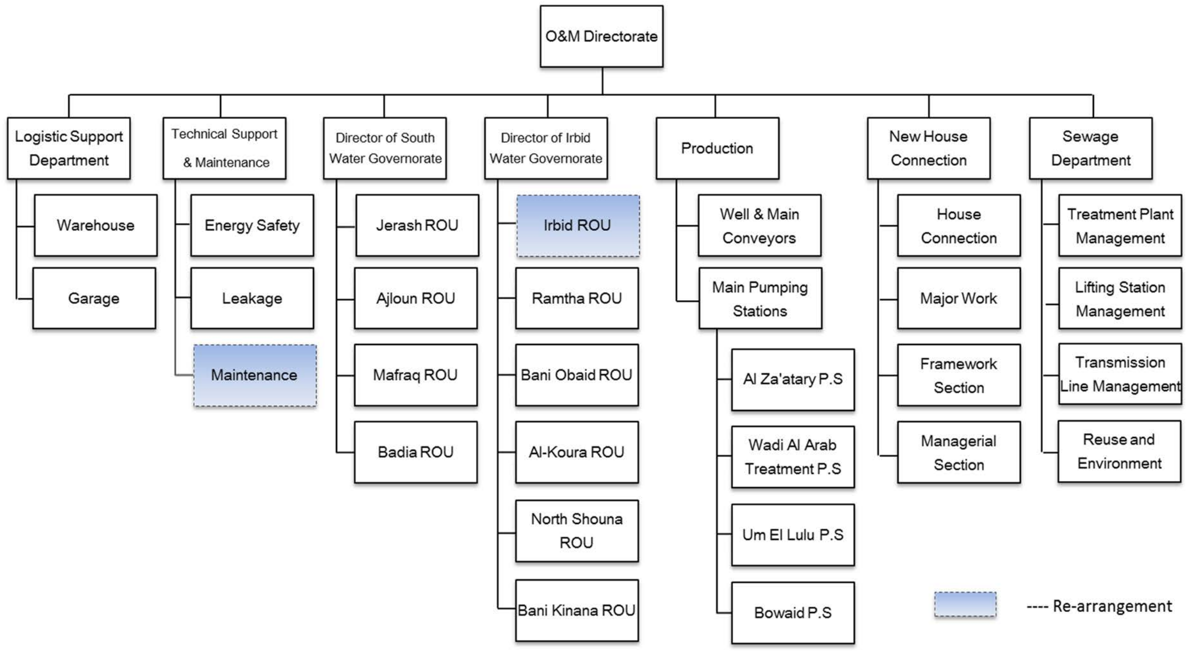
(6) Proposed Organization Structure

Proposed organization structure of YWC overall, O&M Directorate and Irbid ROU for new creation or rearrangement are presented in Figures 7.1, 7.2, and 7.3.



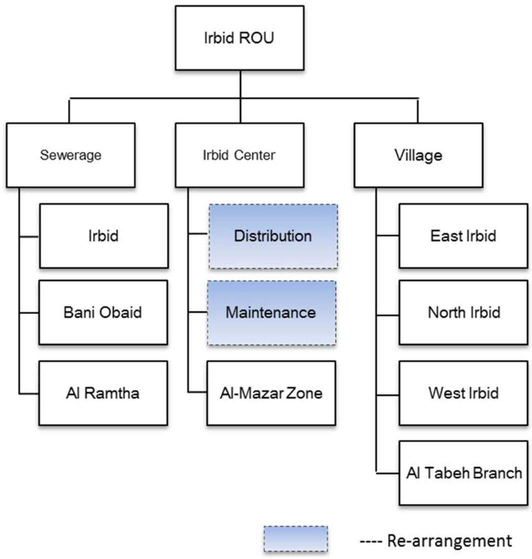
Source: JICA Study Team

Figure 7.1 Proposed Organization Structure (YWC Overall)



Source: JICA Study Team

Figure 7.2 Proposed Organization Structure (O&M Directorate)



Source: JICA Study Team

Figure 7.3 Proposed Organization Structure (Irbid ROU)

7.3.3 Staffing Plan

The appropriate number of YWC staffs by job type for the Master Plan up to Year 2035 is estimated.

The estimation of specific number of O&M staff in water and wastewater sectors is based upon the current operation, the planned new facilities, the intended shift arrangement and the workload anticipated. It should be noted that the necessary staff number depends on the quality of maintenance and the operational performance of the facilities.

The proposed number of staff will be same as the current level although some directorates need more staff but the other directorates such as operator section can be reduced through rationalization of distribution network using DMA and SCADA.

(1) Operation and Maintenance

1) Zebdat Pumping Station and Reservoir (Irbid)

At present, the pumping station is operated manually by switch-on/off of four pumps and opening/closing of valves. One operator each is responsible for this operation in 4 shifts. In the proposed system, one distribution pump will remain both in Case A and Case B, and one transmission pump at Zebdat will be planned in Case B. Hence, current operators will be necessarily remained.

2) Hofa Pumping Station (Irbid)

This pumping station is used for transfer of water to the area outside of the Study Area so that current staff is required.

3) Hodod, Mahasi and Abu Al-Basal Pumping Station (Ramtha)

The existing distribution pump of Hodod pumping station will be converted into a transmission pump so that current operators are required. Mahasi pumping station will be remained as a transmission pump same as current operation. Abu Al-Basal pumping station is same as current O&M and staff number. Thus there will be no change in the number of current operators.

4) ROU office

New distribution pipes are proposed to be laid for Irbid and Ramtha with the target year 2035. Generally new distribution pipes may not require any immediate maintenance of repair and rehabilitation if high construction quality is maintained.

Meanwhile, M/P suggests applying SCADA system for distribution management of Irbid and Ramtha. It may be appropriate that the operation of SCADA is managed by Central Irbid ROU office and Ramtha ROU office. If this system is established, the existing valve operators can be transferred to the maintenance section within Central Irbid ROU and Ramtha ROU. Also, the number of house connection is projected to increase, thus the maintenance workloads of service pipe are supposed to expand.

The Study team proposes to increase the staff number in the following ROU considering the length of new pipeline, the quality of civil works and application of SCADA system for the Irbid central and Ramtha areas. The O&M staffs for waterworks by ROU and that of Irbid Center of Irbid ROU are shown as Table 7.1 and Table 7.2.

Table 7.1 Proposed O&M Staff Number for Waterworks by ROU

Governorate	ROU	Current Staff		Additional Staff		Total (as of 2035)
		Operator/ Plumber	Others	Operator/ Plumber	Others	
Irbid	Irbid Center ROU	43		1		44
	Ramtha ROU	12				12
	Bani Obaid ROU	1	1	2		4
	Bani Kinana ROU	17	1			18
	Al-Koura ROU	5	1			6
	North Shouna ROU	13	2			15

Source: JICA Study Team

Table 7.2 Proposed O&M Staff Number for Waterworks in Irbid Center of Irbid ROU

ROU	Area/ Section	Job Type	Current Staff	Additional Staff		Total (as of 2035)
				Before SCADA application	After SCADA application	
Irbid	Irbid Center					
	- Operation	Valve operator	4	0	-4	0*
	- Maintenance	Distribution Plumber	8	3	4	15*
		Welding	2			2

Note: *This number is shown in the case of transferring redundant valve operators to the maintenance section of the same Irbid ROU after SCADA application
Source:JICA Study Team

5) Technical Support and Maintenance Division
This Division provides technical support service and maintenance of all pumping stations and treatment plants for water supply and sewerage. In order to revive preventive maintenance activity and enrich leakage detection activity, the Study Team proposes the minimum number of additional staffs. The staff number of Technical Support and Maintenance Division is shown in Table 7.3.

Table 7.3 Proposed Staff Numbers of Technical Support and Maintenance Division

ROU	Section	Current Staff	Additional Staff	Total (as of 2035)
Irbid	Maintenance	4	3	7
	Leakage	3	3	6

6) Head Office
In accordance with the organizational arrangement suggested by the Study Team in Section 7.2.2, the staff number of Head Office is shown in Table 7.4.

Table 7.4 Proposed Staff Numbers for Head Office

Directorate	Directorate/Section	Required Staff Number Total (as of 2035)
(Under General Manager)	Business Management and Quality Management Sec.	
	- Business Planning	3
	- Quality management	2
Technical Directorate	Technical Planning Division	
	- Water and wastewater facilities	2
	- Water pipeline and sewer network	2

Source: JICA Study Team

(2) Staffing Level
1) Current Staffing Level
The progress of downsizing staffs can be seen after the recent peak of 1,740 in 2012. The current number of staffs (as of 2014) is 1,649 according to the information from YWC cost center. The staffing level per 1,000 water and wastewater connections of YWC in 2014 is smaller than the average of Jordan and two upper-middle-income countries. From the aspect of staff number per person served, it could be said that the staffing level indicates even better performance than the average of available 3 utilities in Jordan. In comparison to the level of other upper-middle income countries, the staff productivity of YWC is nearly similar to their performances except for Azerbaijan and Kazakhstan.

Table 7.5 Staff Numbers and Staffing Productivity per Connection (2006-2014)

Item	2006	2007	2008		2012	2013	2014
Total staff number	1761	1801	1673	---	1740	1671	1649
Staff number Water and Wastewater (W&WW)/ 1000 W&WW connections	7.3	7.2	6.4	---	6.6	6.1	6.0

Note:
1. Data source: 2006-2008 Management Contract for YWC LLC, 2012-2014 YWC Technical Directorate
2. Data during 2009-2011 is not available

Table 7.6 Staff Productivity of Jordan and Other Upper-Middle Income Countries

IBNET Performance Indicators	Jordan					Albania	Azerbaijan	Bosnia & Herzegovina	Macedonia
	YWC	Jordan Average (3 Utilities)	Aqaba Water Company, W.L.L.	Water Authority Balqa and Zarqa, Madaba and Karak, Maan and Tafila	Jordan Water Company (waters) Miyahuna				
12.2 Staff W&WW/1000 W&WW connection (#/1000 W&WW connections)	6.0	8.7	13.0	9.8	3.4	6.2	2.8	5.2	5.3
12.4 Staff W&WW/1000 W&WW Pop Served (#/1000 W&WW pop served)	0.7	0.9	1.3	1.2	0.2	1.7	0.7	1.3	1.0

Source: JICA Study Team
Note:
1. Data source: IBNET Database
2. Average of Jordan is calculated by using available results of 12.2 and 12.4 (12.2 and 12.4 used here are standard IBNET performance indicator numbers)

2) Target of Staffing Level

JICA Study Team proposes "gradual reform" rather than "radical reform" considering local historical and cultural context, nature of employees and past experience. The appropriate target of the staffing level shall be proposed to be 4.5 staffs per 1,000 connections in Year 2035. If the number of subscribers for water and wastewater increase according to population growth of the northern governorates, the appropriate staffing level of YWC will reach to 2,345 staffs in Year 2035. The projection and the estimation condition are shown as follows.

Table 7.7 Projection of Appropriate Staffing Level

	2014	2020	2025	2030	2035
Number of Subscribers (connection) - Water supply	275,362	320,579	379,020	445,759	521,031
Number of Subscribers (connection) - Sewerage	180,590	215,469	238,084	262,226	286,737
Number of Subscribers - Total	420,326	536,048	617,105	707,985	807,768
Staff W&WW/1000 W&WW connection (#/1000 W&WW connection)	6.0	5.6	5.2	4.9	4.5
Number of Staffs (persons)	1,649	1,786	1,976	2,165	2,345

Source: JICA Study Team
Note:
1. Data source: Year 2014 – YWC
2. Data source: Year 2020, 2025, 2030, 2035 – Estimation by JICA Study Team
3. Population for Northern governorates: 2.87 million in 2035, Coverage ratio: 98 % for water supply

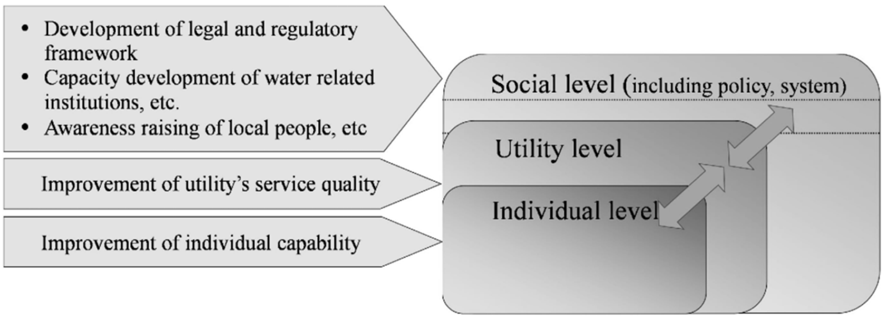
Meanwhile it is important to keep in mind that "number of staffs per 1,000 connections" and "number of staffs per 1,000 population served" are benchmarking indicators, not standards. The staffing level should be flexible and appropriate for the actual management of waterworks and wastewater works. Also, staff productivity should not be utilized for the purpose of downsizing workforce without considering the local context, but should be balanced with the purpose of nurturing proactive workforce with high motivation and high skills. The arrangement of job description and terms of conditions of works could contribute to build up harmonious relations with employees.

7.4 Capacity Development Plan

7.4.1 Outline of Capacity Development

(1) Concept of Capacity Development
Capacity development is defined by JICA as "the process by which individuals, organizations, institutions, and societies develop abilities to perform functions, solve problems and set and achieve objectives". Capacity development not only in technical aspects but also in overall organizational aspects including management and financial issues is essential for water and sewerage utilities to operate their organization and infrastructure facilities in a sustainable manner. In order to support this, capacity development at individual and social level also plays a crucial role.

Capacity development cannot be achieved without human resources. Every utility needs to address that human resources are the greatest assets of the utility and are the most valuable element of capacity development.



Source: JICA (2008) Capacity Assessment Handbook

Figure 7.4 Concept of Capacity Development

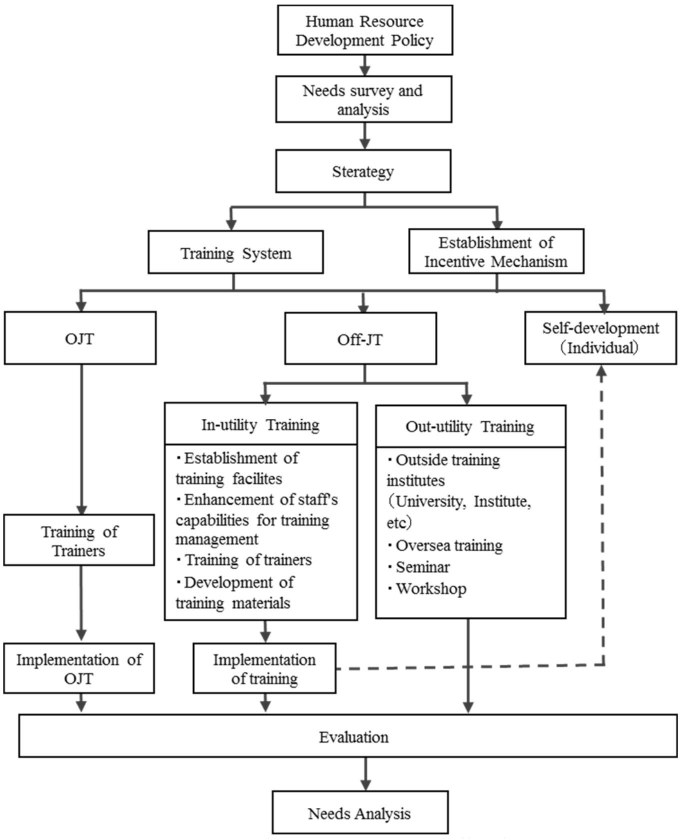
(2) Capacity Development Methods
Training mechanism and capacity development methods are indicated in Figure 7.5. Capacity development should follow a utility's basic policy for human resource development and should be planned based on the result of needs assessment. Main methods of capacity development are: (1) OJT, (2) Off-JT, and (3) self-development.

OJT enhances capacity in terms of necessary technology and capability through a form of training on practical works and trial and error in normal working situation. Off-JT is a form of training through external lectures or education either inside or outside of utility. Self-development is a form of training to develop own capability by individual learning.

For effective capacity development of YWC, combination of all training methods for capacity development namely OJT, Off-JT and self-training are essential. The training subjects of YWC in 2012 were varied from the areas of technical, management, information technology, health and safety and customer service and the trainings were partially funded by the USAID. One weakness of the training system by YWC is that most of training courses are contracted out to outside service providers. It naturally requires a large training budget amount. Alternatively, the adoption of training of trainers (ToT) system could be a solution.

From the long-term view, ToT is expected to nourish resource persons effectively, and that they transfer obtained knowledge and experiences to the next middle or young staff members. At the same time, creation of incentive mechanism and awareness-raising, and development of surrounding environment where the lessons learnt by training are effectively utilized, are necessary.

At the initial stage, it is considered that the assistance of dispatch of external experts by aid agencies, etc. and a technical cooperation project are useful for entire capacity development.



Source: JICA (2008) Capacity Assessment Handbook

Figure 7.5 Capacity Development Mechanism and Methods

7.4.2 Capacity Assessment

Capacity assessment of YWC is conducted in accordance with the JICA Capacity Assessment Handbook. The key items to be checked are selected from the list of overall items which are many in various fields.

Assessment fields are categorized into the following three areas; (1) technical capacity, (2) core capacity (non-technical), (3) enabling environment. The summary of the assessment is shown in Table 7.8.

7.4.3 Capacity Development Plan

The necessary areas for capacity development of YWC in water supply and wastewater sectors in the short- and mid-term up to 2025 are summarized in Table 7.9. Priority is given in the range of high and low. High priority means that the training is urgently necessary within 3 years. While, low priority indicates that the training for the area need to be done up to 2025 and the degree of urgency is not high, but it does not mean that the training needs are low.

Table 7.8 Summary of Capacity Assessment

Category (Large)	Category (Middle)	Category (Small)	Results
Technical capacity	NRW reduction	Leakage detection technology and skill	• Leakage reduction unit exists under O&M directorate • Response to leakage and repair reported by customer is supportive, but proactive measure is assisted by JICA pilot project • Knowledge, equipment and facilities for leakage reduction are not sufficient • No future plan on NRW reduction • Accuracy of customer meter can be checked by equipment in workshop, but repair and calibration cannot be done • Malfunctioning customer meters are replaced
	Water quality management	Operation of waterworks and wastewater works facilities	• Drinking water quality is generally good. Some of discharge water quality from WWTP does not comply with the Jordanian standards, particularly in Fo'arah, Jerash, Mafraq, and Akaider.
		Water quality analysis	• Chemical, microbiological and biochemical sampling and analysis are done
Core capacity (Non-technical aspects)	Financial strength	Financial stability	• No tariff setting guideline • The trend of financial balance of current account of YWC has been in deficit • The deficit amount has generally been subsidized by WAJ • Revenue covers only about 50 % of operating costs • An issue of concern is rapid growth of expenditure during 5 years, equivalent to 60 %
		Procurement of funds	• Fund sources for capital investment are generated fund by YWC, WAJ, international agencies
		Accounting	• Double-entry bookkeeping accounting system has been adopted • Not financially autonomous
		Tariff	• Metered rate is applied • Increasing Block Tariff is applied for WS and WW services • In overall, the tariff rate levels presumably remain at low level
		Revenue and subsidies	• YWC has the authority to levy, collect and retain revenue • Subsidies are provided by WAJ if revenue cannot cover the expenses
		Meter reading, billing and collection	• Bimonthly reading and billing are done • Average collection ratio is 77 % (2013), relatively low • Regional disparity exists, the collection ratio (Mafraq, Badia) is around 50 %
	Governance/ management/ personnel affairs	Organizational function and performance	• Organization restructuring has been reconsidered by Director, not yet clearly concluded • Division of role and responsibility is partially defined, but very limited • Some key information on PIs is collected but seems not sufficient and effectively utilized
		Employment/ transfer/ turnover	• Personnel management is done by Human Resource Development Dept. • Recruitment criteria is established • Progress of staff transfer from WAJ to YWC is very slow, more than 95 % still belong to WAJ
		Personnel management and incentives	• No commendation system • Promotion criteria is not clear, it mostly depends upon personal connections • Performance evaluation system does not exist

Category (Large)	Category (Middle)	Category (Small)	Results
		Communication	• Regular meetings are held for management class • Communication between manager and lower staffs are not sufficient in general
	Training	Plan and Budget	• Training is implemented every year, an annual training plan is developed • Budget amount has decreased during the recent 3 years • Budget largely depends upon outside donor funding, very limited budget in 2014
		Training program	• Engineering training is done mostly by outside provider − Materials: supplied by providers − Trainer: outside service providers • Effectiveness of training program is not sufficiently reviewed
		OJT	• Rarely implemented
		Training system	• Training system exists
		Knowledge sharing and culture	• There is a potential if systemized
		Staff's motivation	• No regular evaluation system, no incentive mechanism for capacity development • Training achievement appears to be not considered in the promotion stage
Enabling environment	External influence	Governance and political influences	• Independent utility as limited liability company, but owned by WAJ • Influence on tariff setting is unknown
		Regulatory bodies	• No regulatory agency
		Procurement	• No function for reduction of corruption
		Cooperation with donors, other water utilities	• Cooperation by aid agencies both in WS and WW sectors • Cooperative relations with WAJ can be seen in maintenance works
	Law, regulations and guidelines	Laws and regulatory framework	• National strategy and policy are established by WAJ
		Regulation and standards	• Licensing system of house connection works for contractor exists in water sector
	Others	Public awareness and IEC	• Little or no IEC activities by YWC

Source: JICA Study Team

Table 7.9 Training Areas for Capacity Development of YWC

Category		Necessary areas for capacity development	Priority		
			3y	5y	～2025
			high		low
Technical capacity	Plan and Design	1. Water Sector Policy		●	
		2. Development Plan			●
		3. Design of System and Facilities			●
		4. Strategic Business Plan	●		
		5. Human Resource Management Plan	●		
		6. Budgetary Planning	●		
	Civil works	7. Plumbing Works for New Connection	●		
		8. Construction Management and Supervision		●	
	O&M	9. Operation Manual			●
		10. O&M Recording and Reporting			●
		11. Hydraulic Analysis/ Pressure management	●		
		12. Electrical Control Panel		●	
		13. Operation - WTP	●		
		14.. Operation - PS & Reservoir		●	
		15. Maintenance - Mechanical Corrective Maintenance	●		●
		16 Maintenance - Mechanical Preventive Maintenance		●	
		17. Maintenance - Electrical Corrective Maintenance	●		
		18. Maintenance - Electrical Preventive Maintenance		●	
		19. Maintenance - Customer Meter and Calibration			●
		20. Maintenance - Desalination Plant		●	
		21. SCADA System Monitoring and Evaluation	●		
		22. Programmable Logical Control	●		
	Water quality	23. Sampling Plan and Skill			●
		24. Skill and Knowledge for Water Quality Test			●
		25. Technique for Quality Analysis and Data Analysis		●	
		26. Monitoring and Advanced Water Quality Analysis (Trace contaminant, Biological analysis)		●	
	NRW	27. NRW Reduction Plan	●		
		28. Water Balance Analysis	●		
		29. Leakage Detection		●	
		30. Leakage Repair and Network Maintenance	●		
Core capacity (Non-technical capacity)	Organization	31. Corporate Culture and Business Mind	●		
		32. KAIZEN Method	●		
		33. Division of Role and Duty	●		
		34. Time Management		●	
		35. Personnel Management	●		
		36. Good Governance and Prevention Measure for Corruption		●	
	Management	37. Sustainable Waterworks/Wastewater Works Management (ISO24512)		●	
		38. Performance Indicators (PIs) and Management Tools	●		
		39. Performance Monitoring and Evaluation		●	
Core capacity (Non-technical capacity)	Management	40. Quality Management (ISO9001, ISO14001)	●		
		41. Management Information System (MIS)			●
		42. Public Procurement Management and Supervision			●
		43. Occupational Health and Safety Management	●		
		44. Computerization and Data Processing and Editing		●	
		45. Computer Literacy and Skill (MS Word, Excel, PPT)		●	
		46. Advanced Computer Skill (Oracle, Unix, etc.)		●	
	Finance	47. Cost Recovery/ Water Tariff Setting	●		
		48. Financial Analysis/ Financial Projection		●	
		49. Asset Management		●	
		50. Effective Billing and Collection	●		
	Public/ Society	51. Customer Relation/Customer Satisfaction	●		
		52. Public Awareness and Education for People	●		
		53. Social Responsibility and Accountability for People		●	
		54. People's Participation and Public Involvement		●	
		55. Environmental Impact Assessment		●	
Enabling Environment	Regulatory framework	56. Water & Wastewater Sector Policy/Regulatory Framework		●	
		57. Water Quality Standards/Effluent Standards		●	
		58. Other relevant legislation (Road, Building, Land etc.)			●

Source: JICA Study Team

7.4.4 Priority Area for Capacity Development

(1) NRW Management

1) Development of Activity Basis for NRW Reduction in DMA model 1-2 area(s)

a) Survey and data collection on current situation of NRW in the target DMA area(s)
b) Development of an action plan for NRW reduction in the target DMA area(s)
The Irbid ROUs under the O&M Directorate will formulate an action plan for NRW reduction in the DMA model areas.
c) Development of format and standard operation manual for mapping and database development
The format and standard operation manual for mapping and database development will be formulated by Irbid ROU in consultation with the Project team.
d) Establishment of attribute information basis on distribution network (diameter, pipe type, location, pipeline length, year of installation, etc.) in the target DMA area(s)

2) Implementation of Leakage Reduction Activities in DMA model 1-2 area(s)
a) Selection of model DMA areas and development of an action plan
One or two DMA model area(s) will be selected. According to the aforementioned NRW reduction plan, an action plan for leakage reduction will be developed.
b) Development of database and drawings on pipeline, installation of necessary materials and equipment
Pipeline and mapping information by using GIS will be developed and necessary materials and equipment will be installed.
c) Implementation of OJT for ROU staffs
OJT on analysis of NRW and on repair and maintenance skills will be transferred to staffs. This activity is an extension of the pilot project activity of the M/P.
d) Implementation of NRW reduction activities in model DMA areas
At the same time as c) above, OJT on leak detection works will be evolved to the staff of Leakage Section under Technical Support and Maintenance by using leak detection materials and equipment (sound bar, water leak detector).
e) Monitoring and evaluation of results of NRW reduction activity
Results of NRW reduction activity will be recorded and monitoring will be continued. Evaluation will be conducted regularly, and the improvement points will be suggested.

(2) Strengthening Human Resource Development System

1) Strengthening human resource management system

a) Development of human resource development plan
Human resource development plans in the middle and long-terms will be developed taking into account an appropriate level of staffing for YWC.
b) Development of job description and standard operating procedures (SOPs)
Clear job description and SOPs will be developed in the each section of YWC.
c) Consideration on application of performance management system and establishment of performance evaluation standards
The possibility of introducing performance management system will be considered in cooperation with Human Resource Directorate. In parallel, the possibility of introducing performance evaluation standards will also be established.
d) Consideration on application of incentive mechanism for employees
The possibility of application of incentive mechanism will be considered in cooperation with Human Resource Directorate.

2) Enhancement of Systematical Implementation of Training
a) Development of a strategic training program for the technical assistance project

Based on an annual training plan of YWC formulated by Training Department, a strategic training program will be established. During the process of the establishment, the priority areas for training will be reassessed.

b) Implementation of training in the priority areas
Training for the priority areas will be implemented by effectively using outside service providers such as WAJ Training Center, manufacturing companies of pipes and pumps, vocational colleges and private training institutions in the initial stage of the Project. The training will be provided to the staffs working in the YWC head office and its regional offices.
The candidate subjects are shown as below.

- Corporate culture and business mind
- Business management and sustainable waterworks
- Plumbing works and pipeline maintenance
- Water treatment technology and operation
- Mechanical corrective maintenance
- Electrical corrective maintenance
- SCADA system and programmable logical control
- Quality management
- KAIZEN method

3) Establishment of a System for Training of Trainers (ToT)

a) Development of a ToT plan and selection of YWC trainers in the key training areas
Several trainers will be selected in key training areas. These candidates should be nominated in the list of trainees for the training aforementioned in section (2).

b) Implementation of capacity development training for trainers
Capacity development trainings for YWC trainers will be carried out by outside providers and the Japanese experts. In combination with the aforementioned training in (2), the necessary knowledge, technology and skills and expertise for the trainers will be developed and enriched.

c) Development of training program by YWC trainers
A training plan including training curriculum, training methods and training schedule will be formulated by YWC trainers.

d) Development of training materials by trainers
YWC trainers will develop teaching materials for their training in collaboration with the Japanese experts. In the process of development, it should be paid attention that the materials need to be easy to learn knowledge, technology and skills and expertise.

e) Implementation of training by trainers
The selected YWC trainers will implement trainings to other staffs working in the relevant areas by using the developed training materials. A feedback system of lessons learnt through the training will be established.

(3) Increasing Public Awareness through IEC Activities

1) Development of an IEC activity plan
An IEC activity plan especially on promoting public awareness of saving water and leak reduction will be developed by Commercial Directorate targeting the Northern Governorates. Effective communication methods such as radio, newspaper, internet, public meeting etc. will be searched and incorporated in the plan.

2) Development of IEC materials
IEC materials on saving water and leak reduction will be developed. Illustrated leaflet and pamphlet, poster, audio-visual teaching materials like DVD will be prepared.

3) Implementation of IEC Activities
IEC activities on promoting public awareness of saving water and leak reduction will be carried out to residential people and school students in the Northern Governorates according to the Plan.

7.4.5 Project Design Matrix of Capacity Development Project (PDM)

Based on current situation of YWC and consideration in the aforementioned section, the following capacity development project by technical cooperation is proposed.

Priority areas within the three fields such as business management of waterworks management, NRW reduction, and water treatment are indicated as below. Activity components and Target to be achieved are shown in the Project Summary (left box) and in the Performance Target (right box), respectively.

Table 7.10 Outline of Technical Cooperation Project for Capacity Development (Sample)

Project Period:	3.5 – 4 years
Executing Agency:	Yarmouk Water Company
Beneficiaries:	Direct Beneficiaries: YWC staffs working in the relevant areas of NRW reduction, human resource management and customer relation, the selected trainees of YWC (Head office, Regional offices), residential people and school students In-direct Beneficiaries Approximately 1.77 million people served by YWC in the Northern Governorates (2012 estimated)

Project Summary	Targets
Overall Goal: Water service quality and service coverage in the Northern Governorates as provided by YWC will be improved	1. Coverage ratio of population served will be increased toward the target level 2. Water service quality will be improved
Project Purposes: Capacity on overall waterworks management by YWC will be enhanced through improvement of NRW management and O&M capacity, and strengthening human resource management and IEC activities	1. Selected performance indicators (PIs) will be improved through the project 2. Knowledge, technical skills and technology obtained by the Project will be utilized for daily operational works
Outputs: 1. Improving NRW Management 2. Strengthening Human Resource Development System 3. Promoting IEC Activities	• NRW ratio in the model DMAs will be reduced by XX % • Human resource development plan will be formulated • Training in the priority areas will be carried out • An IEC activity plan is formulated and IEC activities are carried out
Activities: **1. Improving NRW Management** 1-1 Development of Activity Basis for NRW Reduction (1) Survey and data collection on current situation of NRW (2) Development of an action plan for NRW reduction (3) Development of format and standard operation manual for mapping and database development (4) Establishment of attribute information basis on distribution network 1-2 Implementation of NRW Reduction Activities in DMA Model Areas (1) Selection of model DMAs and development of an action plan	 1-1 An action plan for NRW reduction will be developed 1-2 NRW ratio in the DMA model areas will be reduced

Project Summary	Targets
(2) Development of database and drawings on pipeline, installation of necessary materials and equipment (3) Implementation of OJT for ROU staffs (4) Implementation of NRW reduction activities in model DMAs (5) Monitoring and evaluation of results of NRW reduction activity	
2 . Strengthening Human Resource Development System	
2-1 Strengthening Human Resource Management System (1) Development of human resource development plan (2) Development of job description and standard operating procedure (SOPs) (3) Consideration on application of performance management system and establishment of performance evaluation Standards (4) Consideration on application of incentive mechanism for employees	2-1 Human resource development plan is formulated
2-2 Enhancing Systematical Implementation of Training (1) Development of a strategic training plan for the Project (2) Implementation of training in the priority areas	2-2 Training in the priority areas are organized and carried out
2-3 Establishment of a System for Training of Trainers (ToT) (1) Selection of YWC trainers in the key training areas (2) Implementation of capacity development training for trainers (3) Development of training program by YWC trainers (4) Development of training materials by YWC trainers (5) Implementation of training by YWC trainers	2-3 Training by YWC trainers will be carried out
3. Increasing Public Awareness through IEC Activities	
3-1 Promoting IEC Activities (1) Development of an IEC activity plan (2) Development of IEC materials (3) Implementation of IEC activities	3-1 An IEC activity plan is formulated and IEC activities are carried out

Input:

Expert	Equipment and materials		External conditions
1.Chief Advisor 2. NRW management 3. NRW reduction technology 4. O&M 5. Mechanical and electrical equipment 6. Human resource development 7. Training plan 8. IEC activity, etc.	(1) Activity on NRW reduction • Sounding bar • Ground microphone (leak detector) • Water - pressure gauge • Metal detector • Sluice valve • Flow meter • CAD Software for distribution network drawing • GIS software	(2) Activity on human resource development system • Customer database software • PC and peripheral devices (HQ 2, Daugara Training Center 10) (3) Activity on IEC promotion • IEC materials (4) Training • Training by the experts • Training in the	• A major change of institutional system of YWC by policy change etc. does not occur • Electricity is continuously supplied • Trained personnel do not quit or are not transferred during the Project period

Project Summary		Targets
• Software for hydraulic analysis of pipeline • Vehicle for leak detector • PC and & Printer (HQ 5, regional offices 11)	neighboring countries • Counterparts training (Japan) etc.	

Source: JICA Study Team

7.4.6 Implementation Schedule of Capacity Development Project (Sample)

The implementation schedule of capacity development project is indicated in Figure 7.6.

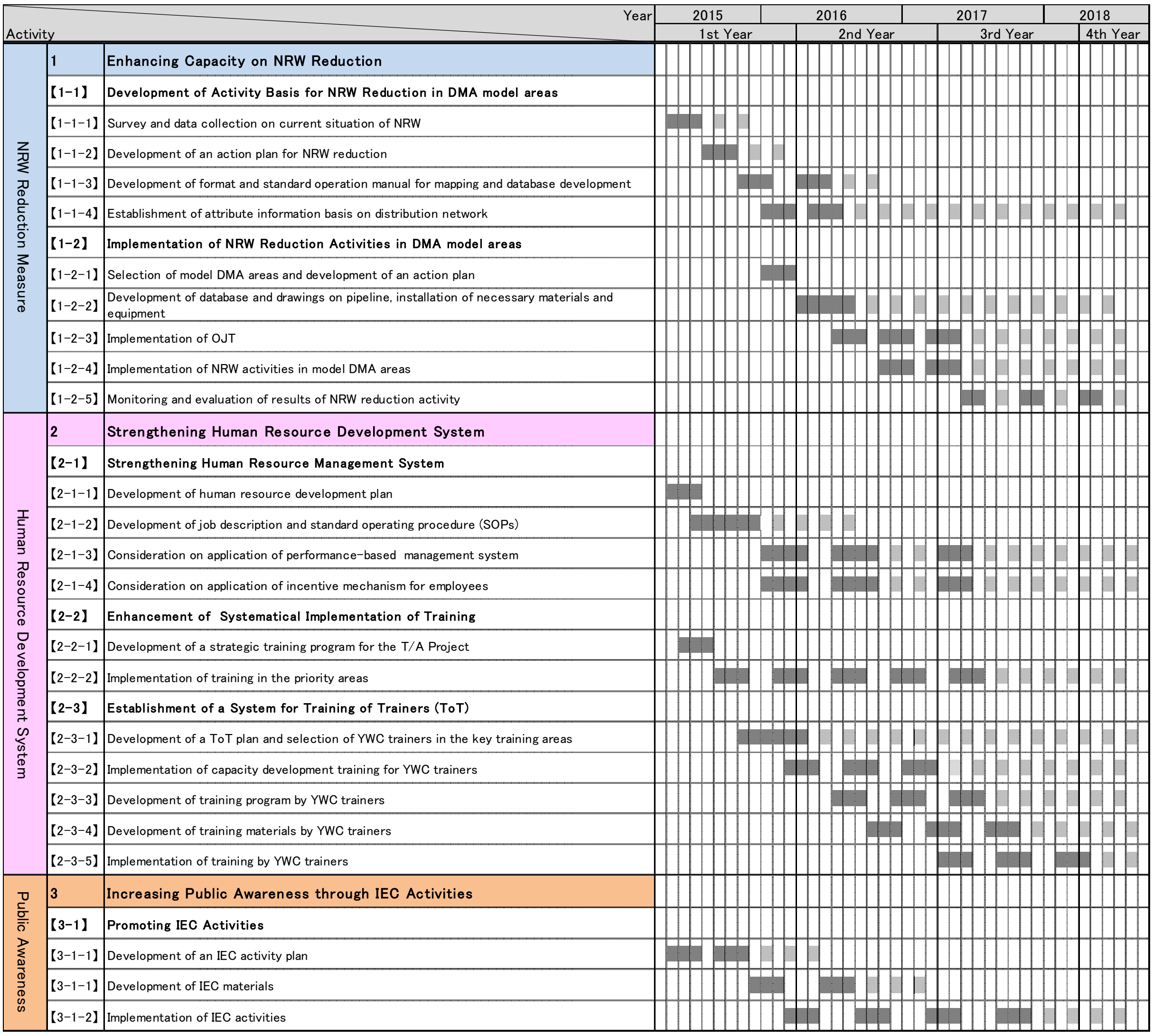


Figure 7.6 Implementation Schedule of Capacity Development Project

CHAPTER 8 IMPLEMENTATION SCHEDULE AND COST ESTIMATE

8.1 Irbid City and Its Suburbs

8.1.1 Project Cost

(1) Components of Direct Construction Cost
The unit cost of following proposed facilities are estimated by reference to the unit costs of recent construction works and the direct construction cost is estimated by multiplying unit costs by quantity of proposed facilities.

1) Transmission facility
   - Transmission Pumps
   - Transmission pipes
2) Distribution facility
   - Distribution Pumps
   - Strengthening
   - Rehabilitation (Replacement)
   - Service pipes & House connections
3) Other facility
   - SCADA
   - DMA
   - Remote Station

(2) Cost Estimation Conditions
The following are cost estimation conditions.

1)	Engineering Service Cost	10 % of Total of Construction Cost
2)	Physical Contingency	10 % of (Total of Construction Cost + Engineering Service Cost + Administration Cost)
3)	Administration Cost	3 % of (Total of Construction Cost + Engineering Service Cost)
4)	Project Cost	Sum total of total Construction Cost, Engineering Service Cost, Physical Contingency and Administration Cost, without Value-added tax
5)	Value-added tax	16 % of Project Cost
6)	Total Project Cost	Project cost including value-added tax

(3) Estimated Project Cost
The summary of the estimated project costs are shown in Table 8.1. The estimated total direct construction cost is 76.43 million JD and the total project cost is 110.5 million JD.

8.1.2 Phasing Concept

(1) Implementation Period
The project period for construction is same as the target year of the master plan; 20 years, with commencement in 2016 and completion in 2035. The construction works will be implemented in phased approach.

(2) Timing of Increased Water Allocation
Additional water sources will be available in 2 stages. In the first stage, 91 MCM/y of water will be available for the northern governorates by 2017 when all the transmission facilities are scheduled to start operation. It is assumed that 121 MCM/y of water will be available in 2020 at the earliest although it is not clear yet.

Table 8.1 Project Costs in Irbid City and Its Suburbs

Description				Quantity	Unit	Unit cost (JD)	Cost (million JD)
Construction cost							
Transmission facility	Transmission Pumps		Zebdat Transmission Pumps	2	sets	1,005,000	1.01
	Transmission pipes		DI 500 mm	3,700	m	250	0.93
Distribution facility	Distribution Pumps		Zebdat Distribution Pumps	2	sets	1,322,000	1.32
	Distribution pipes	Strengthening	HDPE 50 mm	1,546	m	47	0.07
			HDPE 63 mm	434	m	50	0.02
			HDPE 100 mm	46,171	m	58	2.68
			HDPE 150 mm	8,249	m	72	0.59
			DI 200 mm	23,254	m	120	2.79
			DI 300 mm	42,146	m	135	5.69
			DI 400 mm	18,276	m	200	3.66
			DI 600 mm	16,494	m	350	5.77
			DI 800 mm	25,691	m	580	14.90
			DI 1000 mm	1,971	m	850	1.68
			Sub-total	184,230	m		37.85
		Rehabilitation	HDPE 25 mm	3,606	m	42	0.15
			HDPE 32 mm	193	m	44	0.01
			HDPE 50 mm	245,676	m	47	11.55
			HDPE 63 mm	65	m	50	0.00
			HDPE 75 mm	12,230	m	52	0.64
			HDPE 100 mm	30,511	m	58	1.77
			HDPE 150 mm	3,646	m	72	0.26
			DI 200 mm	6,180	m	120	0.74
			DI 300 mm	2,839	m	135	0.38
			Sub-total	304,946	m		15.50
	Service pipes & House connections			53,900	connection	350	18.87
Other facility	SCADA		Irbid ROU (SCADA center), WAJ	1	lump sum		0.24
	DMA			10	place	54,000	0.54
	Remote Station		Zebdat, Hofa	2	place	94,000	0.19
(1) Total of Construction Cost							**76.43**
(2) Engineering Service Cost @ 10 % of (1)							7.64
(3) Administration Cost @ 3 % of (1)+(2)							2.52
(4) Physical Contingency @ 10 % of (1)+(2)+(3)							8.66
(5) Project Cost = (1)+(2)+(3)+(4)							95.26
(6) Value-added tax @ 16 % of (5)							15.24
(7) Total Project Cost = (5)+(6)							**110.50**

(3) Phasing Concept

The following are implementation phasing concepts of the proposed works based on the basic conditions above.

a. Proposed facilities required for increased water allocation in Case A (91 MCM/year of water allocation) are implemented first to distribute increased water amount to the customers equitably. The transmission and distribution pipelines between Hofa reservoir through eastern Irbid to Bait Ras (refer to section 3.1.2) constructed in the Japan's grant aid scheme will satisfy distribution of the increased water so that new facilities are not required for Case A.

b. Therefore, proposed facilities required for increased water allocation in Case B (121 MCM/year of water allocation), which involve restructuring of water distribution system, are implemented first to distribute increased water amount to the customers equitably. Zoning of distribution district, monitoring and control of transmission and distribution amount, implementation of

SCADA to control the distribution pressure, DMA and remote station will be implemented in this phase. This will be implemented in phase 1 from 2016 to 2020.

c. After completion of major works of restructuring of distribution facilities, rehabilitation of the deteriorated network will be started in 2021 and continue up to 2035. As the cost of rehabilitation work is large, the rehabilitation will be implemented in three phases. The phasing will be made based on the age of GI and steel pipe considering age distribution of GI pipe (31 years old or older (80 %), 21 to 30 years old (2 %), 11 to 20 years old (2 %) and less than 10 years old (6 %). Almost all GI pipes have been expired so that phasing of rehabilitation will be made evenly in 3 phases. All required steel pipe which pass more than 40 years will be rehabilitated evenly in 3 phases.

d. Installation of house connection and service pipes will be implemented according to the increase of houses from 2016 to 2035 for entire phases. Also, house connections will be replaced for the consumers along the distribution networks proposed to be rehabilitated.

8.1.3 Facilities and Cost by Phase

The components of proposed facilities and the construction costs by phase are shown in Table 8.2 and Table 8.3, respectively. Construction costs by packages for Phase 1 (2016-2020) projects in Irbid city and its suburbs is shown in Table 8.4.

Table 8.2 Components of Proposed Facilities by Phase in Irbid City and Its Suburbs

Phase	Period	Description
Phase 1	2016-2020	1) Facilities corresponding to 91 and 121MCM/year of water a. Transmission Facility ・ Transmission pump and pipes from Zebdat to Hofa b. Distribution Facility ・ Zebdat distribution pump c. Distribution pipes ・ Strengthening of distribution network to meet the increased water distribution (new installation and rehabilitation of network) d. Other facilities ・ SCADA ・ DMA (pressure reducing valves, flow meter, water pressure gauge, etc.) ・ Remote Station (local control panel for water level, flow and pressure, pressure reducing valves, flow meter, water pressure gauge) 2) Service pipe & house connection Installation to cater for the increase in service population
Phase 2 Phase 3 Phase 4	2021-2025 2026-2030 2031-2035	1) Rehabilitation of distribution network ・ Replacement of GI and aged pipe more than 40 years to reduce the leakage 2) Service pipe & house connection ・ Installation to cater to the increase in service population and to the customers that are connected to the distribution pipes proposed to be rehabilitated.

Table 8.3 Construction Costs by Phase in Irbid City and Its Suburbs

Description				Quantity	Unit	Cost (million JD)	Phase 1 2016 -2020	Phase 2 2021 -2025	Phase 3 2026 -2030	Phase 4 2031 -2035
Construction cost										
Transmission facility	Transmission Pumps		Zebdat TP	2	sets	1.01	1.01			
	Transmission pipes		DI 500 mm	3,700	m	0.93	0.93			
Distribution	Distribution Pumps		Zebdat DP	2	sets	1.32	1.32			
	Distribution pipes	Strength -ening	HDPE 50 mm	1,546	m	0.07		0.07		
			HDPE 63 mm	434	m	0.02		0.02		
			HDPE 100 mm	46,171	m	2.68		2.68		
			HDPE 150 mm	8,249	m	0.59	0.59			
			DI 200 mm	23,254	m	2.79	2.79			
			DI 300 mm	42,146	m	5.69	5.69			
			DI 400 mm	18,276	m	3.66	3.66			
			DI 600 mm	16,494	m	5.77	5.77			
			DI 800 mm	25,691	m	14.90	14.90			
			DI 1000 mm	1,971	m	1.68	1.68			
			Sub-total	184,230	m	37.85	35.08	2.77	0.00	0.00
		Rehabil. (Repl.)	HDPE 25 mm	3,606	m	0.15		0.05	0.05	0.05
			HDPE 32 mm	193	m	0.01		0.00	0.00	0.00
			HDPE 50 mm	245,676	m	11.55		3.85	3.85	3.85
			HDPE 63 mm	65	m	0.00		0.00	0.00	0.00
			HDPE 75 mm	12,230	m	0.64		0.21	0.21	0.21
			HDPE 100 mm	30,511	m	1.77		0.59	0.59	0.59
			HDPE150 mm	3,646	m	0.26		0.09	0.09	0.09
			DI 200 mm	6,180	m	0.74		0.25	0.25	0.25
			DI 300 mm	2,839	m	0.38		0.13	0.13	0.13
			Sub-total	304,946	m	15.50	0.00	5.17	5.17	5.17
	Service pipes & House connections			53,900	Num.	18.87	3.54	5.11	5.11	5.11
Other facilities	SCADA		SCADA center	1	LS	0.24	0.24			
	DMA			10	place	0.54	0.54			
	Remote Station		Zebdat, Hofa	2	place	0.19	0.19			
Total of Construction Cost						76.43	42.83	13.05	10.28	10.28
Engineering Service Cost						7.64	4.28	1.30	1.03	1.03
Physical Contingency						8.66	4.85	1.48	1.16	1.16
Administration Cost						2.52	1.41	0.43	0.34	0.34
Project Cost						95.26	53.38	16.26	12.81	12.81
Value-added tax						15.24	8.54	2.60	2.05	2.05
Total Project Cost						110.50	61.92	18.87	14.86	14.86

Note: LS: lump sum

8.1.4 Operation and Maintenance Cost

The O&M cost per unit m^3 by implementation of the proposed project is estimated for financial and economic analysis of the project.

(1) Condition of O&M cost estimation

1) Composition of O&M cost and base year

The composition of O&M cost for estimation, which is based on the actual cost of year 2013, is as follows.

- Personnel cost
- Electricity cost
- Other miscellaneous cost (such as chemicals, repair)

The cost for purchase of Disi water and the proposed Wadi Al-Arab water in Case B is estimated in Chapter 9, separately.

2) Method of estimation

The incremental cost from the base year of 2013 is estimated.

Table 8.4 Construction Costs by DMAs in Phase 1 (2016-2020) in Irbid City and Its Suburbs

Package	Description			Quantity	Unit	Construction Cost (million JD)	Total Project Cost (million JD)
1	Transmission Pumps		Zebdat TP	2	sets	1.01	1.46
2	Transmission pipes		DI 500 mm	3,700	m	0.93	1.34
3	Distribution Pumps		Zebdat DP	2	sets	1.32	1.91
4	Distribution pipes (Strengthening)	Zebdat Gr.01	DI 200 -800mm	10,139	m	2.57	3.72
5		Zebdat Gr.02	HDPE 150,DI 200-1000 mm	26,390	m	7.68	11.10
6		Zebdat Gr.03	DI 200 -800 mm	13,245	m	7.04	10.18
7		Zebdat Gr.04	HDPE 150,DI 200-800 mm	24,069	m	6.07	8.78
8		Zebdat Gr.05	HDPE 150,DI 200-800 mm	27,673	m	6.29	9.09
9		Zebdat P.01	HDPE 150,DI 200-600 mm	11,375	m	2.35	3.40
10		Zebdat P.02	HDPE 150,DI 200-300 mm	6,965	m	0.92	1.33
11		Hofa Gr.01	HDPE 150,DI 200-800 mm	3,063	m	0.54	0.78
12		Hofa Gr.02	HDPE 150,DI 200-400 mm	12,814	m	1.57	2.27
13		Hofa Gr.03	DI 300 mm	347	m	0.05	0.07
		Sub-total		136,080	m	35.08	50.72
14	Service pipes & House connections			10,100	Num.	3.54	5.12
15	SCADA		SCADA center	1	LS	0.24	0.35
	DMA			10	place	0.54	0.78
	Remote Station		Zebdat, Hofa	2	place	0.19	0.27
	Sub-total					0.97	1.40
	Total of Construction Cost					42.83	61.92
	Engineering Service Cost					4.28	
	Physical Contingency					4.85	
	Administration Cost					1.41	
	Project Cost					53.38	
	Value-added tax					8.54	
	Total Project Cost					61.92	

Note: For defined DMAs and its boundary, refer to Figure 5.16 in Chapter 5.

a) Personnel cost

No personnel cost increases because no increase in staff number in this project as proposed in section 7.3.3.

b) Electricity cost

The following electricity cost per unit water volume are utilized for Case A and Case B, in which pumping scheme of Zebdat pumping station is different. The electricity consumption of Zebdat pumping station in the Case A is minimum as water comes from the eastern transmission line and supply water from Hofa reservoir by gravity, and the electricity consumption in the Case B is increased because water has to be pumped up from Zebdat to Hofa.

Table 8.5 Unit Electricity Cost per Water Volume

(JD/m^3)

	In 2013	Case A	Case B
Zebdat pumping station	0.030	0.006	0.026
Other electricity cost (base)	0.227	0.227	0.227

- The average electricity cost per unit production volume in 2013 is 0.227 JD/m^3 as a base unit cost except that of Zebdat pump station, which is estimated at 0.030 JD/m^3.
- The electricity cost per unit production of Zebdat pumping station is estimated at 0.030 JD/m^3 till 2017, 0.006 JD/m^3 from 2018 to 2020 and 0.026 JD/m^3 from 2021 to 2035.
- The electricity cost in Irbid and Ramtha city and suburbs will be not changed by this project so that the unit cost will be not changed.

c) Other Miscellaneous Cost

Incremental other miscellaneous cost is estimated at 5 % of the total costs of electricity and personnel.

(2) Summary of Incremental O&M costs

The summary of incremental O&M costs are shown in Table 8.6 based on the water supply amount and the cost estimation conditions above.

Table 8.6 Incremental O&M Costs After Project Implementation in Irbid City and Its Suburbs

(Million JD/year)

Item	Current O&M cost	Incremental O&M cost		
	2013	2017	2020	2035
Personnel	0.90	0	0	0
Electricity	4.19	0	3.21	6.08
Other miscellaneous	0.28	0	0.16	0.30
Total	5.37	0	3.37	6.39

Note: The total O&M is calculated by summing up of current and incremental O&M costs.

8.2 Ramtha City and Its Suburbs

8.2.1 Project Cost

(1) Components of Direct Construction Cost

Refer to (1) in section 8.1.1.

(2) Cost Estimation Conditions

Refer to (2) in section 8.1.1.

(3) Estimated Project Cost

The summary of the estimated project costs are shown in Table 8.7. The estimated total direct construction cost is 19.88 million JD and the total project cost is 28.74 million JD.

8.2.2 Phasing Concept

(1) Implementation Period

Refer to (1) in section 8.1.2.

(2) Timing of Increased Water Allocation

Refer to (2) in section 8.1.2.

(3) Phasing Concept

The following are implementation phasing concepts of the proposed works based on the basic conditions above.

- Proposed facilities required for increased water allocation in Case A (91 MCM/y of total water allocation) are implemented first to distribute increased water amount to the customers equitable and then proposed facilities in Case B (121 MCM/year of water allocation) will be implemented in the 1st phase. In this phase, restructuring of water distribution system, zoning of distribution district, monitoring and control of transmission and distribution amount, implementation of SCADA to control the distribution pressure, DMA and remote station will be implemented from 2016 to 2020.

- After completion of major works of restructuring of distribution facilities, rehabilitation of the deteriorated network will be started in 2021 and continue up to 2035. As the cost of rehabilitation work is large, the rehabilitation will be implemented in three phases. The phasing will be made based on the age of GI and steel pipe. 93 % of GI pipes are older than 24 years and almost all pipes have been expired so that phasing will be made evenly in 3 phases. Steel pipe will be not required for rehabilitation as they are new.

- Installation of house connection and service pipes will be implemented according to the increase of houses from 2016 to 2035 for entire phases. Also, house connections will be replaced for the consumers along the distribution networks proposed to be rehabilitated.

Table 8.7 Project Costs in Ramtha City and Its Suburbs

Description				Quantity	Unit	Unit cost(JD)	Cost (million JD)
Construction cost							
Transmission Facility	Transmission pipes		DI 300 mm	5,900	m	135	0.80
Distribution Facility	Distribution pipes	Strength-ening	HDPE 100 mm	7,858	m	58	0.46
			HDPE 150 mm	4,463	m	72	0.32
			DI 200 mm	3,795	m	120	0.46
			DI 300 mm	4,654	m	135	0.63
			DI 400 mm	5,824	m	200	1.16
			DI 500 mm	5,094	m	250	1.27
			DI 600 mm	14,794	m	350	5.18
			Sub-total	46,482	m		9.48
		Rehabili-tation	HDPE 20 mm	722	m	41	0.03
			HDPE 25 mm	289	m	42	0.01
			HDPE 50 mm	19,652	m	47	0.92
			HDPE 75 mm	56,686	m	52	2.95
			HDPE 100 mm	2,107	m	58	0.12
			HDPE 150 mm	246	m	72	0.02
			DI 250 mm	9	m	130	0.001
			Sub-total	79,711	m		4.05
	Service pipes & House connections			13,500	connection	350	4.73
Other facility	SCADA		Ramtha ROU	1	lump sum	224,000	0.22
	DMA			6	place	54,000	0.32
	Remote Station		Mahasi PS, Hodod PS, Abu Al Basal PS	3	place	94,000	0.28
(1) Total of Construction Cost							**19.88**
(2) Engineering Service Cost @ 10 % of (1)							1.99
(3) Administration Cost @ 3 % of (1)+(2)							0.66
(4) Physical Contingency @ 10 % of (1)+(2)+(3)							2.25
(5) Project Cost = (1)+(2)+(3)+(4)							24.78
(6) Value-added tax @ 16 % of (5)							3.96
(7) Total Project Cost = (5)+(6)							**28.74**

8.2.3 Facilities and Cost by Phase

The components of proposed facilities and the construction costs by phase are shown in Table 8.8 and Table 8.9, respectively.

Table 8.8 Components by Implementation Phasing in Ramtha and Its Suburbs

Phase	Period	Description
Phase 1	2016 - 2020	1) Facilities corresponding to 91 and 121 MCM/year of water a. Transmission Facility ・ New transmission pipe from Hodod to Mahasi b. Distribution Facility c. Distribution pipes ・ Strengthening of distribution network to meet the increased water distribution (new installation and rehabilitation of network) d. Other facilities ・ SCADA ・ DMA (pressure reducing valves, flow meter, water pressure gauge, etc.) ・ Remote Station (local control panel for water level, flow and pressure, pressure reducing valves, flow meter, water pressure gauge) 2) Service pipe & house connection ・ Installation to cater for the increase in service population
Phase 2 Phase 3 Phase 4	2021 - 2025 2026 - 2030 2031 - 2035	1) Rehabilitation of distribution network ・ Replacement of GI and aged pipe more than 40 years to reduce the leakage 2) Service pipe & house connection ・ Installation to cater to the increase in service population and to the customers that are connected to the distribution pipes proposed to be rehabilitated

Table 8.9 Project Cost by Phase in Ramtha City and Its Suburbs

Description				Quantity	Unit	Cost (million JD)	Phase 1 2016 -2020	Phase 2 2021 -2025	Phase 3 2026 -2030	Phase 4 2031 -2035
Construction cost										
Transmission Facility	Transmission pipes		DI 300 mm	5,900	m	0.80	0.80			
Distribution Facility	Distribution pipes	Strength-ening	HDPE 100 mm	7,858	m	0.46	0.46			
			HDPE 150 mm	4,463	m	0.32	0.32			
			DI 200 mm	3,795	m	0.46	0.46			
			DI 300 mm	4,654	m	0.63	0.63			
			DI 400 mm	5,824	m	1.16	1.16			
			DI 500 mm	5,094	m	1.27	1.27			
			DI 600 mm	14,794	m	5.18	5.18			
			Sub-total	46,482	m	9.48	9.48	0.00	0.00	0.00
		Rehabil. (Repl.)	HDPE 20 mm	722	m	0.03		0.01	0.01	0.01
			HDPE 25 mm	289	m	0.01		0.004	0.004	0.004
			HDPE 50 mm	19,652	m	0.92		0.31	0.31	0.31
			HDPE 75 mm	56,686	m	2.95		0.98	0.98	0.98
			HDPE 100 mm	2,107	m	0.12		0.12		
			HDPE 150 mm	246	m	0.02		0.02		
			DI 250 mm	9	m	0.001		0.001		
			Sub-total	79,711	m	4.05	0.00	1.45	1.30	1.30
	Service pipes & House connections			13,500	Num	4.73	0.89	1.28	1.28	1.28
Other facilities	SCADA		Ramtha ROU	1	Set	0.22	0.22			
	DMA			6	place	0.32	0.32			
	Remote Station		Mahasi P.S, Hodod P.S, Abu Al Basal P.S	3	place	0.28	0.28			
Total of Construction Cost						19.88	12.00	2.72	2.58	2.58
Engineering Service Cost						1.99	1.20	0.27	0.26	0.26
Physical Contingency Cost						2.25	1.36	0.31	0.29	0.29
Administration Cost						0.66	0.40	0.09	0.09	0.09
Project Cost						24.78	14.95	3.39	3.22	3.22
Value-added tax						3.96	2.39	0.54	0.51	0.51
Total Project Cost						28.74	17.34	3.94	3.73	3.73

Note: LS: lump sum

8.2.4 Operation and Maintenance Cost

The O&M cost per unit m^3 by implementation of the proposed project is estimated for financial and economic analysis of the project.

(1) Condition of O&M cost estimation
Refer to (1) in section 8.1.4.

(2) Summary of Incremental O&M costs
The summary of incremental O&M costs are shown in Table 8.10 based on the water supply amount and the cost estimation conditions above.

Table 8.10 Incremental O&M Costs After Project Implementation in Ramtha City and Its Suburbs

(Million JD/year)

Items	Current O&M cost	Incremental O&M cost		
	2013	2017	2020	2035
Personnel	0.21	0	0	0
Electricity	0.96	0	0.88	1.43
Other miscellaneous	0.06	0	0.04	0.07
Total	1.23	0	0.93	1.50

Note: Total O&M is calculated by summing up of current and incremental O&M costs.